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FINAL REPORT ON RESEARCH RESULTS

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1 Table of Contents

2 Introduction

This report presents the results of the activities of CEN/TC 224/PT06 Phase B. The report follows the decisions on PT06/B work as described in the following documents:

a. The Phase B call for Project Team Experts (Terms of Reference)
b. The Phase A Report (A6 Document)
c. The decision of CEN on the members of the team.
d. The WG6 guidance on the rational behind selection in relation to PT work (as reported by the former PT leader Martin Freer)
e. The minutes of the meeting of the 2nd April 2002, in London to kick-off the PT06 work
f. The final Phase B workplan as reported to WG6 on 1 July 2002

According to the above

1. The work of the team will focus on delivering suitable test methodologies for testing specific features on the accessibility of card reading devices

2. To the extent that resources will permit it, actual testing will take place to validate the methodology.

The following table presents the areas that will be covered and the respective expert taking over the responsibility

Table I

Testing Area	Expert
Vision-Touch	Fransesc Aragall
Interfaces	Jan-Harvard Skjetne
Sound-Audio-Speech	Pantelis Angelidis
Vehicles	Pantelis Angelidis (Originally Martin Freer)

This report was compiled using the individual reports that was to the responsibility of each expert to prepare. Caution has been paid so that each report to be possible to be read autonomously.

The team made every effort to cover as much as possible of the work described in the CEN/TC 224 PT 06 – Phase B, as well as the Phase A report.
The following table presents the coverage of areas to be worked on in Phase B,as described in section 8.2 of the TOR, per expert.

Table II

Expert	**Area(s)**
Skjetne	Human factors / usability standards
Aragall	Forces, Vision and Lighting
Angelidis (vehicles)	Access to card reading devices by drivers of vehicles, Access using hand held terminals and contactless cards
Angelidis (sound-audio-speech)	Sound levels, Intelligibility of spoken messages and Sound types

One can easily come to the conclusion that most of the suggested areas to be worked on in Phase B are covered. Those areas left out, namely 3a,c,d, constitute to the best of the teams judgment, more of a Hand-Held Device (HHD) design exercise than a suitable research area on accessibility.

The following table presents the coverage of areas to be worked on in Phase B, as described in pages 10 & 11 of the Phase A report, per expert.

Table III

Expert	**Area(s)**
Skjetne	10,11
Aragall	8,12,13
Angelidis (vehicles)	4
Angelidis (sound-audio-speech)	5,6,7,17

Comparing the tasks described in the report of Phase A as potential areas of research to the ones in the above Table, one can identify that with the exception of wheelchair related areas of research most of other areas are sufficiently covered.

As far as the wheelchair issues are concerned, the team feels that it does not possesses enough expertise to cover the area on the one hand, whilst on the other there is already a lot of data focusing on wheelchair users as also pointed by CEN/TC 224 in their PT 06 – Phase B call for experts (Section 3, 2nd paragraph).

In addition, along the team work as designed in its workplan, the additional areas related to HHD proposed in page 11 of the Phase A report, were covered as following:

- Point 1: not covered
- Point 2: Skjetne
- Point 3: Angelidis (vehicles)

Finally the team covered, to the extend described in its workplan, the activities 1 to 4 described in the end of page 11 of the Phase A report.

What follows are the four individual report on the research areas as defined in Table I. An effort has been made for the whole team to follow common guidelines and present the results uniformly. The template used, to the extent that this was possible, in all four reports is the following.

Foreword
Introduction

1. **Scope**
2. **Normative References**
3. **Definitions & Abbreviations**
4. **Testing Area**
5. **Methodology of Tests**
6. **Results**
7. **Extensions – Further testing requirements**
8. **Conclusions**
9. **External Relations**
10. **Appendix**

3 THE PT06 Phase B Team Members

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4 References

1. "Guidelines for the Design of Consumer Products to Increase Their Accessibility to People with Disabilties or Who Are Aging: Accessible Design of Consumer Products". NOTE: http://trace.wisc.edu/docs/consumer_product_guidelines/toc.htm.
2. "The Center for Universal Design". NOTE: http://www.design.ncsu.edu/cud/.
3. "UsabilityNet" The objective of Usabilitynet is to promote usability, user-centred design and process improvement in Europe and also further a field NOTE: http://www.usabilitynet.org
4. *ANEC guidelines - http://www.anec.org/researchrica.htm*
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6. CEN/CENELEC Guide 6: "Guidelines for standards developers to address the needs of older persons and persons with disability".
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10. *COST219bis – "COST219bis – Telecommunications for All" / "Guidelines-Accessibility requirements for new telecommunication equipment"*
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15. *ETS 300 679 – "Telephony for the hearing impaired; Electrical coupling of telephone sets to hearing aids"*
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17. *ETSI EG 201 472 V1.1.1 (2000-02), 2000, ETSI Guide, Human Factors (HF);Usability evaluation for the design of telecommunication systems, services and terminals*
18. ETSI EG 202 116 (2002-07) Human Factor (HF); Guidelines fir ICT products and services; "Design for All"
19. *ETSI EG 202-116 v0.0.8 (2002-01), 2002, ETSI Guide, Human Factors (HF); Guidelines for ICT products and services; "Design for All".*
20. ETSI ETR 029: "Human Factors (HF); Access to telecommunications for people with special needs; Recommendations for improving and adapting telecommunication terminals and services for people with impairments".
21. ETSI ETR 166: "Human Factors (HF); Evaluation of telephones for people with special needs; An evaluation method".
22. ETSI ETR 334 (1996): "Human Factors (HF); The implications of human ageing for the design of telephone terminals ".
23. ETSI TR 102 068: "Human Factors (HF); Requirements for Assistive Technology
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31. ISO/IEC Guide 71: 2001 "Guidelines for standards developers to address the need of older persons and persons with disabilities".
32. *ITU-T Rec. E.135 – "Human Factors – Aspects of public telecommunication terminals for people with disabilities"*
33. *ITU-T Rec. P.370 – "Coupling hearing aids to telephone sets"*
34. ITU-T Recommendation E.138: "Human factors aspects of public telephones to improve their usability for older people".
35. ITU-T Recommendation F.901: "Usability evaluation of telecommunication services".
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5 Abbreviations

AGC	Automatic Gain Control
Barge-in	The ability to interrupt an utterance during voice recognition
DSN	Drivers with Special Needs
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GSM-SMS	Global System for Mobile Communications – Short Message System
HHD	Hand-held device
HMI	Human Machine Interaction
SPL	Sound Pressure Level
TTS	Text-to-Speech
VAD	Voice Activity Detection

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Francesc Aragall	1st draft	PT06/B	7/8/2002	v. 0
Francesc Aragall	2nd draft	PT06/B	10/9/2002	v. 1
Francesc Aragall	3rd draft	PT06/B	23/10/2002	v. 2
Francesc Aragall	4th draft	PT06/B	25/10/2002	v. 3

6.1 Foreword

This report has been prepared by Expert **Francesc Aragall** of PT06 Team under Technical Committee CEN/TC 224 "*Machine readable cards, related device interfaces and operations"*, the Secretariat of which is held by AFNOR.

It is intended that this report will become part of the PTO6 – Phase B final report that will couple the Phase A report which is a draft ENV that will become part 6 of a series of standards (EN 1332), under the general title "*Identification card systems – Man-machine Interface"* and the different parts are the following:

- Part 1 : Design principles for the user interface including functions to be represented by symbols;
- Part 2 : Dimensions and location of a tactile identifier for ID-1 cards;
- Part 3 : Key Pads ;
- Part 4 : Coding of user requirements for people with special needs;
- Part 5 : Embossed symbols for differentiation of application on ID-1 cards;
- Part 6 : Provisions for physical accessibility, including physical access for wheelchair users and vehicle drivers, to card reading devices (draft ENV).

This report is one out of four report prepared during Phase B according to the following distribution of work:

Testing Area	**Expert**
Vision-Touch	Francesc Aragall
Interfaces	Jan-Harvard Skjetne
Sound-Audio-Speech	Pantelis Angelidis
Vehicles	Pantelis Angelidis (Originally Martin Freer)

6.2 Introduction

In this report, we present the results of our research on how to include vision related characteristics in the development process of card reading devices.

The report is organised in three sections. Section 6.3 clarifies the scope of the research specifically of the vision and force part. Sections 6.4 and 6.5 contains the results on the research on the vision part, while section 6.6 details recommendations for a card reader device.

6.3 Scope

The areas covered are the following, according to the Terms of Reference (ToR):

4-. Forces – guidance is required on the maximum permissible forces for opening doors, operating keypads, and for inserting, removing or swiping cards.

5-. Vision and lighting – guidance is required in respect of illumination levels for internal or external applications in terms of local area lighting (particularly on relation to personal security) and for task lighting under varying conditions, particularly for users with visual impairments and/or disabilities. Additionally guidance may be required in respect of luminance and contrast levels.

At the same time, the following areas have been researched:

8) Determine how far local light should allow users of terminals to see at night in order to provide a reasonable sense of security.

12) Determine realistic and feasible task lighting requirements (recommendations vary from 200 to 1000 lux; the latter may tend to lead to lots of glare and reflection and may be too much for this application.

13) Determine the minimum width of a card slot (insert or swipe) to assist location of the card.

Finally, and according to the minutes of the meeting of the 2nd April 2002, in London to kick-off the PT06 work:

1. The work of the team will focus on delivering suitable test methodologies for testing specific features on the accessibility of card reading devices.

2. To the extent that resources will permit it, actual testing will take place to validate the methodology.

6.4 Letters and symbols condition.

6.4.1 Contrast.

Contrast depends on the combination of the colour of the background and colour, size and thickness of the letters. Contrast is, in most of the cases, the most important factor for a good legibility.

Table 1. Recommendations for background and letter colours

Symbol or letter	Background	Example
Black	Yellow	**Example**
Green	White	**Example**
Red	White	**Example**
Blue	White	**Example**
White	Blue	**Example**
Black	White	**Example**
Yellow	Black	**Example**
White	Red	**Example**
White	Green	**Example**
White	Black	**Example**

6.4.2 Size, typography and spacing.

Visual acuity is the ability to perceive or distinguish details of the objects. Relation between the reading distance and the height of the object (letters or symbols in a sign) should determine a minimum vision angle of 1/3º.

Table 2: Height of the letter depending on the reading distance.

Distance (m)	Letter height (mm)
10,0	58
50,0	290
100,0	580

Texts should fulfil the following recommendations:

- Relation between width and height of the capital letters (B, E, F...) should be between 0,7 and 0,8.
- Italic fonts, handwriting simulations and baroque style fonts should be avoided.
- It is recommended that text lines with a maximum length of 50-65 characters.
- Text will have normal spacing between words and justified texts should be avoided. Compressions and lengthening of text lines or single words to adjust the length of the line should be avoided.
- Right margin not justified helps the reader.

Not recommended	Recommended
J U S T I F I E D T E X T	Not justified text

- It is recommended not to use capital letters, because they are not easy readable (graphology of small letters (as f, t, l, j, g...) emphasises differences between them). Although one or two word in capital letters could be allowed, continuous text in capital letters are not recommended.

6.5 Indoor lightning projects.

Appropriate lightning conditions are interesting for:

- In industrial lightning is a productivity factor and increases performance at work.
- In shopping areas is a decisive factor to attract consumers.
- In domestic areas it improves visual comfort and makes life more comfortable and friendly.

At least a 20% of our life we are under artificial lightning, so sustainability, energy consuming, visual comfort and security must be taken into account when designing lightning for any specific function.

A good indoor lightning must fulfil the following requirements:

1. Provide enough lightning.
2. Eliminate all possible glaring causes.
3. Provide appropriate electrical appliances for each particular case.
4. Use lightning sources to ensure, in each case, a satisfactory distribution of colours.

In order to design lightning projects, the next steps should be followed:

1. Lightning level required.
2. Selection of lamp typology.
3. Selection of lightning system and electrical appliances.
4. Selection of the hanging height of the electrical appliances.
5. Electrical appliances distribution.
6. Minimum number of electrical appliances.
7. Calculation of the total electric flux.
8. Final distribution of the number of electrical appliances.

The second 4 items (from electrical appliances distribution to final distribution of the number of electrical appliances) depends mainly on the electrical lamp selected, while the first 4 items are more general. For that reason, in this report only requirements on these 4 items are defined.

6.5.1 Lightning level required.

Lightning level required to perform a task depends on the size of the details of the objects, distance between the objects and the eye, reflection factor of the objects, contrast between the objects and the background, time for observation and speed of the objects (if they are in movement).

The following table defines the lighting requirement for different areas and the activities that takes places in those areas.

Table 3. Lighting requirements.

Lighting requirement (lux)	Area description
20	Outdoor spaces
50	Indoor areas with low frequency visits without detailed perception.
100	Indoor areas occasionally visited where tasks are mainly movement and low detail perception.
150	Indoor areas occasionally visited where tasks may require detail perception or may have risk for people or products.
200	Indoor areas permanently occupied with visual tasks not needing detail perception.
300	Indoor areas permanently occupied, with simple visual tasks (big details or high contrast).
500-1000	Indoor areas where tasks needing a fine distinction of details are required.
>1000	Indoor areas with activities needing an extremely fine distinction or low contrast conditions.

An application of these requirements in a transport company defines three lighting levels for the different areas of the station.

Table 4. Lighting requirement in a transport company.

Light requirement (lux)	Description	Area
30 lux	Lighting in outdoor areas	Public way
300 lux	Ambient lighting in indoor areas	Halls, stairs, escalators, ramps, elevators, platforms...
500 lux	Lighting in areas where detailed tasks are required	Information panels, ticket window and automatic vending machine

Finally, as an application to card reading devices the following requirements should be fulfilled:

- The ambient lighting around the terminal area shall be 300 lux.
- Light shall be of sufficient intensity on the working area of the card reading device and not less than 500 lux.

For those areas with a level under 300lux, general lightning should be used. For levels between 300 and 1.000lux the general lightning shall be completed with localised or individual lightning, permanent or temporal, that will help reaching required levels. Localised lightning shall be used for levels over 1.000lux, although general lightning is not excluded.

In those cases where only general lightning is provided, the relation between the minimum lightning level and medium lightning level shall be 1:1’5.

In those cases where individual lightning must be combined with general lightning, levels must be related, so that general lightning level shall have a minimum level as defined in table 5.

Table 5. Minimum level for general lightning.

Individual lightning (lux)	Minimum general lightning (lux)
300	60
500	70
1.000	100
2.000	150
5.000	250
10.000	300

6.5.2 Selection of lamp typology.

- Incandescence lamp: recommended for areas with a lightning level under 200lux and under 2.000hours/year.
- Fluorescent tube: recommended when a high colour temperature is needed (4.500ºK – 6.500ºK). At the same time it is recommended for areas with a lightning level over 200lux or over 2.000 hours/year.
- Mercury fumes lamps: recommended when lightning quality conditions are not crucial (for industrial use) but not in areas with card reading devices.
- Sodium fumes lamps: not recommended because of its monochrome light.

6.5.3 Selection of lightning system and electrical appliances.

- Direct lightning is appropriate for high level lightning requirements on a work plane or specific area. The light loss is minimised but more than one lamp must be used for each area, in order to reduce unpleasant shadows.
- In half-direct lightning part of the light is reflected on the ceiling. It is only recommended in areas with low ceilings, it allows high level lightning with soft and gentle shadows.
- Diffused lightning gives more importance to reflection on ceilings and walls so shadows almost disappears. It is recommended soft colours for walls and ceiling in order to reduce absorption losses.
- In indirect lightning, light coming from walls and ceiling is more important that light coming from primary sources. Shadows and glare are avoided and makes the observer feel calmed and relaxed.

6.5.4 Selection of the hanging height of the electrical appliances.

Defining:
d: vertical distance between electric appliance and the work place (at 0’85m from the floor).
d’: vertical distance between electric appliance and the ceiling.
h: distance between the work place and the ceiling.

Table 6. Hanging height.

Lightning	Minimum requirement	Recommended requirement
Direct, half-direct or diffused	*d=2/3*h*	*d=4/5*h*
Indirect	*d’=h/4*	

6.6 Requirements of a card slot.

6.6.1 Card readers requiring swipe action.

For card readers that require a swipe action to enter the data he following requirements should be considered:

- Horizontal swipes should be available in either direction with either hand.
- Vertical swipes should be downwards and available to either hand.
- Provide space to access the swipe channel and use guiding grooves or sculpting on the insert and retrieve ends of the channel.
- Ensure there is sufficient space for at least 95th percentile fingers to grip the card, when it is inserted for swiping. Card should overhang at least 2,6mm from the outer part of the card slot, to ensure the card swiping.
- Ensure the channel edges are smooth and robust to withstand wear, and protect against skin or fingernail damage.
- Provide clear indication to show the required orientation of the card and the direction of travel.
- Wherever possible, allow for the card to be swiped in more than one orientation.
- Ensure that the pull forces required to swipe the card are possible across 99% of the possible user population. Force resistance should not exceed 1,5-2N (similar to a linear slider).

6.6.2 Card readers requiring insert and retrieve action.

For card readers that require an insert and retrieve action to enter the data consider the following user requirements:

- In preference use card readers that accept cards with the short edge leading, it allows the user better grip with the card, and prevents accidental insertion with the wrong longer edge.
- Provide clear indication to show any required orientation of the card, and test this on a sample of representative users.
- Wherever possible, allow for the card to be inserted in more than one orientation.
- Provide smooth sculpted grooves to aid correct insertion, and provide sufficient space for at least 95th percentile fingers to retrieve the card with an adequate finger grip on the card. Card should overhang at least 2,6mm from the outer part of the card slot, to ensure the card extraction.
- Ensure that the push/pull forces required to insert and retrieve the card are less than 25N such that they are possible across 99% of the possible user population.

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Fransesc Aragall - ProAsolutions SL, Jan Heim and Jan-Håvard Skjetne - SINTEF of PT06 Team under Technical Committee CEN/TC 224 "*Machine readable cards, related device interfaces and operations*", the Secretariat of which is held by AFNOR.

It is intended that this report will become part of the PTO6 – Phase B final report that will couple the Phase A report which is a draft ENV that will become part 6 of a series of standards (EN 1332), under the general title "*Identification card systems – Man-machine Interface*" and the different parts are the following:

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This report is one out of four report prepared during Phase B according to the following distribution of work:

Testing Area	Expert
Vision-Touch	**Fransesc Aragall**
Development of interfaces	**Jan-Håvard Skjetne**
Sound-Audio-Speech	**Pantelis Angelidis**
Vehicles	**Pantelis Angelidis (Originally Martin Freer)**

7.1 Introduction

In this report we present the result of our research on how to develop smart card applications with a design for all approach. The result is a proposed development process based on EN ISO/IEC 13407: Human-centred design processes for interactive systems. The process is tailored for developing “user interface to card reading devices targeted for the general public”.

7.2 Scope

This document is mainly to support the development of "user interface to card reading devices targeted for the general public". However, "neighbour" applications like home banking and home shopping (not necessarily using a card) may also benefit form the suggestions here.

The main users of this document will be project managers, or developers with a high-level responsibility for the development of the user interface of the application.

7.3 Normative References

[0] ETSI EG 202 116 (2002-07) Human Factor (HF); Guidelines fir ICT products and services; "Design for All"
[1] CEN/CENELEC Guide 6: "Guidelines for standards developers to address the needs of older persons and persons with disability".
[2] ETSI EG 201 472 (V1.1.1): "Human Factors (HF); Usability evaluation for the design of telecommunication systems, services and terminals".
[3] ETSI ETR 029: "Human Factors (HF); Access to telecommunications for people with special needs; Recommendations for improving and adapting telecommunication terminals and services for people with impairments".
[4] ETSI ETR 166: "Human Factors (HF); Evaluation of telephones for people with special needs; An
evaluation method".
[5] ETSI ETR 334 (1996): "Human Factors (HF); The implications of human ageing for the design of telephone terminals ".
[8] ETSI TR 102 068: "Human Factors (HF); Requirements for Assistive Technology
[9] ISO 9241-11 (1998): "Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11: Guidance on usability".
[10] ISO/IEC Guide 71: 2001 "Guidelines for standards developers to address the need of older persons and persons with disabilities".
[11] EN ISO/IEC 13407: Human-centred design processes for interactive systems".
[12] ITU-T Recommendation E.138: "Human factors aspects of public telephones to improve their usability for older people".
[13] ITU-T Recommendation F.901: "Usability evaluation of telecommunication services".
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[25] POULSON, D., M. Ashby, and S. Richardson, (1996) UserFit. A practical handbook on user-centred design for Assistive technology. Brussels: TIDE 1062 USER project. NOTE http://www.lboro.ac.uk/research/husat/include/1-7.html gives overview of methods involving people with special needs.
[26] RESPECT (1998) 'Requirements specification and evaluation for user groups with special needs', WP6 Deliverable D6.2, Telematics Applications Project TE 2010 RESPECT project, Requirements Engineering and Specification In Telematics, August 1998. NOTE: http://info.lboro.ac.uk/research/husat/eusc/guide/special_needs.doc

7.4 Definitions & Abbreviations

CARD READING DEVICE

The process proposed in this document is mainly restricted to develop the elements of the interface between the user and the system. That is the card, some elements of the terminal, and the communication between the card and the terminal. Requirements gathered could however affect the rest of the system.

TRUST

Assurance and certitude regarding the ability of the product to behave according to the claimed effectiveness.

In this context the effectiveness will be in relation to how secure a transaction is, in particular with respect to:

- abuse of information (credit card numbers, pin codes, personal information etc.)
- unwanted side effects (for example personal information reviled to third parties)
- unexpected system behaviour (loss of information, incomplete transaction etc.)

DESIGN FOR ALL

This document will apply the ETSI EG 202 116 (v1.2.1.) three-level model's first level definition unless otherwise stated:

> *Mainstream products designed according to good human Factors practice, incorporating considerations for people with impairments, that can be used by a broad range of users*

TECHNICAL ACCESSIBILITY

Technical accessibility means that the application follows the standards and guidelines which enable people to access the information and functions in the application, but because an application is technically accessible doesn't mean that it will be usable.

7.5 Assessment

A review by user organisations and national industry of the proposed minimum process was conducted by sending out the draft for comments and by presenting the draft in a meet with a forum consisting of user organisations, public organisations and telecommunication companies.

Feedback was only received from the meeting with the forum. The main concerns was on two specific aspects around which characteristics were selected. The telecommunication company was concerned by setting the age of 15 as a lower boundary. Smart cards was expected on several products and services in near future which had children as users. As a consequence the age characteristics was removed. The other concern was from the user organisations on which type of user groups was selected. To meet that concern the naming of specific user groups was replaced with type of problem and the user group was set only as an examples.

7.6 Methodology of Assessment

The result was achieved by making a review of the existing literature in the field of development processes of Design for all products and synthesised it to a necessary minimum development process.

7.7 Results

The review of literature did show that there is considerable amount of guidelines on how to develop specific elements of an user interface in an design for all approach. There is also some information on how the development process should be performed, but these process descriptions are general and could be difficult to follow for developers without human factor competence. There was therefor suggested a process that is based on ISO 13407 [11], but tailored to the smart card domain and with the general public is the target consumer.

7.8 Developing user interface to card reading devices targeted for all people in a "Design for all perspective"

The rest of this document follows the structure of EN ISO/IEC 13407: Human-centred design processes for interactive systems and should be read with this standard as a background. The suggestions in this document can be seen as a further specification of the ISO 13407 in order to cover the particular application of the standard to "user interface to card reading devices targeted for all people". Therefore, important information that is relevant to all human-centred design processes will not be repeated in this document but should non the less be taken into serious account.

7.8.1 Rationale for adopting a human-centred design process

ISO 13407 emphasizes the ergonomic, economic and social benefits as a rationale for adopting a Human-Centered Design process. When products and services are more accessible and usable we achieve products and services that:

- Are easier to understand and use, thus reducing training and support costs.
- Improve user satisfaction and reduce discomfort and stress.
- Improve the productivity of users and the operational efficiency of organisations.
- Improved product quality appeals to the users and can provide a competitive advantage.
- Reduce social exclusion of those who can not use and interact with non-accessible products and services.

For application in the smart card area it is important to notice that widespread use of card reading devices in shops, ATMs, as electronic keys and in connection to home PCs makes these devices an integrated part of many people's daily life. Low usability of such devices will make many products and services unavailable to large user groups.

7.8.2 Introduction to human-centred design process

User involvement in the design process is crucial to ensure that the product or service will be designed having in mind human diversity and thus, will be designed for all. ISO 13407 defines that the incorporation of a human-centered approach is characterized by:

- The active involvement of users and clear understanding of user and task requirements
- An appropriate allocation of functions between users and technology
- The iteration of design solutions
- Multidisciplinary design

7.8.2.1 The active involvement of users and clear understanding of user and task requirements

It is essential to understand and define the context of use, the tasks and how users will work with the future product or service. The involvement of user must be present in each stage of the design process, but in different ways and using different techniques.

Having the general public as the target group is a big challenge with respect to user involvement. The ultimate goal for a human-centred design process is that the participants involved in the design process are *representative* for the intended user population. (Books on

general statistical methods in the social sciences give advice on how to draw random and stratified samples from a defined population). However, involving specified target groups with a particular set of skills and/or disabilities might be a good alternative to being "representative" in a statistical sense.

The definition of the intended user population should be guided by the knowledge and specifications elicited by applying chapter 7.8.4.1 and 7.8.4.2.

7.8.2.2 An appropriate allocation of functions between users and technology

Technology should help and, in some cases, replace the user in some tasks. It is important to consider whether restraints on user actions can be compensated by appropriate technology.

7.8.2.3 The iteration of design solutions

As far as technology is improving day by day and the wishes and needs of users varies, we can never have a definitive design. The expectations from users changes while designers are planning a new system or product and then again the new context of use may change the user requirements to the technology.

7.8.2.4 Multidisciplinary design

Different skills are required when designing, i.e. visual designers, marketing experts, human factors experts, trainers, system designers, field experts, end-users. The minimum team consists of the designer and the user.

In addition the usual members of a design team one should consider to involve end-users representatives from interest groups and organisations as well as experts with special knowledge of important sub-groups. The end user should not be part of the design team, but they should have an active role in evaluating the design proposals.

7.8.3 Planning the human-centred design process

One major concern is how to get in touch and interact appropriately with the relevant group of potential users, their user representatives or user organisations. It is important to acknowledge that different stakeholders have different roles in the design process.

End users' role is as test persons and informants for eliciting user requirements. It is important that the participants are asked only to represent themselves, and that the composition of all the test participants should be representative for the whole population of potential users. It is therefore important that the user population is clearly defined (see chapter 7.8.4.2).

User representatives have a role in the process as the users "advocate". They might see to that the users' rights are not violated, and that their integrity is respected. This is important both with respect to the human-centred process as such, and for the final product. A user group or a user organisation will be helpful in appointing user representatives to participate in the project. A user representative should have a contact into the user organisation to ensure that she/he represent the user groups view.

User experts have a role in eliciting requirements, and evaluation of the product. Evaluation is best done in a systematic way, for example as a "Heuristic evaluation" (see http://www.usabilitynet.org).

7.8.4 The design process

In a human-centred design process we define four main activities within the design process:
- Defining the context of use.
- Specifying user and organisational requirements.
- Producing prototypes.
- Evaluating the designs

7.8.4.1 Understand and specify the context of use

To implement a Design for All approach to the design of smart card products and services it is necessary to understand the diversity of users, their abilities and capabilities, and the limitations they may have in their abilities and capabilities, whether they be temporary, long-term or permanent. The purpose of this section is, then, to briefly outline the various abilities and capabilities of human beings and their possible limitations.

It is important to consider some main characteristics of the users:
- Age range
  It should be decided weather the product is intended for children or not.
  Inclusion of elderly users might influence the assessment of the range of users' ability with respect to sensory and motor abilities.
- Visual abilities
- Dexterity
- Mobility
- Hearing (if sound feed-back is used)
- Acquaintance with similar products
- Language
- Culture

A more complete list of different characteristics is in appendix 1.

A typical specification that cover most user groups in a "design for all" perspectives should cover the following:

It should be possible to operate the product for persons –
- that can not hear
- that are colour blind
- that don't speak the native language
- that are not familiar with national or local symbols
- with degraded dexterity (required level needs to be specified)
- with degraded vision (required level needs to be specified)
- that have limited range - e.g. a user sitting in a wheel chair
- that have limited memory capacity, both short and long term (required levels need to be specified)
- that are not familiar with computer jargon

If products are designed according to these groups most users should be able to use the product.

The physical context of use is also important to identify like indoor/outdoor, lightning, frequency of use (wear and tear) and noise.

It should be decided whether:

- It should be possible to operate the product in an environment that is noisy (maximum level needs to be specified if the product uses audio input or output)
- It should be possible to operate the product under minimal lightning conditions (minimum level needs to be specified)
- It should be possible to operate the product in bright sunshine
- The product should tolerate rain and snow
- The product should endure frequent use (specified as number of transactions per day)

Another point is the description of tasks that each user group of the card reading device will have in the newly designed or redesigned product or service. Different techniques have been developed to analyse and describe the tasks. (See for example http://www.usabilitynet.org for an overview of methods.)

Also the description of the equipment should be defined, with the relevant characteristics of the hardware, software and materials. Finally a description of the environment is necessary, including technical environment (i.e. the local area network), the physical environment (i.e. workplace, colours, lighting), ambient environment (i.e. pressure, temperature, humidity) and the social and cultural environment (i.e. attitudes, user specialisation).

7.8.4.2 Specifying user and organisational requirements

ISO13407 states that different aspects should be considered in order to identify relevant user and organisational requirements. These requirements should be specified in a form that can be subsequently been assessed at the stages of user testing and evaluation.

In the smart card domain there is important to consider the following aspects.

- The allocation of function between tasks performed by the human personnel and tasks performed by the technology should be specified
  Is it feasible to allow more than one way to input the card in the reader?
  Is a pin-code always necessary?
- Privacy
  Can other people see my pin code?
- Response time
  How long must the user wait before the transaction is acknowledged?
- Trust
  Can I be sure that the information I submit is not misused?
  Can I be sure that the transaction really was carried out?
  Can I be sure that there are no unwanted side effects of the transaction?
- Error proneness
  How does the device handle user errors?
  How likely is it that the device will not behave in accordance to specifications?
- Operability
  Does work or other context requirements limits the operation of the product?
  Are both hands free; are there dust, dirt or pollution that interfere with the operation?
- Legal and ethical issues
  What are the legal requirements for such products?

What are the ethical issues raised by the use of this product?
Surveillance of use with and without user's consent

7.8.4.3 Producing prototypes and design solutions

Prototypes are used to test specific features of a product or service before the final design. The prototype can be used in different parts of the designing process and be used to test different things, depending on the accuracy of the design. Different types of prototypes can be built: full-simulation, mock-up, models, paper based schemes, computer simulations, scenarios or storyboards.

It is advisable to produce low-fidelity prototypes or mock-ups early in the design process. For a card reading device it is feasible to try out the physical appearance and the user interactions at an early stage. One should in particular look into how intuitive the sequence of events (present card, give pin code, receive feedback, return card etc.) are to potential users. The accessibility, in the sense of reaching and having important information within the visual field, can also be assessed in low-fidelity prototypes.

When it comes to the assessment of display characteristics, keypad characteristics and response times, with of card sloth, lightning demands, using prototypes with high fidelity is advised.

There are lots of good reference materials for specifying the user interface and designing the user interface. It is important not to "start from scratch" and try out all possible variations of the user interface.

Guidelines and standards achieving "Design for All" products are valuable sources of information.

See the following documents for further information:

Best practice manual , TrailBlaser 8 , eEurope Smart cards (to be defined more precise)
This is a best practise manual which aim to help developers to develop consistent user-friendly smart card applications.

ETSI EG 202 116 (2002-07) Human Factor (HF); Guidelines for ICT products and services; "Design for All"
This is an comprehensible ETSI report which has a compiled set of Human Factor guidelines which shall encourage a "Design for All" approach of ICT products and services.

"Guidelines for the Design of Consumer Products to Increase Their Accessibility to People with Disabilities or Who Are Ageing: Accessible Design of Consumer Products".
This is a set of guidelines for developing consumer products in a design for all approach. NOTE: http://trace.wisc.edu/docs/consumer_product_guidelines/toc.htm

To get more information on how to develop products which are technical accessible the following resources give well documented information:

Web Accessibility Initiative (WAI)
WAI, in co-ordination with organisations around the world, pursues accessibility of the Web through five primary areas of work: technology, guidelines, tools, education and outreach, and research and development. NOTE: http://www.w3c.org/WAI/Resources/#gl

ETSI TR 102 068: "Human Factors (HF); Requirements for Assistive Technology
This report gives information on the interconnection between the technical aid and the ICT system.

Microsoft Accessibility tools and guidelines
Microsoft has different tools and information on how to tailor and adapt the user interface in a system based on Microsoft technology. NOTE: http://msdn.microsoft.com/accessibility

Accessible Java programs
IBM has written a technical document on how to make Java program technical accessible. NOTE: http://www-3.ibm.com/able/snsjavag.html

7.8.4.4 Evaluate designs against requirements

Feedback from evaluations can help designers to know and highlight areas or concepts difficult to understand by the user or those specific details of the design that are not easy to use by groups of users.

When including usability techniques and analysis in the early stages of the design process, development costs can be reduced, because potentially costly mistakes can be avoided and, in most cases, the product or service is more successful because it fits better users' wishes and needs

In order to ensure that as many as possible, independently of their abilities, capabilities and limitations, will be able to interact with the designed product or service, we must ensure that diversity is included in the testing methodologies.

A good strategy in this respect would be to test the product against people with specific disabilities, rather than against a "random sample" of the general population. A random sample would consist of proportionally the same user groups as the population, which would mean that it might contain only few participants from each of the disability groups and a large number of people with no apparent problems in using the product. Testing against people that might have problems using the product ensures that all people can use it.

We can include this diversity using three different techniques:

- Empathic modelling - Modifying the perception of reality of the designer
- Expert assessment - Assessment by user organizations and usability experts
- Testing with end users - Including groups of disabled users

It is generally advised to assess the different design solution through several iterations, each new iteration taking advantage of the previous trials. Expert assessments and Empathic modelling have greatest value early in the design process, while actual user trials should be applied later.

During the first stages of the design, with the first prototypes, the main objective is to check those aspects of the product or service that can be critical for the later development. These critical areas can be found by the own designer (when modifying his/her perception) or by the experts themselves.

In a second stage, when planning real users involvement, experts should define the testing methodology to be applied, the number of users needed and, in some cases, their characteristics. For example, if we are testing a specific part of the navigation system for blind people it is obvious that it is not necessary to include wheelchair users as part of the users involved.

7.8.4.4.1 Empathic modeling - Modifying the perception of reality of the designer

When developers are working on the concrete design of the product, they often don't have enough time and motivation to start an evaluation with users. Empathic modelling modify the designer's perception to have in mind human diversity and simulate possible users of the product or service. See USERfit for a further description (http://www.lboro.ac.uk/research/husat/include/1-7.html).

Table 1. Modifying designer perception.

Limitation	Methodology
People with restricted visual field (e.g. tunnel vision).	Interact with the product or service using black glasses with only vision in the middle. *(More description is needed with the help of optometrists)*
People with obstructed vision (e.g. cataracts).	Interact with the product or service using grated glasses. *(More description is needed with the help of optometrists)*
Blind people.	Interact with the product or service using black glasses.
Wheelchair user.	Interact with the product or service sitting in a chair.
People using crutches.	Interact with the product or service using only one arm or hand.
Hearing acuity	Interact with the product or service using headphones.
Tactile perception	Interact with the product or service using motorbike or gardener gloves.

This methodology should only be used for specific features and should never replaces testing methodologies with end users and user representatives. At the same time, with this methodology, critical aspects of the design can be detected early and with low costs.

7.8.4.4.2 Expert assessment - Assessment by user organizations and usability experts

Assessment from user representatives and usability experts is very valuable, mainly to the following reasons:

- Existing knowledge: some questions that could be tested or included in the design can be studied in other development processes and existing literature is available. In these cases, assessment from experts will reduce cost and test methods are not required. For example, nobody should start a test to determine the general guidelines to physical access from users sitting in a wheelchair.
- In some areas, e.g. testing with people with learning difficulties can be difficult and costly. In these cases, it is preferable to use experts on the problems that people with severe learning difficulties have.

An experts on different user groups and their abilities can be engage in different kinds of assessment, for example Heuristic evaluation or focus groups.

7.8.4.5 Testing with end users - Including groups of disabled users

Usability evaluation is a process for gathering information about how users will perceive and use a product or system. There are several methods for ensuring informative feedback from potential users on proposed design solutions. For an overview of methods including end users see http://www.usabilitynet.org [24], ITU-T Recommendation F.901 [13] or EG 201 472 [2]. It is however not simple to apply all methods to all user groups. Participation in such processes may demand skills that not all users possess.

If there are high demands on writing and reading abilities large user groups would not be able to participate, which will make the trial less representative. To participate in a focus group or a brainstorming session might demand cognitive and social skills that all users might not have. “Think aloud” is difficult, if not impossible, if the participant don’t have the necessary speech and linguistic abilities. Several users find it hard to express their thoughts to completely strangers. Many users might have an overly pleasing attitude towards the project and project staff, so they may hold back critical comments. Applying human-centred methods to user groups with different kind of disabilities is discussed in detail in the handbook USERfit. (An online version is available at http://www.lboro.ac.uk/research/husat/include/1-7.html).

Some of the applications of card reading devices might include contexts that are hard to simulate in a laboratory or an office, for example in payment terminals, entrance devices or ATMs. In such cases it is difficult to simulate the strain and insecurity that might arise from the presence of other people while using the device, therefore it is important to do field studies as a part of the evaluation.

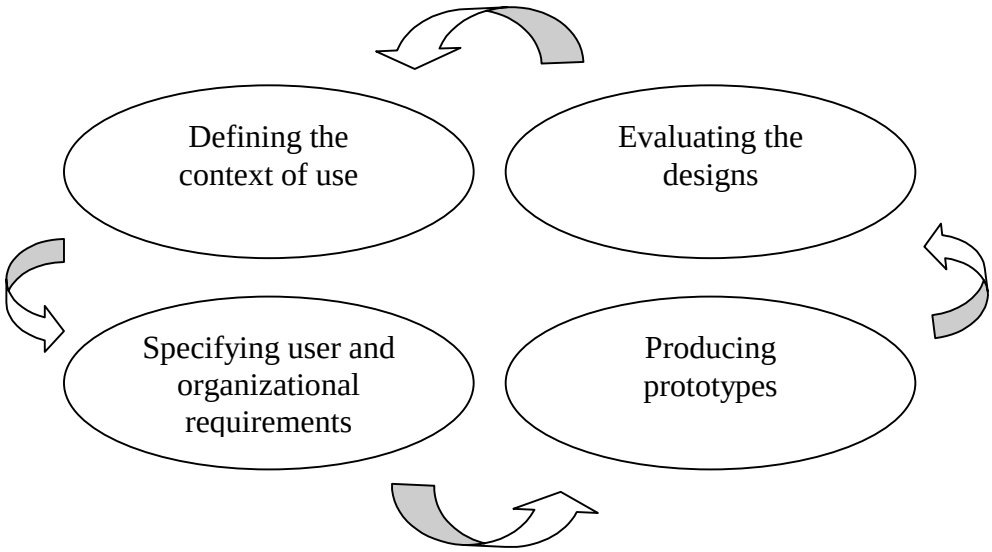
7.8.4.6 Design activities in the products life-cycle

The design and development process is not linear but circular. However, the iterations should not stop once an acceptable solution has reached the market. In order to have products and services that cover real users’ needs, the context of use should be reassessed also after deployment of the product.

On one hand the technology is improving day by day, and what is not possible today will be possible in the near future. This means that the allocation of functions between human and technology could be changed. For example, we are defining requirements for card readers and, in the near future, maybe these readers will be absolutely different due to the introduction of contact-less cards and use of mobile technology.

On the other hand, wishes and needs of users are also changing and therefore changing the user requirements.

Figure 1. Design process flowchart.



7.9 Extensions – Further testing requirements

The review showed that the there are three possible areas for further testing:

- A questionnaire which could measure TRUST as an important factor in smart card applications
- A questionnaire which could measure the FUN factor which is important to ease learning and adoption of smart card applications
- A validation of the process proposed in this report

7.10 Conclusions

The research showed that there is a need for a simple human-centred process in the smart card domain. A process was suggested as an answer to that need.

7.11 Appendix 1 - Abilities, capabilities and limitations

ABILITY	GROUP	SPECIFIC COMPONENT
VISION	Visual field	Blindness
		Tunnel vision
		Partial loss of peripheral vision
		Loss of central vision
	Visual acuity	Difficulty in seeing distant objects
		Difficulty in seeing nearby objects
		Difficulty in seeing details with poor illumination
		Difficulty with adaptation to brightness
		Difficulty in perceiving rapid flickering
		Only perception of shadows and lights
		Difficulty in focusing on nearby objects
	Visual threshold	Difficulty in perceiving contrast
		Difficulty in adapting to darkness
	Color perception	Difficulty in differentiating cool colors
		Color disabilities
		Vision in black and white
HEARING	Hearing acuity	Inability to hear sounds
		Inability to hear sounds at usual volume
		Reduction of perceptible frequencies
		Speech discrimination and comprehension
	Directional hearing	Difficulty in discriminating the source of sounds
TACTILE PERCEPTION	Cutaneous sensitivity to pressure	Inability to detect pressure on the skin
	Cutaneous sensitivity to temperature	Inability to sense thermal stimuli
	Cutaneous sensitivity to materials	Allergic reactions to certain materials
	Tactile sensitivity	Reduced ability to identify objects and textures
OLFACTORY PERCEPTION	Olfactory sensitivity	Reduced ability to perceive odours
TASTE	Taste sensitivity	Reduced ability to perceive tastes
TRANSIT		Inability to walk, use of wheelchairs or pushchairs
		Inability to lift legs
		Walks slowly
		Use of crutches, sticks or zimmer frames
POSTURE	Standing position	Inability to reach upright position
		Difficulty in standing for
		Long periods
		Fits and epilepsy
		Postural fatigue
	Sitting position	Postural fatigue
		Inability to change posture
	Horizontal position	Inability to change posture
	Laterality	Left handed

ABILITY	GROUP	SPECIFIC COMPONENT
LARGE MOVEMENTS		Difficulty in flexing, twisting and rotating body
		Poor force and endurance
		Restricted articular movements
		Use of only one arm
SMALL MOVEMENTS		Difficulty with pincer grasp
		Difficulty with grasp
		Difficulty in controlling small movements
		Restricted articular movements of hands
		Use of only one hand
		Use of no hands
		Poor force and endurance
COGNITION	Orientation	Difficulty with orientation in space and time
	Memory	Difficulty in remembering processes signals, locations, etc
		Difficulty in remembering all the steps in complex operations
	Logical processes	Difficulty in understanding complex processes
	Talking	Inability to or difficulty with talking
CULTURE	Habits	Difficulty in accepting changes of habits
	Previous knowledge	Difficulty in understanding concepts distant from own knowledge
	Foreign population	Difficulty in understanding language

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Pantelis Angelidis	1st draft	INA	7/8/2002	v. 0
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Pantelis Angelidis	Final document	PT06/B report	10/9/2001	v.1.3

8.1 Foreword

This report has been prepared by Expert **Pantelis Angelidis** of PT06 Team under Technical Committee CEN/TC 224 "*Machine readable cards, related device interfaces and operations",* the Secretariat of which is held by AFNOR.

It is intended that this report will become part of the PT06 – Phase B final report that will couple the Phase A report which is a draft ENV that will become part 6 of a series of standards (EN 1332), under the general title "*Identification card systems – Man-machine Interface"* and the different parts are the following:

- Part 1 : Design principles for the user interface including functions to be represented by symbols;
- Part 2 : Dimensions and location of a tactile identifier for ID-1 cards;
- Part 3 : Key Pads ;
- Part 4 : Coding of user requirements for people with special needs;
- Part 5 : Embossed symbols for differentiation of application on ID-1 cards;
- Part 6 : Provisions for physical accessibility, including physical access for wheelchair users and vehicle drivers, to card reading devices (draft ENV).

This report is one out of four report prepared during Phase B according to the following distribution of work:

Testing Area	Expert
Vision-Touch	**Fransesc Aragall**
Interfaces	**Jan-Harvard Skjetne**
Sound-Audio-Speech	**Pantelis Angelidis**
Vehicles	**Pantelis Angelidis (Originally Martin Freer)**

8.2 Introduction

In this report, we present the results of our research on the acceptable levels of ambient noise in the vicinity of card reading devices which are installed in public places. The applications taken into consideration include human-device interactions involving speech and/or sound, as well as telephony applications. In close conjunction with this case, lies the study of the intelligibility of spoken messages against different acoustic levels of background noise.

This study recommends an adequate methodology and means by which background noise measurements should be performed. The goal is to define the thresholds over which an acoustic shielding of the card reading machine is considered necessary.

Finally, some basic recommendations and design guidelines are be presented for a formal definition of the level, form, type and distance requirements fro the case where audio signals are used to help the visually impaired to locate a card reading devices.

The report is organized in seven sections and an Appendix. Section 8.3 clarifies the scope of the research. Sections 8.4 & 8.5 present the abbreviations and references used in the document. Section 8.6 contains the results of the literature review in the area. Section 8.7 presents the main core of the results, i.e. the proposed methodology for testing on audio. Further extensions on the present work are suggested in Section 8.8, whereas the report concludes in Section 8.9. The Appendix 8.10 describes two templates used for testing.

8.3 Scope

The scope of this document is to present all necessary guidelines and methodologies for testing the accessibility of card reading devices installed in public places. The testing area of our concern is sound, audio and speech. In all cases, every effort has been made in order to meet the “design for all” concept.

The main area covered by this report is (as defined in section 8.10.2 of the Phase B call for experts):

6. **Sound** – guidance is required in respect of sound levels, intelligibility of spoken messages and sound types (and testing methods) under various ambient noise conditions for audible signals, audible messages and location signals. The possibility of investigating speech input as a means of overcoming physical access problems (in particular determination of how it should work, how to control process, terms / words, instruction, task pacing, locations for speakers and microphones and sound levels and volume control required in various ambient noise conditions).

Moreover, the following areas were decided to be researched during the Phase B of PT06 as suggested in Phase A report.

5. The levels of local ambient noise for which acoustic shielding becomes necessary, especially for telephones or interaction involving speech / sound.
6. The level, form, type and distance requirements for acoustic location signals emitted from terminals to help visually impaired user locate them.
7. The intelligibility of spoken messages against different levels of ambient noise.

8.4 References

[1] CEN/TC224 PT06 N1388 – Phase B "*Call for project team experts – Terms of Reference*"

[2] CEN/TC224 PT06 – A6 Document – "*Phase A Final Report*"

[3] ITU-T Rec. E.135 – "*Human Factors – Aspects of public telecommunication terminals for people with disabilities*"

[4] ITU-T Rec. P.370 – "*Coupling hearing aids to telephone sets*"

[5] ETS 300 381 – "*Telephony for hearing impaired people; Inductive coupling of telephones earphones to hearing aids*"

[6] ETS 300 679 – "*Telephony for the hearing impaired; Electrical coupling of telephone sets to hearing aids*"

[7] COST219bis – "*COST219bis – Telecommunications for All*" / "*Guidelines-Accessibility requirements for new telecommunication equipment*"

8.5 Definitions & Abbreviations

AGC	Automatic Gain Control
Barge-in	The ability to interrupt an utterance during voice recognition
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HHD	Hand-held device
SPL	Sound Pressure Level
TTS	Text-to-Speech
VAD	Voice Activity Detection

8.6 Standards review

An up-to-date investigation of relevant current standards has been carried out. The main area of research was in telecom and telematics related documents. A list of all the documents (standards, recommendations or technical reports) reviewed is given in the following table.

Table 1

Document Type/No	Std. Body	Title
ITU-T Rec. E.135	ITU	*Human Factors – Aspects of public telecommunication terminals for people with disabilities*
ITU-T Rec. P.370	ITU	*Coupling hearing aids to telephone sets*
COST219bis	COST	*"COST219bis – Telecommunications for All" / "Guidelines-Accessibility requirements for new telecommunication equipment"*
ETR 029	ETSI	*Human Factor (HF) - Access to telecommunications for people with special needs. Recommendations for improving and adapting telecommunication terminals and services for people with impairments*
ETR 068	ETSI	*European standardisation situation of telecommunication facilities for people with special needs*
ETR 345	ETSI	*Human Factors (HF) - Characteristics of telephone keypads and keyboards; Requirements of elderly and disabled people*
ETS 300 381	ETSI	*Telephony for hearing impaired people; Inductive coupling of telephones earphones to hearing aids*
ETS 300 679	ETSI	*Telephony for the hearing impaired; Electrical coupling of telephone sets to hearing aids*
ETS 300 488	ETSI	*Telephony for hearing impaired people; Characteristics of telephone sets that provide additional receiving amplification for the benefit of hearing impaired*

Even though none of these documents found to have direct relation with the specific research subject of the workplan (acoustic shielding / ambient noise / intelligibility of spoken messages), some basic design guidelines can be adopted in our case.

Hearing impairment can affect the whole range or only part of the auditory spectrum. The important spectral area for speech perception is between 250 and 4000Hz. The term deaf is used to describe people with profound hearing loss, while hard of hearing is used for those with mild to severe hearing loss.

It should be pointed out that although many of the 80 Million hard of hearing people in geographical Europe will have problems, for example, using a public phone in a noisy location, they will however not necessarily consider themselves as disabled or be registered as such [7].

8.6.1 Volume control

The public terminal should, if possible, be located in “low-noise-level” environment with good architectural acoustics. The telephone should be equipped with an adjustable volume control which can be identified and located visually and by touch.

Volume controls, whether they be contained within the handset or integrated into the terminal, should be capable of increasing the volume within the range of 12dB minimum and 18dB maximum above the non-amplified state. The 18dB maximum should not apply where an automatic reset (i.e. on-hook) to the non-amplified state is provided. But even in the case of an automatic reset capability, the level should never exceed 20dB above the non-amplified state. However, care should be taken that under no circumstances should the maximum attainable amplification be great enough to cause either hearing damage or acoustic feedback. It is preferable for the volume to be always reset to the non-amplified state when the handset is returned to the cradle or after a short time-out [3] [4].

As hearing impaired people do not necessarily have elevated thresholds of loudness discomfort, some form of output limitation will be required. Recent work has indicated that Automatic Gain Control (AGC) can provide a better automatic means of limitation than peak clipping. In addition, it is recognized that the frequency response to give maximum intelligibility to some hearing impaired people may require shaping.

It is estimated that with the provision of additional amplification to the levels recommended above, possibly up to 80% of hearing impaired users would benefit even when not using their hearing aids to couple to the telephone set. If a hearing aid is worn in addition and inductive coupling is also provided, then the proportion of hearing impaired users who will be able to have satisfactory telephone conversations will increase further [4].

8.6.2 Hearing aids

Public terminal devices that facilitate voice communications should be equipped with handsets that are hearing aid compatible through inductive or electric coupling. These handsets generate a magnetic field to which hearing aids may couple [3]. All necessary requirements for magnetic field intensity for telephone compatibility with hearing aids can be found in [4], [5] and [6].

8.6.3 Visual indication & other guidelines

Some general guidelines regarding acoustic output format and other aspects of the overall system design are the following [7]:

- Always provide alternative visual indication for any acoustic signal (lights and/or LCD displays).
- All tone signals should include high and low frequency components.
- If possible, provide user selectable sounds with different pitch.
- If pitch cannot be selected by user, high pitch sounds should be avoided.

- A connector for external earphones should be provided as alternative to loudspeakers.
- Pay phones should be able to adapt to user profiles on Smart Cards (EN 1332-4). The technology that is developing around smart cards enables a user to store their own preferences on the memory chip of a smart card. Smart card based telephones would allow a user's card to instruct the telephone to make specific adjustments. This could be adjustments to sound quality, volume, typeface sizes and language preferences.

8.7 Methodology of Tests

In this chapter, we will discuss about the recommended methodology of the tests. We can focus on two main areas of research, (a) ambient noise measurements and (b) acoustic aided locating of the terminal device. As defined in the scope of the present document, ambient noise measurements will investigate the need for additional acoustic shielding of the card-reading device, as well as the intelligibility of spoken messages for different levels of background noise (areas 5 and 7 recommended in Phase A). On the other hand, acoustic aided locating of the device is under investigation under the scope of research area 6 recommended in Phase A.

8.7.1 Ambient noise measurements

The proposed methodology for the measurement of the maximum permissible background noise level is illustrated in Figure 1.

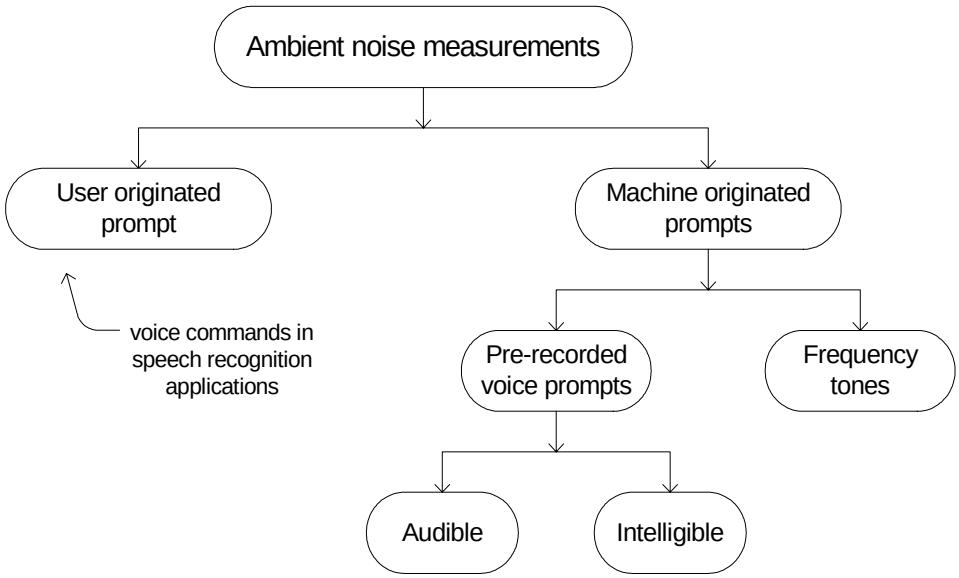

Figure 1. *Ambient noise measurement methodology (indoor/outdoor).*

In all cases, there should be a distinction between indoor and outdoor applications. There are different design considerations that should to be taken into account when the device is to be used outdoors, compared to an indoor environment.

Moreover, we consider the following sub-categories which apply in both indoor/outdoor as illustrated:

1. The message under consideration is user originated. An example of such a message is a user prompt (command) that is passed to the machine in applications incorporating speech recognition technologies.

2. The prompt is machine originated. The majority of voice prompts in all applications are coming from the card-reading device. This case draws the most of our concern. Different types of prompts should be tested:

   2a. Pre-recorded voice prompts. In this case, voice messages (or text-to-speech messages) should be tested in terms of audibility and intelligibility for different ambient noise levels.

   2b. Single frequency tones. In applications having simple man-machine interface, some prompts shall have the form of single frequency tones or combination of simple tones. In such cases, an examination of the frequency ranges for best audible tones should be carried out for different groups of people.

8.7.1.1 Measurement setup

The measurement setup for the lab trials shall contain the following equipment:

- ✓ Acoustic noise generator (white / pink noise)
- ✓ Audio amplifier
- ✓ Microphones
- ✓ Sound meters
- ✓ Loudspeakers
- ✓ Headphones
- ✓ Computer

At first, for the measurements to be realistic, some recordings of typical values of background noise levels shall be performed in sites where card-reading devices (in general) are to be installed. For example, next to a city road in extreme traffic conditions (outdoor application) or in a crowded corridor of a public building (indoor application).

These recordings should be used as noise samples in the measurements (in addition to the acoustic noise generator).

Three different cases shall be examined in detail during the lab trials. For either indoor or outdoor applications, all sub-categories presented earlier (regarding the type of the audio signal) should be investigated.

In special applications like public telephone terminals, there’s a different approach since the user has the ability to operate the device with a handset. This case will be examined separately.

The measurement setup for applications that incorporate speech recognition technology is illustrated in Figure 2.

In these cases, the ambient noise source is simulated by an acoustic noise generator connected to a loudspeaker. On the other hand, the card-reading device is simulated by a

personal computer connected to a loudspeaker(s) and a microphone for all necessary speech communication between the user and the device.

In other cases, communication between the user and the device is to be carried via a conventional keypad. The measurement setup for this particular case (except telephony applications) is illustrated in Figure 3, where the microphone has been replaced by a keyboard.

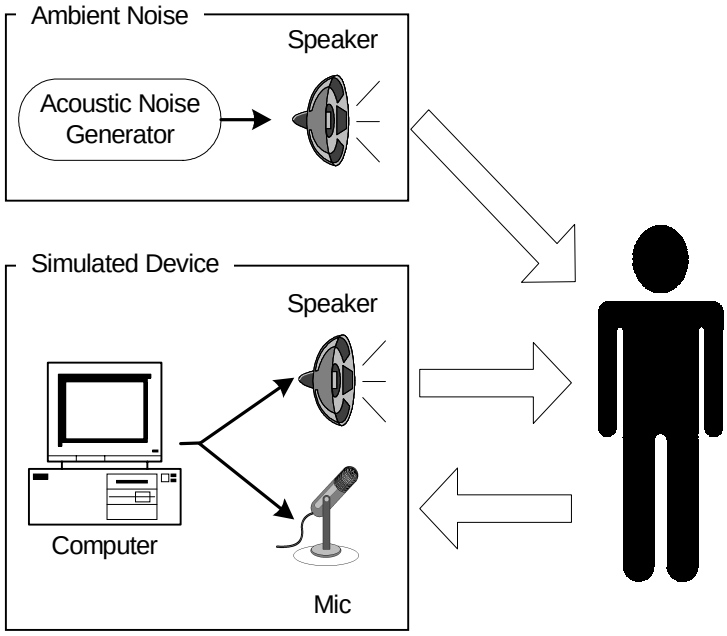

Figure 2. *Lab trial measurement setup (speech recognition applications).*

The acoustic noise generator shall be able to generate white noise in different sound pressure levels (SPL) that can be adjusted externally (the use of an audio amplifier is recommended).

Normal transactions between the user and the device are simulated using the computer while manually increasing the ambient noise level. The maximum permissible SPL is recorded for each case. The SPL value of the background noise shall be measured either at the position of the card-reading device or, alternatively, at the position of the user relative to the device (usually about 1m distance from the device), no matter where the noise generator's loudspeakers are located during the tests.

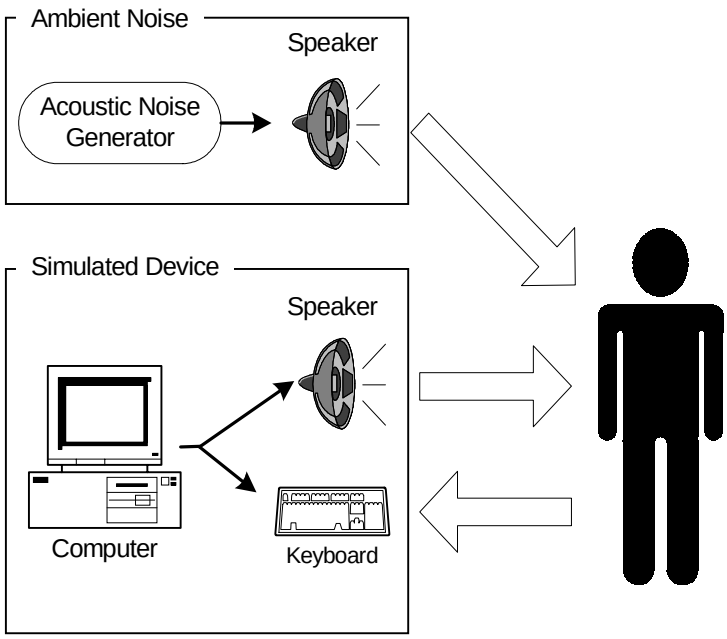

Figure 3. *Lab trial measurement setup (general case).*

8.7.1.2 User originated messages

If the application is about to use speech recognition techniques during the user interaction, the setup in Figure 2 shall be deployed in the lab according to the following guidelines.

The recognition engine on the card-reading device shall be configured and optimized using echo cancellation and noise reduction.

Echo cancellation improves the quality of a speech signal by diminishing any echo that might have been introduced by the telephone line. To support barge-in, the application should also support echo cancellation. Otherwise, the recognition engine cannot provide accurate results because the echo from the played prompt is often mistakenly assumed to be the user's voice.

For recognition accuracy and efficiency, it is critical for the system to distinguish leading or trailing background noise or silence from the utterance itself before sending it to the recognizer. Modern recognition engines have algorithms to reduce the incoming steady state background noise. The engine enhances the user originated message and effectively filters out noises such as tones, buzzing, humming and hissing.

This mechanism was not designed for speech recognition with non-steady state background noises such as other voices behind the primary speaker. As noted earlier, the same measurements should be carried out also by using pre-recorded noise samples from real installation sites, instead of a noise generator.

In the case of speech recognition applications, this should be taken into serious account since the noise generator produces steady-state noise (white spectrum) and a potential noise reduction mechanism in the recognition engine could filter out all incoming noise, hence giving us erroneous or misleading results.

The use of noise reduction mechanisms in such applications increases the CPU usage for the recognition engine. There is a trade-off between noise reduction efficiency and computational cost. Therefore, this mechanism should be used depending on the required overall speed of the application.

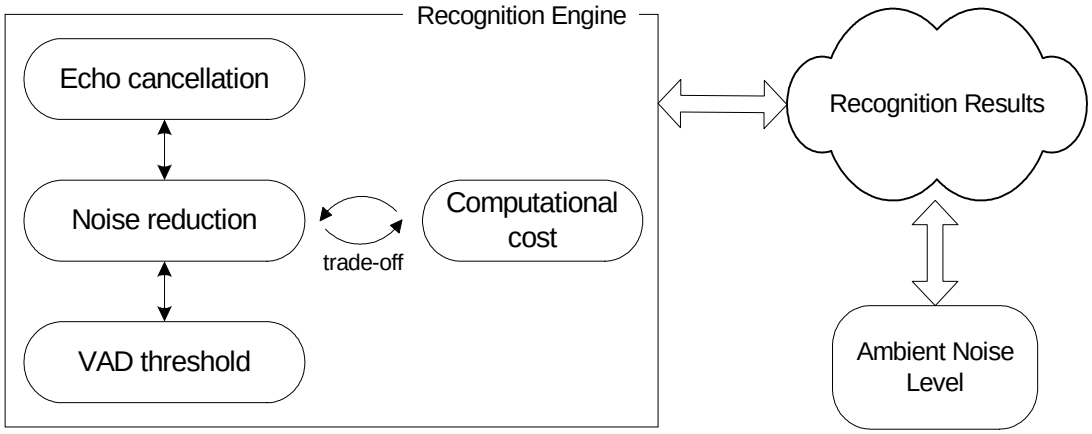

Figure 4. *Relations between configuration parameters and acceptable ambient noise level for applications with speech recognition enabled.*

Taking into account all the above configuration aspects, tests shall be performed by increasing the ambient noise level and recording the recognition results. At the same time, some tuning of the recognition engine should be performed in terms of VAD thresholds. Increasing this threshold can result in worse recognition performance for constant user utterance level and background noise level.

The overall acceptable background noise level (SPL) shall be retrieved according to the application's recognition requirements (e.g. the confidence levels for specific VAD threshold using echo cancellation and noise reduction mechanisms).

All tests shall be performed using pre-recorded typical voice prompts played back as input to the recognition engine. This ensures that the speech level and characteristics from the user during the trials is constant and uniform at all instances. The playback shall be performed with a loudspeaker placed in front of the device and at typical distances from it (height about 1,80m – 0,5m distance from the machine).

A typical list of recommended speaker prompts for some applications is given below:

- Digits (all digits shall be tested)
- "Yes" / "No" (confirmation dialogs)
- "Abort" / "Cancel"
- "OK" / "Enter"
- "Increase volume" / "Decrease volume"
- "Money Withdrawal"
- "Money Transfer"

The testing procedure is summarised in section 8.4

8.7.1.3 Machine originated voice messages

No matter if the user input is via speech commands (see above) or by a standard keypad, this test is carried out to examine the audibility and intelligibility of pre-recorded voice prompts that the device is playing back to the user (see Figures 2 and 3).

The user is asked to verify the spoken out message. The process is repeated until the user fails to do so at which case the SPL is noted (see Appendix). Messages are transmitted at random order. The threshold level is verified by repeating all messages.

Two sub-cases can be distinguished regarding the quality and source of the voice prompt. This pre-recorded message can be either a high quality digital voice recording (up to 44100Hz – 16bit – stereo) played back in a set of loudspeakers, or a digital synthesized voice prompt made by a TTS engine.

These messages shall have the form of a potential prompt for any application. Typical examples are given below:

- “Please insert your card”
- “Invalid card!”
- “Please enter your PIN code”
- “Please take your card”
- “Would you like a receipt?”
- “Amount of money for transaction?”
- “Please make a selection”

The testing procedure is summarised in section 8.10.4

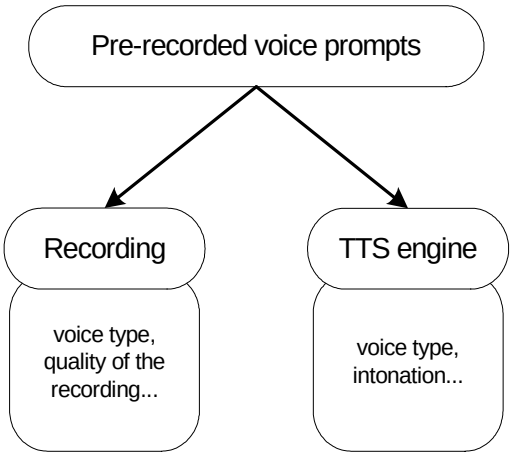

Figure 5. *Parameters affecting the intelligibility of spoken messages.*

In the first case, it depends on what kinds of recordings are used by the specific application in order to use them for the lab trials. Taking into account that normal speech signals consist of spectral components about as high as 8000Hz, we consider that the minimum quality of pre-recorded prompts shall be at least of telephone quality (high frequency components at

4000Hz). Lower quality is considered inadequate for such applications. In general, a worst case scenario can be adopted and all tests shall be performed using pre-recorded messages sampled at 8000Hz – 8bit – mono.

In both cases, many different prompts shall be used in order to achieve high accuracy. Moreover, different types of voices shall be used for the recordings, including some variants of specific male and female voices.

Text-to-speech technologies can be used in some applications. For a TTS using a modest phoneme database the resulting synthesized audio file could be very hard to understand in extreme ambient noise conditions. The intelligibility of messages produced by such a system increases when the prosody of speech has been carefully designed. In some cases, there should be different intonation curves applied to some prompts. In general, intonation shaping is recommended when investigating the intelligibility of spoken messages in noisy environments.

8.7.1.4 Machine originated tone messages

For simple man-machine interfaces where the prompts have the form of single frequency tones or combination of simple tones, the following guidelines apply.

The spectrum of audible tones is limited by human anatomy of the ear. The minimum audible frequency tone is about 16Hz and the maximum is about 20kHz. The upper boundary is gradually decreasing with age to about 10kHz.

The field of hearing for any human ranges from 100Hz to 8kHz for normal speech sounds. In general, high frequency components (greater than 8kHz) shall be avoided in all cases. Simple frequency messages are also considered inappropriate since there are humans that suffer from severe hearing loss in specific spectrum areas. Therefore, combination of tones is highly recommended for such kind of messages.

Moreover, early research in electroacoustics shows that the human ear can’t distinguish easily two tones different in frequency and in level. For that reason, the decision for the tones must meet specific requirements in order for the tones to be equally audible.

Another critical consideration that should be taken into account is the masking effect. According to acoustics theory, a single frequency tone at a specified sound pressure level can mask all tones in a wider spectrum area (towards the highest components) of a level specified by the appropriate masking curves.

Therefore, the decision and design of frequency tone messages for card-reading devices has to meet the aforementioned requirements.

Taking into account all of the above, the intelligibility and audibility of this kind of messages can be tested according to the same methodology mentioned in section 8.7.1.2. All messages are played to the user while increasing the background noise level (using both noise generator and pre-recorded noise samples) until the intelligibility of the message is not acceptable.

The testing procedure is summarised in section 8.10.4

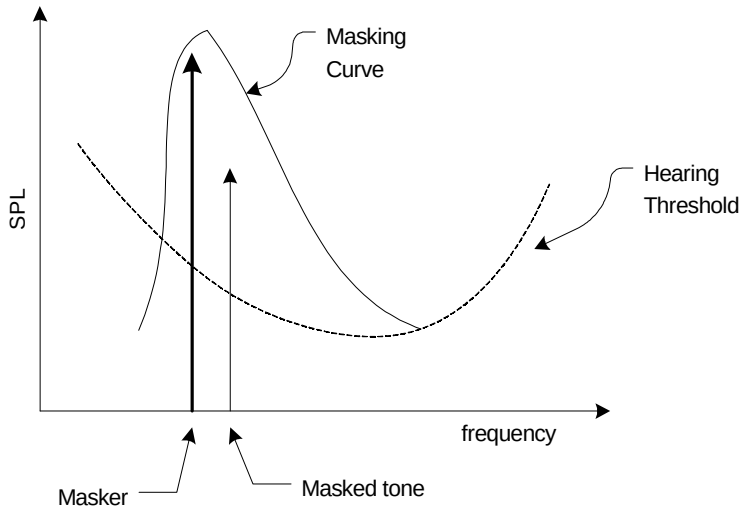

Figure 6. *Masking of a tone by a louder tone.*

8.7.1.5 Machine originated prompts - Summary

In both cases, when investigating machine originated prompts (either voice or tone messages), the maximum permissible ambient noise levels are extracted by testing the intelligibility of spoken messages by the end user. In order to meet the "design for all" concept, these tests should be carried out for many different groups of people.

Every effort shall be made to involve people from various population groups, in order to validate the simulation results and generalize to an extent the main conclusions extracted from the trials. The main concern shall be to record feedback from people with hearing disabilities, since this group is expected to pose stricter requirements in audio interacting design for card-reading devices.

The population sample that is needed for these tests has to be large enough to be considered representative in statistical terms. The expected range for the age of users is about 18-65 years (this can be extended some years further). There is no need for complete representation for the whole range, since problems in the usage of card-reading devices are expected in special groups of population. Therefore, in the users sample there shall be elderly people (which are hard of hearing due to ageing) and people with special disabilities (hearing impairment) of any age. These groups are considered the worst case for the trials.

The design guidelines presented earlier in chapter 4 (older standards) can be adopted here as well. The gain of the audio output in those cases (where spoken messages are played back from a loudspeaker) is obviously limited sometimes depending on the surrounding environment (e.g. hospital).

8.7.1.6 Telephony applications

In the case of a public telephone terminal, the user has the ability to operate the device using a handset. The methodology is the same as before, taking into account that the spoken messages by the device are played back into the handset and not on a loudspeaker. The tests

can be carried out using the same guidelines as before, with the addition of the majority of the guidelines that can be adopted from older telecom standards (chapter 4).

Therefore, hearing aids can improve the overall susceptibility of the system to external noise sources. Volume control can be used without any problems to the surrounding environment. Furthermore, in telephony applications the use of acoustic shielding shall be considered inevitable in some cases because of privacy reasons as well as for protecting from ambient noise.

All acceptable background noise levels that have been recorded for each of the above cases (if applicable), shall next be compared against each other and the worst case scenario shall be adopted for the application. This level of ambient noise shall finally be compared with the average background noise measurements from the final installation site. This comparison shall provide the information regarding the necessity of any acoustic shielding.

8.7.1.7 Summary of results – Acoustic shielding

The measurement process described in the aforementioned paragraphs shall be used to extract useful conclusions about the application under consideration. Assuming that we have recorded the background noise profile of a real site (where is to be installed a card-reading device) for a large period of time, we shall calculate the safe usage percentages of the device (potentially installed in the specified site) by using the information extracted from the lab trials.

The term ‘safe usage percentage’ is used to describe the percentage of people that will be served by the installed device without problems (caused by ambient noise) for a specified / guaranteed percentage of time (given that no additional acoustic shielding has been provided on-site).

- Measurements for the background noise profile of a site shall be performed and the following statistical values shall be extracted from the profile:

L_{xx} The noise level that has been exceeded for a ‘xx’ percentage of time in this site.

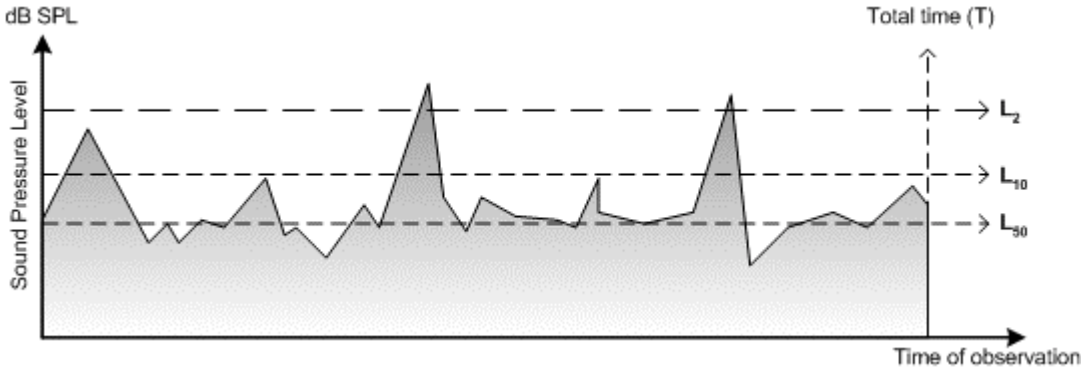

Figure 7. *Definition of mean levels L_{xx} in the noise profile chart (example graph).*

Figure 7 illustrates the definition of the mean levels for 2, 10 and 50% of the total observation time.

The information behind L_2 (or L_{10} for example) noise level is that these levels have been exceeded only for 2% (or 10%) of the total time. This guarantees that for the rest 98% (or 90%) of the time, the background noise level will be below that level at the specified site.

- The results of the lab trials shall be statistically processed and a graph of the following form shall be created (example graph – figure 8).

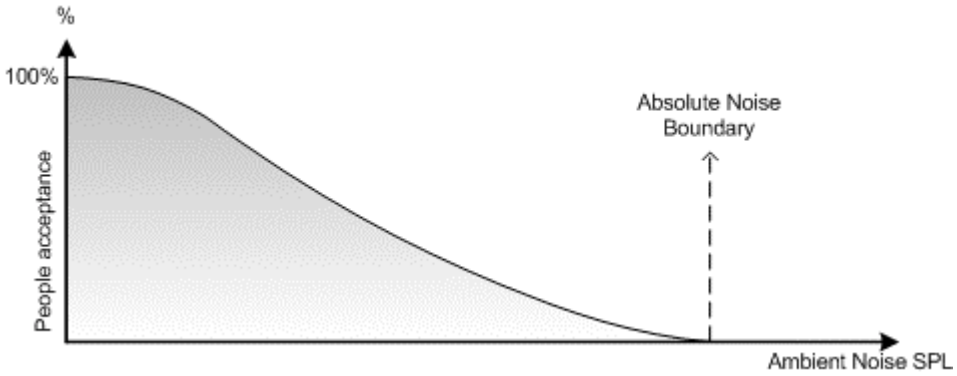

Figure 8..*Distribution of acceptable noise levels (example graph).*

Figure 8 illustrates the cumulative distribution of the results (the percentage of users that have accepted the specified ambient noise SPL). The absolute noise boundary is the maximum noise level for which none of the users could understand the spoken messages (0%).

Using the measured data so far, we shall extract the safe usage percentages for the device under consideration (and for the specific installation site). The process is illustrated in figure 9 below:

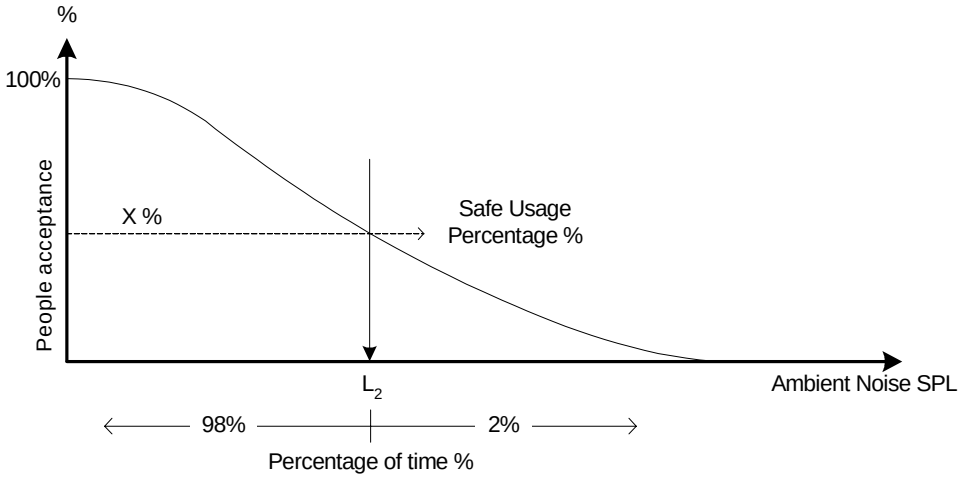

Figure 9. *Extraction of safe usage percentage for specified percentage of time (example graph).*

Marking the appropriate noise mean level (in this example L_2) at the SPL axis, the distribution curve reveals the percentage of people that accepted this ambient noise level.

Summarizing, this approach provides guarantees that for 98% (for the specified example – see figure 9) of the time the device installed on that site will serve safely a percentage X% of the people, without any acoustic shielding.

Depending on the application's requirements about these percentages, there shall be a decision about the necessity of additional acoustic shielding for this card-reading device, if for example the percentages are considered too low for the application.

8.7.2 Acoustic aid for locating the device

In the case of visually impaired users and not only, there shall be an audio signal helping them locate the card-reading device. Two different sub-cases shall be examined, as far as the acoustic source is concerned:

8.7.2.1 The source is located at the card reading device.

The methodology for this kind of application is the same as before (section 8.7.1.2). Many of the aforementioned principles apply in this case as well. The type of the acoustic signal shall be determined by reviewing the results of the previous lab trials (pre-recorded voice message vs. frequency tone message). The level of this audio signal shall be also adopted from previous tests.

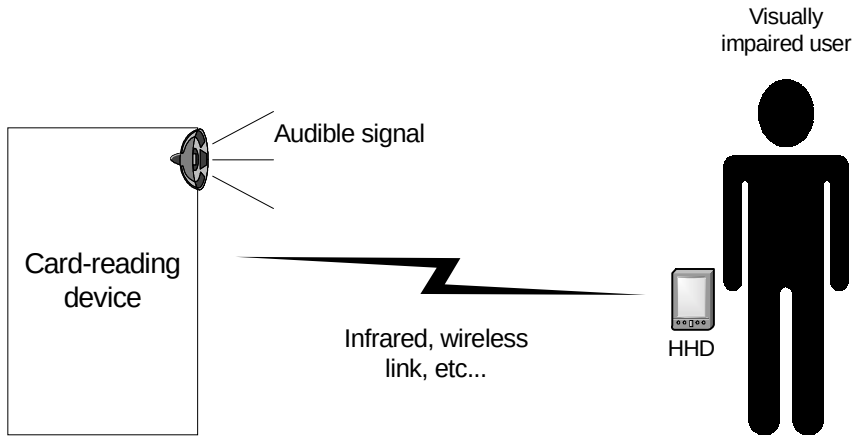

Figure 10. *Handheld device assisting user to locate card-reading device.*

8.7.2.2 The source is located at a handheld device carried by the user.

This case shall be preferred because the audible signal can be at a lower level and thus it is less annoying for others moving at the surrounding environment. Moreover, the user shall be capable of adjusting the parameters of the audio signal in proportion to its own needs or even disabling this auditory feature (depends on the implementation). Optionally, the HHD shall be able to guide the user by providing navigational messages rather than just tones.

Although simple tone audio messages provide no information about the exact position of the card reading device, this kind of messages shall be used as alarms for informing the user about the existence of a device in his near vicinity. Such messages shall be used with simple hand-held devices with no extra hardware for more complicated informative messages.

Moreover, if the application allows this case, the HHD shall provide more complex audio messages (preferably voice prompts) with navigational instructions assisting the user to find the card-reading device. In the case of a more sophisticated device, there shall be an option for the card-reading machine to scan its surrounding environment for visually impaired users (carrying special equipment – see below) asking for special assistance. This will provide all necessary information for the machine to instruct precisely the user towards the exact position.

In the case of users with other than visual impairments, there shall be an option for the card-reading device to send to the user's HHD a map with detailed instructions and exact position of the machine.

Two options shall be considered for this implementation.

a) The signal is user initiated.

In this case the user knows that a card-reading device is in the near vicinity and asks the machine for additional help if possible. This help shall be in the either the position of the device and/or (more specifically) the slot where the user should place his/her card. In the case of simple alarm signals (as described above), the user can ask if any card-reading devices are near him and a pre-defined alarm signal shall provide this information to him.

b) The signal is produced automatically.

In this case, the user shall carry a smart card 'tagged' with an ID for visually impaired users which starts the audio signal (or the voice navigational messages) when detected by a card-reading machine in a specified distance. The distance shall be appropriate in order not to disturb neighboring services (if any) and suitable for the user to hear the audible help. Furthermore, if an automatic system is to be implemented, there shall be an option by the user (in the case of a HHD) to disable all automatic informative messages if not wanted.

As illustrated in figure 10, the form and type of communication between the machine and the HHD carried by the user, in order to achieve this kind of service can be anything from infrared to new emerging wireless technologies. The exact description of this communication and the hardware implementations of the smart card or the HHD are out of the scope of the present work (see deliverable 3 of Phase A).

8.8 Extensions – Further testing requirements

The methodology described in 8.7.1, regarding the ambient noise measurements is directly applicable and can be immediately implemented, as soon as a desirable amount of test users is gathered. As pointed out earlier, the sample has to be large enough in order to achieve high accuracy in the extraction of results and to meet the "design for all" concept.

Since the major conclusions that come out of this measurement process are highly dependant on the statistical properties that have been extracted by the lab trials, special care shall be taken into account when selecting the population groups for use in the tests (these groups define more or less the final statistical properties of the test results).

Further extensions that shall be considered for the future are the categorizing of population groups according to specific applications. Surveys shall be carried out in the form of questionnaires in order to gather more information about the usage of public placed card-reading devices by these groups of population. These surveys will be of much help in a later stage when the user's samples are built for our lab trials.

Special groups of people (e.g. with hearing disabilities) shall be weighted differently when selecting the user's sample for the measurements. Special care should be considered for these people not only because they provide the worst-case-scenario for our designing process, but also because they usually suffer from state analgesia in most of their everyday life activities.

In the near future, there shall be an effort to perform as many trials as possible in order to acquire enough statistical data from the end users so that the design process to be much more simplified.

As for the recommendations described in section 8.7.2, it is clear that at the present moment the technological trends are favorable. HHDs, which can be used for testing, are already available in the market, as for example mobile phones equipped with GPS receivers and PDAs with mapping features. Modern communication protocols, such as GPRS, should be exploited for smart-card devices accessing.

A considerable effort towards additional development of such hardware is highly recommended. In addition, intense collaboration with the smart-card industry and the manufacturers of card-reading devices shall be considered in order to proceed with the necessary alterations to their current models.

Further collaboration with other service providers shall be taken into account in order to incorporate mapping services as described in section 8.7.2.2 for example. This service requires central management and cartographic databases interconnected to the card-reading device infrastructure. There aren't any current protocols designed and tested for such applications.

8.9 Conclusions

In the present work, we have presented and drafted a measurement setup and complete methodology for carrying out lab trials. The focus area of research was the investigation of the level of ambient noise that is acceptable before an acoustic shielding becomes necessary for a card-reading device.

Taking into account all aspects and recommendations presented in Phase B workplan, in addition with some recent design considerations that were investigated during the research work, the methodology contains a full-setup description, including all equipment that is required.

All available design guidelines that were extracted from previous standards and documents (related to telecom applications) have also been presented. Extensions based on current trends on communication technology are finally discussed.

8.10 Appendix – Testing Report Template (example)

This appendix presents some example report templates for each test that is to be carried out.

8.10.1 User originated prompt test (Section 8.7.1.2)

Name		**Date**	__/__/____
		Time	__:__

ASR engine used			
Configuration	**Echo Cancellation**	**YES**	**NO**
	Noise Reduction	**YES**	**NO**
	Initial VAD threshold		

Speaker Prompts			
1		**6**	
2		**7**	
3		**8**	
4		**9**	
5		**10**	

Test Results				
Prompt	**Recognition result**			**Ambient Noise dB(A)**
	SUCCESS	**Confidence Level**	**VAD**	**SPL @ device**

Overall SPL (minimum of successful recognitions)	**dB(A)**

8.10.2 Machine originated voice message test (section 8.7.1.3)

Name		**Date**	__/__/____
		Time	__:__

Voice Prompt		**Engine / Quality of recording**
TTS synthesized		
Pre-recorded		

Voice Message List							
Prompt		**Type**		**Prompt**		**Type**	
		TTS	**REC**			**TTS**	**REC**
1				**6**			
2				**7**			
3				**8**			
4				**9**			
5				**10**			

Test Results		
Prompt	**Total users who accepted intelligibility**	**Ambient Noise dB(A)**
		SPL @ device

Total number of participating users	

8.10.3 Machine originated tone message test (section 8.7.1.4)

Name		**Date**	__/__/____
		Time	__:__

Tone Prompt Type	**Single Tone**	**Multi-tone**

Tone Prompts List (Frequency Components - Hz)			
1		**6**	
2		**7**	
3		**8**	
4		**9**	
5		**10**	

Test Results			
Prompt	**Signal type description (continuous, discreet, etc…)**	**Total users who accepted intelligibility**	**Ambient Noise dB(A)**
			SPL @ device

Total number of participating users	

8.10.4 Testing Procedures

User originated prompts (section 8.7.1.2)

1. The equipment to be used is listed in section 8.7.1.1
2. Deployment of measurement setup depicted in figure 2 (section 8.7.1.1)
3. Preparation of testing parameters (see report template in section 8.10.1)
4. Initialization of noise source's SPL (set to minimum)
5. Test user is seated in front of simulated machine (PC) at 0,5m distance
6. Test prompt is spoken by the user
7. Recognition result is reviewed (SUCCESSFUL or not)
8. In case of successful recognition, proceed to step 11.
9. Noise SPL is measured at the machine using high precision sound-meter.
10. If recognition is unsuccessful, the noise SPL in marked in test report (see template in section 8.1). Proceed to step 12.
11. Repeat steps 6 to 10 for increased noise level (same prompt)
12. Repeat steps 4 to 11 for different test prompt (same user)
13. Repeat steps 4 to 12 for different test user

Machine originated voice message (section 8.7.1.3)

1. The equipment to be used is listed in section 8.7.1.1
2. Deployment of measurement setup depicted in figure 2 (section 8.7.1.1)
3. Preparation of testing parameters (see report template in section 8.10.2)
4. Initialization of noise source's SPL (set to minimum)
5. Test user is seated in front of simulated machine (PC) at 0,5m distance
6. Test prompt is played back
7. User verifies the spoken message (TRUE or FALSE)
8. If TRUE, proceed to step 10.
9. If FALSE, proceed to step 13.
10. Noise SPL is measured at the machine using high precision sound-meter.
11. Increase the number of total users who verified the spoken message for this particular noise SPL.
12. Repeat steps 6 to 11 for increased noise level (same prompt)
13. Repeat steps 4 to 12 for different test prompt (same user)
14. Repeat steps 4 to 13 for different test user
15. Mark all data in test report (see template in section 8.10.2) as derived from the above process.

Machine originated tone message (section 8.7.1.4)

1. The equipment to be used is listed in section 8.7.1.1
2. Deployment of measurement setup depicted in figure 2 (section 8.7.1.1)
3. Preparation of testing parameters (see report template in section 8.10.3)
4. Initialization of noise source's SPL (set to minimum)
5. Test user is seated in front of simulated machine (PC) at 0,5m distance
6. Test message is played back

7. User verifies that heard the tone message (TRUE or FALSE)
8. If TRUE, proceed to step 10.
9. If FALSE, proceed to step 13.
10. Noise SPL is measured at the machine using high precision sound-meter.
11. Increase the number of total users who verified the played message for this particular noise SPL.
12. Repeat steps 6 to 11 for increased noise level (same prompt)
13. Repeat steps 4 to 12 for different test prompt (same user)
14. Repeat steps 4 to 13 for different test user
15. Mark all data in test report (see template in section 8.10.3) as derived from the above process.

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9 REPORT ON ACCESSIBILITY OF CARD READING DEVICES FROM DRIVERS	
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9.1 Introduction & Scope

This section is aiming at providing the necessary background information & rationalization to the analysis taken place from section 4 onwards.

9.1.1 Objectives & Scope of research coverage

The current document is dealing with (a) access to card devices from drivers while seating in their vehicles, and (b) use of mobile devices for accessing parking spaces, only.

Therefore, issues concerning the "on-foot" access of transport related card devices (such as public transport ticketing terminals for example) are out of scope of the current document.

More precisely, according to the PT06 phase A workplan, the report covers the following points of phase B research work:

- *Reach from vehicles, including disabled drivers; vehicle window heights and sizes; ability to use swipe cards vs insertion cards* vs contactless cards.
- Investigate the use of mobile phones (or other HHD) to help disabled drivers access designated parking spaces; how should these be secured; communication and information encoding; how one stop transfer of rights to ineligible parties;

With respect to the former bullet point, only physical access to device and actual usage of smart cards will be investigated. Thus, any user actions concerning issuing, loading & re-loading, as well as purchasing of the card before or after the card usage are out of scope of the current document.

The objective of the phase B research work is to *deliver suitable test methodologies for testing specific features on the accessibility of card reading devices*. In this sense the current document intends to provide rather the questions relevant to the design of a related system (which then need to be adequately covered by system designers and implementers) than the actual answers on how the system must be designed. This statement is generally true, unless previous standardization work has provided with quantitative and thorough validated data regarding specific features.

When issues related to vision, touch, force, interfaces, sound, audio, speech occur during research, then links and references to the work items of the other PT members is provided.

9.1.2 Scope of readership

The current document is intended primarily to system suppliers (designers, product or system providers, manufacturers, integrators) and secondarily to system purchasers (decision makers, policy makers, system owners).

The objective is to provide practical guidelines on how the design for all ethos could be incorporated into the system's design from the very beginning to the final system delivery and operation.

9.1.3 Technology solutions and applications

One must understand first of all, the context of technology applicability in various application areas. To do so he/she needs to take into account the range of available or emerging technology solutions (regardless of the use of cards or not) and their compatibility/suitability/affordability to relevant application areas. Although, this seems at the beginning as rather a cost-effectiveness exercise ("best technology for my budget") suited to decision makers, it is nevertheless, very relevant to the usability/accessibility issue: different technological solutions offer different automation and thus require different user involvement. The following table shows current situation:

	Technology solutions							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Magstripe cards	*Contact cards*	*Proximity cards*	*Vicinity cards*	*Mobile phones /HHDs*	*RF Tag based EFC (monolane)*	*RF Tag based EFC (multilane)*	*Autonomous EFC (GPS/GSM)*
General description	Based on magnetic stripe technology; User either swipes the card or insert it in a slot	Smart card; User insert it in a slot	Smart card, RF communication; User presents the card in front of the reader (distance approx. 10 cm)	Smart card, RF communication; User presents the card in front of the reader (distance approx. 100 cm)	GSM, SIM based; Different solutions for transaction: SMS, bluetooth	DSRC based, communication between tag in the vehicle and roadside equipment; Tag is mounted at vehicle's widescreen	DSRC based, communication between tag in the vehicle and roadside equipment; Tag is mounted at vehicle's widescreen	GPS/GSM based; Location (or cell) based charging
General comments								
Level of User friendliness	Less user friendly;	User friendlier than (1);	User friendlier than (2);	No user involvement required; User friendlier than (3);	Relatively user friendly	No user involvement required; Full automation & very user friendly;	No user involvement required; Full automation: Most user friendly;	No user involvement required; Full automation: Most user friendly
Technical status & perspectives	Extremely mature & not promising;	Mature & promising; Standards available	Mature & promising; Standards available	Not promising;	Emerging;	Mature but standards not finalized;	Relatively mature, but standards not finalized;	Emerging
Availability	Widely available solutions;	Widely available solutions;	Available solutions, especially for access control;	Not many available solutions;	Not commercially available solutions	Available solutions	Available solutions	Not many available solutions
Cost effectiveness	Not costly investment; Not costly operation; Not so high throughput	Not costly investment; Not very costly operation; Not so high	Not very costly investment; Not very costly operation; One of the higher throughput solutions	Not very costly investment; Not very costly operation One of the higher throughput solutions	Unknown	Costly investment; Costly operation, but one of the higher throughput	Costly investment; Costly operation but the highest throughput	Costly but the highest throughput

		throughput						
Application areas								
Tolling (A)								
Parking access							N/A	N/A
Urban road or zone access							N/A	N/A
Urban pricing								
ATM (B)						N/A	N/A	N/A

(A): In mainstream tolling applications usually more than one means of payment are acceptable (sometimes at the same lane) for the same toll plaza: magstripe/chip credit cards, magstripe/chip stored value cards, chip bank e-purse cards, and tag-based EFC. Moreover, the exception handling in case of the tag-based EFC system breakdown is often executed through the use of a magstripe/chip toll card containing the "contract".

(B): Banks would very difficult accept a contactless operational environment

Colour	Explanation
	Widely preferred solution at the moment, but not promising in the future
	"Hot", available and envisaged to prevail in the short term
	Promising but will not prevail in the short term
	Emerging and probably promising in the long term
	Available but not promising

Technologies number 6, 7 and 8 are obviously out of scope of the PT's work, since (a) in terms of HMI there is no difference between the able-bodied and the disabled driver due to the high level of automation, and (b) they do not include the use of smart card technology. Furthermore, technology number 5, although smart card based and HDD, should be considered out of scope due to the uncertainties concerning its actual use and potential market penetration.

The purpose of the table above is to prove the following points:

- Users (any kind of them) do not care for smart cards, tags or anything like that; they simply care for easy to use, quality and not expensive service that suits their needs. Therefore, the results of our limited-scope work (only access to card devices) are just a minimal fraction of what could be contributed from the usability point of view.
- Full automated and high user-friendly technological solutions in the vehicle-related domain do exist; their implementation could solve many (if all) problems related to user – system interaction.
- However, the implementation of these solutions is dependent on their technical maturity, availability and above all cost-effectiveness. User friendliness is a minimal criterion for one adopting a solution.
- Different application areas follow different patterns of technology solutions' adoption due to the variations in the height of economic sizes and required traffic throughput (i.e. parking versus tolling).
- In multi-choice payment/access means environments, such as tolling, the question of accessibility of a certain alternative has limited value: a disabled driver could easily prefer a tag based EFC lane, and not care for accessing a smart card system located at the next lane.
- Market and technological trends are unpredictable factors; they should though, always taken into consideration when "design for all" decisions are to be taken.
- It should be highlighted that the inclusion of design for all principles in the system's design is not the end of the story; The design-for-all principles should also be incorporated in the business modeling: if, for example, a disabled driver is eligible to tolling discounts because of his disability, but the EFC system has been modeled to provide one tariff for all, then the disabled driver would either choose to use a manual lane (least user friendly, but accepts discounts) or the EFC lane (most user friendly, but loses discount). In both cases he/she loses a bit of the service he/she deserves.

9.2 References, relevant work & missing links

[1] EQA guidelines – www.eqa4accessibility.org/manual.htm
[2] Teiresias guidelines - www.tiresias.org/guidelines
[3] ANEC guidelines - http://www.anec.org/researchrica.htm
[4] European Disability Forum guidelines - http://www.accessibility.lexir.net/
[5] Infopolis 2 project guidelines- http://www.ul.ie/~infopolis/
[6] TELSCAN project guidelines & user requirements - http://hermes.civil.auth.gr/telscan/telsc.html
[7] TELEPAY project - http://www.ertico.com/activiti/projects/telepay/telepay.htm
[8] E-PARKING project - http://www.erf.be/projects/pr_EPARKING.htm
[9] http://www.cenorm.be/isss/Workshop/URI/Default.htm
[10] TELAID (Telematic Applications for the Integration of Drivers with special Needs, DRIVE II project V2032, Commission of the European Communities

9.3 Definitions and abbreviations

DSN	Drivers with Special Needs
EFC	Electronic Fee Collection
GSM-SMS	Global System for Mobile Communications – Short Message System
HHD	Hand Held Devices
HMI	Human Machine Interaction

9.4 Research Methodology

The methodology is based on task analysis method.

The work will be carried out in three phases.

In the **first phase (I),** all relevant current standards & design guidelines are reviewed. The emphasis is on documents embracing the "Design for all" concept. All relevant findings are listed and if possible re-validated in phase III.

In the **second phase (II),** the sequence of user tasks that constitute a complete transaction is decomposed into the subsequent "user tasks-moves" required. A generic approach includes the following: i) user reaches the card device, ii) uses the card device, iii) obtains feedback from user interface, iv) evacuates the card device area.

Appropriate alternative scenarios of complete transactions are devised according to possible characteristics of the transport service (for example, barriers or no barriers).

Different user groups are identified and their specific requirements as per each user task are catalogued (in qualitative terms). It is also important to distinguish between different types of vehicles as well (i.e. certain disabilities may lead to vehicle adaptations that may complicate driver's task).

The objective is to develop a matrix per scenario in which user groups' requirements are matched to user tasks. The analysis at this stage defines which of the requirements need to be investigated in the phase III (are responsibility of this work item) and which are investigated by other research areas of this project (for example, sound, vision characteristics of the interfaces).

Quantitative findings of the phase I are inserted in the matrix if appropriate. Finally, a filtering process is undertaken to define these requirements most likely to affect design parameters. The latter are selected to be the Test indicators of the next phase.

The following figure shows the steps that have been followed in the framework of sub-phase II.

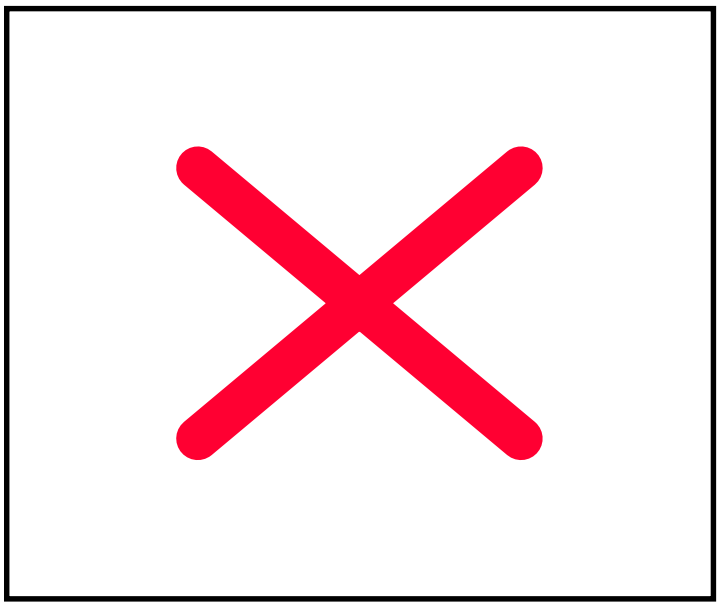


Figure 1: Methodology process for phase II

The **third phase (III),** includes the preparatory activities for tests as well as the plan for actual testing and measurements.

Furthermore, in the framework of this work item, the use of HDD's to help disabled people access designated parking spaces is investigated. The issues covered include the security aspects and actions to be taken in order to safeguard the process. The work is based on review of existing standards and guidelines, as well as experts' views. The outcome is a functional description of the process, also defining non-functional security requirements for the successful operation of such a service. The results are presented in the Appendix, **section 10.4**.

9.5 User tasks & process variations: Reach from vehicles

In order to complete a full transaction the user has to accomplish the following generic series of tasks (Generic Process – Base Scenario):

1. Approach the card reading device by car, and stop the car by the card reading device at correct point (Generic Task I)
2. Pull his/her[1] hand out of the car window and present the card to the card reading device (Generic Task II)
3. Receives transaction feedback information, (Generic Task III)
4. Retrieves the card and pull in back his hand (Generic Task IV)
5. Starts rolling the car and evacuates the transaction area (Generic Task V)

The above are the "normal" procedures for nowadays mainstream card based systems of this kind. However, there are variations in the generic process and therefore in the user requirements due to the use of different technologies (for example, contact or contactless cards) and physical layouts (for example, barriers or no barriers).

Furthermore, there are extensions/alteration to the base scenario due to exceptions occurring while the execution of the transaction (for example, system malfunctions)

For these reasons the elaboration of different processes variations and additional scenarios is necessary.

Card technologies: Variations 1 - 4

Variation 1: Use of Magstripe card (swipe)

- Direct effect to Generic Task II: The user swipes his card (Variation II –1)
- Indirect effect to Generic Task I: Accuracy of stopping the car (Variation I –1)
- Direct effect to Generic Task IV: Retrieval of the card (Variation IV –1)

Variation 2: Use of Magstripe or contact card (insert in slot)

- Direct effect to Generic Task II: The user inserts his card (Variation II – 2)
- Indirect effect to Generic Task I: Accuracy of stopping the car (Variation I –2)
- Direct effect to Generic Task IV: Retrieval of the card (Variation IV – 2)

Variation 3: Use of Contactless-proximity card (present card up to 10 cm)

- Direct effect to Generic Task II: The user presents his card in front of device, up to 10 cm (Variation II – 3)
- Indirect effect to Generic Task I: Accuracy of stopping the car (Variation I –3)
- Direct effect to Generic Task IV: Retrieval of the card (Variation IV – 3)

Variation 4: Use of Contactless-vicinity card (present card up to 100 cm)

- Direct effect to Generic Task II: The user presents his card in front of device, up to 100 cm (Variation II – 4)
- Indirect effect to Generic Task I: Accuracy of stopping the car (Variation I – 4)
- Direct effect to Generic Task IV: Retrieval of the card (Variation IV – 4)

[1] From this point onwards, the user will be assumed of masculine gender, and will be referred as "he", "him", "his" etc

Physical layout: Variations 5 - 6

Variation 5: Use of barriers

- Direct effect to Generic Task V: The user evacuates the transaction area after the barriers are open (Variation V –5)
- Indirect effect to Generic Task IV: The user retrieves the card and then the barrier opens (Variation IV –5)

Variation 6: No use of barriers

- Direct effect to Generic Task V: The user evacuates the transaction area immediately – No obstacles (Variation V –6)
- Indirect effect to Generic Task IV: The retrieval of the card is an independent action to the evacuation of the transaction area (Variation IV –6)

Exception's occurrence: Variations 7 – 8

Variation 7: Exception (transaction failure due to system's malfunction or card's inadequacy)

Following Generic task II, the user is informed of the problem through user interface (Variation III – 7) and repeats Generic Tasks II - IV:

- Repeated Task II-7
- Repeated Task III-7
- Repeated Task IV-7

Variation 8: Permanent failure

If the transaction cannot be completed under no circumstances, then exception handling mechanism is activated:

- User is informed of the problem (Variation III – 8)
- Exception handling (Additional Task VI– 8)

The correct synthesis of these variations will cater for the optimized simulation of real-life situations.

Variations 1-4 are "either or" type, and thus excluding one the other.

Variations 5 –6 are also "either, or" type, and thus excluding one the other.

Variations 7 –8 could occur for any variations 1-6, and thus should always be taken into account.

The combination of the variations, as explained above, would lead to the identification of several scenarios of use depending on the card technology, physical layout and exception handling occurrence parametres.

9.6 Identification of relevant user categories

This section attempts to define the relevant context of use for the vehicle related card applications. For this reason the relevant user categories, as well as their specific characteristics, for example their inabilities and required adaptation of vehicles are listed and analysed.

A/A	General user categories	Impairment	Disability	Special needs with respect to:	Adaptation to standard vehicles	Special vehicles used
A	**Skeletal impairments**					
1		Motion of lower limbs	• Cannot use both legs • Cannot use one leg • Uncontrolled lower limbs movement	Access / movement to and from the vehicle Driving the vehicle – Vehicle control	• Hand controlled clutch • Adaptations to automatic clutch • Push lever brakes under steering wheel • Left/Right hand accelerator	N/A
2		Motion of upper limbs	• Limited use of arms • Can only use one arm • Cannot move arm quickly	Access from inside the vehicle Vehicle control Using controls	• Foot controlled gear selector • Steering knob • Joystick controlled for brakes/accelerators • Motor controlled sun-shields • Foot controlled parking brake • Joystick steering	• Rotate plate foot controller steering system • Vertical steering • 4-way joystick for steering/breake/accelerator • Knee steering
3		Motion of upper body	• Difficulty in moving head/neck • Cannot move head/neck • Difficulty in moving trunk	Looking for information & controls outside the vehicle Vehicle control Access / movement to and from the vehicle Driving the vehicle – Vehicle control	• Special mirrors required • Rear view video camera • Wide – angle lens on rear window	N/A
4		Anthropometrics	Short stature	Looking for information/signs outside the vehicle	• Extension of toggle switches •	N/A
5			Short legs	Driving the vehicle	• Brake/accelerator adaptations for short legged stature	N/A
6			Short arms	Access from inside the vehicle Vehicle control	• Brake/accelerator adaptations for short armed stature	N/A
7		Co-ordination & dexterity	Difficulty using hand	Using controls	• Extension of toggle switches	N/A
8		Force	Reduced force in legs	Vehicle control	• Servo assisted brakes/acceleration	N/A
9			Reduced force in arms	Using controls Vehicle control	• Lower arm controlled brakes	N/A

A/A	General user categories	Impairment	Disability	Special needs with respect to:	Adaptation to standard vehicles	Special vehicles used
B	**Vision impairments**					
10			Total blindness	DO NOT DRIVE	N/A	N/A
11			Reduced visual activity	Vehicle control Choosing lane Looking for information Using controls	N/A	N/A
12			Reduced field of vision	Choosing lane Looking for information	• Special mirrors • External visual aids • Video cameras/head-up displays	N/A
13			Low contrast sensitivity	Illumination Looking for information at night Using controls at night	N/A	N/A
14			Glare sensitivity	Vehicle control	• Special windows • Headlight wipers (a standard feature to some expensive cars)	N/A
15			Night blindness/dark adaptation	Vehicle control	N/A	N/A
16			Colour blindness	Obtain coloured information	• Adequate coloured Head-up displays	N/A
C	**Hearing impairments**					
18			Total deafness	Obtaining voice information / instructions	• Visual warnings	N/A
19			Partial deafness	Obtaining voice information / instructions	• Visual warnings	N/A
D	**Language and speech**					
20		Language	Cannot read at all	Obtaining text information / instructions	N/A	N/A
21			Reads very slowly	Obtaining text information / instructions	N/A	N/A
22			Cannot understand some words	Obtaining text information / instructions	N/A	N/A
23			Cannot understand language	Obtaining text or voice information / instructions	N/A	N/A
24			Cannot understand abstracts	Obtaining symbol information / instructions	N/A	N/A

A/A	General user categories	Impairment	Disability	Special needs with respect to:	Adaptation to standard vehicles	Special vehicles used
25		Speech	No speech	Providing voice information	N/A	N/A
26			Slow speech	Providing voice information	N/A	N/A
27			Unclear speech	Providing voice information	N/A	N/A
28			Low volume of speech	Providing voice information	N/A	N/A
E	**Cognitive impairments**					
29			Difficulty in understanding instructions	Obtaining information / instructions Use of controls	N/A	N/A
30			Difficulty with new tasks	Use of controls	N/A	N/A
31			Difficulty performing simple tasks	Use of controls Exception handling	N/A	N/A
33			Difficulty performing complex tasks	Use of controls Exception handling	N/A	N/A
34			Slow response time	Use of controls	N/A	N/A
35			Impaired short term memory	Using information / instructions	N/A	N/A
36			Impaired long term memory	Using instructions	N/A	N/A
37			Limited attention span	Using instructions	N/A	N/A
38			Difficulty with decision making	Use of controls Exception handling	N/A	N/A
39			Limited spatial awareness	Vehicle control	N/A	N/A
40			Right/left confusion	Vehicle control Use of instructions	N/A	N/A
41			Phobias	Vehicle control Use of controls	N/A	N/A

Table 2: User categories, inabilities and other characteristics

9.7 Matching tasks & processes with user categories' characteristics

The purpose of this section is to identify what are the relevant user requirements for each one of the user tasks defined in section 2.

9.7.1 Effects of user disabilities on tasks

The following table shows which of the identified tasks and their variations of section 2 are affected per user category defined in section 3.

A/A	General user categories	Impairment	Disability	Task affected	Explanation
A	Skeletal impairments				
1		Motion of lower limbs	Cannot use both legs	• Generic task I • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Easy vehicle maneuvering
2			Cannot use one leg	• Generic task I • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Easy vehicle maneuvering
3			Uncontrolled lower limbs movement	• Generic task I • Generic task V • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Control actuation • Easy vehicle maneuvering
4		Motion of upper limbs	Limited use of arms	• Generic task I • Generic task II • Generic task IV • Generic task V • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Easy reach/use of the card • Easy retrieval of the card • Control actuation • Easy vehicle maneuvering
5			Can only use one arm	• Generic task I • Generic task II • Generic task IV • Generic task V • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Easy reach/use of the card • Easy retrieval of the card • Control actuation • Easy vehicle maneuvering
6			Cannot move arm quickly	• Generic task I • Generic task II • Generic task IV • Generic task V • Additional	• Inaccurate positioning of the vehicle in front of the device • Easy reach/use of the card. Time out operation • Easy retrieval of the card • Control actuation. Time out operation • Easy vehicle

A/A	General user categories	Impairment	Disability	Task affected	Explanation
				task VI	maneuvering. Time out operation
7			Uncontrolled upper limbs movement	• Generic task I • Generic task II • Generic task IV • Generic task V • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Easy reach/use of the card • Easy retrieval of the card • Control actuation • Easy vehicle maneuvering
8		Motion of upper body	Difficulty in moving head/neck	• Generic task I • Generic task II • Generic task III • Generic task IV • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Easy reach/use of the card • Obtain feedback from terminal • Easy retrieval of the card • Easy vehicle maneuvering
9			Cannot move head/neck	• Generic task I • Generic task II • Generic task III • Generic task IV • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Easy reach/use of the card • Obtain feedback from terminal (i.e. visible) • Easy retrieval of the card • Easy vehicle maneuvering
10			Difficulty in moving trunk	• Generic task I • Generic task II • Generic task III • Generic task IV • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Easy reach/use of the card • Obtain feedback from terminal (i.e. visible)
11			Cannot move trunk	As above	As above
12		Anthropometrics	Short stature	• Generic task I • Generic task III	• Choose the right lane • Obtain feedback from the terminal
13			Short legs	•	•
14			Short arms	• Generic task II • Generic task IV	• Reach / use the card • Retrieve the card
15		Co-ordination & dexterity	Difficulty using hand	• Generic task II • Generic	• Easy reach/use of the card • Easy retrieval of the card

A/A	General user categories	Impairment	Disability	Task affected	Explanation
				task IV	
16		Force	Reduced force in legs	• Generic task I • Additional task VI	• Inaccurate positioning of the vehicle in front of the device • Easy vehicle maneuvering
17			Reduced force in arms	• Generic task II • Additional task VI	• Easy use of the card • Easy vehicle maneuvering
B	Vision impairments				
18			Total blindness	N/A	N/A
19			Blind in one eye	• Generic task I • Generic task II • Generic task III • Additional task VI	• Choose lane. Inaccurate positioning of the vehicle in front of the device • Use the card • Obtain feedback from terminal • Easy maneuvering
20			Reduced visual activity	• Generic task I • Generic task II • Generic task III • Additional task VI	• Choose lane. Inaccurate positioning of the vehicle in front of the device • Use the card • Obtain feedback from terminal • Easy maneuvering
21			Reduced field of vision	• Generic task I • Generic task III • Additional task VI	• Choose lane. Inaccurate positioning of the vehicle in front of the device • Obtain feedback from terminal • Easy maneuvering
22			Low contrast sensitivity	• Generic task I • Generic task III	• Choose lane • Obtain feedback from the terminal
23			Glare sensitivity	• Generic task I • Generic task III	• Choose lane • Obtain feedback from the terminal
24			Night blindness	• Generic task I • Generic task III	• Choose lane • Obtain feedback from the terminal
25			Dark adaptation	• Generic task I • Generic task III	• Choose lane • Obtain feedback from the terminal
26			Colour blindness	• Generic task III	• Obtain feedback from the terminal
C	Hearing impairment				
27			Total deafness	• Generic task I	• Coordination of controls (accelerator/clutch/gear

A/A	General user categories	Impairment	Disability	Task affected	Explanation
				• Generic task III	shift) • Obtain feedback from the terminal
28			Partial deafness	• Generic task III	• Obtain feedback from the terminal
D	Language and speech				
29		Language	Cannot read at all	• Generic task III	• Obtain feedback from the terminal
30			Reads very slowly	• Generic task III	• Obtain feedback from the terminal
31			Cannot understand some words	• Generic task III	• Obtain feedback from the terminal
32			Cannot understand language	• Generic task III	• Obtain feedback from the terminal
33			Cannot understand abstracts	• Generic task I • Generic task III	• Choose lane • Obtain feedback from the terminal
34		Speech	No speech	• Generic task III	• Communicate with employee (if required)
35			Slow speech	• Generic task III	• Communicate with employee (if required)
36			Unclear speech	• Generic task III	• Communicate with employee (if required)
37			Low volume of speech	• Generic task III	• Communicate with employee (if required)
E	Cognitive impairments				
38			Difficulty in understanding instructions	• Generic task I • Generic task II • Generic task III • Generic task IV • Generic task V • Additional task VI	• Choose the right lane • Use the card • Understand feedback from terminal • Understand that should retrieve the card • Understand that should leave the transaction area • Execute exception handling instructions
39			Difficulty with new tasks	• Generic task I • Generic task II • Generic task III • Generic task IV • Generic task V • Additional task VI	• Choose the right lane • Use the card • Understand feedback from terminal • Understand that should retrieve the card • Understand that should leave the transaction area • Execute exception handling instructions
40			Difficulty	• Generic	• Choose the right lane

A/A	General user categories	Impairment	Disability	Task affected	Explanation
			performing simple tasks	task II • Generic task III • Generic task IV • Generic task V • Additional task VI	• Use the card • Understand feedback from terminal • Understand that should retrieve the card • Understand that should leave the transaction area • Execute exception handling instructions s
41			Difficulty performing complex tasks	• Generic task III • Additional task VI	• Understand feedback from terminal • Execute exception handling instructions
42			Slow response time	• Generic task IV • Generic task V • Additional task VI	• Timely retrieval of the card • Timely leave the transaction area. Time out • Timely execution of the exception handling procedure. Time out
43			Impaired short term memory	• Generic task II • Generic task III • Generic task IV • Additional task VI	• Forget to present the card • Forget what was the feedback from the terminal about • Forget to retrieve the card • Forget instructions. Time out
44			Impaired long term memory		
45			Limited attention span	• Generic task II • Generic task III • Generic task IV • Additional task VI	• Forget to present the card • Not paying attention to feedback from terminal • Forget to retrieve the card • Do not follow exception handling process instructions
46			Difficulty with decision making	• Generic task IV • Generic task V • Additional task VI	• Not deciding whether the card should be retrieved • Not deciding to roll the car • Not deciding to follow the exception handling process instructions
47			Limited spatial awareness	• Generic task I	• Accurate positioning of the vehicle
48			Right/left confusion	• Additional task VI	• Not follow the exception handling process instructions correctly
49			Phobias	• Additional task VI	• Phobia to follow exception handling process instructions

9.7.2 Effects on system elements

The following table shows which *generic* elements of the system are affected per task by possible users' disabilities, based on the analysis performed in the previous section.

	Element of the system affected						
Task affected	**Signalling**	**Lane layout**	**Device technical characteristics & design (incl. force, distance of card)**	**Device positioning & sizing**	**User interface (incl. Lighting and ambient noise)**	**Complexity of operations**	**Instructions**
Generic task I	Yes	Yes					Yes
Generic task II			Yes	Yes			Yes
Generic task III			Yes	Yes	Yes	Yes	Yes
Generic task IV				Yes		Yes	Yes
Generic task V	Yes	Yes					Yes
Additional task VI	Yes	Yes				Yes	Yes

9.7.3 General system requirements per task

The following table shows how specific user requirements (as derived from previous analysis) per task affect system design requirements.

Task	**Variations**	**General User requirement**	**Specific user requirement**	**General system requirement**	**Remarks**
Generic I	I – 1	Choose the right lane	Illumination (22) Lighting (23, 24, 25) Use of symbols (29-32) & text (33)	Signaling must be clear & understandable at all times of the day and under all weather conditions Instructions must be clear and understandable at all times of the day and under all weather conditions	Drivers with upper or lower limb impairments are facing many difficulties in lane keeping, because they require more concentration on the driving task itself, which consequently reduces their concentration in precise maneuvering
		Accurate positioning of the vehicle		Lane layout must not have sharp edges & curbs Enough length for braking the vehicle	
	I – 2	As above		As above	

Task	**Variations**	**General User requirement**	**Specific user requirement**	**General system requirement**	**Remarks**
	I – 3	As above		As above	
	I – 4	As above		As above	
Generic II	II – 1	Easy reach		• Distance from vehicle window must be within 500 mm • Device must be at same vertical level with ground • Height above surrounding ground level should be 1050 +/- 50 mm for normal PCs • Height above surrounding ground level should be 1500 +/- 50 mm for vans	Different height required due to variations in vehicles' windows' heights.
		Locate the reader		The exact position where the smart card should be placed must be clearly indicated	
		Easy swipe		Force Swipe direction must be up to down	
	II – 2	Easy reach			
		Locate the reader		Drivers facing difficulties in moving head/neck must be able to locate the reader befohand	
		Easy insertion		The reader if possible must be adequately designed in order to allow operation by both sides	
	II – 3	Easy reach		As above	
		Locate the reader		As above	
	II – 4				
Generic III					
	III – 4	Get clear and understandable confirmation for	Provision of both visible and audible confirmation	The audible signal must be such that the majority of people with disabilities is able	

Task	Variations	General User requirement	Specific user requirement	General system requirement	Remarks
		succesfully completed transaction		to conceive	
	III – 8	Get clear directions on what to do next			
Generic IV & V	IV/V – 1	Enough space for maneuvering Guidance may be required for next steps			
	IV/V – 2	As above			
	IV/V – 3	As above			
	IV/V – 4	As above			
	IV/V - 5	Get enough time to complete transaction and evacuate the card reader area		More time is required by Drivers with Special Needs to evacuate the card reader area	The designer should consider the possibility that the Driver may not have visual access to the gate barrier (i.e. in the case of parking spots the system should be designed in a way that the barrier remains open until the vehicle has stopped inside the designated spot
Repeated II – 7		Clear instructions on what to do next			
Repeated III – 7		Clear instructions on what to do next			
Additional VI –8		Provide both audible and visible information on how to ask for assistance			

Table 3: User requirements per user task

9.8 Methodology of Tests

9.8.1 Test concept & workflow

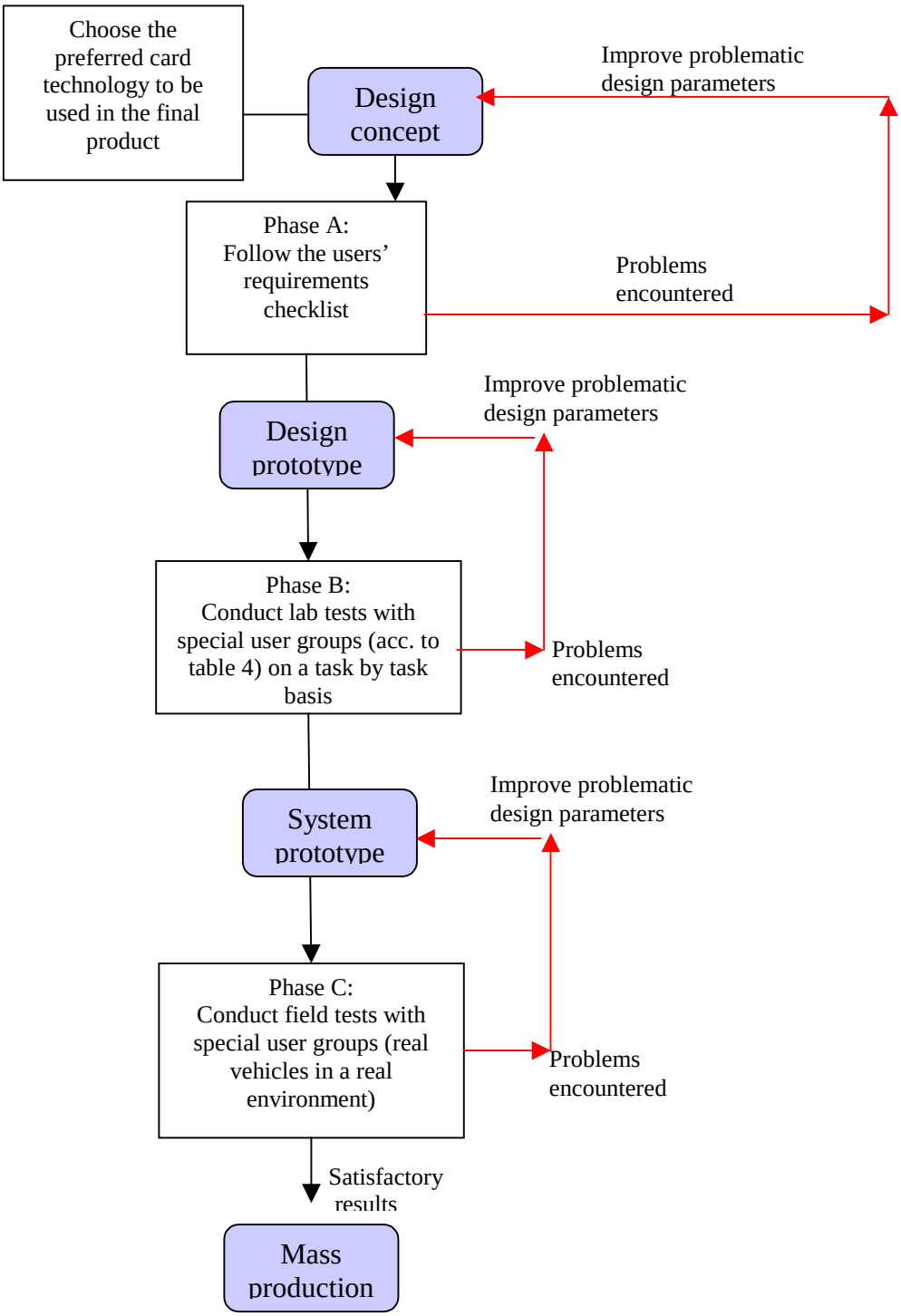
The primary objective of this chapter is to provide system suppliers (designers, product or system providers) with a testing methodology for assessing the various accessibility aspects of reading devices from vehicles. According to the User Task analysis presented in chapter 5, the driver completes a full transaction by executing five subtasks:
Generic Task I: Approach the card reader and stop the vehicle at correct point
Generic Task II: Pull out his hand and present the card to the card reader
Generic Task III: Receive transaction feedback information
Generic Task IV: Retrieve the card and pulls in back his hand
Generic Task V: Evacuate the transaction area

Moreover a set of variations has been introduced to cover the various card technologies (Variations 1-4), physical layout (Variations 5,6) and exception's occurrence (7,8).

The recommended methodology presented hereinafter allows the designer to build his own scenario of testing according to its individual system components and special characteristics. The first step in this process deals with choosing the preferred card technology as well as the system's physical layout (with or without gate barriers) . Then a prototype has to be prepared taking into account the users' requirements checklist (see APP. 1, form 1.1). The next step involves a set of lab tests with real vehicle in a testing environment on a task by task basis (e.g. lab test for each one of the generic tasks II, II, IV). Finally field trials are conducted (real vehicles in real environment) for the whole chain of Generic Tasks I through V (inlc. Variations 7 & 8 for exception handling, system failures etc.)

The methodology suggests a three-level approach for conducting tests with DSN:

1. Phase A - Conceptual design. A checklist is presented for all basic requirements that the system has to fulfill. It is absolutely necessary to complete this task before attempting any kind of initial system development and testing (either lab of field) thereafter.
2. Phase B - Testing a prototype (lab tests), where a matching of system and user requirements is taking place (participation of DSN is required but able-bodied users can also be included to identify differences and conflicting requirements if any).
3. Phase C - Preparing for mass production, where field tests in real life situations is taking place (active involvement of DSN is required)


Choose the preferred card technology to be used in the final product
Design concept
Improve problematic design parameters
Phase A: Follow the users' requirements checklist
Problems encountered
Design prototype
Improve problematic design parameters
Phase B: Conduct lab tests with special user groups (acc. to table 4) on a task by task basis
Problems encountered
System prototype
Improve problematic design parameters
Phase C: Conduct field tests with special user groups (real vehicles in a real environment)
Problems encountered
Satisfactory results
Mass production

9.8.2 Checklist

Prior to the commencement of the system development, the system designer must ensure that items of a usability checklist are taken into account and will be implemented. The checklist provides with the system requirements as deriving from the user requirements identified in the previous analysis. Some of the items of the checklist are presented in quantitative terms (quantitative data exists from other standards) while other in qualitative terms and must be interpreted by the designer himself.

In the appendix **(section 11.1)**, a sample of the checklist is provided.

9.8.3 Testing procedures for lab tests and field trials

The first thing that should be recommended regarding tests is to emphasise people's abilities, not their limitations. The evaluators shall understand the issues concerning drivers with disabilities, and should be either thoroughly experienced in the field, or if newcomers to the field, thoroughly briefed, and tests supervised by usability experts. Although it is true that common-sense and courtesy go a long way, it is also true that one ignorant mistake can cause the volunteer to put up a barrier fairly quickly.

It is highly recommended to provide sufficient time before the testing to understand the traveller's abilities, needs and preferences. If a vehicle is used, allow plenty of time for volunteers, to become familiarised with it but in any case it is preferred to use their own vehicles. It is also deemed of great importance to establish the degree of familiarity the persons have with technological devices. As a matter of fact, some persons who are elderly suffer from technophobia but on the contrary, a person with physical or sensory impairments may be an expert in using a computer for example. All the research protocol to be used in the assessment will have to be design with these issues in mind.

In general terms Tasks I - V should be evaluated by means of field trials involving various categories of disabled users as well as able-bodied drivers, while Tasks II, III and IV can be evaluated by disabled drivers also in a simulated and controlled environment.

Table 4 provides a matrix of all possible scenarios providing information on the type of test required as well as the type of dissabilities that need to be included in the sample.

	Card Technologies				Exception handling	Permanent failure
	Magnetic stripe/Smart card		**Contactless Smart cart**			
Generic Task	**V 1 Swipe**	**V 2 Insert in slot**	**V 3 Contactless – prox.**	**V 4 Contactless – vicinity**	**V 7**	**V 8**
I	Field Trials **CD, L, U,**	Field Trials **CD, L, U,**	Field Trials **CD,**	Field Trials **A**		

	B	**B**	**L,U,B,C**			
II	Field trials Lab test **CD,U, C, B**	Field trials Lab test **CD, U, C, B**	Field trials Lab test **CD, U, C, B**	Field trials Lab test **A**	Field trials Lab test **U, C, B**	Field trials Lab test **U, C, B**
III	Field trials Lab test **V,H,C,R**	Field trials Lab test **V,H,C,R**	Field trials Lab test **V,H,C,R**	Field trials Lab test **V,H,C,R**	Field trials Lab test **V,H,C,R**	Field trials Lab test **V,H,C,R,S**
IV	Field trials **U, UB, C, CD**	Field trials **U, UB, C, CD**	Field trials **U, UB, C, CD**	Field trials **U, UB, C, CD**		
V	Field trials **L,U,C**	Field trials **L,U,C**	Field trials **L,U,C**	Field trials **L,U,C**		

Table 4: Types of individual tests

KEY: V – Visual/R – Reading/H – Hearing/S – Speech/L – Lower Limbs/U – Upper limbs/B – Upper body/C – Cognitive/CD – Coordination, Dexterity/A – Able-bodied

9.8.3.1 Lab tests

Simulation tests are to be performed in a lab and require two car bodies (one conventional vehicle and one van) with the driver's side door/window and full cockpit with steering wheel: **"Real vehicles in lab environment"**. Moreover, it is recommended to provide various card reading devices' prototypes on a moving basis at the vertical level.

Objectives:
The objective is to test the subjects' performance with respect to each one of the Generic Tasks II – IV (with their respective variations) independently, but also the subjects' performance regarding the complete series of tasks from II to IV.

Test types:
Each Generic Task (and their variations) is performed independently several times (up to ten times) by all the study "drivers". The tests should be performed for different heights of the reader device position. The focus should be on the first execution of the test(s) for each task, during which the comments and views of the test subjects should be sought.

The study "drivers are performing then the whole series of the respective Generic Tasks II – IV several times.

Methodology:
The results from the tests should be based on:

- Measurements of objective quantitative test indicators.
- Analysis of subjective quantitative test indicators (user rating) collected by means of questionnaires.
- Lab qualitative observations. The tests should be supervised by the designers, and if these are not experienced in usability aspects, by usability experts as well. During the tests the supervisors should take notes with respect to any problems encountered. Furthermore, and given that lab conditions allow the

direct communication with the subjects, the latter should also provide their comments at the moment of test execution.
- Qualitative results from focus group meeting after the execution of the tests.
- The subjects' performance should be video recorded for further evaluation.

The results (especially quantitative) should be analysed per subject, user category and then overall.

Test indicators:
- Measurements (see sample form in Appendix, section **10.2.1**):
  - Successful completion of the task (1st time subjects using the system)
  - % of successful completion of the task (subsequent times using the system)
  - time in sec for the successful completion of each task
  - % successful understanding of system's feedback (for Generic task III)
  - Successful completion of the whole series of tasks (1st time subjects using the system)
  - % of successful completion of the whole series of tasks (subsequent times using the system)
  - total time in sec for the successful completion of all tasks
- Rating (see sample questionnaire in Appendix, section **10.2.2**):
  - Easiness to locate reader (for Generic task II)
  - Easiness to reach reader (for Generic task II)
  - Easiness to insert or swipe or present card (for Generic task II)
  - Overall easiness to use
  - Easiness to understand instructions & operation
  - Easiness to learn using the system
  - Easiness to understand feedback from the system (for Generic task III)
  - Convenience
  - Friendliness of user interface

Subjects:
A sample of 8 – 10 drivers can be deemed certifiable; the subjects should cover all the user categories presented in table 4, or respective impairments should be simulated by abled technical experts (but not the designers themselves) by using appropriate means.

9.8.3.2 Field trials

Field trials should be conducted with experienced Drivers with Special Needs (DSN) who are driving their own cars with all necessary adaptations. The study drivers are asked for example in Generic Task I type of test to approach the card reading device in a way that they can successfully perform Generic Task II.

Objectives:
The objective is to test the subjects' performance with respect to a complete transaction, covering all Generic tasks (with their respective variations). The tests however, should also allow the examination and rating of subjects' performance with respect to each one of the Generic Tasks II – IV (with their respective variations) independently.

Test types:
A complete transaction, covering all Generic Tasks (and their variations) is performed independently several times by all the study "drivers". The height of the reader's position is fixed.

Methodology:
The results from the tests should be based on:

- Measurements of objective quantitative test indicators.
- Analysis of subjective quantitative test indicators (*users' rating*) collected by means of questionnaires.
- Analysis of subjective qualitative remarks by the subjects regarding possible problems, collected by means of questionnaires.
- Is recommended that the subjects' performance is also video recorded for further evaluation.

The results (especially quantitative) should be analysed per subject, user category and then overall.

Test indicators:

- Measurements (see sample form in Appendix, **section 10.3.1**):
  - Successful completion of the whole transaction – without exception handling (1st time subjects using the system)
  - % of successful completion of the whole transaction – without exception handling (subsequent times using the system)
  - % successful understanding of system's feedback (for Generic task III)
  - % of operations timed out
  - % of successful exception handling cases
  - % of times a subject forget his card in the device
  - total time in sec for the successful completion of all tasks
- Rating (see sample questionnaire in Appendix, **section 10.3.2**):
  - Easiness to locate reader (for Generic task II)
  - Easiness to reach reader (for Generic task II)
  - Easiness to insert or swipe or present card (for Generic task II)
  - Overall easiness to use
  - Easiness to understand instructions & operation
  - Easiness to learn using the system
  - Easiness to understand feedback from the system (for Generic task III)
  - Convenience
  - Friendliness of user interface (for Generic task IV)

Subjects:
A sample of 20 drivers can be deemed certifiable; the subjects should cover all the user categories presented in table 4.

9.9 Conclusions - General recommendations

9.9.1 Conclusions from research work

9.9.1.1 General

- Limited information exists regarding the subject of access to reading devices from drivers.
- The analysis taken place has been based on "task analysis", and resulted to a proposed test methodology suitable for designers of card-based systems for tolling, parking as well as other applications that require the access of the reading device from a vehicle. However, it should be noted that different application areas may require slightly differentiated approach.
- Driving a car is a complex and highly dynamic task and thus it is important to determine which aspects of the driving task are critical for drivers with special needs. A widely-used driving task model suggests three levels: control, maneuver and strategic. The control task concerns the actual vehicle handling where driver's continuous attention is required and the reaction time is deemed critical performance factor. At the maneuvering level the interaction with other drivers and the physical layout of the roadway is included, while the strategic level represents tasks such as trip planning and navigation. Finally workload is another critical aspect of the driving task for the disabled. As it is widely acknowledged driving a car is normally not particularly difficult. But for a driver with tetraplegia, who has to do with two impaired limbs what the able-bodied is doing with four limbs it becomes a tiresome task, even if the vehicle is adequately adapted.
- Therefore, the accessibility of card reading devices from drivers is certainly not simply an issue of studying the reaching of the device from the vehicle. The analysis of "reaching the device" is by itself quite complicated as a (disabled) user is further burdened by the constraints his position in the vehicle is imposing; moreover, the analysis must take into consideration other aspects such as:
  - Required driving tasks, as well as
  - Other aspects covered in different sections of the PT's work report (present in situations in which the user could also access the device "on foot") such as (a) user interface, (b) obtain feedback, (c) ambient noise, force, lighting etc.

9.9.1.2 Specific

- Contactless cards should be generally, preferred over contact smart cards or magnetic cards.
- The size of vehicle window seems to play a very limited role with respect to accessibility, even for specially adapted vehicles.
- On the other hand, the height of the vehicle window is a very important parameter. The vehicles most likely used by DSN are either normal private cars or specially adapted vans; these have quite different requirements as per the position of the card reading device. The only feasible solution seems to be the existence of two readers at different heights. This is one solution already adopted to cover normal cars and trucks for tolling applications.

- The user must be able to locate the card reading device easily. For that reason the card reader must be obvious on the box accommodating the equipment, and especially for contactless cards must have a wide field of detection.

9.9.2 Extensions and further research

- It is generally recommended that the system is always aware of any special drivers' requirements (but not their actual impairments as this would be a breach of their privacy). This information could be stored in the drivers' smart cards and could be used for system adaptation when required. The CEN/ISSS Workshop Agreement 13987:2000 URI is based on EN 1332, and covers this issue and therefore is recommended that the PT support this specification.
- Ageing is characterised by a global reduction in attention resources, leading in reductions in cognition and perception as well as various deficits in language, memory and spatial ability, impairments which according to the author's point of view can be deemed substantially covered by the functional classification presented in the previous chapters. Already senior citizens are not thoroughly studied in the analysis, it is believed that their inclusion in the proposed tests as subjects would further enhance the validity of the test results.
- Finally, the proposed test guidelines should and must validated through actual testing. The best way is to propose these to be part of the evaluation process of relevant research projects and/or commercial companies.

9.10 Investigation of the use of HHDs for accessing parking spaces

In recent years the development of numerous telematics systems have improved, enhanced and enriched the lives of the various categories of users that have adopted and utilised these new technologies. To date, in Europe, the EU's 2nd, 3rd and 4th Framework Research Programs have been successful in supporting and promoting a partnership between European industry, academia and service providers to develop innovative and world-beating telematics services and new, leading-edge technologies. Moreover, the introduction of the "Inclusive Design" concept opened a number of new opportunities in considering the needs of the widest possible array of users. It is now widely accepted that varying ability is not a condition of the few but a common characteristic of being human and also that personal self-esteem and identity is deeply affected by our ability to function in our physical surroundings with a sense of comfort and independence.

Finding a reserved parking space that is free is a frequently-mentioned problem among the disabled drivers. These spaces are rarely signed, even within the car park! The main issue, however, is knowing which car park in a town has parking spaces available for orange badge holders at any given time. Another problem here is that badges are issued to people who are barely entitled to them, so that facilities are made more scarce for those in the most acute need for reserved parking, not to mention the numerous cases of abuse by non-disabled drivers.

Taking into account the widespread use of cellular phones in Greece the EU/DGXIII funded project TELSCAN demonstrated an access control system to prevent unauthorised use of specially reserved parking spots. The smart card operated gate-barrier allowed access to authorized users at a public parking lot. The availability of the parking spaces was communicated through a GSM server system, while the system was designed to enable the disabled user to pre-book a parking space through his/her cellular as well.

The system comprised by the following items:

- 2 detective loops (one was placed on the pavement next to the s/c reader and another one on the pavement inside the parking spot
- 1 contactless s/c reader placed
- 1 automated gate barrier placed right in front of the parking spot

An industrial PC placed on the parking entrance kiosk, acquiring data from the s/c reader and the two detective loops and transmitting them through a UHF wireless system to the dispatch center and its main server. Moreover, the same server, gave permission to the system on-spot, when the ID number of the smart card was authorized to have full access to the service. The same server informed all interested users via GSM-SMS requesting either current availability of the parking spot or interactive communication with the booking service.

Under the specific application the driver gets in the parking lot from the main entrance, and stops the vehicle in front of the s/c reading device, right above the detective loop on the pavement. With his/her left hand places the card close to the antenna (proximity type s/c) and waits for a few seconds for the on-site industrial PC

to check whether the card holder is authorized to occupy the parking spot. As soon as the relevant matching proves successful, the automated gate barrier opens up and remains in this position until detective loop 2, inside the parking spot gets activated. For safety reasons, the system was designed in a way that the gate barrier remained open, unless loop 2 becomes free, that is the car exited the spot.

All transactions being made between the smart card antenna and the PC - updated every 10 minutes – were transmitted via UHF wireless communication, to the remote main server, so that information regarding parking availability and the pre-booking service can be obtained through the GSM-SMS application.

The following items were examined through an expert evalution and questionnaire analysis:

- The exact positioning and minimum distance required for the contactless smart card while transmitting all needed information to the s/c antenna (This was also directly related to the physical position of the s/c reader box).
- Total amount of time required by the system for checking the user ID number, and further processing the relevant information to the gate barrier in front of the parking spot.
- User friendliness of the HMI for the booking application over the GSM-SMS
- To indicate other ways of facilitating the booking service (INTERNET, conventional phones with or without help from an operator etc)
- Overall usability of the system
- Their willingness to pay for such a service in the future

The evaluation task included the definition of the usability indicators mentioned above and the involvement of an adequate sample of various categories of disabled drivers. More particularly, the “reservation of & access to parking spaces for disabled” services have been tested for a period of three months involving a user panel of more than 10 disabled drivers.

With respect to the overall concept, one out of two users found the service extremely useful, 30% very useful and 20% useful, while in terms of the booking over the cellular phone facility more than 80% found it very useful, with 20% of no interest to them because they were not own a mobile phone. On the other hand, 43% found the ‘access control’ aspect extremely useful, 48% very useful and 9% useful.

Moreover, 6 out of 10 users expressed their willingness to pay for such a service, provided that adequate number of such parking spots will be available in the future, while a great consensus (90%) has been observed, in terms of their decision to plan more trips with their private vehicles.

Users expressed their concerns about the card reading advice location and time-frame available to complete their transactions. More particularly, and with respect to the latter, 52% believe the time-out function was just the right one, but on the other hand 35% perceived the time left for completing the transaction and park “too little”, while 13% perceived it as being too much. A number of users having

upper limb disabilities stated that the use of a contactless smart card is still problematic, in terms of the distance required for the smart card to be “read (<100mm)

In order to prevent unauthorised use of the s/c, the licence plates of the car were included in a specific data field of the card. Therefore it was proposed that enforcement could be realised either by using an OCR system or by means of physical enforcement.

9.11 APPENDIX – Testing Report Templates (examples)

9.11.1 Phase A: General system's requirements sample checklist

ACCESSIBILITY OF CARD READING DEVICES FROM DRIVERS		
General users' requirements checklist		
	Yes	**No**
Device technical characteristics		
Is the exact position where the card should be placed clearly indicated?		
Is a pushing/pulling/rotating force required (in particular, controls which need holding down or those which require concurrent pushing/pulling and rotating)?		
In case your design requires a vertical card swipe, is the reader direction up to down?		
In case your design requires a horizontal card swipe, is the user able to swipe in either direction with either hand?		
In case your design requires a card insert do you provide a guiding groove leading to the slot?		
In case your design involves contact less proximity card the maximum distance between the card and the reader should not exceed 100mm		
Device positioning		
Is distance from vehicle window to the card reader within 500 mm?		
Is the Reading device located at same vertical level with ground ?		
Is height above surrounding ground level between 1050+/- 50 mm for conventional passenger cars (1500+/- 50 mm for vans) for the zone of manual controls?		
User interface		
Is precision required in the use of controls (e.g. small buttons or a continuous rotary knob)?		
Are there any obstacles nearby preventing the driver from making easy contact with controls?		
The designated zone for manual controls is approx. an area of 200mm (height) by 400mm (width) ?		
The designated zone for information and instructions is approx. an area of 500mm (height) by 1000mm (width) ?		

Have you considered providing the driver with feedback concerning complete transaction both audible and visible?		
Complexity of operations		
For optimal control performance, are both hands required?		
Instructions		
Is simple vocabulary used?		
In case of system failure, do you provide detailed guidance (both visible and audible) on what to do next?		
In case of permanent failure, do you provide the driver with the means to call for assistance (e.g. a button for assistance)		

9.11.2 Phase B: Testing with prototypes – (Real vehicle in a testing environment)

9.11.2.1 Sample test form

ACCESSIBILITY OF CARD READING DEVICES FROM DRIVERS SEATING IN THE DRIVER'S SEAT			
Subject's name:		Date:	…../…./….
Subject's impairment:		Time:	…..:…..

Type of test	Prototype	
Card technology in use:		
User interface characteristics:		

Test results per task					
Prompt	Successful completion (1st time)	Successful completion (subsequent times)	Time (in sec. Required to complete task)	Successful understanding of system's feedback	Remarks
Generic Task II					
Generic Task III					
Generic Task IV					

Test results for all tasks				
Prompt	Successful completion (1st time)	Successful completion (subsequent times)	Time (in sec. Required to complete all tasks)	Remarks
Whole series of Tasks II - IV				

9.11.2.2 Sample questionnaire

Please rate the following (rate from 1 to 5, where 1 means poor and 5 means excellent):

Easiness to locate reader

1 2 3 4 5

Easiness to reach reader

1 2 3 4 5

Easiness to swipe (or insert or present) card

1 2 3 4 5

Overall easiness to use

1 2 3 4 5

Easiness to understand instructions and operation

1 2 3 4 5

Easiness to learn using the system

1 2 3 4 5

Easiness to understand feedback from the system

1 2 3 4 5

Convenience

1 2 3 4 5

Friendliness of user interface

1 2 3 4 5

COMMENTS regarding the above mentioned aspects:
……
……
……
……
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9.11.3 Phase C: Testing for mass production – (Real vehicle in a real environment)

9.11.3.1 Sample test form

ACCESSIBILITY OF CARD READING DEVICES FROM DRIVERS SEATING IN THE DRIVER'S SEAT			
Subject's name:		Date:	…../…./….
Subject's impairment:		Time:	…..:…..

Type of test	Prototype	
Card technology in use:		
User interface characteristics:		

Test results							
Prompt	Successful completion (1st time)	Successful completion (subsequent times)	Time (in sec)	Operations timed out	Successful exception handling	Forget the card in the device	Problems encountered
Generic Tasks I - V							

9.11.3.2 Sample questionnaire

Please rate the following (rate from 1 to 5, where 1 means poor and 5 means excellent):

Easiness to locate reader

1 2 3 4 5

Easiness to reach reader

1 2 3 4 5

Easiness to swipe (or insert or present) card

1 2 3 4 5

Overall easiness to use

1 2 3 4 5

Easiness to understand instructions and operation

1 2 3 4 5

Easiness to learn using the system

1 2 3 4 5

Easiness to understand feedback from the system

1 2 3 4 5

Convenience

1 2 3 4 5

Friendliness of user interface

1 2 3 4 5

COMMENTS regarding the above mentioned aspects:
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