



Safety signage made easy using parametric CAD-based software

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Abstract

As a result of current legislation safety signs are increasingly common in public places. The purpose of safety signs is to guide people to a final location in a limited amount of time. But is sign location always effective? Do users have an adequate viewing range or cognitive ability to interpret the information on signs? Is the number of safety signs adequate for their areas of influence? Is there an excessive amount or is there just enough? Are these questions always answered?

The authors noted that the choice of safety sign location is often not an easy one for professionals such as architects and engineers. It was felt that a graphical tool that could be easily integrated with AutoCAD, a tool commonly used by design professionals could be helpful.

As a starting point to the research and development process the authors analysed the basic aspects of safety signalling such as sign sizes and perception distances. The main purpose of the tool is to aid the placement of graphical symbols on architectural plans. However, the tool also allows for analysis of their areas of influence and the adaptation of those areas to different places in the building. Orientation of signs is also important. The tool takes pathways into account which reduces errors in sign orientation, especially where arrows are included.

This paper describes tool development with particular focus on development stages and difficulties.

1 Introduction

The positioning of safety signs in construction plans should take several issues into account such as standards, legal issues, spatial dimensions, visual obstacles and limited perception, among others. As a result of this, the signing project phase can be very complex in some cases. Previous literature describes a variety of options, from the use of location optimization algorithms [1] to the special considerations to take with people with disabilities to read and locate exit signs [2].

As the design and positioning of safety signs is pertinent at the design stage, computer-aided design (CAD) is typically used to generate, view and modify plans, especially by engineers and architects. A tool in this format to simplify the signalling process could be considered very useful. This paper highlights different possibilities to develop the process of signalling plans of buildings, especially when they have significant dimensions or complexity. The considered possibilities are compared in order to optimize the process of placing the required signs, modifying their locations or physical features (size and shape) and testing different combinations both easily and quickly.

Several different examples will be shown including sign placement software developed by the authors. The software tool was intended to simplify the signalling process but always taking into account the need to cover the safety requirements when we deal with safety

aspects. In this sense, both the European Council Directive 92/58/EED [3] and the Spanish Royal Decree 485/1997 [4] were taken into account, as well as standards, such as the American National standard Z535 series [5], UNE 1115:1985 [6], UNE 23034:1988 [7] and other technical documents [8-9] that were also consulted during the early stages of this project development.

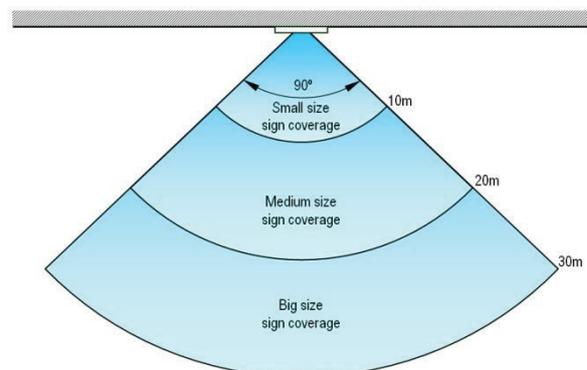


Fig. 1 Areas ideally covered by the three different sizes of flat signs.

An important requirement in the field of safety signalling is to be able to check if the placed signs are sufficient to cover a required area. There is a need to consider the size and physical shape of each sign, for

example larger signs are easier to view over larger distances. In general, there are three different sign sizes which have viewing distances up to 10 m, 20 m and 30 m as shown in fig. 1.



Fig. 2 A panoramic sign.

Moreover, each size can be composed of different physical shapes: flat signs (fig. 1), perpendicular to the wall (fig. 3) and panoramic signs (figs. 2 and 4). Each of these shapes can be perceived within a different angle, defining the ideal covered area of signs. Thus, combining size and shape, it is possible to obtain several different line of sight areas in which the sign can be correctly viewed. However, do we always match the sign to task?

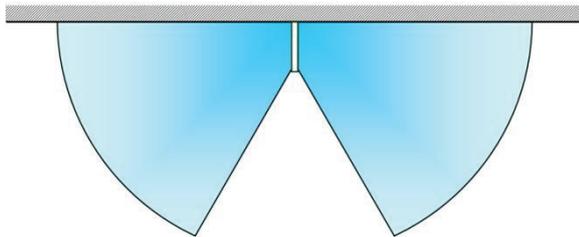


Fig. 3 A wall-perpendicular sign and its ideal covered area.

Visual obstacles, like columns or walls, must be taken into account as they may obscure initial line of sight. This is why we consider tracing rays within the covered area as the best option to indicate actual line of sight areas, as shown in fig. 5.

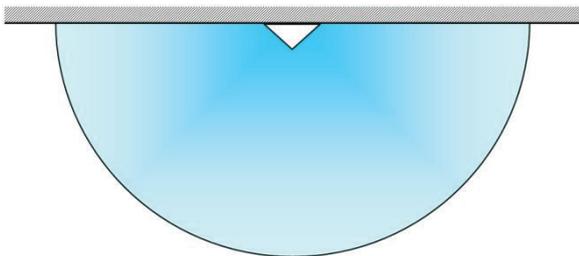


Fig. 4 A panoramic sign and its ideal covered area.

These rays are simple lines starting at a common point (centre of a sign) and with the same length: 10, 20 or 30 metres, depending on the sign size. The clear advantage of this technique is the possibility of taking into account all the intersections of these rays with visual obstacles to cut them, obtaining a real covered area representation.

In 2007, Spanish company Implaser (www.implaser.es) contacted the Spanish researchers with the idea of developing an innovative tool for signage layout and design. The company had several basic

requirements. The first requirement was to use their standard symbols, as well as their internal codification and to develop a tool to be used in an AutoCAD® (www.autodesk.com) environment as they considered that it was the most commonly used CAD package by their customers. After a period of research and development a CAD-based tool, ImplacAD®, was released in February 2008.

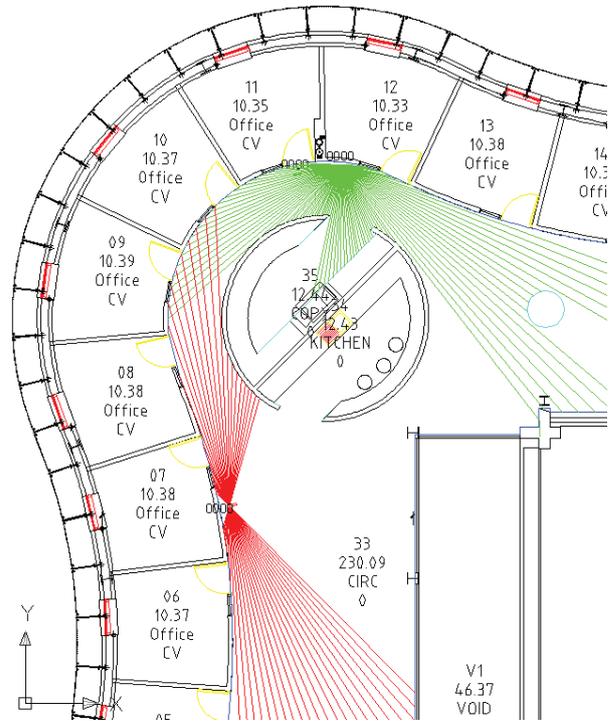


Fig. 5 Real covered areas, defined by rays, of two signs (one panoramic and one wall-perpendicular) in a plan.

However, after two years the possibility of using the tool in a project outside of Spain was considered in order to develop its international potential. It was proposed that the tool be used in a major construction project in Birmingham, United Kingdom. For use in this project the tool required major changes, such as taking into account British Standards [10], new types of signage (not only for safety purposes) and wayfinding design. The noted requirements were researched and reviewed. After careful consideration, it was concluded that a new tool should be developed. This new tool was based on a new working philosophy and an engine in development since 2002 that has been used to generate several applications.

It was decided that the final tool should be tested in a more complex environment so as to explore its full potential. The research team at the University of Zaragoza (Spain) has established a working relationship with researchers at Loughborough University (UK). This new working relationship makes it possible to test the software in complex projects, under different legal requirements and standard frameworks.

2 Previous methods: manual insertion vs. ImplacAD®

When developing a safety signalling process with the help of AutoCAD®, we can assume that the insertion of blocks is going to be applied. This can be done manually,

by inserting pre-drawn blocks with the sign symbols, or by using a tool like ImplacAD®, which simplifies the process. This software tool comes with a collection of blocks for signalling and makes it easier to graphically check if the placed signs are sufficient for a designated area. Both of these possibilities are compared.

2.1 Insertion of signs

When placing safety signs manually, we should consider the use of block libraries. Their use and possible applications have been widely described in previous literature [11]. For this reason it is assumed that some kind of library is always going to be used. Following this process, blocks can be imported from one of the libraries, which can be commercial and/or created by users. Of course, another possibility is to use a plug-in like ImplacAD®, where the library is a part of the tool. Another advantage is that the blocks used in this tool to represent safety signs can show the covered area, attending to the physical features of each sign (size and shape, as previously explained). Fig. 6 compares both processes: manual and ImplacAD® supported and shows how the second one makes the insertion both easier and faster.

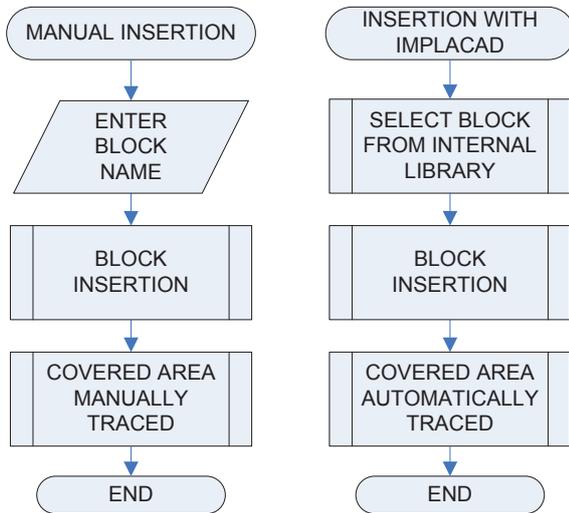


Fig. 6 Sign insertion process: Manual vs. ImplacAD®.

As we can observe, in the case of manual insertion, libraries can be more or less organized, depending on several aspects, like experience of the user or time that the library has been being used, as it could have been improved along that time. In the case of using a tool, it would be assumed that its developers have already thought about these questions, so it will follow some kind of logical criteria to order the blocks. For example, in ImplacAD®, signs were created and classified attending to their sizes, shapes, etc, and they have a logical code to be easily identified.

The scheme in fig. 6 shows how, in the case of the manual process, the ideal covered area must be calculated and traced.

2.2 Block insertion

The block insertion process can be considered a subroutine within the insertion process and, as previously explained, it can also be done manually or using a

software tool. In both cases, it will follow the same scheme:

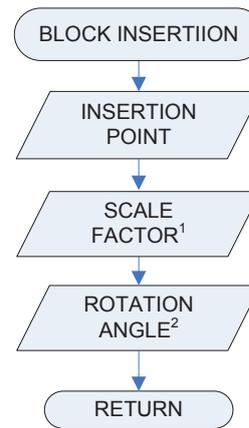


Fig. 7 Block insertion process: Manual vs. ImplacAD®.

The insertion point should be defined according to the same criteria in all signs, to facilitate the insertion process.

The scale factor (see 1 in fig. 7) refers to the scale of the block and must be coherent with the plan scale. As this could be a critical aspect in many cases and errors can easily appear, both manually and using ImplacAD®.

The rotation angle (see fig. 7) must be adjusted to the particular geometry of a plan, not forgetting problems with the User Coordinate System (UCS).

2.3 Covered area

This aspect is very different when using the tool than when the covered area is manually traced. This area, composed by a series of rays (each ray is traced using a simple line) is automatically inserted by the tool, but when we insert signs manually the process is not so immediate. As fig. 8 highlights, this process implies to start drawing the first line to delimit the area in which the safety sign can be correctly viewed. Its length, always considering the global scale used in the plan, depends on the sign size. With the first line, a series of similar lines must be traced making an array and so defining the ideal covered area (see fig. 5). The angle of this area depends, as shown in previous figures, on the physical shape of the sign. An important consideration to take into account is that the angle of this covered area must be adapted to the rotation angle of the sign block.

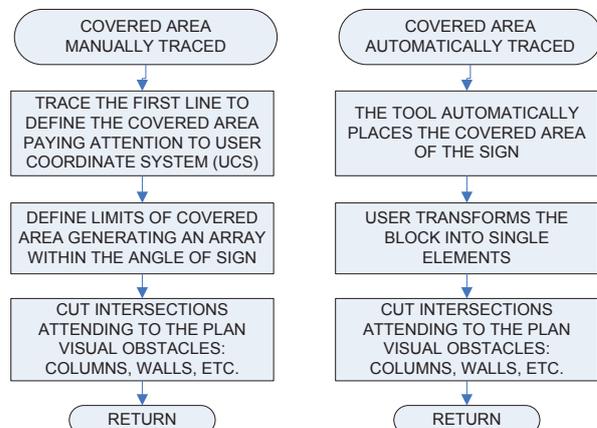


Fig. 8. Editing process: Manual vs. ImplacAD®.

The previous process is automatically done when using ImplacAD®. Then, in both cases, the user must cut the

lines taking into account their intersection with visual obstacles, like columns or walls.

2.4 Editing

After inserting signs, editing is considered necessary in many situations. This process is shown in fig. 9, comparing manual and ImplacAD® editing processes.

Both processes start erasing the sign to edit (but not the rays that define the covered area). After this, we insert the new block as previously described (see section 2.2). Then, two situations may occur. If the covered area is already correct, we have finished in case of manual insertion. In case of using ImplacAD®, we just need to erase the covered area of the recently inserted block. In the other case, when the covered area is not acceptable, we must erase and retrace it, if we are manually operating, or accept the new one, automatically inserted by ImplacAD®.

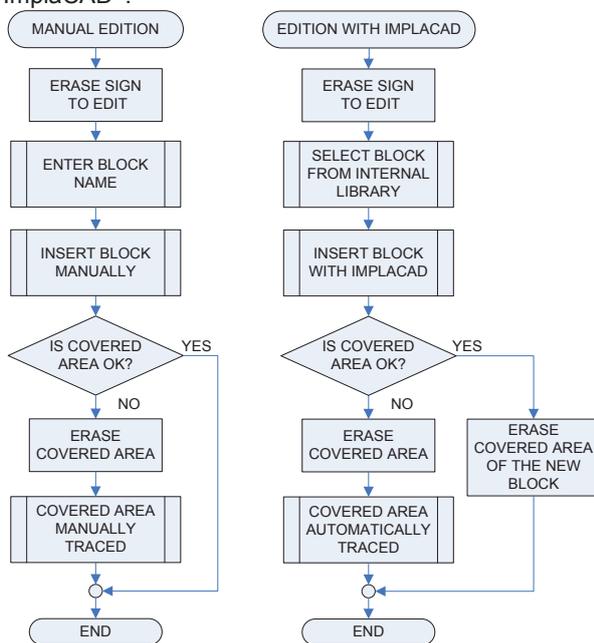


Fig 9 Covered area: Manual vs. ImplacAD®.

2.5 Move and rotate

Finally, the process of moving or rotating the sign is considered. This process always starts by moving and/or rotating the block and the covered area, as fig. 10 shows. In a second stage, the covered area must be adapted considering the new position of the sign in the plan; that is, new visual obstacles can affect the perception of the sign and, in some cases, old ones will not affect it at all or just partially.

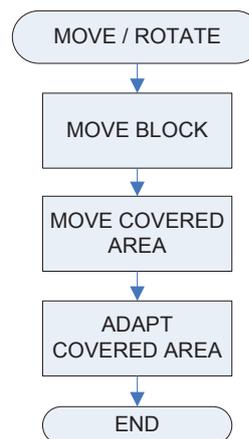


Fig. 10 Relocation and rotation: manual vs. ImplacAD®.

To move the covered area, all the individual lines must be pre-selected and the adaption will now be based on two commands: trim and extend. This adaption can be very complex in some cases and it makes the whole design process slower.

3 Innovative method: SignCirCAD®

In the previous section we have compared two signalling methods and seen that using a CAD specific tool has clear advantages. However, the design and implementation process also highlighted some gaps in ImplacAD®'s applicability and for this reason it was decided that a new tool based on an innovative working method should be developed. This new tool is called SignCirCAD® and its approach is described below.

3.1 Preparation of the drawing file

When a new drawing is started, the plan scale must be correctly set so that it is considered during the whole process. This information is automatically saved in the file, it is only required once and will help avoid dimensional mistakes.

This working method requires defining the limits of the surfaces to be signed at the beginning in order to save time later. This definition is based on tracing a polyline delimiting every surface and it can be done manually or automatically, when the drawing geometry makes it possible. When the surface limits are known, their intersection points with the rays that define the covered area can be obtained and they can be automatically trimmed. A significant feature of this tool makes it possible to generate listings of the inserted safety signs and, as we started defining the different surfaces within a plan, those listings can classify the signs depending on the surfaces in which they are. Surfaces can contain obstacles such as islands representing columns, panels, for example. They are selected by users so that ray intersections can be defined easily and quickly with visual obstacles. Another application of this new procedure is the possibility to obtain valuable dimensional data about surfaces and areas that signs are covering, so their quantity can be optimized from different points of view, such as geometric or economic.

As the defined surfaces have exits and to know their position is a key to correctly define pathways, the new tool makes possible to associate exits to their respective signs. This innovative feature makes it possible to calculate distances between inserted safety signs and

exits, which especially interesting with emergency evacuation signage. That is how the new tool can easily highlight the closest exit, being able to adapt the direction of the arrow that some signs contain, avoiding dangerous errors.

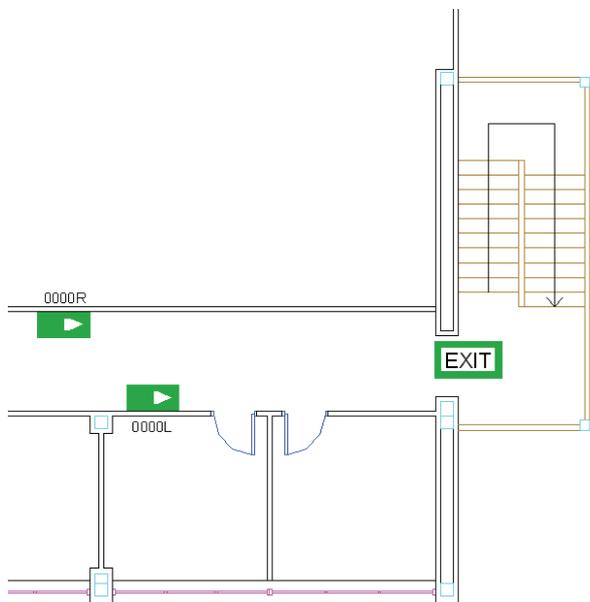


Fig. 11 Arrow directions signalling the closest exit.

3.2 Block definition

In the definition of sign blocks, there are important changes that may help in several aspects. One of these changes is that now the sign symbol and the group of rays used to define the covered area are together, in the same block, making the edition process easier than before (as we can compare with section 2.4).

With previous methods, to make changes in one of these parts, i.e. sign or rays, did not affect to the other one. In this sense, the new tool had an internal problem: it was possible to find same signs with different 'global shapes'. This occurred because rays were automatically adapted, so the definitive shape of every sign could be very different from the original one (with an ideal covered area).

A solution was obtained by giving a different name to every single block in a plan. To do so, every block has information about the kind of safety sign that it contains by means of an attribute that makes it recognizable and unique.

The new working method made it necessary to add information to blocks, as we have started to describe. With the previous procedures, the block name let the tool to identify it, while users could recognize it viewing its geometrical shape. Now, to recognize the signs, features like shape or colour are complemented with an associate code.

Adding the necessary information to define the safety sign block, it is possible to improve the edition process without needing user involvement. The tool regenerates the edited blocks, taking out information from the original one, and adding changes according to the user's modifications.

The tool automatically saves the following data:

- CODE. Commercial or internal code (it can be customized if necessary) that makes possible to

identify a sign block. If this code ends with L or R, it means that the arrow of the sign point to Left or Right direction. That code-ending draws the arrow in the correct direction and lets the software recognize it and even change its direction taking into account where the closest emergency-exit is, as shown in fig. 11.

- TYPE. Signs can be included in one of the following groups: flat, wall-perpendicular or panoramic. It defines the physical shape of a sign and thus, as explained previously, the covered area of the sign (covered angle and direction of rays).
- SIZE. This depends on the size of a sign inserted in a plan and takes into account the global scale of the drawing. The length of rays directly depends on this size to define the covered area.
- ATTENUATION. This contains a proportional factor to be applied to the length of the rays in order to represent different visibility conditions, e.g. smoke presence, disabled person's perception or darkness.
- Other information about graphical representation, such as colour or density of rays.

3.3 Sign insertion

The insertion process under the new perspective can be considered substantially improved when we compare it to previous methods as follows.

- 1) **Block selection.** One of the first differences that a user perceives when using the new tool is that it is not necessary to select a block from a library. Instead, this block is created from a collection of parameters, e.g. colour or dimensions. This parameter selection is made in the 'Sign insertion' window (see fig. 11).

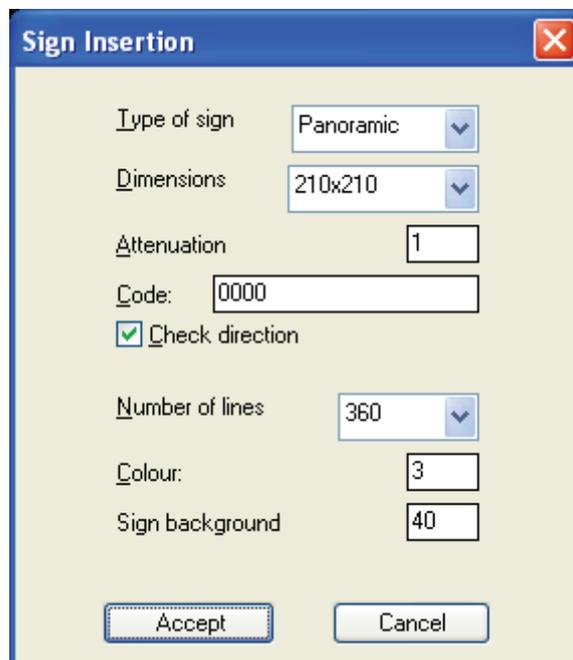


Fig. 12 'Sign insertion' window.

- 2) **Insertion point:** When the user clicks on the sign location, the tool checks several aspects. The surface in which the sign has been placed is identified, so limits to look for intersections with coverage-rays can be found. The tool also checks if the block was inserted at a wall, which is very common, and if so the wall angle is automatically calculated as it is possible

to obtain the correct rotation angle to assign to the sign block.

- 3) **Block scale factor:** This scale is established by the tool taking into account the global drawing scale, which was defined in the beginning of this process, as explained in section 3.1.
- 4) **Rotation angle:** This can be calculated automatically if the sign is placed at a wall (the tool detects it) and, if not, the user is asked for its value, which is manually set.
- 5) **Tracing rays to define covered area:** As the rotation angle of the block is known, the necessary calculations can be done using the tool. Rays are automatically traced and trimmed, saving significant editing time. To do so, the tool looks for all the intersections between rays and surface limits, including the defined islands.
- 6) **Single block definition:** When the block has been inserted and completely adapted, all the parts are grouped defining a single block per sign.

4 Conclusions

- 1) The new tool automates signage design which saves time when testing signage combinations. This in turn has economic benefits.
- 2) The sign block orientation is automatically obtained by the tool because it calculates the tangent and perpendicular directions to the insertion wall. This is especially interesting when inserting or moving signs in complex surfaces, such as curves, where task completion time is highly reduced.
- 3) Parametric blocks are used as a basis for the tool and, as a result, the editing process has been made easier. Moreover, the tool memory size is also reduced from almost 1GB to around 1MB which makes library maintenance unnecessary.
- 4) The fading parameter makes it possible to consider several scenarios in just one drawing file. By simply changing the value of this parameter and selecting all the signs within the drawing, the ray lengths are automatically modified, so that all the covered areas are updated.
- 5) The most important feature of the presented tool is that it can help engineers and architects to avoid serious errors at the design stage, thus avoiding rework leading to economic losses.

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