Specification of symbols used on Audio-Tactile Maps for individuals with blindness

D2.2 Creation of tactile symbols

Prepare by :	Konstantinos Charitakis
Contributors	All partners
Work Package :	No 2
Email:	kcharitakis@uom.edu.gr
Form:	Final

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THE ATMAPS CONSORTIUM

No.	Partner Name	Logo
1	University of Macedonia (UOM) – Project Coordinator	
2	Karlsruhe Institute of Technology (KIT)	
3	GeoImaging Ltd (GEO)	
4	National and Kapodistrian University of Athens (UOA)	
5	Mustafa Kemal University (MKU)	
6	Panhellenic Association for the Blind (PAB)	
7	Association of Barrier Free Access (ABFA)	

ABBREVIATIONS

Term	Explanation
IVIs	Individuals with Visual impairments
AT-Maps	Audio-Tactile Maps
AT-symbols	Audio-Tactile Symbols
WP	Work Package

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1. INTRODUCTION

The second deliverable of Work Package 2 (Deliverable 2.2) includes the creation of symbols (AT-symbols).

Initially a variety of tactile symbols created each one of which aiming to depict different spatial information to be included in audio-tactile maps.

The design of the symbols was based on the outcomes of the user requirements elicitation process that took place in previous task of the project (Deliverable 2.1 – Definition of user requirements).

The creation of the tactile symbols was implemented through specific phases. During the first phase, the tactile symbols were created by researchers and their legibility (ease of identification) was initially checked by a small group of blind individuals. The tactile symbols created include point symbols, linear symbols and areal symbols in order to depict different types of spatial or general information.

It was decided from the research team that at this stage the produced tactile symbols will not be associated to spatial or general information derived from Deliverable 2.1 as it was initially proposed in the project proposal, since this is subject to change based on the conducted tests at a later stage in order the produced symbols to be evaluated first.

Moreover the audio part of the symbols was not produced at this phase. It was decided by the research team that the audio part of the symbols will consist of audio descriptions of the spatial or general information derived from the previous task of the project (Deliverable 2.1). The audio part will be produced and associated to the audio-tactile symbols at later stage.

The main reason for using audio descriptions and not audio sounds (eg. earcons, spearcons etc.) is that in the latter case an audio-tactile legend would be needed to be used together with the audio-tactile map.

Moreover, the use of an audio-tactile legend would be technically and practically difficult to be applied in public areas.

The outcome of this task is the development of an initial database that includes tactile symbols in order to be applied in different types of AT-Maps in the next phases of the project.

2. PROCEDURE OF SYMBOLS' CREATION

In this section, the phases of the symbols' creation procedure are presented thoroughly.

2.1 Tactile symbols design

During the symbols' design phase, the design of an initial list of tactile symbols was carried out. The analysis of the user requirements elicitation process that took place in previous tasks of the project (Deliverable 2.1) was considered. The outcomes of the user requirements phase defined the lists of information to be included in audio-tactile maps and the format the users - Individuals with Visual Impairments (IVIs) - prefer each information to be included in audio-tactile maps respectively.

The AT-Maps are divided into the following different types of maps: 1) Indoors maps (inner space of buildings), 2) Neighborhoods/ residential areas maps 3) Campus maps (school, college or university campuses), 4) Maps of city centers 5) Political maps, 6) Physical maps, 7) Historic maps, 8) Thematic maps (e.g. climate characteristics, population density health issues). On this basis, it is perceived that the user requirements analysis carried out through questionnaires, was conducted on all these different types of maps.

A variety of different symbols was created, each one of them aiming to depict different spatial information (e.g. a circle for the representation of a tree, a triangle for the representation of steps etc.). The creation of the tactile symbols was implemented through some specific stages.

2.1.1 Basic principles of symbols' creation

As mentioned above, in this stage the initial database of tactile symbols was completed. Firstly the tactile part of the symbol was created and its graphic display took place. It is crucial for the developed tactile symbols to be user friendly, readable, easy to be distinguished and easily identified on tactile maps without causing any

confusion to the individuals with visual impairments. The basic principles followed for the development of the tactile symbols are listed below [1].

Moreover, the tactile symbols must be discrete. The size of the map must be almost the size of two wide open palms (A3 size paper), minimizing the hand separation during the exploration of the map. The tactile symbols must be simple and minimal. They cannot be consisted of too many different elements. Too much information and detail causes confusion. At the same time, another basic principle that had to be followed is that when designing a symbol or a string in general, there needs to be taken into consideration that this exact series of symbols is going to be used on the design of a map or on a series of maps (in this case AT-Maps). This basically means that they should be easily identified by the users. The suitability of a tactile symbol is directly related to the time required to be identified when included in the map.

2.1.2 Symbols' design process

After researching and testing the key design principles about tactile symbols to be used on tactile maps for individuals with visual impairments; the process of creating the tactile part of the symbols took place.

The tactile symbols were created in order to depict spatial information based on the information derived from the previous task of the project. The information derived from the user requirement specification phase included point, linear and areal spatial information.

The characterization of the derived information into a point, linear or areal symbol (i.e. an obstacle is depicted by a point symbol, a lake is depicted by an areal symbol etc.), depends mainly on the map scale because that is the factor that defines the level of map generalization and on the category of the information (e.g. the conversion of areal symbols to point symbols in a large scale map), but also based on its given actual dimension and based on bibliography and previous experience. For example, the classification of the information is based not only on the actual dimension of it, but also on the frequency of occurrence in the maps and also on the mapping scale of the designed map (i.e. a hall/room is depicted by a linear symbol in the indoors map, while

when included in a campus map, a hall/room might be depicted by a point symbol etc.).

Therefore the design and creation of symbols was based on these three categories of symbols (point, linear and areal).

Based on the user requirements 263 tactile symbols were needed In total: 173 point symbols, 64 linear symbols, 26 areal symbols as it was derived by the user requirements elicitation process in previous task of the project (Table 1).

	1.Indoors	2.Neighbor-Residential_Area	3.Campuses	4.City center	5.1 Political	5.2 Physical	5.3 Historic	5.4 Thematic
Point	114	172	173	170	18	34	50	94
Linear	29	64	43	59	18	27	26	33
Areal	7	26	20	31	6	23	11	10

Table 1: Number of unique symbols for each type of map based on the user requirements elicitation process

As it is perceived, the maximum number of symbols for each category was identified, in order to cover all future possible cartographic needs for every AT-Map that is going to be designed.

One of the basic parameters that were taken into consideration during the creation of symbols was the eligibility of each symbol in order for it to be used in all different types of maps if needed. While designing the symbols, it was also taken into account the possible need for them to be used in maps of different scale (the symbol's size should not create restrictions, as well as its format should not bear any resemblances to another symbol).

Therefore all designed symbols differ in variables as shape, size, orientation, texture and line thickness in order to avoid any similarities and ease the identification of them. As already mentioned, it is important that the developed tactile symbols and maps must be user friendly, readable and easily identified without causing any confusion to the individuals with visual impairments. The analysis below shows the basic principles that were applied to each type of tactile symbols (point, linear and areal symbols).

2.1.2.1 Point symbols

The size of the point symbols depends on the shape of the symbol. Most of the point symbols were created in a variety of different sizes depending on the shape of the symbol. Symbols that are commonly accepted as simple ones such as circles or squares were created in three to four different sizes.

The same applies to solid circles or squares. Symbols shaped as circles or squares that consist of contours were designed with contours in various thicknesses and can vary from three to four sizes.

A symbol consisting only by a contour can be designed in smaller dimensions where as a solid one cannot be designed in the same size and format. It is crucial for a solid symbol to have the correct size in order for it to be easily identified (Picture 1).

Furthermore, the more complex the shape of a point symbol is (e.g. if composed of a square inside of a square), the larger the size that is required (Picture 2). At the same time, the thickness of the lines during the design is very important. This happens due to the fact that the narrower the external dimension of the symbol is, the thicker the line should be, so as for it to be easily identified. Lastly, the point symbols' external acmes (geometrical shapes) should not exceed the number four (4).

Picture 1: Different sizes of solid point and non-solid symbol

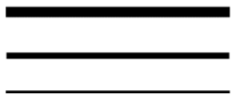
Picture 2 : Point symbol with complex form

2.1.2.2 Linear symbols

In linear symbols the width of the solid line can vary between three widths unlike the more complicated symbols where there are less than two widths (Picture 3). Priority was given to the linear symbols consisting of patterns that result from the repetition of

patterns of the same geometric shapes (Picture 4). Such linear symbols are more convenient for the individuals with visual impairments who tend to use them in various symbolisms. Linear symbols that use geometrical shapes appear in only one width for reasons of simplicity.

Special emphasis was given to the size of geometric shapes (i.e. triangles) the repetition of which led to the creation of the linear symbol (Picture 5). Finally in order for them to be readable they should maintain an intermediate size.



Picture 3: Three different widths for solid symbols

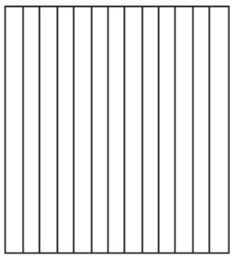
Picture 4: Linear symbols which result from repetition of squares

Picture 5: Complex geometrical linear symbols have bigger size

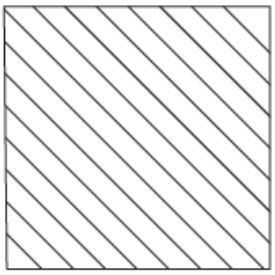
2.1.2.3 Areal symbols

Areal symbols should be discrete and easily identified by the users. The distance between the lines within the areal symbols should have the right proportions so that there is no confusion caused between small and large areal symbols (e.g. should not be any confusion between sea and lake symbols). The distance between the fill-in lines in the areal symbols must be standardized so that there is no confusion between the linear and the aerial symbols.

During the design of the areal symbols, priority was given to the creation of symbols consisting of repetition of lines (either horizontal, or diagonal, or vertical with variations in the thickness of the lines) (Picture 6, 7).Then the areal symbols-patterns were designed based on other geometrical shapes.



Picture 6: Areal symbol composed of vertical lines



Picture 7: Areal symbol composed of diagonal lines

The design of the symbols mentioned above was implemented with the use of a vector graphics design software. Aiming towards the creation of the symbol database (point, linear, areal), a series of tactile printouts of the designed tactile symbols were created using the method of printing tactile graphics on microcapsule paper. It took many prints so as to clarify that the tactile symbols are easily identifiable through touch.

After finalizing the design of tactile symbols, three different lists of tactile symbols were created: one list for point symbols, one list for linear symbols and one list for areal symbols. The symbols were initially indexed in the lists based on their degree of difficulty regarding complexity, legibility and ease of identification. This initial evaluation was performed based on the researchers' experience.

3.1.3 Classification of symbols and information

In order to have complete matches between the symbols and the information derived from the user requirements elicitation process conducted in previous phase of the project, the maximum number of tactile symbols created was 263 symbols. The tactile symbols created included: 173 point symbols, 64 linear symbols, 26 areal symbols.

However the creation of such a large number of tactile symbols lead to the creation of very complex tactile symbols that would be difficult to be identified and easily to be confused.

Therefore a simplification was needed and similar information was grouped were possible. It was decided that the extra information that didn't match the grouping, would be added later by adding audio information were needed. After the grouping of the information the total number of tactile symbols needed is identified to a list of 160, consisting of the easier symbols based on researchers experience and bibliography. The removed symbols were chosen according to the degree of difficulty in the identification.

The final list of the 160 symbols consisted of 100 point symbols, 40 linear symbols and 20 areal symbols.

3.1.4. Users' reviews[1]

After finalizing the number of the symbols for all three categories (point, linear and areal) a first assessment from two individuals with visual impairment took place. Throughout the design of the tactile part of the symbols a wide range of corrections was made based both on basic tactile symbols design principles and the experience of researchers.

However, the evaluation of the tactile symbols even from a very small sample of non-sighted users was very useful. This early evaluation was held in order the final lists of point, linear and areal symbols to be created. The final evaluation of the tactile

[1] In order to view the symbols' shapes go to Annex I (page 30)

symbols created will be based on specific indicators and is going to take place later in the project.

Therefore, three different pilot tests - one for each category of tactile symbols- were created. The symbols were aligned in columns and printed on A3 sized microcapsule paper.

The initial evaluation of the tactile symbols produced utilizing the three pilot tests were conducted with two blind individuals members of the Panhellenic Association for the Blind as project partner organization from Greece. The users evaluated each symbol separately while at the same time they also made comparisons between the tactile symbols. During the tests the researchers were recording and making the remarks needed. The aim of these initial tests was to check the readability and legibility of the symbols. Moreover, users pointed out possible confusion between symbols.

The users' comments were studied and then applied to the tactile symbols. Moreover, all the necessary changes were made in order to modify the symbols that were designed throughout this stage.

Below are listed in detail each user's comments related to the symbols.

User 1

Regarding the test of point symbols, User 1 observed a confusion between symbol 1, symbol 2 and symbol 3 (point-symbols). He added that it would be more easily identified if there was a greater gradation of the symbol's size. Also the user identified a problem to the symbols 22 and 23. These symbols were marked as unreadable due to small size. The symbol 35 was characterized as inappropriate for visual impaired users. Same comments were made for the point tactile symbol 36, which was declared inappropriate and was confused with symbol 35. The same characterization was given for the symbol 38 and also there was confusion between symbol 38 and the previous two.

For the symbols 50, 51, 52, 56, 57, 58, 62, 63 and 64 it was stated that they should be larger in order to be readable. The symbols 68 and 69 were characterized as hardly readable, while it was stated that there was confusion between the two. For the symbols 75, 76, 79, 81, 82 and 83 it was stated that the length of lines needed to be larger in order to be readable. For the symbols 85 and 86 it was stated that there was confusion between them. For the point tactile symbols 91 and, it was stated that there were hardly readable. And finally the point tactile symbol 100 was noted that it was confused with the symbol 13.

Regarding the test of linear symbols, the user observed for the linear tactile symbol 14 that the dots from the repetition of which it is created should have a larger size to be readable. The symbol 17 was characterized as hardly readable. The symbol 18 was confused with the symbol 12. For the symbol 21 it was stated that there should be no distance between the lines, as well as for the symbol 20. For the symbol 25 it was remarked that it should be larger than the dots. For the symbols 26 and 27 it was noted that we must increase the size of the triangles. The symbols 30, 31, 32, 33 and 34 should be enlarged while the symbol 38 it was noted that we should increase the distances between the squares in order for it to be easily readable. The symbol 39 was characterized as not easily readable while the symbol 40 was confused with the symbol 22.

At the areal symbol's test, the observations of the user were fewer. More specifically, he noticed confusion between the surface symbols 11, 12, 13 and 14. For the surface symbol 15 he stated that we should increase the size of the new triangles as well as for the symbol 16 that needs to have the size of x increased. Finally for the symbol 18 the user noticed that the squares' line thickness should be increased.

User 2

Regarding point symbols' test, the user noticed that there was confusion between symbol 1 and symbol 3. Their sizes have slight differences resulting in them not being easily recognizable. For the symbols 9 and 10 the user noted that the differentiation in the size of the diameter of the circle was not easily perceived, whereas the internal dot

hadn't the same problem. Also the user identified the same problem with User 1 to the symbols 2 and 23.These symbols were marked as unreadable due to their small size. Furthermore, the user has made exactly the same comments with User 1 on the symbols 35, 36 and 38. Also he noted that he confused the symbol 43 with the symbol 11, and the symbol 44 with the symbol 12. About the symbols 53, 54 and 55 the user noticed that he could not recognize that the external shape of them was square but perceived them as rectangles. Additionally the symbol 62 was confused with the symbol 10. For the linear symbols 75 and 76 he made the same remarks with User 1. For the symbols 78 and 79 the user stated that should be enlarged in order for them to be readable. Finally the symbols 91, 92 and 100 were classified as hardly readable.

Regarding the linear symbol's test, the user noted that there is confusion due to the minimal variation in symbols' 1 and 2 sizes. Also there was confusion between symbols 6 and 7 due to the minimum line thickness' modulation of the symbols. About the symbol 15 it was noted that there was confusion due to insufficient differentiation of the shape of the symbol. Also the user stated that there was confusion between the symbols 12, 19 and 23. Regarding the symbols 26 and 27 the user made the same observations with User 1, as well as for the symbol 31. In addition there was confusion between the symbols 32, 36 and 37 because of limited differentiation of the symbol's figure. Finally, for the linear tactile symbol 39 it was noted that we need to enlarge both geometric shapes by repetition of which linear symbol is created, and the gaps between them.

For the areal symbols' test, the observations of the user were much more regarding User's 1 comments. User 2 pointed out that the thickness of the lines of areal tactile symbol was large thus making the horizontal lines look like a single surface and making them unreadable. For the surface tactile symbols 11 and 14 it was noted that there was confusion between the two signs because of the similarities in their shape. In order for the symbols to differentiate, the user noted that the circles from which the symbol 1 consists of should be enlarged. Finally, although the symbol 20, was described as very minimal and easily readable, it was observed that it could be confused with symbol 13 when used in the same map.

2.2 Presentation of tactile symbols created

The indexed point, linear and areal tactile symbols are represented in the tables below. In this final database of tactile symbols, audio information was not assigned at this stage of the project.

2.2.1 Point Symbols

Below is the list of point symbols created. Each point symbol is assigned a unique reference number.

Ref No.	Point Symbol
P1	
P2	
P3	
P4	
P5	
P6	
P7	
P8	
P9	
P10	

Ref No.	Point Symbol
P11	
P12	
P13	
P14	
P15	
P16	
P17	
P18	
P19	
P20	
P21	
P22	
P23	
P24	
P25	
P26	

Ref No.	Point Symbol
P27	
P28	
P29	
P30	
P31	
P32	
P33	
P34	
P35	
P36	
P37	
P38	
P39	
P40	
P41	
P42	

Ref No.	Point Symbol
P43	
P44	
P45	
P46	
P47	
P48	
P49	
P50	
P51	
P52	
P53	
P54	
P55	
P56	
P57	
P58	

Ref No.	Point Symbol
P59	
P60	
P61	
P62	
P63	
P64	
P65	
P66	
P67	
P68	
P69	
P70	
P71	
P72	
P73	
P74	

Ref No.	Point Symbol
P75	
P76	
P77	
P78	
P79	
P80	
P81	
P82	
P83	
P84	
P85	
P86	
P87	
P88	
P89	
P90	

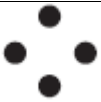
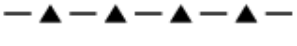
Ref No.	Point Symbol
P91	
P92	
P93	
P94	
P95	
P96	
P97	
P98	
P99	
P100	

Table 2 : Point tactile symbols with audio information

2.2.2 Linear Symbols

Below is the list of linear symbols created. Each linear symbol is assigned a unique reference number.

Ref No.	Linear Symbol
L1	
L2	
L3	
L4	
L5	
L6	
L7	
L8	
L9	
L10	
L11	
L12	
L13	
L14	
L15	
L16	
L17	
L18	
L19	
L20	

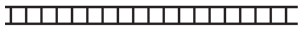
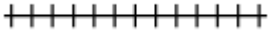
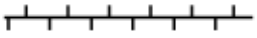
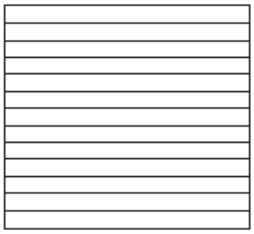
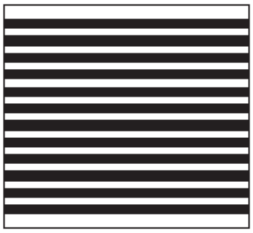
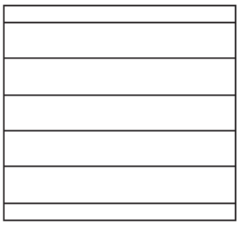
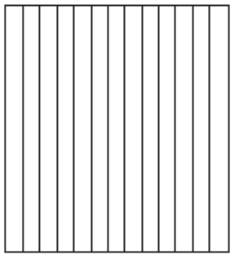
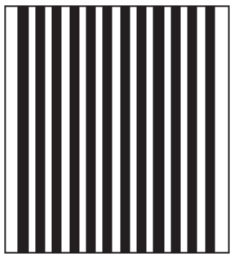
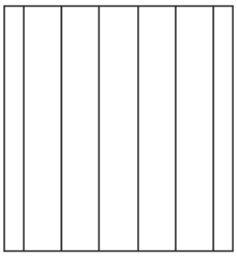
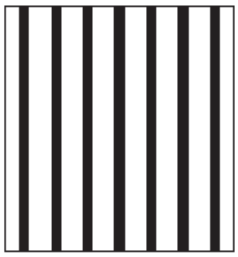
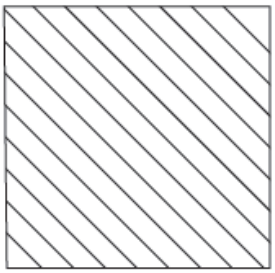
Ref No.	Linear Symbol
L21	
L22	
L23	
L24	
L25	
L26	
L27	
L28	
L29	
L30	
L31	
L32	
L33	
L34	
L35	
L36	
L37	
L38	
L39	
L40	

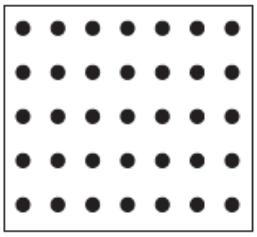
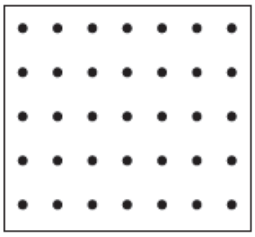
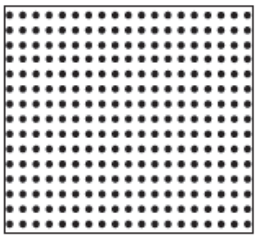
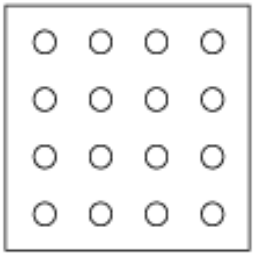
Table 3: Linear tactile symbols with audio information

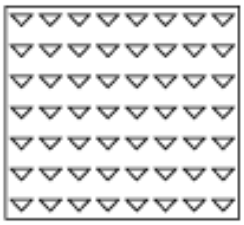
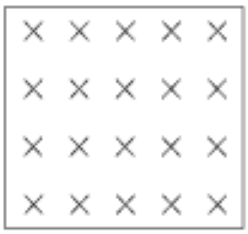
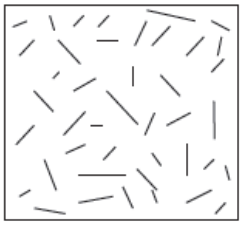
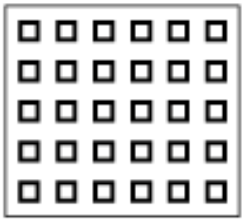
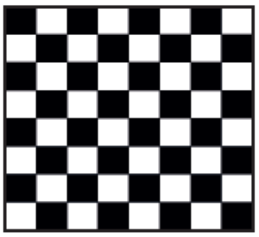
2.2.3 Areal Symbols

Below is the list of areal symbols created. Each areal symbol is assigned a unique reference number.

Ref No.	Areal Symbol
A1	
A2	
A3	
A4	

Ref No.	Areal Symbol
A5	
A6	
A7	
A8	
A9	

Ref No.	Areal Symbol
A10	
A11	
A12	
A13	
A14	

Ref No.	Areal Symbol
A15	
A16	
A17	
A18	
A19	

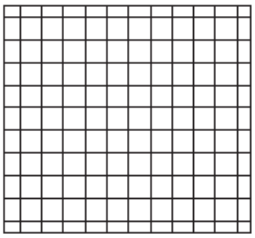
Ref No.	Areal Symbol
A20	

Table 4: Areal symbols with audio information

REFERENCES

[1] An Orientation and Mobility Curriculum for Students with Visual Impairments, Pogrund et al., 1995