Bachelor Assignment Industrial Design Engineering

Urban Communication Pavilion

The design of a multifunctional interactive object to introduce the smart city paradigm in public space

Hanke Nijman

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ENEA

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Hanke Nijman
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Executed at:
ENEA – Italian Agency for New Technologies, Energy and Sustainable Economic Development
Via anguillarese 301
00123 S.M. Galleria (Roma)
Italy

University of Twente.
Bachelor Program Industrial Design Engineering
Postbus 217
7500AE Enschede
The Netherlands

Examination committee:
A. H. M. E. Reinders
M. Annunziato
A. O. Eger

English Summary

Within this assignment a multifunctional interactive object is designed to introduce Italians in public space to 'smart cities'. In context of this project, smart cities are defined as cities in which quality of life and a sustainable environment are enhanced by connection and communication between different urban networks and smart products and services.
Current developments in smart cities focus mainly on the theoretical and technical field. The main goal of the design of this assignment is to focus on citizens, and to introduce them to the smart city paradigm.

To create guidelines for the design, several analyses are made on the field of smart cities, possible functions and interactions, the target group and public space in Italy. Using these analyses, a program of requirements is defined.

Through different concepts, the final design is chosen. The urban communication pavilion is a on its own functioning interactive pavilion, where users can share media like text, images and music through touch screens, a ticker and sound boxes. The urban communication pavilion is part of a network of similar objects and next to that, it can be reached by social networks on the internet and agents who can add information on a specific field.

Within this assignment, the main concept of the urban communication pavilion and the design of the object itself are defined. For further development of the urban communication pavilion, firstly, the interaction design of the object should be designed. Then the technical design of the urban communication pavilion needs to be fixed before a prototype can be produced.

Dutch Summary

Binnen deze bacheloropdracht is een multifunctioneel interactief object ontworpen, om Italianen in de openbare ruimte kennis te laten maken met ‘smart cities’. In de context van dit project zijn smart cities gedefinieerd als steden waarin de levenskwaliteit en een duurzame omgeving bevorderd worden door verbindingen en communicatie tussen verschillende stedelijke netwerken en ‘smart’ producten en diensten. Huidige ontwikkelingen in ‘smart cities’ richten zich voornamelijk op theoretisch en technisch vlak. Het belangrijkste doel van het ontwerp van deze opdracht is om juist inwoners van steden kennis te laten maken met het fenomeen ‘smart cities’.

Om tot richtlijnen voor een ontwerp te komen zijn verschillende analyses gedaan op het gebied van smart cities, mogelijke functies en interacties, de doelgroep en publieke ruimte in Italië. Aan de hand van deze analyses is een programma van eisen opgesteld.

Via verschillende concepten is het uiteindelijke ontwerp vastgelegd. Het ‘Urban Communication Pavilion’ is een zelfstandig functionerende interactieve kiosk waar gebruikers media als tekst, geluid en afbeeldingen kunnen delen en bekijken via touch screens, een lichtkrant en geluidboxen. Het ‘Urban communication pavilion’ is onderdeel van een netwerk van gelijksoortige objecten en kan daarnaast bereikt worden via sociale netwerken op internet en door ‘agents’ die specifieke informatie kunnen toevoegen.

Binnen deze opdracht is het algemene concept van het ‘Urban communication pavilion’bedacht en is het ontwerp van het object an sich vastgelegd. Voor verdere ontwikkeling van het ‘Urban communication pavilion’ zal allereerst het interaction design gedefinieerd moeten worden. Vervolgens dient het ‘Urban communication pavilion’ verder gedetailleerd technisch uitgewerkt te worden, alvorens een eerste prototype geproduceerd kan worden.

Preface

Before you lays the report of my bachelor assignment executed at ENEA – Italian Agency for New Technologies, Energy and Sustainable Economic Development. This report describes the process and results of the project I worked on to complete my Bachelor Industrial Design Engineering.

Thanks to ENEA, I got the opportunity to work on a design assignment in Italy to contribute to the development of the smart city, an uprising paradigm in urbanism. With my interest in urbanism, innovation and living abroad this assignment was the perfect opportunity for me.

I would like to thank my tutor at ENEA, Mauro Annunziato for his enthusiasm, complicity and creative input that stimulated me to look to the project with different point of views.
To Giuseppina Giuliani and Fabio Moreti, thanks for creating a positive working environment and their helping hand to make me feel comfortable at the office.

Claudia Meloni was helpful with her architectural view on the design. I would like to thank her for that and her complicity and the open conversations we had.
I would like to thank Angèle Reinders for her tutoring in the process and her academic input from Twente University.

At last, thanks to my friends in Italy for the good time I had there, and my friends and family in the Netherlands for their complicity during my stay in Italy.

I enjoyed working on this bachelor assignment and the experience of working full-time and living abroad and especially the objective of this assignment have made me wiser and given me more insight in my future plans.

I hope you enjoy reading my report,

Hanke Nijman

Table of Contents

1. Introduction

The theory of smart cities is a new development in urbanism and spatial planning, in context of this project, smart cities are defined as cities in which quality of life and a sustainable environment are enhanced by connection and communication between different urban networks and smart products and services.

Within ENEA, the Italian Agency for New Technologies, Energy and Sustainable Economic Development a team works on a 'smart cities and eco-industry' project, to further develop the smart city paradigm. At the moment, their contributions to smart cities focuses mainly on the theoretical and technical field. Therefore, this assignment focuses on citizens and users.

The objective of this project is to design a multifunctional interactive object to introduce Italians to smart cities in public space. Within this assignment, the focus lies on the definition of the main concept and its functioning and the design of the body of the object.

For the definition of the main concept, first the main idea of the product is defined in consultation with the 'smart cities and eco-industry' team at ENEA, which is shown in chapter 2. In chapter 3, the different analyses made on the fields of smart cities, possible functions and interactions, the target group and public space in Italy are described, concluded in the program of requirements.

Chapter 4 starts with the description of the main concept, after which the development of the final concept is described. This body design of the chosen concept –The Urban communication Pavilion – is further developed in chapter 5.

The urban communication pavilion is evaluated by looking back at the program of requirements in chapter 6. The final design and the results of the evaluation lead to the conclusions and recommendations for ENEA for further development of the urban communication pavilion in chapter 7. At last, the bibliography is given in chapter 8.

2. The main idea of the Urban Communication Pavilion in Smart cities

The objective of this project is to design a multifunctional interactive object to be placed in public space and contributes to the smart city. Below the goals of the project and the main concept are described.

2.1. Goals of the project

The main goal of the smart city concept is to improve quality of life of people on different aspects. The goals set for this project by ENEA 'smart city and eco-industry' team are as follows:

1. Let Italian people and society experience some aspects of the smart city paradigm
2. Show the possibilities of interaction with urban space at different levels.
3. Give a contribution to the cohesion of the social community, to stimulate the contact between people and develop awareness of their everyday environment.

2.2. Description of the main concept

With PLC technologies, it's possible to sent data through power lines (Adams *et al.*, 1988). The connection by power lines between light poles creates an existing urban network to sent data, which can contribute to the smart city.

To improve the quality of life in open public spaces in the city, a system of multifunctional interactive objects will be designed. The main goals of this project are stated above. The different objects will interact not only with people, but also with each other through the use of for example PLC technologies.

Each object (a node in the system) will be placed in an open public space in different cities throughout Italy, and attract the people over there. Because cities and public spaces within cities always differ from each other, the design and detailed function of each node can differ. Therefore, it's possible that objects can differ in target group and functioning.

For this bachelor assignment, the main concept is developed. After which the object that will fulfill these functions is designed.

2.3. Basic requirements

The requirements below are stated by the ENEA project team 'smart cities and eco-industry'. These are including in the Program of requirements on page 33.

- Connect to a network
- Function on its own
- Attract people
- Be sustainable
    - Sustainable energy use: close to zero net energy use throughout the year
    - Use of sustainable materials
    - Teach people about sustainability and/or the environment

3. Analyses phase

In this chapter, the analyzing phase of the project is described. The analyzing phase concludes with the program of requirements and wishes, which gives the requirements and wishes for the to be designed object.
In this chapter the analysis of smart cities, the market and other similar objects, functions, the target groups, interactions and location are described. In appendix 4 on page xii an analysis of possible technologies and theories is given.

3.1. Analysis of the term 'smart cities'

A current development in urbanism is the 'smart city', where the city will be developed in a 'smart' way to improve quality of life of people. Hollands (2008) states that we know surprisingly little about so-called smart cities, particularly in terms of what the label ideologically reveals as well hides. The main goal of this chapter is to give some background information of the interpretation of the term smart cities in literature and give the definition which will be used in the context of this project. This definition is defined by the ENEA 'smart cities and eco-industry' team, and can be found at the end of this chapter.

3.1.1. Smart cities in literature

The main problem with the definition of 'smart cities' is that cities can proclaim themselves as 'smart', which according to Hollands (2008) happens a lot because of it's promotional benefits. In this paragraph the different aspects and characteristics seen in definitions of smart cities will be explained, to give an overview of the variety in interpretations of the term smart cities.

Giffinger *et al.* (2007) have defined six characteristics of a smart city. These characteristics summarize the different aspects that are connected to smart cities in literature, but most studies and projects only focus on some of these aspects (see Market analysis on page 13). Studies to the definition and ideology of the smart city agree on the fact that these different aspects all should be taken into account in the ideal smart city (Weening, 2006; Caragliu *et al.*, 2009), but these studies don't focus on the implementation of smart cities in the near future.
The six characteristics defined by Giffinger *et al.* (2007) are smart economy, smart people, smart living, smart governance, smart mobility and smart environment. Each characteristic is defined by a number of factors, which are shown in Figure 1. All characteristics contribute to the main goal of the smart city – Improving quality of life – at the moment or in the future.

Where intelligent or digital cities focus on ICT infrastructure and the use of it within the city (Komninos, 2002), the smart city is distinguished by taking more aspects of the city into account (Hollands, 2008; Weening, 2006), these different aspects can be summarized by the six characteristics. Within the smart city, the relationship between ICT and the city is a main focus, the view on the form of this relation and the use of ICT widely varies (Weening, 2006).

Although there are a lot of positive effects expected of the implementation of smart cities, critisism also exist. Weening (2006) states that smart city projects with a perspective focussed on the future tend to have an optimistic view on the impact of the implementation of ICT technologies on the city.

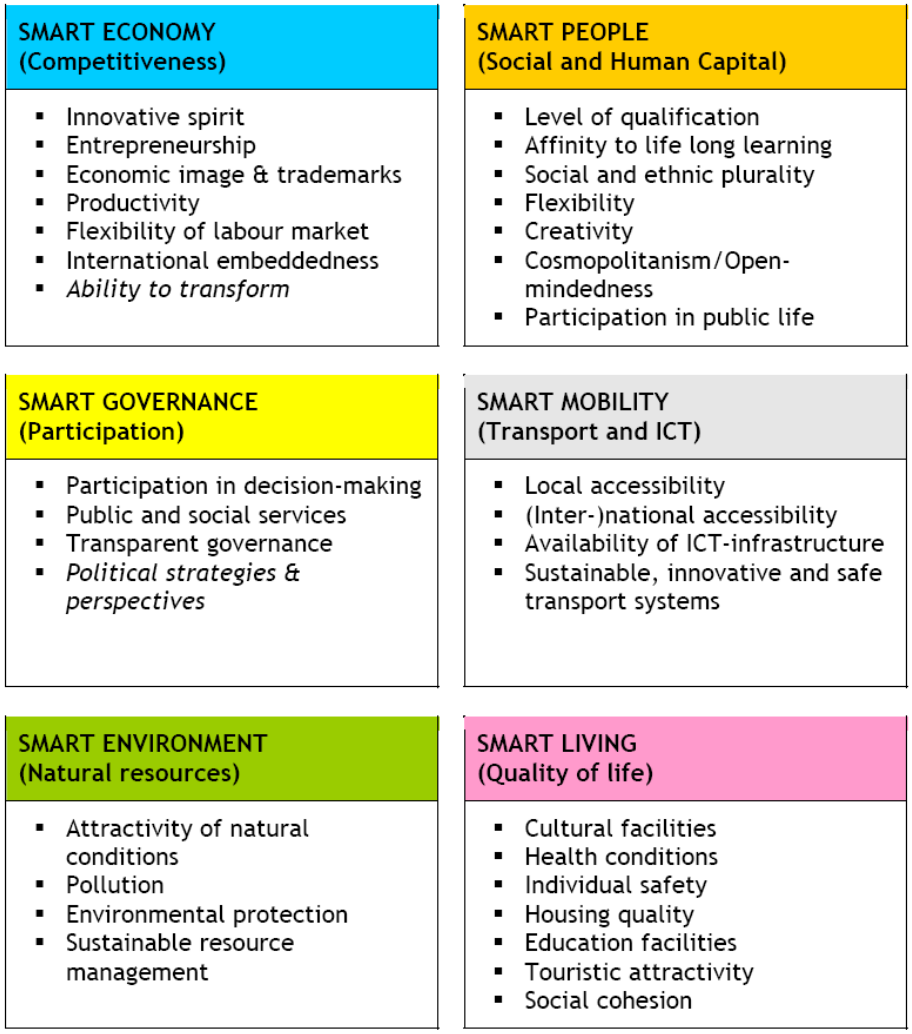

Figure 1: Characteristics of the smart city

According to that, the influence of smart city development might be overestimated. Hollands (2008) discusses the definition of smart cities and speculates on some general principles which would make them more progressive and inclusive. In his article, Hollands defines several risks of the current development of smart cities, including the polarization of the city on different aspects "by the growing contrast between incoming knowledge and creative workers, and the unskilled and IT illiterate section of the local poorer population" (Hollands, 2008, p. 312). Hollands concludes that cities should include all citizens and different stakeholders in developing a real smart city.

Although the exact definitions of smart cities vary and there are some critics on the implementation of the smart city, there are no objections found in literature to the development of the concept of smart cities. Literature studies and current projects dedicated to the smart city focus on different aspects of the smart city, which can be summarized by the characters of the smart city defined by (Giffinger *et al.*, 2007). The main goal of the smart city is to improve quality of life at the moment or in the future. This goal should be achieved on all different aspects of the smart city.

3.1.2. Definition of smart cities in the context of this project

The definition of smart cities used in the context of this project is defined in consultation with the 'smart cities and eco-industries' team of ENEA and is given below, with the corresponding characteristics:

Smart cities are cities in which quality of life[1] and a sustainable environment[2] are enhanced by connection and communication[3] between different urban networks and smart products and services[4].

Smart products and services are defined by an integration of functions and the possibility to connect to other smart products, smart services and urban networks by the use of ICT technology. With the use of smart products and services, the possibilities of products and functions are increased.

[1] Smart living
[2] Smart environment
[3] Smart mobility
[4] Smart people, smart economy and/or smart governance

3.2. Market analysis

The smart city is an uprising development in urbanism. Although the idea of the smart city is widely known, in many places the implementation is limited to the use of already existing technologies in a wider space, like the use of a broad wireless mesh at a historic wall in Londonderry for touristic information (Wireless walls, n.d.) or measuring the movement of traffic and pedestrians through the cell phone network in Rome (Calabrese *et al.*, 2007). Next to that, the development of the smart city is expressed by single smart objects, or a combination of those, as in the digital mile of Zaragoza (Zaragoza Milla Digital, n.d.).

In Figure 2, an impression of different smart products in public space is given. After that, each product is shortly described. These products are analyzed on target groups, functions, used technologies and characteristics. Most of this information is used in other analyses.

Figure 2: Collage Smart Products in public space

For the market analysis, only objects that contribute to the smart city in public space are analyzed.

3.2.1.1.Zaragoza Digital Bus Stop (Figure 3)

The Adaptable Bus Stop is designed for the Expo 2008 Zaragoza. The adaptable bus stop incorporates several types of digital technologies in order to offer new services to the public, to allow for cost-effective manufacturing, and to enable the generation of advertising revenue.

Figure 3: Zaragoza Digital Bus Stop

A parametric design model determines a unique design for each stop providing optimal sheltering at minimal cost. Bus passengers can plan their trip on an interactive map, exchange community relevant information on a digital message board, surf the web, and use the media on the bus shelter as an interface to their mobile devices (SENSEeable City Lab, 2006).

A design with similar functions as the Zaragoza Digital Bus Stop is the Eyestop, designed for the province of Florence (SENSEable City Lab, 2009).

3.2.1.2.Digital Water Pavilion (Figure 4)

Also designed for the expo 2008 in Zaragoza, the digital water pavilion is a public information point. It's an interactive building, fluid and sensory. Instead of traditional walls, it features curtains made of 'digital water'. The digital water pavilion combines the natural look of water with several digital technologies (Pr & Media Relations Professional, 2008).

Figure 4: Digital Water Pavilion

3.2.1.3.The cloud (Figure 5 and Figure 6)

The cloud is a landmark structure to accommodate the Olympic Games in London 2012. The lightweight transparent tower, composed of a "cloud" of inflatable, light-emitting spheres, would create a spatial, three-dimensional display in the skies of London, fed by real time information from all over the world.

Figure 5: The cloud

Within the cloud, energy will be harvested by solar energy and the potential energy of people who will ascend and descend the cloud. This energy should be sufficient for the energy needs of the cloud (Richards, 2010).

3.2.1.4.Philips Sustainable City Light (Figure 7 and Figure 8)

With the sustainable city light, Philips tries to transform the personality of any community from industrial to ecological, harmonizing forces of nature and working with the planet, not against it. It collects its own energy from sun and wind by transforming its appearance throughout the day. At night, its LEDs beam light only where needed - and only when needed - through proximity sensing.

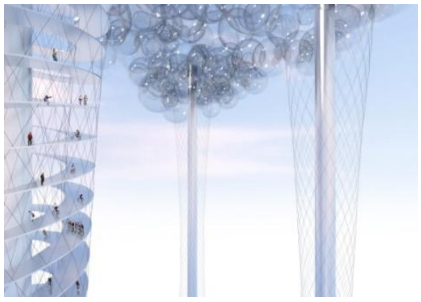

Figure 6: The cloud

It not only provides green lighting, but can actually supply power back to the grid when it overproduces electricity, making it a light pole that generates rather than consumes power (Koninklijke Philips Electronics N.V., 2008).

Figure 7: Philips sustainable city light

Figure 8: Philips sustainable city light

3.2.1.5.Flyfire (Figure 9)

The flyfire is a free form display that can produce images in the air, to be seen from public places. The images are created by small remote controlled helicopters with a multi color LED light, that can fly through the air. This way, a free form display in three dimensional space can be created (SENSEable City Lab, 2010)**.**

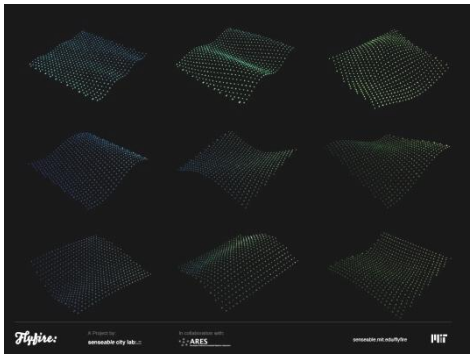

Figure 9: Flyfire

3.2.1.6.Memory paving (Figure 10)

To make people consider the physical impact of their daily lives on the city and to show them the pedestrian paths and busy pedestrian places, Memory paving is created for Zaragoza Digital Mile. Every time a footstep falls on a paver, the intensity of light of this paver increases. This way, common and uncommon paths of pedestrians will be showed, and people can change their paths accordingly. (Frenchman & Mitchell, 2006, pp. 66-67).

Figure 10: Memory Paving

3.2.1.7.The Copenhagen Wheel (Figure 11)

A more private product, but commonly used in public space is the Copenhagen Wheel. This bike stores the energy which is generated while cycling or braking, and makes it available if you need an extra boost. It can be controlled by iPhone, which gives the user directions and up to date travel information. Next to that the Copenhagen wheel gives information about the air quality.

At last, there are plans to make it possible to connect the bike to the energy net, so it can be a supplier of energy. (SENSEable City Lab, 2009)

Figure 11The Copenhagen Wheel

3.2.1.8. Live Singapore

The project “Singapore LIVE!” doesn’t include a product like the projects above, but exist of a big service network. At the moment the SENSEable City Lab is working on an open platform, with the goal to make all information about the city up-to-date and accessible to the people. The information will be gathered by the actions of people themselves,

automatic as well as manual. In the future it's not only possible to get information about traffic, but also about closing times or the stock of shops. (SENSEable City Lab, 2010)

3.2.2. Analysis of the different objects

To analyze the different products, the target groups, functions, used technologies and the aspect of the smart city to which they contribute of the products are listed. This information can be found in the table on the next page.

The information about target groups, functions and used technologies is used in the corresponding analysis of the project. Next to that, the goals of the products are analyzed. Every product adds to the main goal of the smart city – Improving quality of life – in some aspect. Therefore the products are categorized by the characteristics defined by (Giffinger, Kraman, Fertner, Kalasek, Pichler-Milanovic, & Meijers, 2007), which can be found in the Analysis of the term 'smart cities' on page 10.

Product	Target group	Functions	Used technologies*	Characters
Zaragoza digital bus stop	bus passengers	- Create entertainment - Stimulate communication Indirect between people From government to people - Give information - Supply connectivity - Monitor busses - Create shade - Stimulate participation in public life	- interface with mobile devices: Wi-Fi Mesh, Bluetooth, SMS, e-mail - interactive touch screen - GPS tracking - adaptable design depending on location	- Smart People - Smart governance - Smart mobility - Smart living
Digital water pavilion	visitors of event (milla digital)	- give information - attract people - gain attention for the milla digital - create entertainment - transform of form	- digitally operated electromagnetic valves - Leaving an open system where technologies can be improved - camera operated control system hydraulic pistons to move the roof	- Smart living - Smart people
The cloud	visitors of event (Olympics)	- gain attention for the Olympics - give information - attract people - harvest energy - create indirect communication	- collection and re-use of rain - solar power - harvesting potential energy - spatial displays	- Smart people - Smart living - Smart environment
Sustainable city light	people passing by	- harvest energy - monitor movement of people - light according to movements	- solar and wind power - focused led lighting - environmental sensors	- Smart environment - Smart living
FlyFire	unknown	- create entertainment - give information - give education	- RGB-LED - micro helicopters	- Smart living - Smart people
memory paving	pedestrians	- monitor walking paths - light the walked paths	- touch sensors - led lighting	- Smart people - Smart living
Copenhagen wheel	cyclists	- harvest energy - monitor environment - give information - give power by harvested energy	- environmental sensors - harvesting of kinetic energy - connection to smart phones: Bluetooth	- Smart environment - Smart living - Smart mobility
live Singapore	Citizens	- give up-to-date information - harvest information - create communication	unknown	- smart living - smart mobility

*not mentioned within the technologies, but always used is software.

3.2.3. Analysis of the added values of the products

To give an overview of the contribution of existing projects to the smart city paradigm, the occurrence of the characteristics is listed in Table 1.

Character	Occurrence
Smart Living	8
Smart people	5
Smart environment	3
Smart mobility	3
Smart governance	1
Smart economy	0

Table 1: Occurrence of characteristics in Smart Products in Public Space

Within the occurrence of these characteristics, some stand out. Because the project focuses on the design of a smart object in a public space, similar projects are studied. All of these projects also have a main focus on the people in public spaces and enhancing their quality of life (smart living).

One of the characteristics of smart objects is that they integrate multiple functions. Therefore, most objects not only contribute to smart living, but also to other aspects like smart people, smart environment or smart mobility.

It's remarkable that the characteristics smart governance and smart economy almost don't occur. A reason for this might be the implementation of the product, which becomes more difficult with multiple stakeholders. Within the studied objects the most important stakeholders are the designers, producers, target group and purchasers (most of the time government). For contribution to smart economy or smart governance also the private sector (businesses) and government services should be taken into account.

For the characteristic smart people, most projects try to increase the participation in public life, enhance creativity and introduce people to the smart city (creating cosmopolitanism/open mindedness). Next to that, some of the studied projects try to make people aware of their impact on the environment (in example the cloud and memory paving).

3.2.4. Conclusions of the market analysis

It can be a challenge to include smart economy and smart government in the project. However, the main goals of this project are to introduce people to the smart city paradigm, show interaction possibilities and stimulate social cohesion, and not to develop all characteristics of the smart city.

Nevertheless it would be positive to develop the smart city on as much characteristics as possible within these main goals.

3.3. Functional analysis

To give an overview of the possible functions of the object, a functional analysis is made.

Possible functions	Specifications
Lighting	of the object
	of the square/park
stimulate relaxation	
bring people together	
increase the original functioning of the square	
give information about	Cultural heritage
	News
	Events
	Weather
	Mobility
	Accommodations
	Restaurants
give education on	Sustainability
	Science topics
	Town identity (ethnics, history)
	Art
	Communication
	smart cities
	physical health (sports, food)
	Mental health (wellness experience)
stimulate communication	between government and people
	between individuals
	between groups of society
	at the spot
	on long distances
Create a physical experience	by use of different sentences (hear, sight, smell, feel, taste
	by sports
stimulate playing	
stimulate creativity development	
stimulate social cohesion by	stimulation of communication (see stimulate communication)
	giving education about society (see give information)
create economic opportunities	advertising/commercials
	gaining information about needs of people
Monitor the environment	

The different functions are clustered in six possible aspects of the object. These aspects are social communication, information, comfort, physical activities, edutainment and monitoring.

Social communication includes all functions that contribute to social contacts between different people, while the communication from government to people is part of the Information aspect, as well as commercial information and giving information about different subjects. Also giving information for education is part of this aspect.
The Comfort aspect includes the relaxation function of the object, not only creating places to sit, but also creating a good atmosphere in the environment is part of this aspect.
The Physical aspect is about physical health and the physical experience. This includes for example sporting exercises, but also changing the state of the object by moving.
Education is partly based in the information aspect, but also in the edutainment aspect. Here the education created by entertainment is included. Next to that, also entertainment in general is part of this aspect.

These different aspects are used to give an overview of the added values for different target groups, in the target group analysis.

3.4. Target group

The main target groups of adults without children and young people are chosen from the determined possible target groups: young people (from 14-25); elderly people (65 years and older); adults without children; adults with children; tourists and the government. These different target groups are described by scenarios in appendix 1 on page i.

More information on the target groups and their use of public space is given in the analysis of the public in the location analysis on page 27.

3.4.1. Choice of target group

The choice of the target groups is based on the added value for the six determined target groups, the overlap in their use of the public space and the number of Italian people reached.

First, an overview of the added values for the different target groups is made. To do so, the members of the 'smart cities and eco-industry' team valued the added values of the aspects (stated in the Functional analysis on page 19) for the target groups. The main results can be found in the table below. The detailed results can be found in appendix 1 on page i.

Added values of the object per target group and aspect - Cumulative results									
	Size of target group	Percentage of population[1]	social communication	information	comfort	physical activities	edutainment	monitoring	total
Young people (14-25)	7.327.879[2]	12,2%	18	7	2	10	14	0	51
adults with children (0-14)	12.215.518 [3]	20,3%	7	6	11	6	17	0	47
adults without children (26-65)	33.393.856 [2, 4]	55,6%	12	9	13	13	6	0	53
tourists	43.200.000[5]	--	4	18	11	3	6	0	42
elderly people (65+)	11.457.143 [2]	19,1%	10	9	17	5	5	0	46
city government	--	--	1	8	0	0	1	18	28
Total			52	57	54	37	49	18	267

[1] Total population: 60.045.068 (ISTAT, 2009)

[2] (ISTAT, 2009)

[3] Estimated number of parents with young children

Calculation: ——————

Number of children: 8428708 (ISTAT, 2009); Number of children born per woman (Fertility rate): 1,38 (United Nations Department of Economic and Social Affairs, 2007)

[4] Including all people from 26-65.

[5] Number of international tourist arrivals in 2009 (World Tourism Organisation, 2010)

The chosen main target groups are 'young people' and 'adults without children', which have the highest score of total added value as can be seen in the table. On these target groups will be the main focus during the design. The choice of these target groups doesn't mean other target groups are excluded. If possible, aspects should be enhanced to reach other target groups. Next to the results of the added values, the choice of target groups is based on more aspects:

One of the goals of the project is to introduce Italian people and society to the smart city paradigm. Therefore the main target groups exit of Italian citizens, and no tourists.
The smart city is a new development and is expected to develop further in the future. To gain most of the above stated goal, it's important to introduce the young society to the smart city paradigm. Young people are an important target group, because they are the society of the future.

To introduce as much people as possible to the smart city paradigm, the size of the target group is important. The target group of young people would only be able to reach 12% of the Italian society. To create the widest possible target group, the combination of young people and parents without children can be made. In this way 67,8% of the society could be reached with the object.

The use of public space by young people and adults without children is quite similar as can be seen from the scenarios given in appendix 1, therefore the same functioning and design can reach both target groups.

3.4.2. Competences and restrictions

Each target group has different competences and restrictions. Below two important aspects regarding competences and restrictions – the use of modern technologies and language skills – are discussed for all target groups.

As stated above, it's important to try to reach as many people as possible. If possible, different aspects can be enhanced to create a larger public. Therefore the competences and restrictions include all target groups.

3.4.2.1. Use of modern technologies

In Italy, people are used to using cell phones. Nine years ago, in 2001, 93,5% of the people between 16 and 55 (part of the now chosen target groups) and 73,9% of all Italians used a cell phone (Callegaro & Poggio, 2004). Now, almost ten years later, these numbers have only grown. Italian people are used to using cell phones and being reachable. Also the use of the smart phone is in up rise, 31,99% of the Italian people use a smart phone in (Mussinelli, 2010). Although about one third of the Italians has experience with smart phones; it's assumed that a significant part of the Italian people isn't used to 'smart' intuitive products.
However, most people with experience on smart phones probably are part of the main target groups. However, in this target groups not everybody has experience with smart phones.

While the cell phone is commonly used in Italy, internet use is different. 51,7% of the population uses internet (data from august 2009) with a user growth of 127,5% in 10 years, compared to a 67,6% usage in the European Union with a user growth of 257,8% in 10 years. In the European Union, Italy is the 22nd country in internet use of 27 countries. In these statistics, the internet user is defined as someone who has access to an internet connection point and has basic knowledge to use the internet technology (Miniwatts Marketing Group, 2010). There are no statistics found about the internet use amongst the chosen target group. However it's assumed that this target group has above average access to the internet.

3.4.2.2.Language

In 2005, 29% of the Italians spoke well enough English to have a conversation. Thereafter spoke 14% French, and 6% another second language (Eurobarometer, 2006). It is expected that higher educated people (like students or professional workers) have better knowledge of English. To include Italian people as a target group while using a language as interaction, it's best to use Italian, if the target group exists of mostly students or professional workers, it's possible to use English. However, a barrier will still exist.

However, amongst tourists, English is a much wider spoken language than Italian. If the target group of tourists and Italians is combined, it's important to develop a communication that can be understood by both.

3.4.3. Functions regarding the chosen target group

To determine which aspects of the functioning of the project should at least be integrated in the design, and where the opportunities lay, the results of the added values of aspects for the different target groups are used. The table with the results can be found below.

Added values of the object per target group and aspect Cumulative results							
	social communication	**information**	**comfort**	**physical activities**	**edutainment**	**monitoring**	**total**
Young people (14-25)	18	7	2	10	14	0	51
adults with children (0-14)	7	6	11	6	17	0	47
adults without children (26-65)	12	9	13	13	6	0	53
tourists	4	18	11	3	6	0	42
elderly people (65+)	10	9	17	5	5	0	46
city government	1	8	0	0	1	18	28
Total	52	57	54	37	49	18	267

The highest possible score is 18 points.

To determine the main aspects of functioning, the added value for the chosen target groups and their sums is shown to the right.

	social communication	**information**	**comfort**	**physical activities**	**edutainment**	**monitoring**
Young people (14-25)	18	7	2	10	14	0
adults without children (26-65)	12	9	13	13	6	0
Total	30	16	15	23	20	0

3.4.3.1.Requirements

The aspect with the most added value for both groups is social communication. One of the requirements is to create a multifunctional object, this can be done by multifunctionality on the field of social communication, or to include other functional aspects. If other functional aspects will be included, edutainment and physical activities are the ones with next most added values.

3.4.3.2.Opportunities

The aspects of information and comfort have a close score. However, comfort adds pretty much value to adults without children, but is expected to add little value for young people. The scores of information are closer.

To give a clear view of the opportunities, all target groups should be taken into account, then the following aspects stand out:

- Edutainment for adults with children
- Information for tourists
- Comfort for elderly people
- Monitoring for the city government

All of these aspects for these target groups will be discussed with regard to the main target groups.

Edutainment for adults with children

To combine edutainment for adults with children; adults without children; and young people, the abilities of the different groups should be taken into account. A main concern is the high difference in physical and mental development. The target group differs from children with low locomotion abilities and only small language knowledge (and possibly no reading capacities) to the high educated and/or high locomotion skilled adults and students.

Another difference is the physical proportions of the target groups. Where young people and adults have similar physical proportions (Girls are grown to almost fully length at the age of 14, where boys are grown to almost fully length at 17 (World Health Organisation, 2007)). The physical proportions differ a lot from the physical proportions of children. Also interest in subjects of entertainment differ for different target groups.

To create an edutainment functioning that suits as well young people as adults with children and adults without children, it's important to create a design that is accessible for these different target groups (as well physical as psychological), but stays interesting for the different target groups.

Information for tourists

Information is interesting for different target groups, depending on which information is given. Italians could be interested in current events, news and up to date information about traffic or weather. Tourists could also be interested in this information, but have another specific need, about touristic information.

If an information service is combined for the main target groups and tourist, language knowledge can be a problem. Although there are ways to solve this problem (multi-linguistic information, a common intuitive way of communication, not based on language), the role of giving information to tourist is in

most touristic places already fulfilled by tourist offices. Therefore the added value for society of this function wouldn't be high enough.

Comfort for elderly people

Although comfort isn't a need for all target groups, and therefore doesn't seem like a functional aspect that adds value to the product if combined with some target groups, the comfort aspect does give some benefits to other target groups.

Including the target group of elderly people does give extra requirements regarding cognitive ergonomics, mainly because elderly people aren't used to smart products, while the main target groups are interested in them and have more experience. To overcome this gap, the object could focus on elderly people regarding only the comfort aspect, and not the other aspects (social communication and physical activities/edutainment), meanwhile, the comfort aspect should also focus on the main targets. If this form is chosen, it will be important to keep elderly people away from other functions without humiliating them in any way.

Monitoring for city government

The results of the study state that only government benefits from monitoring functions, this is mainly because the results of monitoring need to be processed. The information resulting from this process can be interesting not only for government, but also for other target groups (i.e. information about climate, traffic, air quality).

There are two ways of monitoring, one is the passive monitoring. This way, only the environment will be monitored by sensors, which doesn't change the user experience of the project. Next to that, active monitoring gives the possibility to monitor needs and wishes of people by interaction. However, this does make there are more visible functions accessible for users, while it's important to keep the object comprehensible.

To really gain from monitoring, it's best to implement sensors in different places and combine this information. In future, also different sensor networks could be combined to gain information. Thus monitoring of the complete city can't be achieved with only one or two prototype nodes.

Conclusions on opportunities

The most interesting opportunities for the prototype are edutainment for adults with children and comfort for elderly people. These may also be interesting for other target groups, which should be taken into account while designing.

With these opportunities the object can add more value for society. However, it's important that the object can be understood well by the target groups. Therefore it's important to keep it comprehensible and intuitive, with not too many features. During the design, the opportunities which add value should e kept in mind, but the focus needs to remain on the main target groups and their understanding of the object.

3.5. Interaction analysis

Within the system different scales and levels of interaction are possible. The possible scales of interaction are shown in the table below. Not only the stakeholders, but also the type of interaction is mentioned. For a better understanding, an example of each form of interaction is given.

3.5.1. Interaction scales

Interaction between	Type of interaction	Example
User – Object	Direct physical/virtual	Action of user changes state of the object
User – User	Direct physical	Communication between users at the spot
User – Object – User	Direct virtual	Communication through audio/video
	Indirect virtual	Communication by leaving information and reacting on it through the object
Group – Object – Group	Direct virtual	Communication through audio/video
	Indirect virtual	Actions of multiple users change the state of the object, which will be shown to other groups by (other) objects.

3.5.2. Interaction Levels

On each scale interaction can take place on different levels. The different levels of interaction are as follows, with also an example given:

Interaction Level	Function aspects	Example
Functional	Comfort, physical activities, edutainment	Changing the light of the object according to the needs
Communication	Social Communication, Edutainment, Monitoring	Answering a virtual survey from the government
Commercial	Information, monitoring	Promotional activities of companies/review platform of products
Creative	Social communication, comfort, edutainment	Sharing art pictures or creating a drawing on a touch screen
Information	Social communication, information, physical activities	Giving information about things to do in the surrounding environment

3.5.3. Conclusions on Interaction analysis

The used levels and scales of interaction depend on the different concepts and aspects of functions. Because social communication is an important aspect, there should be at least interaction on one the following scales:

- User – User
- User – Object – User

Also Group – Object – Group interaction can enhance social communication.

Next to that, the functional aspect that will be included – social communication – needs the communication level of interaction. In the table above an overview of the possible interaction levels and the function aspects to which they contribute are listed.

3.6. Location

Because the object will be placed in public space, it is important to take the surroundings of the object into account in the design. As there is no fixed location of the placement of the object, a reference location is chosen and analyzed. The reference location – Piazza dell'Immacolata – is chosen based on the analyses of four squares. These analyses and the conclusions on choice of location are described in appendix 2 on page vi. In this paragraph, the analysis of the chosen location and the requirements following from it are described.

The analysis of Piazza dell'Immacolata is based on five visits to the square on different days and times of the day and on conversations with people who stayed at the square.

Piazza dell'Immacolata lies in the district of San Lorenzo which is known for its bright nightlife, popular amongst young people. La Sapienza University, the biggest university of Rome and Europe (Quacquarelli Symonds Limited, 2010), borders this district, and makes it even more attractive for students. The use and look of the square differs between summer and winter, due to the summer festival 'San Lorenzo in Piazza' from July until October.

3.6.1. Surrounding facilities

The district of San Lorenzo was created between 1884 and 1888, when a lot of residential buildings where built in Rome. Originally the residents at San Lorenzo were the unskilled poor working class. Because of its isolated location by railway station, the train maintenance location and a large cemetery, the district of San Lorenzo feels like a village within the city, which makes it an interesting reference location because of the feeling of city as well as village. The last few years, more and more students came to live in the district, and brought even more liveliness. With this, the young families moved to more quiet places in Rome. Therefore, the current residents mostly exist of students, single adults and elderly people who still feel connected to the neighborhood. Nevertheless the district and its residents still welcome all kinds of people. (Le Fasi Storiche, 2006)

Piazza dell'Immacolata lies in the centre of San Lorenzo and therefore has a lot of different facilities around. Directly adjacent on the square is a church, which is opened daily between 10 a.m. and noon, and a high school with cultural, linguistic and social science faculties. This school hosts students between 14 and 19 years old. Diagonally bordering the square is another square, which hosts a daily market. On this daily market there is a food section and a section with clothes, shoes and domestic goods.
At night the many bars, restaurants, clubs and the cinema are the main facilities around the square.

3.6.2. Architecture and atmosphere

Since the redesign of the piazza in 2003 and 2004, Piazza dell'Immacolata is a pedestrian zone that enhances the relaxation in the district. Three interesting points of the redesign are the focus on cultural heritage, the placement of seats and trees to enhance relaxation and the facilities for the since then held summer festival (Boccaci, 2004).

An impression of the architecture and atmosphere of the square is given in Figure 12. The relatively small square (50m by 30m) is surrounded by three to five storey high buildings, with a height between about 15 to 20 meters. On one side of the square is a church, which has a height of about 25 meters. The main colors used in the architecture and surroundings are warm earthy colors, such

as yellow and red. Other used materials are natural stones, grey for the pavement and white for accents on the pavement and the benches.

On the square there are some small trees, which give the square a more natural atmosphere. This is increased during summer, when extra greenery is placed for the summer festival.

It is important that the object fits with the atmosphere and architecture of the environment, but also has a design that matches with the smart city paradigm.

Figure 12: Collage Piazza dell'Immacolata

3.6.3. Placement of the pavilion

The festival 'San Lorenzo in Piazza' is held every year on Piazza dell'Immacolata from July until October. During this festival, the square hosts some market stands and a stage, where activities like performances, exhibitions and workshops are held every evening. Because of this festival, the use of space on the piazza between summer (July - October) and winter (November – June) highly differs.

A detailed analysis on the use of space during summer and winter can be found in appendix 3 on page x.

From this analysis follows the available space during summer and winter is on the sides of the square and next to the podium. The object can't be placed in the middle of the square, because of the use of the stage during summer. The available places to place the object are shown in the figure

- On the southern and eastern corners of the square, close to where the stage is in summer

Figure 13: Possible locations

- On the western corner of the square, some market stands should be replaced and the fencing should be changed.
- On the northern corner of the square, where a market stand has to be replaced in summer.
- Other available places are between the market stands during summer.

On all of these places, the maximum size of the object is about 3,5 by 3,5 meters. However, the form of the object can influence these measurements, because the walking paths should be kept free.

3.6.4. Functional analysis

To give a clear view on the use of the square by the public, a functional analysis is made. The different functions of the square are determined, after which the allocation of each function is registered.

The main function of the square is relaxation, but also pedestrian traffic is an important function of the square. Within relaxation, the square also has a social function as a meeting point for people, where they relax together. In the table below, the allocation of each function is shown.

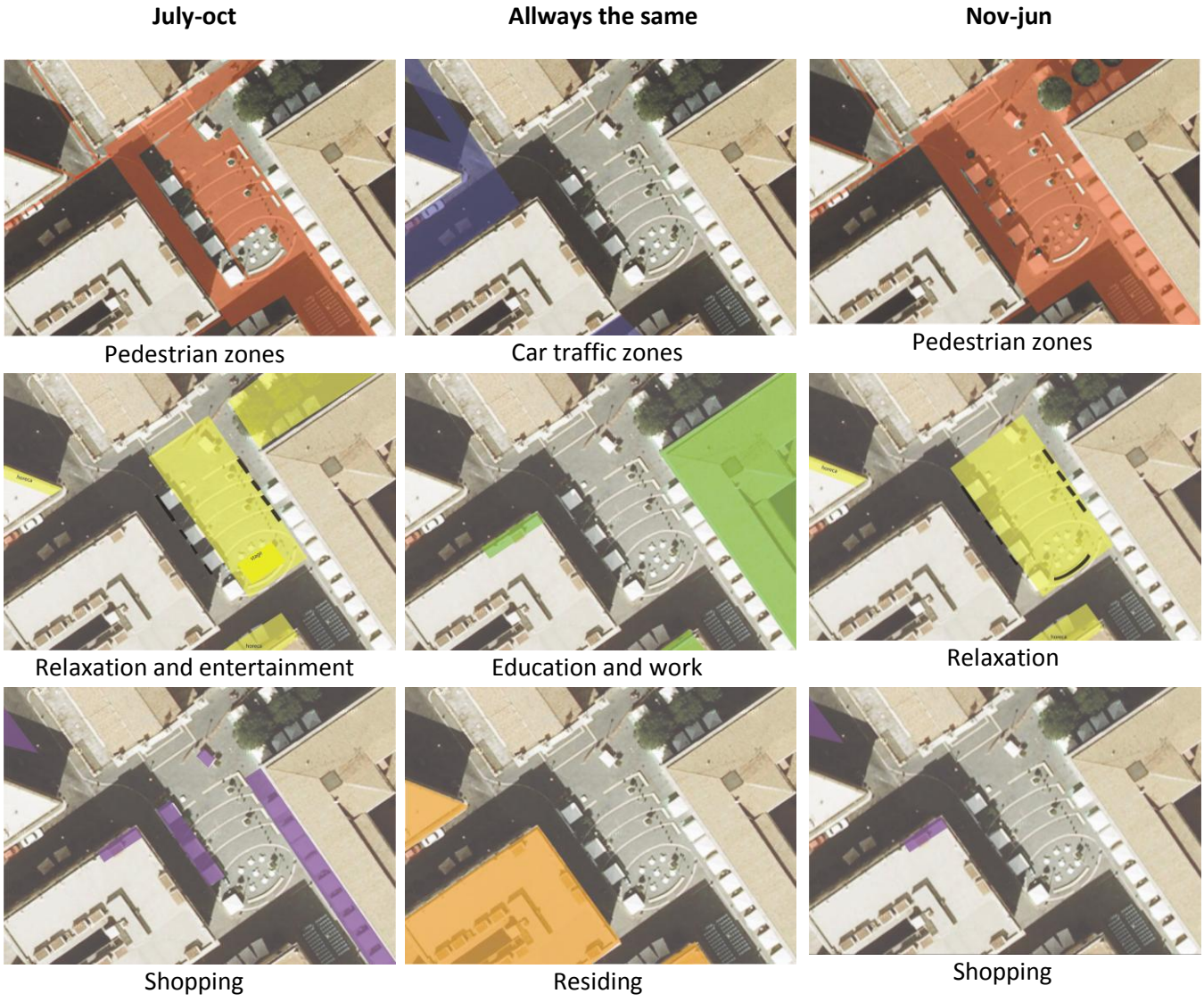

Figure 14: Functional analysis specified per function

3.6.4.1.Conclusions of functional analysis

The main functions of the square are relaxation and pedestrian traffic. The object can enhance the functions of relaxation and entertainment and especially the social function of the square, but it is important not to hinder the pedestrian traffic. It is interesting to attract pedestrians as target groups. Therefore the object should be placed on the west side of the square so pedestrians pass at both sides during summer and winter. The object will be placed on the northwestern corner of the square, where now a market stands and some fences are placed. The market stands can be put closer together to create more space, and in the fences a gap can be created. In the southwestern corner, the location is relatively crowded with functions because of the stage placed over there in summer, therefore these are less suitable.

3.6.5. Public

From the target groups described in the target group analysis, the group of young people (teenagers and students) is most represented at the square. Next to that, adults without children are often present. Besides these two main groups, also elderly people and adults with children can sometimes be seen. Tourists are nearly never present at this location.

The public and their use of the square will be described by their activities at the square.

3.6.5.1. Relaxing people

Most of the public at the square spends their time relaxing. During the day, different groups of people can be seen. While in morning most people are busy with working, studying or something else, there are not that many people relaxing. People relaxing are mostly students or students from the Liceo Classico (aged 14 to 19) while having a break or finishing their classes. Also working people or adults with young children take a moment to relax at the square. Elderly people are mostly seen when there is a mass at church.

University students entertain themselves at the square by conversations with each other and being together, while Liceo students are also interested in more entertainment, as is explained in the scenario of Matteo in appendix 1.

At night during summer, the piazza turns into a real festival location where mostly young people (but also some adults without children) meet to be together and enjoy the activities of the festival. Most people sit outside on the stairs, where they have a drink bought at a market stand or local shop.

Also seen at the square are some tramps. They mostly spent their time sitting at a bench or close to a building at the side of the square, looking around and trying to make conversation.

3.6.5.2. Working people

With the market stands at the square there are also vendors staying there. While keeping an eye on their market stand, they have a chat with each other and sit down on a bench, this happens mostly during the day, because there are a lot of customers in the evening.

3.6.5.3. Passers-by

With multiple facilities in the surroundings of the square, and its central location in San Lorenzo, many people pass by the square. Most people passing by are elderly people and adults without children, when they come from the daily market closeby in morning. Other facilities attracting

people to pass the square are the school, church and university close by. While passing by, people are likely to stop and have a quick social chat with each other before moving on.

While passing by, especially elderly people and local residents are likely to stop and have a quick chat with a friend or neighbor they pass.

3.6.5.4. Bar visitors

On the south side of the piazza is a bar with a terrace. This terrace is crowded during the whole day, at the morning with adults and students having breakfast, during afternoon with businessmen having a business lunch and also students. During night the terrace is crowded with mostly students.

3.6.5.5. Conclusions on the public

At the moment, students come to the square for social activities, and entertain themselves with them, while teenagers are looking for more entertainment. To serve these both target groups it's important to enhance the social activities of students in an easy accessible way, and to enhance social contact for teenagers by entertainment, giving information about activities in the surroundings and sharing media with each other.

The quality of life on the square for relaxing people can be enhanced by some activities to do. Especially when waiting alone, interaction can enhance the entertainment and relaxation. However, this should also be easy accessible and not necessarily time consuming.

While elderly people are seen at the square frequently, this target group should also be taken into account. However, this is a more difficult target group, because elderly people are not used to smart products or the concept of the smart city. The main focus will be on young people and adults without children, therefore the main design should be adapted to them. To create added value for elderly people, giving information without interaction is an interesting function.

3.6.6. Conclusions of the location analysis

The object will be designed for the northwest corner of Piazza dell'Immacolata. The design should fit with the open and lively atmosphere of the square, the buildings and its architecture and the modern developments of the smart city.

The functioning should enhance entertainment and social relaxation, without replacing the existing relaxation function of the square. To attract teenagers as target group, the object should give information about activities in the surrounding environment and give the possibility to share media. To attract students the object should focus on the social function of the square. To include elderly people as a target group, the object should also be giving information without interaction.

3.7. Conclusions of the analyses

Within the smart city theory, six different characteristics can be defined. It would be interesting to contribute to all characteristics of the smart city. However, people aren't used to the smart city paradigm and it's therefore important to keep the product comprehensible. It will be interesting to contribute to as many characteristics as possible, but the focus should be on the goals of the project:

1. Let Italian people and society experience some aspects of the smart city paradigm
2. Show the possibilities of interaction with urban space at different levels.
3. Give a contribution to the cohesion of the social community, to stimulate the contact between people and develop awareness of their everyday environment.

The chosen main target groups are 'young people' and 'adults without children'. In the design process, the focus should be on these main target groups. Based on the results of a study to added values of different functional aspects for the target groups the main functioning of the product should be on social communication.

The object will be designed for piazza dell'Immacolata in the district of San Lorenzo in Rome. Main target groups at this square are young people, adults without children and elderly people. To include the last, it's important to create some functioning without interaction. The most important function of the object will be the sharing of media (text, images, video and sound). Therefore it's important to allow users to give input and to show the media. Next to that, information about different events and organizations should be added.

One of the requirements stated by ENEA project team 'smart cities and eco-industry' is to create an interactive object. Because social communication is a required functional aspect, it's important to create interaction between people (user-user, user-object-user or group-object-group), and not only interaction between object and user.

Next to that, there are different levels of interaction. A required level of interaction is on communication level, because of social communication as a required functional aspect. Different levels of interaction can contribute to different functional aspects.

3.7.1. Program of requirements and wishes

With the results of the analyses and the requirements and goals stated by the ENEA project team 'smart cities and eco-industry' a program of requirements and wishes is made and shown below.

Program of requirements for the to be designed prototype		
Category	**requirement**	**specification**
Functioning	Fulfill multiple functions	On the aspects of social communication
	Communicate with other objects	connect to the lighting network
	Stand-alone functioning	
	Interaction with users on multiple levels	At least communication level
	Teach people something about the environment and/or sustainability	
	Enhance relaxation, social function and entertainment at the square	
	Share media (text, images, video and sound)	Input of media Output of media
Use	Weatherproof	Proof against the weather conditions in Italy
	Intuitive use	No manuals needed
	Multiple users at the same time	5 individuals at the same time, access points for groups of at least 5 people
	Be comprehensible for users	No conflicting functions Create a clear view of the functions for users Give information without interaction to be comprehensible for elderly people
	Attractions to stay close to the object	Places to sit/stand in the near surroundings
	maintenance	Only occasional maintenance needed No cleaning of the object itself needed
Design	attract young people attract adults without children	Stand out in the environment Have a modern design
	fit within the architecture/urban design of the surroundings	Fit within style of collage Maximum size is 3,5 by 3,5 meters, with details depending on the form of the object
	Fit within the open and lively atmosphere	
	Don't hinder pedestrian traffic	
	Have a look that fits the smart city paradigm	
sustainability	Sustainable energy use	Use of energy efficient materials and technologies
	Use of sustainable materials	
Safety	Create a high perception of safety	Light the environment at night
	Physical safety	No sharp edges

		No small holes where users can get hurt
	Digital safety	Protection against harmful information posted by users

Program of wishes for the to be designed prototype		
Category	**requirement**	**specification**
sustainability	Sustainable energy use	Net zero energy use throughout the year

4. Concept generation

Before developing different concepts, first the main functions and interactions of the object are determined, to define which parts need to be implemented.

4.1. Functions of the object

The main function of the object will be to create a platform for sharing media in a public environment. At the moment, sharing of media often happens through web applications and social networks like Facebook, Twitter and YouTube, which are commonly used by the main target group (young people and adults without children).

With the possibility to share media through an object in public space (at a square), the sharing of media and communication is not only digital and individual, but is brought to groups of people at the square. This way, personal communication and the social and relaxation function of the square are enhanced.

In this project, the functions of the object are focused on the sharing of media. However, with the use of the same hardware in future the functions of the object can be enhanced by software.

4.2. Interactions and communication

The interaction of users with the object is based on the sharing of the media text, images, video and music. Therefore the two main functions of the object are showing media and giving users the possibility to add, create or request media.

A diagram of the system can be seen in Figure 15.

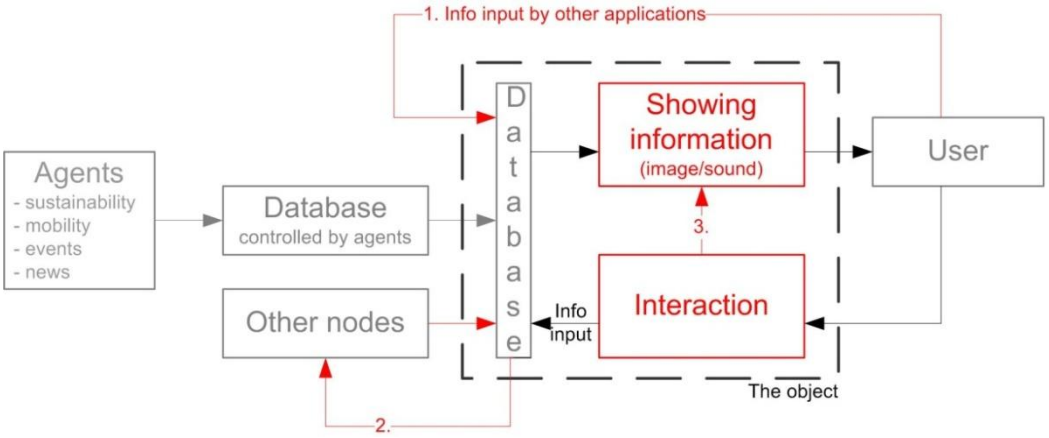

Figure 15: diagram of the system

4.2.1. Showing media

To show the media of text, images, video and music, visual and audio output are needed.
For visual output text will be shown on a ticker and images and video will be shown on full color screens. These screens can eventually be used to show other information; these details should be decided in the interaction design, which is no part of this project.

Two options for audio output are audio boxes or mini-jack plugs. Audio boxes can be heard by multiple users at once, and can therefore stimulate the social communication and cohesion. However, the sound might also disturb other people at the square and therefore limitations to the

sound volume are needed.
Mini-jack plugs where users can plug in their own headphones are a more private option where people can adjust volume and played sounds to their own preferences. However, people have to bring their own headphones and there is less stimulation of social cohesion.
Both audio playback options have their own benefits and disadvantages and should both be implemented in the object.

4.2.2. Copyrights

Not all media can be easily added, because of copyrights. While text and images are easier to share, for music or videos a permission of the maker is needed to share even a small sample of these (Buma/Stemra, n.d.). Music and video need to be checked for copyright infringement, which takes complicated copyright policies and controlling. An example of an application with sharing of music and video and controlling copyrights is YouTube (YouTube, n.d.). Although autonomously controlling copyright infringement would be difficult, sharing of music and video can be possible by embedding videos from YouTube. In further development of software it's also possible to create an autonomous copyright infringement control system.

4.2.3. Tagging

To create more structure and overview within the different media, it should be possible to tag media. With each message or picture having its own code it's possible to reply to media. Next to that, the objects should be tagged. The object is part of a network of similar objects and most ways of adding information will be general for all objects. Therefore, a tag for the desired object (location) should be inserted in media if it is not uploaded locally, or if it is added locally but should also be shown at other objects.

4.2.4. Input of media

There are roughly four ways for the input of media, which are the input of media by

- Users at the object
- Users through other applications
- Agents
- Other objects

4.2.4.1.Input at the object

Users can input media at the object by using touch screens, a webcam and USB and SD slots to input pictures from digital camera's or phones. With the touch screens users can create images or 'paintings' and give text input by a keyboard on the touch screen.

4.2.4.2. Input through other applications

Next to the input of media at the object, users can add media by other applications. Therefore the database of the object will be connected to social networks as twitter (text), YouTube (video and music) and Flickr (images). This way, people can share media they think is interesting for the public at the square, even if they're not there.

Text can also be added by text messages (SMS) to a specific phone number, and images can be added by MMS. As 31,9% of Italians own a smart phone (Mussinelli, 2010), Wi-Fi and Bluetooth connections will be established at the object, so media can also be added through smart phones.

4.2.4.3. Input by agents

To include more 'smartness' in the object, common information can be inserted by agents from government or companies. This information can be based on in example the fields of traffic and mobility, environment and sustainability, news and events. With information about sustainability and environment the object learns people something about these aspects. Agents have the responsibility to structure these media. For the use of this information, applications might be created which run on the provided touch screens.

4.2.4.4. Input by other objects

The input by other objects is created by the tagging of media. Therefore, the input is not precisely inputted by other objects, but it is added by users at other objects.

4.2.5. Conclusions on required parts for interaction

The parts needed in the object for the above described interactions are stated in the table below, together with the number of parts needed. To create multiple places where people can use the object it is decided to have at least 3 touch screens. To make it possible to show enough images and video's two full color screens for visualization will be used. These full color screens could eventually be touch screens, but this costs more energy.

With the above mentioned parts and computer hardware, it's possible to increase the functioning of the object in several ways by new software.

Part	Number
Full color screens	2
Ticker	1
Sound boxes	1 set
Mini-jack plugs	3
Touch screens	3
Webcam	1
USD and SD slots	1 each
Wi-Fi and Bluetooth transmission	1 each

4.3. Development of different concepts

Based on above mentioned needed parts for interaction and the program of requirements and wishes some concepts are developed.

Also some concepts which not fitted the above stated requirements where developed. Two of these can be seen in Figure 16.

The development of the concept was a continuous process, where constantly choices were made and that one concept was developed further, with multiple options.

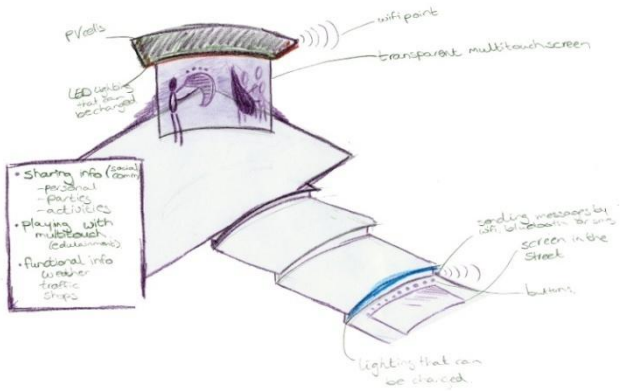

Figure 16: Concepts of transparent large screen and a screen implemented in the ground.

After different brainstorms and sketches, two concepts where defined, which are shown in Figure 17. From these, the pavilion concept was chosen to develop further in consultation with the client (the tutors at ENEA). This design makes it possible to make a distinction between the showing of information and interaction. With the interaction on the inside of the object, users can get a sheltered feeling, but in the meanwhile stay in a public and open area.

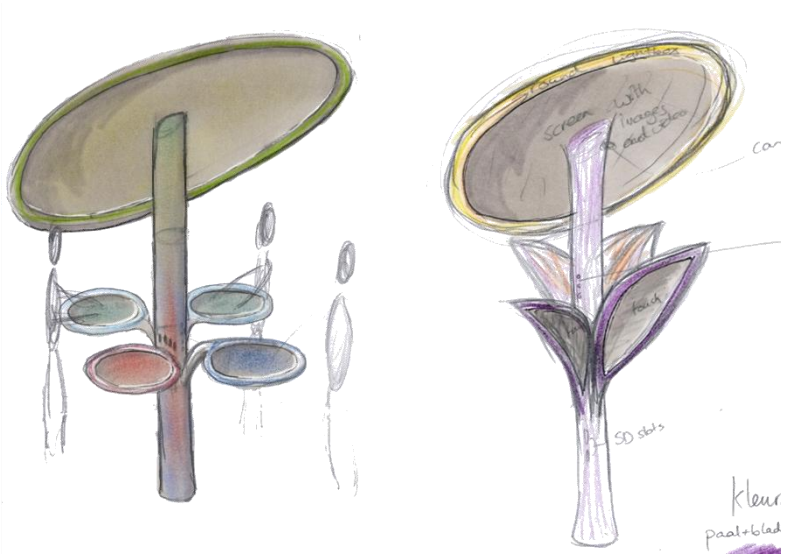

Figure 17a: Concept flower/tree

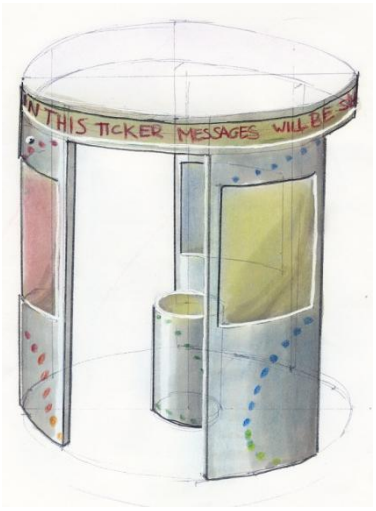

Figure 17b: Pavilion concept

For the development of the pavilion concept, a brainstorm for the final form and shape is made, to create a more open atmosphere than the circular form as shown in Figure 17b. With this, also the possibility to sit down and use a horizontal screen is elaborated. The development of this concept can be seen in Figure 18

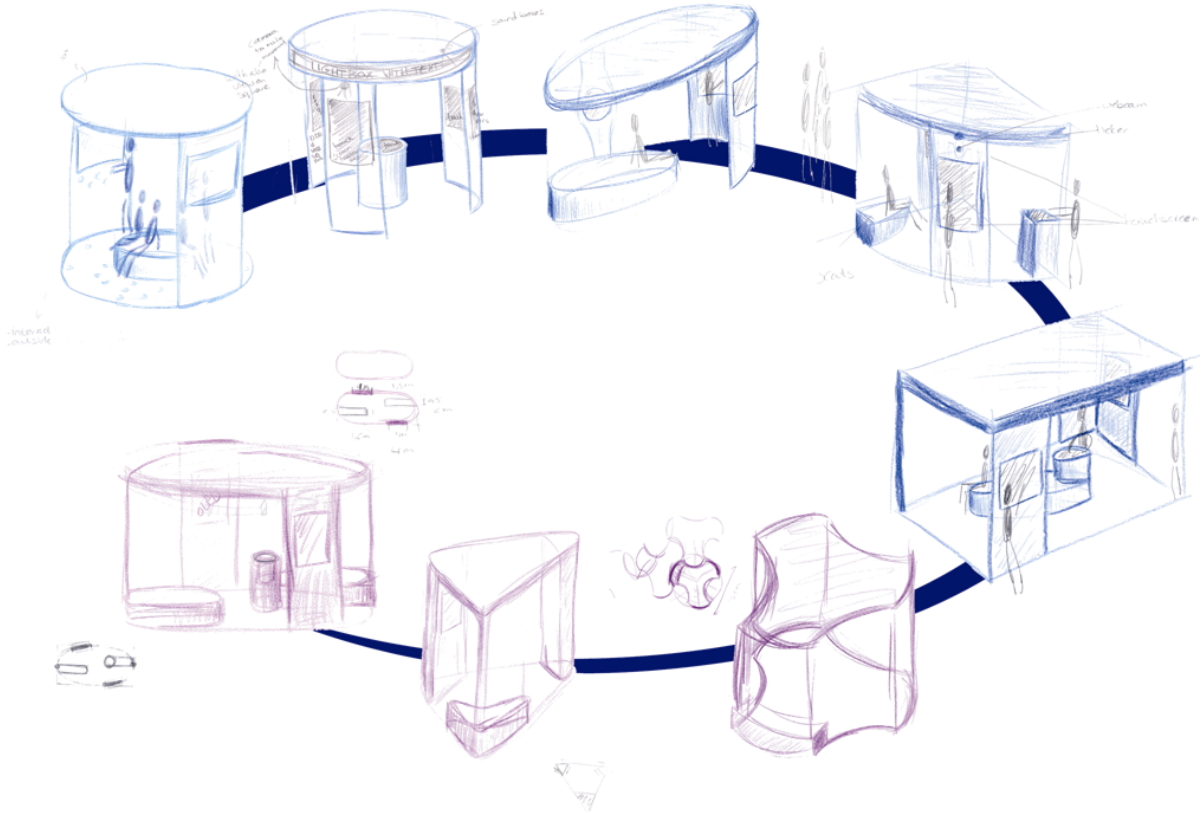

Figure 18: Development of concept pavilion

Finally, an elliptical shape with two panels holding screens is chosen as a final concept.

4.4. Development of final concept

Before the detailed design of the final object, first the final concept is defined further. In the last part of this paragraph, the different parts and the form and layout of the object are described. One of the wishes stated in the Program of requirements and wishes on page 33 is to make the object energy autonomous, to show people the advantages of sustainable energy, therefore energy should be produced at the object, which could be done by the use of PV modules. To see if the efficiency of these PV modules is high enough for adapting the design to the requirements following from the use of PV modules these calculations and requirements are shown in the next paragraph.

4.4.1. Photovoltaic Modules

To make the object energy autonomous, photovoltaics can be used to produce energy. Because of the location of the object – on a square surrounded by buildings – other ways of energy generation (like wind turbines) are not possible.

The use of photovoltaics has influence on the design of the object, because the PV modules (which can be placed on the roof) should be placed in an optimized inclination and azimuth to create maximum energy production.

Sketches of the object with the use of PV models and therefore an inclined roof (with different inclinations) are shown in Figure 19 to Figure 21. In these sketches and during the calculation of energy production, the elliptical concept was not yet developed, and a rounded concept is used. However, the surface of the roof of the elliptical concept is similar, so the calculations and results below can still be used.

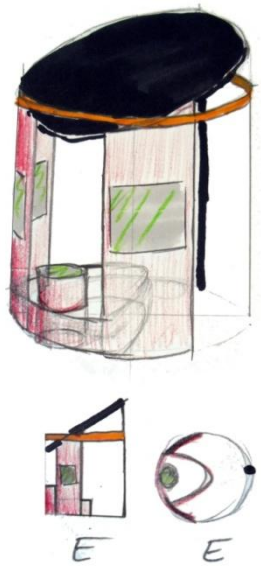

Figure 19: Circular concept with PV modules 1

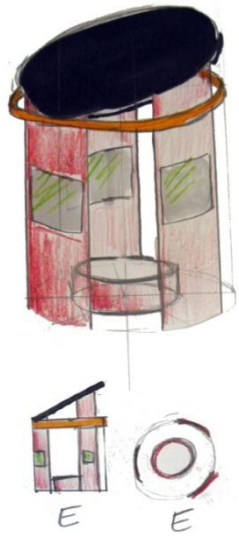

Figure 20: Circular concept with PV modules 2

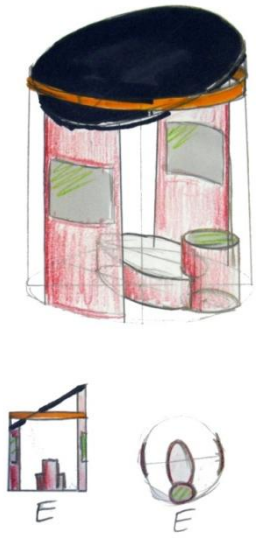

Figure 21: Circular concept with PV modules 3

The energy use of the object is shown in table 2. With the energy use, these PV modules and the above shown concepts 18 to 19% of the total energy consumption can be produced if the object is never placed in full sun. However, on the chosen reference square, there is always shading during some time of the day, even on the sunniest spot. With the simulation program PVSyst, the shading

factor for the three possible locations with most sun is calculated. The results of energy production including shading factor can be seen in table 3.
On the reference square the maximum covered energy use is 13 to 14% for the concepts shown above.

Part	average power consumption (W)	estimated power consumption a piece (W)	number of pieces	total power consumption (W)	times used during a day (h)	energy use daily (Wh)	energy use yearly (kWh)	% of total
computer visualization	60-500[x]	100	1	100	14	1400	511	10%
computer interaction		250	1	250	7	1750	639	12%
computer hibernation	60-500	5	2	10	3	30	11	0%
touch screens	48-246[xi]	200	2	400	7	2800	1022	20%
normal screens	50-150[xii]	100	2	200	14	2800	1022	20%
ticker	125-200[xiii]	150	1	150	14	2100	767	15%
sound boxes	[xiv]	25	2	50	7	350	128	2%
presence sensors		10	5	50	24	1200	438	8%
Led Lighting	unknown	1	100	100	12	1200	438	8%
subtotal						13630	4975	95%
margin	5%					682	249	5%
total consumption						14312	5224	100%

Table 2: calculations of energy consumption

Within these calculations, mini-jack plugs, webcam and USB/SD slots are neglected because they are integrated in the energy consumption of the computer. The pressure sensors are neglected because their consumption is really small. The energy use of a wifi router is not included at the moment, because no data of this could be found on the internet.

inclination	energy production (kWh)	% of consumption
0	541,832	10,4%
5	564,616	10,8%
10	588,824	11,3%
15	602,352	11,5%
20	644,36	12,3%
25	676,4	12,9%
30	712	13,6%
34	747,6	14,3%

Table 3: calculation of energy production including shading factor

The detailed calculation of energy use and energy generated by photovoltaics can be found in appendix 5 on page xv.

4.4.1.1. Conclusions on the use of PV modules

The use of PV modules has much influence on the look of the object, because this means the roof needs to be placed in an angle between 25° and 34°. However, the produced energy is relatively low, and therefore it's more difficult to show people the advantages of sustainable energy.
Because of the low results, no photovoltaic modules will be used. However, to show people more

about sustainability, green energy can be used and people can be informed by using the ticker and screens.
Green energy can be used from the grid or sufficient PV panels can be placed on buildings nearby. These solutions can be part of the project when the object is produced and placed, but don't influence the design at the moment.

[x] Depending on functioning, between 60 en 250 watt for basic up to professional desktops (Bray, 2006), for high powered gaming dekstops it can be 500 watt (Dell, 2010)
[xi] depending on size: for 55 cm, 48 W, for 106 cm,246 W, in between the changes are about linear (PC Connections, Inc, 2010), (Nextag Inc., 2010)
[xii] (Vergelijk.nl, n.d.)
[xiii] Hargo Geijbels (personal communication; e-mail, November 5, 2010)
[xiv] (PC Speakers, n.d.)

4.4.2. Form and lay-out

The final design of the object can be seen in Figure 22.

The elliptical object with axis from 4 and 2 meters has five screens and a ticker to interact with people. The touch screens are located on the inside of the panels and a horizontal touch screen is placed in the middle of the object.
The bench on one end of the long axis creates seating places to enhance relaxation.
An open space is created at the centre of the object to invite people to walk through the object. This walking path is stimulated by the porches on the roof.

The object can be used by individuals or small groups of 3 to 4 people.

Figure 22: Final concept

4.4.2.1. Panels and vertical screens

To create a more open and dynamic object, the two panels are placed close to the short axis, but a bit out of the centre to create the walking path. The one meter wide panels hold a touch screen on the inside and a squared screen on the outside. Above the outside screen facing the centre of the square a webcam is placed.
The inside of one panel also holds the USB and SD slots, while the inside of the other panel holds the mini-jack plugs and sound boxes.

4.4.2.2.Roof

The roof, supported by the two panels and two poles, is used to give shelter for users. The roof has the same form as the ellipse pavement, and is extended by two porches to invite people to walk through the object and create more shelter.
The roof is surrounded by a ticker, which shows text messages to the people at the square. The two porches will be transparent to give the roof a more 'light' feeling. Sketches on the design of the porches can be found in appendix 6 on page xix.

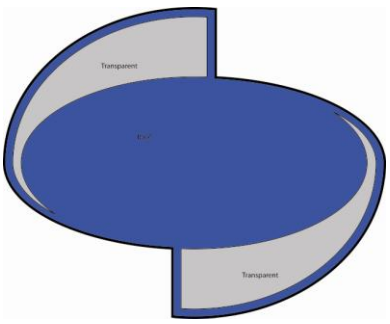

Figure 23: Top view of roof

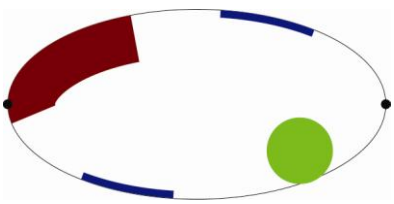

Figure 24: layout of seats, horizontal screen and panels

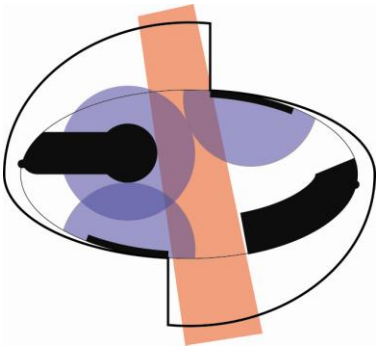

Figure 25: top view of walking paths

To drain the rain water, two drainage pipes are implemented within the poles. The roof slightly

slopes, so the water flows to these two points. The roof is slightly curved to make the water flow to the drainage pipes.

4.4.2.3. Layout of seats and horizontal screen

For the design of the layout of the seats and horizontal screen different options are made and shown in Figure 26 to Figure 31. The choice between layouts is based on the following aspects:

- Use of horizontal screen
- Place of horizontal screen
- Place and number of seats

Use of horizontal screen

Users can use the horizontal screen by standing around it, or by sitting next to it, like at a desk. In last case, seats need to be created. These options are shown in concept 3 and 4. Because of the form of the bench, in concept 3 there is not enough space for users' legs. Different places for the screen in concept 4 are tried, but no right place could be found because of the required space around the screens and seats, and the required free space for the walking path and use of the vertical screen. Therefore, users will stand around the horizontal screen. This way, more people can see and use the screen at the same time, without blocking other functions of the object.

Place of horizontal screen

Because most interaction takes place in the centre of the object, also the horizontal screen will be placed close to the centre of the object. This way, there is also enough space for users to stand around the screen and being sheltered by the roof. A preference lays to concept 2, 5 and 6, concept 1

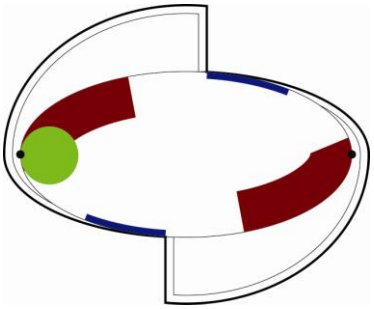

Figure 26: layout concept 1

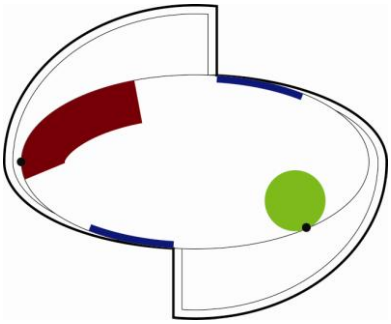

Figure 27: layout concept 2

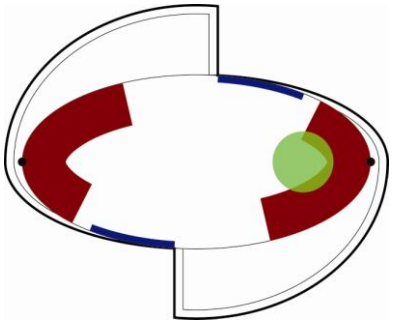

Figure 28: layout concept 3

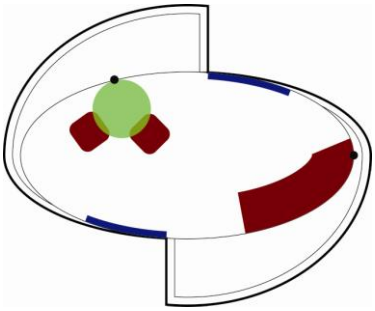

Figure 29: layout concept 4

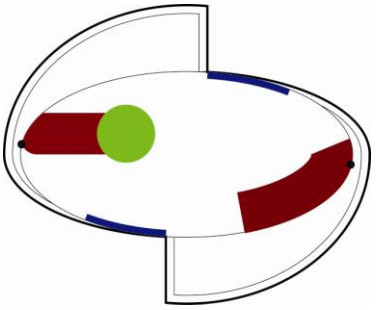

Figure 30: layout concept 5

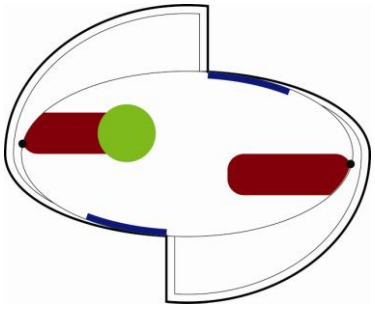

Figure 31: layout concept 6

is eliminated.

Place and number of seats

Concept 5 and 6 are preferred because their number of seats. The difference between these concepts is the free standing bench. However, the bench connected to the horizontal screen only has a length of 90 cm, where only two people can sit. In the meanwhile, they will be sitting close to the horizontal screen, where other groups of people can be standing. Therefore, concept 2 is chosen. The free standing bench has a rounded form, because this creates more seating places then the straight bench, as used in concept 6.

5. Detailed design of the urban communication pavilion

In this chapter, the detailed design of the concept is described. First the object and the different parts, their functioning and dimensions are described. The estimations made to define the dimensions are given in paragraph 5.2. In the last paragraph the choice of materials is described.

5.1. Design and function allocation

The urban communication pavilion, which can be seen in Figure 32, fulfills multiple functions and the several parts fulfill different functions. A list of the parts and which functions they fulfill is given below; afterwards the different parts, their functioning and dimensions are described.

Part	Functions
Roof	Give sheltering Lighting
Ticker	Show information
Panel	Show information Create interaction Support the roof
Bench	Create seating places Hold computer
Horizontal screen	Create interaction Give information
Poles	Support the roof Water drainage

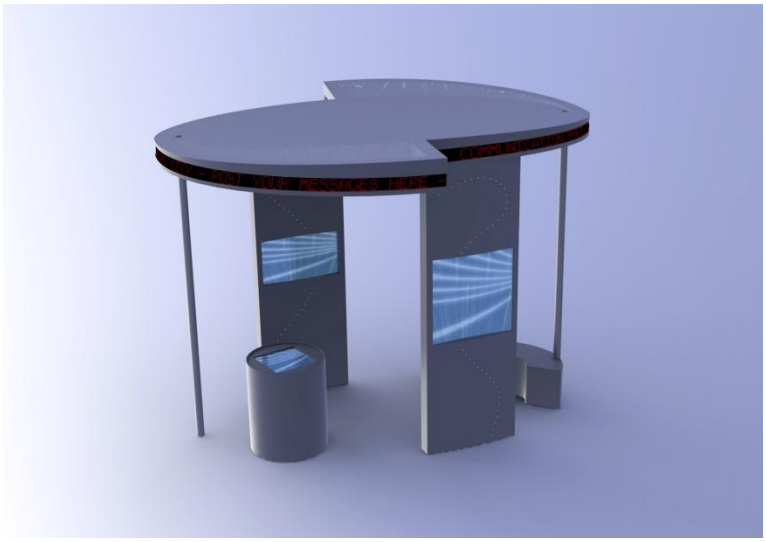

Figure 32: Rendering of the object

5.1.1. Roof

The main function of the roof is to give shelter and to show information by the ticker. Next to that, the roof with its extended porches invites people to enter the pavilion, and therefore gives a sheltered but open look. The porches are transparent to create a more light feeling. For lighting of the pavilion, LED's are placed within the roof. Details about the lighting are described in the next paragraph. An exploded view of the roof is shown in Figure 33.

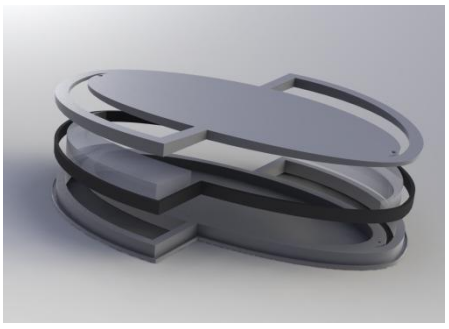

Figure 33: Exploded view of roof

The roof holds the ticker to show information, and inside it holds a Wi-Fi and Bluetooth hotspot for communication. Therefore an empty space in the centre of the roof is created. To save on weight and material, this space is enlarged over the whole surface of the roof. The cables to connect the Wi-Fi router, Bluetooth hotspot, ticker and lights enter the roof via the panels.

The dimensions of the roof has the form of an ellipse with axes of 4,4 by two meters. This way, combined with the porches, the roof extends over the main elliptical shape on which the layout of the design is based.

The porches are defined by the form of an ellipse with axes of 4,4 by 3,6 meters and the placement of the panels. The transparent parts in the roof are shaped on the outside of the original ellipse (of four by two meters) and an offset of the outside of the roof of 15 cm. This offset holds the ticker, which is estimated to need 48 mm in thickness.

The top of the roof is double curved to make rain water flow to the drainage in the poles. The surface is formed by two parabolic splines which both have a height difference of 5 cm. Therefore, the thickness of the roof changes between 20 and 30 centimeters.

The dimensional charts can be found in appendix 8.1 on page xxiii.

5.1.2. Lighting

The lighting of the pavilion has – next to lighting – the function of giving a more modern look by using an ambilight pattern around the landscaped and squared touch screens. The LEDs placed in the roof for functional lighting are placed in the elliptical pattern to outline the shape on which the design of the pavilion is based.

All lighting of the pavilion is created by using multicolor LED's. Therefore, the amiblight pattern can adopt the colors used on the screen. The ambilight LED pattern can be seen in Figure 34 and more detailed on the dimensional charts of the panel in appendix 8.2 on page xxiv.

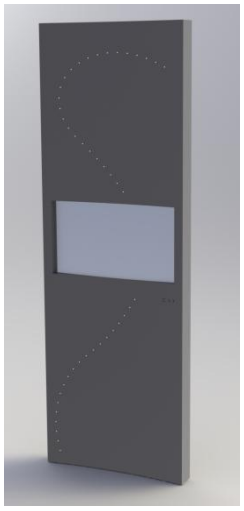

Figure 34: inside view of panel

5.1.3. Panel

The two panels supporting the roof have the same look, but the functions slightly differ. The panels have both screens on inside and outside.
The on interaction focusing 40" touch screens on the inside of the panels have a 16:9 proportion and therefore fit within the one meter wide panel.
The screens on the outside of the pavilion, which focus on showing images and information, are squared to show different orientated images (landscaped or portrait) equally, these screens have the same width as the inside touch screens.

The panel facing most of the square has a webcam, which can be used by users to make movies or pictures, or it can film the happenings on the square to show on the internet or other pavilions in the network. Although the interaction is located on the inside of the pavilion, also the webcam should be controlled; therefore the outside screen is also a touch screen.
On the inside of this panel, 2 USB and 2 SD slots are provided to put in information to the pavilion by plugging in SD cards or USB sticks.

The other panel focuses on the inside on the sharing of sound. Therefore, sound boxes and 5 minijack slots are provided. These boxes and mini-jack slots can be operated by the inside touch screen.

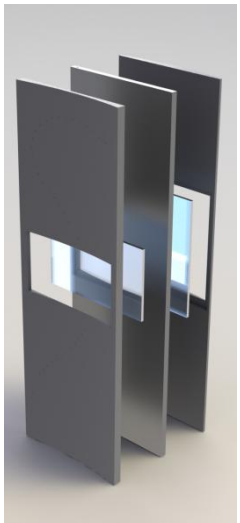

Figure 35: exploded view of panel

To make the screens accessible for maintenance, the panels are built of three parts. The middle part supports the roof and holds the cables connecting the technical parts in the roof to the computer and grid.
The outside parts are placed against the middle part, and hold the screens (landscaped and squared).

For maintenance of the screens, the outside parts can be removed, and the screen can be accessed. Cables to connect the screens are placed inside the outside panels. The three separate parts can be seen in Figure 35: exploded view of panel.

The one meter wide panels have a height of three meters and a thickness of about 14 centimeters. Both screens are placed on eye height within arm's reach for operating the touch screens. The detailed dimensions of the panels can be seen in appendix 8.2 on page xxiv.

5.1.4. Bench

The rounded bench placed on the end of the long axis of the pavilion has two main functions, which are to enhance relaxation by creating seating places and to house the computer on which the system of the pavilion will be running. The bench is shown in Figure 36 and Figure 37.

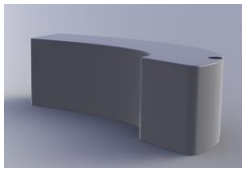

Figure 36: View of Bench

To hold the computer, the inside of the bench is hollow. On one side, a grid is inserted for fresh air for the fan of the computer.
For maintenance, the computer can be accessed by disconnecting the top of the bench to the bench itself. This and the grid can be seen in Figure 37. The cables that will connect the computer to other hardware will run through the bottom of the bench and the ground to amongst others the panels.

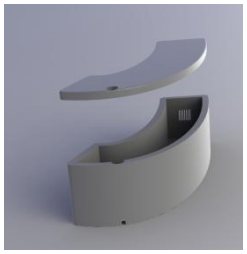

Figure 37: Exploded view of bench

The shape of the bench is determined by the ellipse of four by two meters and a 40 cm offset. The length of the bench on the long side is determined by the distance to the panel. The bench has a sitting height of 450 mm, which is based on the anthropometric dimensions stated by Motmans (2005).

The largest part of the computer fits easily inside the bench if vertically placed (for dimensions see appendix 7 on page xx). The dimensional charts can be found in appendix 8.3 on page xxv.

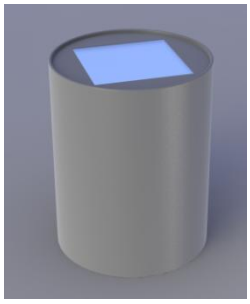

Figure 38: View of horizontal screen

5.1.5. Horizontal screen

The horizontal screen is designed to exist of a circular touch screen.
However, at the moment circular touch screens only exist in conceptual products, and are not produced yet. The only circular screen produced – as a prototype – is a 75 mm diameter screen from Toshiba Matsushita Displays (2007). This company is contacted for further information, but without useful results.

Therefore, it is decided to use a squared screen within the circular shape. The circular shape of the body remains for a more dynamic flow around the screen. Next to that, it is expected that a circular touch screen can be used in the future.

The touch screen connects to the computer through cables running below the pavement. The height of 1 meter is based on anthropometric data from Motmans (2005). With this height, it is also not likely that people will sit on the screen. The horizontal touch screen can be seen in Figure 38.

The horizontal screen is placed on a height of 1 meter, which is based on the anthropometric dimensions and guidelines on working heights of Motmans (2005).

The screen itself has an active surface of 480 by 480 mm, and outer dimensions of 552 by 552 mm, as stated in paragraph 5.2.1 on page 49. This fits within the circular body holding the touch screen, which has a diameter of 80 cm. The dimensional charts can be found in appendix 8.4 on page xxv.

5.1.6. Poles

The poles, placed on the end of the long axis of the basic ellipse shape are designed to support the roof and for water drainage. The roof has a double curved surface that makes the water flows to the poles. On the bottom, the water is let onto the square, where it can flow to the standard water draining facilities on the square.
Because of the relatively small surface, no direct connection to the sewage is needed. The main function of draining the water it to prevent is from flowing down on the sides of the roof. A render of the pole can be seen in Figure 39.

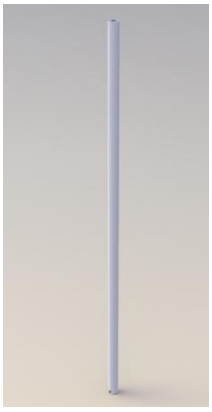
Figure 39: View of Pole

The dimensions of the poles are based on the required size for water drainage, which are two pipes with a diameter of about 34 mm. Therefore, the poles have a diameter of 80 mm and a length of 3 meters. The dimensional charts can be found in appendix 8.5 on page xxv.

5.1.7. Pavement

To create the same use of cables running under the ground and use of pressure sensors for presence detection in every situation, the pavement is part of the design. With this pavement, also the form of the basic ellipse with axis of 4 and 2 meters on which the shape of the pavilion is defined is accentuated.

To save energy, pressure sensors are placed in the pavement, to detect the presence of users, so the object and its screens will only be turned on when people are around. The pressure sensors are placed on the seats and the entrances to the pavilion. For example, pulsor stress sensors of (Sure Action Incorporated, n.d.) can be used. Combined with the information of use of the touch screens, the activity of users can be detected. The inside screens and horizontal screen will be turned off if no activity is detected for one minute.

5.1.7.1. Movement sensors on square

The outside screens, ticker and computer will be turned off when no people are present at the square to save more energy. The features of Wi-Fi and movement and pressure sensors will stay turned on, but no computer operation is needed to do so. However, as soon as people enter the square, the outside screens and ticker should be turned on immediately, where the computer is the limiting factor. Therefore the computer will be turned into stand-by mode to enable a faster start up.

The presence of people (and therefore activity) on the square will be detected by movement sensors placed on the lighting poles on the corner of the square. The sensors have a reach of 180° and 21 – 30 meters (Allied Trade Group, Inc, 2010) . With sensors placed on the lighting poles on the corner of the square, the whole square can be detected.

5.2. Technical parts and connections

In the paragraph Interactions and communication on page 37 the required parts for interaction are defined. In Figure 40 the allocation of the technical parts is shown in a schematic view of the pavilion. The links between the different parts is categorized by different colors.
This figure gives information on the data and information flow within the pavilion between technical components. For information on the data flow between the pavilion, users, agents and other pavilions, see Figure 15 on page 35.

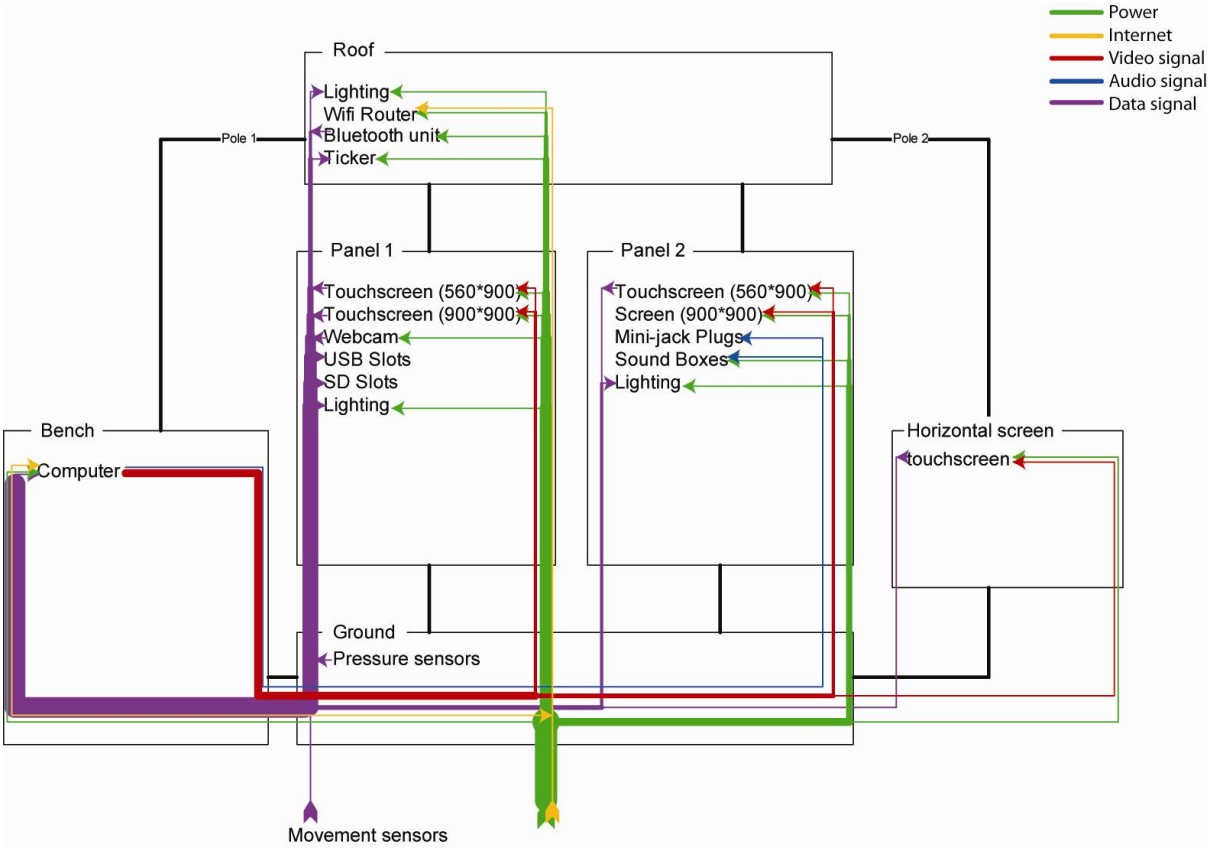

Figure 40: Technical parts allocation and flow of power and data

5.2.1. Assumed dimensions

For the internal design of the pavilion, some information about dimensions and connections of technical parts was required, but not all detailed information could be obtained. Based on the information that was obtained estimations of the space needed are made. The detailed estimations can be found in appendix 7 on page xx.

	Length	height	depth
Landscaped touch screen	969,4	582	23,2
Squared touch screen	969,4	969,4	23,2
Horizontal touch screen	552	552	23,2
Ticker		120,4	48
Router	193	30,5	116,8
Bluetooth Dongle	49,36	7,55	17,99
Computer[1]	325	150	267

SD card[2]	24	2,1	32
USB plug[2]	12	4	13
Mini jack[2]	3,5	3,5	15

[1]These are the dimensions of the largest part, more open space is needed for other parts, but the inside of the bench will be sufficient. To cool the computer, a grid for fresh air is needed.

[2]These are the dimensions of the to be inserted parts, the space needed for the slots is bigger.

5.3. Choice of materials

5.3.1. Requirements

The most important requirements regarding material choice are as follows:

- fit within the surroundings of the location
- fit within the smart city paradigm
- Be resistant against the outdoor conditions in Italy
- Be strong enough.

The first can be expressed the collages of the analyzed squares (figures 1 to 4 in appendix 1 on page i) with a main focus on the chosen square (Figure 12) the second requirement can be expressed by the collage from the market analysis (Figure 2: Collage Smart Products in public space).

From the collage of the market analysis, it can be concluded that the color use is based on black, white and grey colors and sometimes dark blueish colors, sometimes combined with an accent in a bright color (red, purple).
The materials used usually have a 'light' and modern look, like metals, glass and plastics with a high or satin gloss look.

In the location analysis, it is concluded that heavy materials like brick, concrete, cement and stones are used in the surroundings, with warm earthy colors like yellow, orange and red, with a mat or satin look.

Because the difference in look and materials in the smart city paradigm and the surroundings, it is important that the pavilion has a more neutral look. Next to that, materials should be as well opaque as transparent (for the transparent part of the roof).

For resistance against outdoor condition in Italy, following conditions are in order: temperatures between -10 and +50°C, rain and exposing to UV radiation.

5.3.2. Chosen materials

For the pavilion itself, two different materials are used (except for the technical parts). The parts supporting the roof (the middle plane of the panel and the poles) need to be strong; therefore these are made from stainless steel.
To save in weight (for especially the roof), and to have a wide variety of options of color, forming and transparency, the rest of the pavilion is made from plastic. Different plastics that meet the requirements which can be used as well transparent as opaque are in example PVC, acrylic (PMMA) or ionomers. However, for outdoor use, most plastics need to be treated in a special way. Therefore, the detailed materials to use should be defined in further research.

At last, for the pavement a layer that can be applied to different surfaces will be used. A manufacturer of this kind of layers is Edfan, which produces microcemento (EDFAN, n.d.). The pressure sensors can be placed under this layer. Depending on the pavement of the square where the pavilion is placed, extra foundation is needed.

To fit within the surroundings and the smart city paradigm, a neutral look is chosen. The plastic parts will be given the same look as the satin finished grey stainless steel, by giving it a grey color and satin finish.

The color accents within the pavilion will be given by the ambi LED lights and the screens, to give a more modern look.

6. Evaluation

For the evaluation of the design, the program of requirements and wishes is checked. About the functions of the pavilion not all requirements can be evaluated, because the design of the software and exact interaction programs still has to be done. In this further design, the stated requirements should be taken into account.

6.1. Main requirements

The main requirements, stated in paragraph 2.3 on page 9 are mostly met. The pavilion connects to a network, functions on its own and is designed to attract the target group in public space. The basic requirements regarding sustainability are not all met; this is described in paragraph 6.5.

6.2. Functioning

Most of the requirements regarding functioning have to be met within the interaction design. However, the pavilion is designed in a way that it doesn't impede to meet these requirements in the interaction design, and these requirements were used as a guideline while designing the object.

6.3. Use

With the design of the pavilion and the choice of technical parts and materials, the requirements of maintenance and weatherproof are fully taken into account. The pavilion can be used by multiple users at the same time (as well individuals as groups). However, the specification of 5 individual users at the same time is not met.

This is due to one of the other requirements, namely the comprehensibility. To keep the pavilion comprehensible, a division between interaction and showing information is made. Therefore, it is not possible to have five individual users interacting with the pavilion at the same time, but it is possible for more people to see the information.

The comprehensibility and intuitive use are also mostly defined by the interaction design, which still has to be done.

6.4. Design

The pavilion attracts people by the open look and the walking path through it, enhanced by the porches.

The size of the designed pavilion is a bit larger than the original stated maximum size, but the form also changed. Instead of a squared or circled object, the object is now lengthier, and therefore uses the same surface.

The pavilion has a neutral look to fit within as well the surroundings as the smart city paradigm. However, because these two styles are quite opposite to each other, the look of the pavilion is kept neutral and simple to fit in with both.

6.5. Sustainability

Within the choice of materials, sustainability is taken into account; however, the detailed material choice still has to be made.

At the moment, the energy consumption of the pavilion is not close to zero, as stated in the basic requirements, and a wish in the program of requirements and wishes. In the calculations made, it is shown that this is not possible for the designed pavilion and its size. However, in the future project, it might be possible to install photovoltaic modules close to the pavilion to generate enough energy.

6.6. Safety

To create a high perception of safety, the pavilion has an open but solid look and it is lighted during the evening. However, more research can be done to the use and design of lighting and the results of it on safety perception.

For physical safety, the object has a solid design with no small edges. The bottlenecks for physical safety in the later detailed design are the plugs for USB and mini-jacks and the grid for PC ventilation.

The digital safety should be taken into account with the interaction and software design.

7. Conclusions and recommendations

Most important goal of the project was to contribute to the development of smart cities, with a focus on people, their knowledge of smart cities and social cohesion. With the designed pavilion, Italians are introduced to the smart city paradigm by bringing 'known' smartness of social networks to public space, instead of an individual approach of social networks.

The result of this bachelor thesis is a first conceptual design of a multifunctional interactive pavilion to introduce Italians to the smart city paradigm. This pavilion focuses on young people and adults without children, and is designed to be placed in squares in Italy. Because the objective of the assignment was quite free for different interpretations, first a thorough analysis of the different aspects of smart cities and Italian background is made. Therefore, the final design and especially the interaction design of this project should be developed further before a prototype can be produced and tested. For this further design, the following recommendations are made:

7.1. General recommendations

As said above, First of all the pavilion should be developed further regarding the technical detailed design and the interaction and software design. Next to that, within further design it can be interesting to look at the following points:

At the moment, the pavilion has a neutral look to fit in within the surroundings and the smart city paradigm. However, this design is based on one reference square and three other visited squares. It might be interesting to create a look that is adaptable to the surroundings, to create more cohesion between pavilion and its surroundings.

The designed pavilion is supposed to be part of a network of pavilions. The conceptual design for a node in the network is made in this project, and – as said – can be developed further in the future. However, for a functioning system, it is important that also the network itself should be designed. For the infrastructure PLC technologies (as mentioned in The main idea of urban communication pavilion in smart cities) can be used, but different options should be explored. Also the possibility of the use of an external server should be taken into account.

An important aspect within smart city development is sustainability. At the moment, the pavilion uses as much sustainable materials as possible, but it is energy consuming. Therefore, while placing the pavilion, a project about sustainable energy in the surroundings of the pavilion can be generated. With the use of for example photovoltaics on buildings closeby, the energy use of the pavilion can be balanced.

7.2. Recommendations regarding technical detailed design

Also within the technical detailed design, sustainability is an important subject. With the choice of the detailed technical parts and materials it is important to take sustainability and energy use into account. With the choice of these technical parts, a more detailed research to the restrictions and requirements regarding cables, dimensions, ventilations and operating circumstances that come with them should be made.

Next to that, the developments in technology on the fields of touch screens and other interaction methods should be closely followed. A specific part for this is the development of round touch

screens. Another option is to develop a new installation for a round touch screen working with projection, to create the round touch screen for which the pavilion is designed.

The above stated recommendations are only two more important further developments. As said, before the pavilion is ready to be produced the more detailed design should be done. With this, the requirements stated on page 33 should be taken into account.

7.3. Recommendations regarding interaction and software design

As said in the analysis of smart cities on page 10, six characteristics of smart cities are defined. It is interesting to contribute to more of these characteristics by implementing them in the software and interaction design by for example the use of agents.

Before the interaction design and the software design first a detailed research should be done to what is possible and what people want for interaction. Conclusions from this research combined with requirements stated on page 33 will give the requirements for the software and interaction design.

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Appendices

1. Target group analysis

The determined possible target groups are as follows: young people (from 14-25); elderly people (65 years and older); adults without children; adults with children and tourists.

Next to these five target groups, which are described by different scenarios, two other groups are explained. These groups (passers-by and local residents) are part of the different target groups, but use public space in a specific way.

1.1. Description of the possible target groups

1.1.1. Young people

The group of young people can be split up in to two other groups: teenagers and students, which are described by two different scenarios below.

Student Catalina

Catalina is a 22 year old student. During the weekdays she attends her classes. Between them she usually relaxes with fellow students and sometimes studies at the public places at campus, like the library and a square outside.
At night she meets with her friends in public squares, where they have the opportunity to get something to eat or drink. She and her friends hang out together and chat. Because students aren't that punctual, Catalina (or her friends) usually have to wait for each other. Luckily Catalina has a smart phone, so she has something to do when she has to wait a long time.

Teenager Mateo

After school, the 15 year old Mateo always meets his friend at the same wall close to a public park. On their way there, they buy something to eat and drink at the supermarket. Over there, Mateo listens to some new music a friend of his brought. After sharing some music and the latest news Mateo and his friends are thinking of what to do that afternoon and in the weekend. They agree to go to the shopping mall in the weekend, but can't find out what to do that day. After a while, they find a ball and start to play some football before going home for dinner.

1.1.2. Elderly People

The group of elderly people exists of all retired people. Nowadays, the Italian government is changing the retirement age to 65 years for both man and woman in 2012 (AFP, 2010). Therefore, the size of this target group will be determined by the number of people of 65 years and older.

Mister and misses Bardi

At the bar, the 68 year old mister Bardi is meeting some other men, where they have a coffee while discussing the latest news and sport results. After a few hours, somebody brings a pack of cards, and they start a card game. However, mister Bardi isn't joining, he's going to meet with his wife.
Miss Bardi went out with some women; they spent the morning strolling around the market. While chatting about their family and some cosmetics, they looked for some new sewing materials, to create presents for their grandchildren.
After that, Mister and Misses Bardi come together, to visit their grandchildren. They're taking them

out for an afternoon in the park, where the children can play. Over there, their grandson tries to talk them into using a cell phone, but mister and misses Bardi don't want it, because they think they don't need it.

1.1.3. Adults without children

The target group 'adults without children' contains all adults when they are without children. Next to childless people, also parents are part of this target group when they are out without their children. The age of this target group is 25-65.

Lorenzo during working hours

During the week, Lorenzo Pazzi works at a company as a sales manager. When he goes to work or returns home, he's always in a hurry, but at lunchtime he has the possibility to relax a bit. Today, Lorenzo and his colleagues go out together to a small restaurant. They chat about the new smart phone that's just released and discuss the news. After some time, they go back to their office. Outside, they meet Allesandro, who spent his lunch break by reading a book and enjoying the sunny weather. He just bought a sandwich at the corner.
When arriving back in the office, Lorenzo has a meeting with another colleague, who just came back from the fitness centre during lunch time.

Loredana in her spare time

This weekend, Loredana is meeting a lot of friends. On Friday night, she's going to have a drink with some friends in a bar in the city centre. With two of the girls, they decide to go to the shopping mall next day. On Saturday morning one of her friends calls in sick, so Loredana calls some other friends to go to the mall together, one of her friends will pick her up by car at home.

1.1.4. Adults with children

Lorenzo in his spare time, while with his family

When arriving home from work, Lorenzo greets his children who have been at school al day. While his wife, Maria, is cooking diner, Lorenzo goes out to walk the dog. Last weekend they went out with the children to a shopping mall, where they bought new clothes. On Sunday they met Maria's parents and went out to a park, where the children could ride on a bicycle and use the playground. This weekend, Lorenzo and Maria are planning to take the children on a trip to the seaside, where they can enjoy the sun and relax a bit, while the children can play.

1.1.5. Tourists

Julia, Mary and Josephine

After a long morning of sight-seeing in Rome, Julia, Mary and Josephine want to have a little break, to give their feet some rest. They find a nice piazza and sit down on the stairs near the fountain. After chatting about the things they've seen, they see a church on the square, where they would like to know something about. Unfortunately they forgot their travel guide, so they can't look it up.
After visiting the church, they discuss where to eat. They want to find a nice place close there. Mary tries to ask an Italian guy, but because of the language barrier he can't help them. However, after wandering around, they find a nice place to have lunch.

1.1.6. Other groups

Local residents

Because local residents usually move to other places for relaxation or social activities, no scenario of the current situation can be made. However, an explanation of the current situation is given below.

In Italy, there are a lot of commuters. People are used to travel to go to work, relax or for social activities. Throughout the cities and surrounding areas are a lot of places for relaxation or social activities, like big shopping malls, parks, playgrounds or the seaside and lakes. However, within residential areas there are little opportunities for relaxation and social activities, because Italians tend to go out for these things.
The same problem exists in small villages, where most of the time there's also no central meeting point, but residents go out to the big shopping malls or relaxation spots in the surrounding areas.

People passing by

Because passers-by don't use public squares in particular nowadays, no scenario can be written about this. However their situation is described below.
People passing by public places don't intend to stop there, but are heading for something else. If the use of the public place should be increased for passersby, it's important to grab their attention. However, they are not planning to spent time there, so the attraction should be very accessible, without asking too much from the people passing by.

1.2. Study of added values

Different target groups and aspects of functions are defined in the functional analysis and target group analysis. To create an overview of the combinations which add most value to society, a study of the added values has been carried out amongst the ENEA project team of 'smart cities and eco-industry'.

Every member of the team rated each aspect of function on how much added value it would have for the specific target group with a rate between 0 and 3 (with 3 as the highest added value). The total results of the study are the summed values given by the different people. The cumulative results are shown in the table below. The conclusions to these results can be found in the paragraphs 3.4.1 and 3.4.2.

The ratings given by the team members are shown in the tables on the next page, where the group to which each member belongs is marked.

Added values of the object per target group and aspect Cumulative results							
	social communication	**information**	**comfort**	**physical activities**	**edutainment**	**monitoring**	**total**
Young people (14-25)	18	7	2	10	14	0	51
adults with children (0-14)	7	6	11	6	17	0	47
adults without children (26-65)	12	9	13	13	6	0	53
tourists	4	18	11	3	6	0	42
elderly people (65+)	10	9	17	5	5	0	46
city government	1	8	0	0	1	18	28
Total	52	57	54	37	49	18	267

Stefano Pizzuti	social communication	information	comfort	physical activities	edutainment	monitoring	total
students and teenagers	3	0	0	2	1	0	6
adults with children	0	1	0	2	3	0	6
adults without children	1	2	3	0	0	0	6
tourists	0	3	3	1	1	0	8
elderly people	0	3	3	0	0	0	6
city government	0	0	0	0	0	3	3
total	4	9	9	5	5	3	35

Fabio Moretti	social communication	information	comfort	physical activities	edutainment	monitoring	total
students and teenagers	3	0	0	1	2	0	6
adults with children	0	1	2	0	3	0	6
adults without children	1	0	2	3	0	0	6
tourists	0	3	1	0	2	0	6
elderly people	0	2	3	0	0	0	5
city government	0	2	0	0	0	3	5
total	4	8	8	4	7	3	34

Giuseppina Giuliani	social communication	information	comfort	physical activities	edutainment	monitoring	total
students and teenagers	3	2	0	1	2	0	8
adults with children	2	1	2	1	3	0	9
adults without children	2	2	1	2	3	0	10
tourists	0	3	1	0	1	0	5
elderly people	2	0	3	1	2	0	8
city government	0	1	0	0	0	3	4
total	9	9	7	5	11	3	44

Hanke Nijman	social communication	information	comfort	physical activities	edutainment	monitoring	total
students and teenagers	3	2	1	2	3	0	11
adults with children	3	0	3	1	2	0	9
adults without children	3	1	2	3	1	0	10
tourists	2	3	3	0	0	0	8
elderly people	3	1	3	2	1	0	10
city government	1	3	0	0	1	3	8
total	15	10	12	8	8	3	56

Mauro Annunziato	social communication	information	comfort	physical activities	edutainment	monitoring	total
students and teenagers	3	1	0	2	3	0	9
adults with children	1	1	3	0	3	0	8
adults without children	2	2	2	2	0	0	8
tourists	0	3	2	0	0	0	5
elderly people	2	1	3	1	0	0	7
city government	0	1	0	0	0	3	4
total	8	9	10	5	6	3	

Claudia Meloni	social communication	information	comfort	physical activities	edutainment	monitoring	total
students and teenagers	3	2	1	2	3	0	11
adults with children	1	2	1	2	3	0	9
adults without children	3	2	3	3	2	0	13
tourists	2	3	1	2	2	0	10
elderly people	3	2	2	1	2	0	10
city government	0	1	0	0	0	3	4
total	12	12	8	10	12	3	57

2. Choice of location

To determine the location of the object, different locations are analyzed. Following aspects are taken into account for the choice of location:
The location should accommodate the main target groups: young people and adults without children and there should be enough space to put the object. It is important to use a square that already functions well, to focus on the object and its users while designing, instead of on the attractiveness or lay-out of the square.

To make a choice of location, different locations are analyzed. The analyzed locations are chosen based on information from several employees at ENEA. There are four locations analyzed: a square in Bracciano and two squares and a park in Rome. The different locations are analyzed on space, public and use and surroundings.

2.1. Analysis of different locations

2.1.1. Bracciano - Piazza IV Novembre

Bracciano is a town with 18.6 thousand citizens (Comuni-Italiani.it, 2010) which lies at the shore of Lake Bracciano. Piazza IV Novembre is situated in the centre of the town.

figure 1: Collage Bracciano – Piazza IV Novembre

Space

The relatively large square in the centre of town with dimensions of 50 by 50 meters, lies on the hill of Bracciano. With the square equally leveled, the surrounding roads are above the square on one side, and beneath it on the other. The well-designed square accommodates a war memorial monument and the main entrance to the Palazzo Communale (Town Hall) which now hosts a small museum. In the centre of the square a fountain is surrounded by three palm trees and some greenery. The square has several facilities: multiple seats, lighting, waste bins and a drinking fountain, a tourist office kiosk, a paper kiosk and at the side of the square there's a café with a terrace.
The square emits a quiet and relaxed atmosphere.

Public and use

The square is commonly used by the target groups of elderly people, parents with children and adults without children. There are almost no young people gathering at the square during the day. Although the square is mostly used for relaxation, it also accommodates some festivals and markets through the year.
During the summer months, the Bracciano Lake attracts several tourist, therefore it is expected that the square accommodates tourist in the main season.

Surroundings

The square lies in the town centre of Bracciano and is therefore surrounded by restaurants, (governmental) offices and shops, which are usually close in the afternoon. Close by is the Castello Orsini – Odescalchi which is, next to the lake, one of the main touristic attraction points of Bracciano.

2.1.2. Piazza dell'immacolata – San Lorenzo – Rome

Piazza dell'Immacolata lays in the district of San Lorenzo in Rome, between Termini station, the Verano cemetery and Università La Sapienza, the biggest university of Rome (Quacquarelli Symonds Limited, 2010).

figure 2: Collage Piazza dell'Immacolata – San Lorenzo

Space

The relatively small square (50 by 30 meters including small streets at the side) descends little, with the church of Santa Maria dell'Immacolata at the high end. The design of the pavement leads attention to a central point at the low end. The car-free square has multiple seats, waste bins, lighting and trees.
The square has a lively and relaxed atmosphere.

Public and use

Because the square is so close to Rome's biggest University, there are many students seen at the square, as well during the day between classes as at night, to enjoy the night life in San Lorenzo. Adults without children can be found at the square too, from working people during their break to moms while their children are at school. Few elderly people visit the square.
During summer (from July until October) a summer festival is held at the square, with performances, art exhibitions and market stands alongside the square.
People use the square to pass by from different places, have a look at the different stands during their brake, have something to drink or eat at a terrace or just relax on a bench.

Surroundings

Diagonally connected to the square is another square with a daily market with a food division and a division with clothes, shoes and domestic products. This daily market attracts many people, who pass by piazza dell'Immacolata.
With a mix of bars, cafés, restaurants and clubs the district of San Lorenzo is popular amongst young people and adults without children in Rome. With the university close there are always a lot of students.

2.1.3. Villa Mercede – San Lorenzo – Rome

Another place in San Lorenzo (close to University of La Sapienza and Termini station) is the park of Villa Mercede.


figure 3: Collage Villa Mercede – San Lorenzo

Space

Villa Mercede is a park which can only be entered during the day by the main entrance. With all greenery and trees, the park doesn't leave much open space that can be used. Within the park is a small playground for children and a basketball field. The park accommodates one of the libraries of Rome, which houses about 20.000 books and has a user surface of 320 square meters.

The park itself has dimensions of about 90 by 100 meters, but the largest open space, which is between the playground and the library and surrounded by benches, is 20 by 10 meters. With the greenery and trees the park has a quiet and relaxed atmosphere.

Public and use

In the park, the target groups of elderly people, adults with children and some students can be found. Most people are seen close to the playground and library, where also the open space is. The park is used for relaxation in multiple ways. Next to the playground and seats, there's also a basketball field, where sports can be played.

Surroundings

The busy roads that surround the park don't have much influence on the atmosphere of the park, because the park is surrounded by walls. With the University of La Sapienza and a retirement home close by, more elderly people and students are seen in the surrounding environment. At the entrance of Villa Mercede there are some stands which sell food or newspapers. A few streets ahead are the shops and bars of San Lorenzo.

2.1.4. Piazza di santa maria liberatrice – Testaccio – Rome

Close to Trastevere, at the other side of the Tiber, is the district of Testaccio. In the centre of Testaccio there is piazza di santa maria liberatrice.

figure 4: Collage Piazza di santa Maria Liberatrice - Testaccio

Space

Piazza di Santa Maria Liberatrice is a large square, with the atmosphere of a park. The square has a length of 150 meters, and a width varying from 75 meters at one side, to 20 meters at the other. The square exists of three circles spread over the length, which are connected by a path. The remaining space is filled with greenery and trees. The three circles are as follows (from the small to the wide side).

- The first is the smallest square, with a diameter of 16 meter. In the middle of this circle is a small monument, which is surrounded by several benches.
- The largest circle is in the middle, and connects with the pavement on the sides of the square. This circle has a diameter of 35 meters and is surrounded by a small wall which invites to be seated on. At the side there are a few large trees. Although this circle square is really big and invites for something in the middle, it is empty at this moment.
- The third circle has a diameter of 27 meters and contains a playground for children. There are not only seats on every circle, but also along the path and the sides of the complete square. With its greenery, the square emits the atmosphere of a nice and quiet park.

Public and use

On the square are several parents with children (close to the playground) and elderly people, there are many non-working people, but almost no other adults without children or young people. The square is mainly used to relax.

Surroundings

Connecting to the square is the church of Santa Maria Bellatrice, which probably attracts a lot of elderly people during masses. Around the square is a quiet road, a lot of residential buildings and few bars. The square is on the other side of the Tiber as Trastevere, which is a popular neighborhood amongst students and tourists. However, there are no students and tourists visiting the square currently. Close to the square is also a daily market, which is only opened in the early morning hours.

2.2. Conclusions

From the analyzed locations, two stand out for different reasons. Piazza dell'immacolata in San Lorenzo is the only location that has a public that fits the preferred target group well, and Piazza di Santa Maria Liberatrice in Testaccio stands out because the available space at the centre of the square, where the object can add much value.

Although the space at Piazza di Santa Maria Liberatrice fits the requirements for a location very well, the use of the square and the public don't fit the desired target group. Piazza dell'Immacolata fits the requirements on target group, space and use of the square best. Therefore the object will be designed for this square.

3. Location analysis – Use of space

The festival 'San Lorenzo in Piazza' is held every year on Piazza dell'Immacolata from July until October. During this festival, the square hosts some market stands and a stage, where activities like performances, exhibitions and workshops are held every evening. Because of this festival, the use of space on the piazza between summer (July - October) and winter (November – June) highly differs.

3.1. Use of space during winter

Figure 5: Use of space during winter

During winter, the square exists of an open space which slightly slopes with four steps of about 20 centimeters, the placement of benches and trees can be seen in the image above. On the bottom of the stairs is a relatively large open space, which is fenced off from the side of the square by another bench.

3.2. Use of space during summer

Figure 6: Use of space during summer

As can be seen, the sides of the square are used as passage ways. The open space in the middle remains, but is used as the 'theater' for the stage. At night people sit down on the stairs and the chairs placed especially for performances.

The low stage is fenced off by temporary placed greenery, to prevent people from walking on it during the day.

4. Analysis of possible technologies and theories

To create a clear view of what is possible with modern technologies, an analysis of different theories which can contribute to the project is made. Next to that an analysis is made of possible technologies that can be used within the object, sometimes to reflect a theory.

4.1. Theories

In this paragraph the theory of the smart city isn't discussed. More information about this theory can be found in the analysis of the term 'smart cities' on page 10.

4.2. Info mobility

Info mobility refers to access to (digital) information, anywhere, anytime. Therefore, the information is 'mobile' (Moraïtis, Petraki, & Spanoudakis, 2003). Examples of info mobility are the iPad or the use of smart phones to connect to the internet. With info mobility, users are always and everywhere able to check on up-to-date information.

4.2.1. Green Mobility

The main theory of green mobility focuses on a future use of transportation. The ideology of green mobility is a transport system producing zero emissions and sparing the surface landscape, while people can travel hundreds of kilometers daily (Ausbel, Marchetti, & Meyer, 1998). To reach this goal, (Ausbel, Marchetti, & Meyer, 1998)suggest new and more integrated implemented transportation such as airplanes and magnetic levitating trains. Their study states that to optimize the use of transportation means the implementation takes about 100 years. Therefore, Ausbel *et al.* state that current developments should be continued to create green mobility.

Within the smart city, especially the combination of green mobility with info mobility is interesting. If detailed dynamic traffic information is available, the traffic can be optimized through the use of info mobility.

4.2.2. Web 2.0:

Web 2.0 is a theory about the use of the technologies of the World Wide Web. Within the first generation of the use of the World Wide Web users could only access information, which could only be changed by the owner. With Web 2.0 the World Wide Web became more interactive, by using users as sources of information (crowd sourcing) (Anderson, 2007; O'Reilly, 2005). Some examples of web 2.0 applications are Facebook, YouTube and Wikipedia.

There are some difficulties with the use of crowd sourcing. If everybody is able to change or add content, it's easy for people to do harm. Therefore users of these applications need to be cautious and critical to information given. Most applications created the option of voting for relevance of contributions, commenting on information to help people in deciding about reliability. Next to that, it's often possible to report abuse of applications. If abuse is reported by users, the creators or owners of the application take action if necessary (Facebook, n.d.; Twitter, n.d.).

4.2.3. Sustainable materials

In the designing world a lot of theories exist about sustainable design and these theories have different views on how sustainable designs should be made. However, the life cycle of materials and products is an important part of sustainable design.

To make a sustainable design, the whole life cycle of materials and products should be taken into account, which includes the following stages: raw material acquisition, manufacturing of materials, production of the product, use/reuse/maintenance while the product is actually 'used' by the user, and waste management, when the product is disposed (Scientific Applications International Corporation, 2006). To analyze the sustainability of the life cycle of a product, a life cycle assessment can be made. Within the choice of materials, the life cycle of materials need to be taken into account.

4.3. Technologies

Different technologies are listed according to different categories (renewable energy sources, interaction, lighting and materials). Within this paragraph not all possible technologies are listed, but a focus is made on interesting technologies that can contribute to this project. For some technologies, an extra explanation is given bellow.

4.3.1. Renewable energy sources

- solar energy
- wind energy
- water energy
- hydropower
- Biomass
- gaining energy through people[1]

4.3.2. Interaction

- Sensors (for example audio, visual, touch, or air quality)
- Transmission[2]
    - Bluetooth
    - Wi-Fi
    - Power Line Communication[3]
    - GPS
    - Sms/mms
    - email
- Audio output
- Visual output
    - Light
    - Form transformation (hydraulics,
    - Screens/displays (spatial display the cloud)
    - Electronic ink[4]
- (Interactive) touch screens

4.3.3. Lighting

- Daylight transportation through fiber optic cables
- Compact Fluorescent Light (CFL)[5]
- Light Emitting Diode (LED) [6]

[1] During the market analysis on page 13, there appeared some ways of generating energy through the movement of people.

- Harvesting energy through walking movements:
  With the use of piezoelectric technologies in ground surfaces, energy can be harvested from people walking over the surfaces. This technique is used in the Underground in Tokyo (Ogasawara, 2008)and in an energy generating dance floor in a disco in London, where it's said to supply for 60% of the energy needs of the disco (Trotter, 2008).
- Next to the harvesting of energy through walking, it's possible to use specific movements to gain energy, for example by cycling.

[2] Within the interaction analysis (on page 17) two ways of transmission can be defined: the transmission between object and user, and the transmission between two (or more) objects. The stated technologies for transmission can be used in one or both of these ways.

[3] Electronic ink is a new technology, used in e-readers. The use of electronic ink has the advantages of reading on paper, but with up-to-date information. The e-ink microcapsules contain positive charged white pigment and negative charged black pigment. By changing the pattern of the electric field, a black/white image occurs. When there's no electrical field applied, the image stays in the pattern of the last applied electric field. Therefore, E-ink only consumes power for the change of an image, and not if it stays the same. Because E-ink works with electrical fields, the image can only be two-colored. (E-Ink Corporation, n.d.)

[4] With Power Line Communication technologies, it's possible to send data through power lines (Adams, Rochelle, & Symonds, 1988). An example of the implementation of these technologies in public space is the Minos System, a remote monitoring and control system for outdoor lighting (UMPI Elettronica S.R.L., n.d.)

[5] CFL Light bulbs are up to 10 times more efficient than incandescent light bulbs and use up to 80% less energy (Energy efficient Lighting, n.d.). The newer CFL lights give a warm comfortable light, instead of the cold white of older CFL's, and are available in multiple designs. Although CFLs are low cost in producing and use, the recycling of the CFL light is more difficult, because CFLs contain the toxic mercury.

[6] Another development in sustainable lighting is LED lighting. LED lights have a lifetime of ten times the lifetime of CFL lights and contain no toxic matter (Energy efficient Lighting, n.d.). Next to their sustainability, the applications of LEDs are interesting. The small size of LEDs makes it possible to light specific points, but it's also possible to bundle LEDs to create a wider light bundle.
Next to one colored LEDs, also RGB LEDs exist. These LEDs have the feature to change the color of the light.

5. Energy use

One of the requirements is to use energy efficient technologies, and one of the wishes is to make the object energy autonomous. The only useful option for energy production on this kind of object, placed on squares in cities is solar energy. Therefore, an analysis of the energy consumption and energy production is made. With the use of the above stated parts and this measurements of the roof solar energy can only cover about 14% of the total energy needs.

5.1. Calculations of energy consumption

A first calculation of energy consumption gave a result of about 8000 kWh a year. To decrease the energy consumption, the touch screens for interaction will be off if there are no people close around the object. If there are no people at the square at all, all screens will be turned off and the computer will be put in a hibernation mode.

To analyze the presence of people, different sensors are used. To analyze the presence of people close to the object pressure sensors in the ground will be used. To analyze the presence of public at the square presence sensors as used in alarm systems or garden lighting are used.

As this is a preliminary energy consumption calculation, the hours resulting from the sensors discussed above are estimated.

Part	average power consumption (W)	estimated power consumption a piece (W)	number of pieces	total power consumption (W)	times used during a day (h)	energy use daily (Wh)	energy use yearly (kWh)	% of total
computer visualization	60-500[vii]	100	1	100	14	1400	511	10%
computer interaction		250	1	250	7	1750	639	12%
computer hibernation	60-500	5	2	10	3	30	11	0%
touch screens	48-246[viii]	200	2	400	7	2800	1022	20%
normal screens	50-150[ix]	100	2	200	14	2800	1022	20%
ticker	125-200[x]	150	1	150	14	2100	767	15%
sound boxes	[xi]	25	2	50	7	350	128	2%
presence sensors		10	5	50	24	1200	438	8%
Led Lighting	unknown	1	100	100	12	1200	438	8%
subtotal						13630	4975	95%
margin	5%					682	249	5%
total consumption						14312	5224	100%

Table 1: calculations of energy consumption

Within these calculations, mini-jack plugs, webcam and USB/SD slots are neglected because they are integrated in the energy consumption of the computer. The pressure sensors are neglected because their consumption is really small. The energy use of a wifi router is not included at the moment, because no data of this could be found on the internet.

5.2. Calculations of energy production by PV modules

To calculate the possible energy production, sample data of PV modules has to be used. This information comes from (FVG Energy, 2009). These PV modules are quite small (270*380 mm), and therefore most of the surface can be used. There are more efficient PV technologies, but these modules all have measurements of about 1,5 meter by 80 cm, only 2 to 4 (depending on the inclination) can be placed on the roof, and most surface is unused. Therefore the energy production yearly will be the same or even less.

The used PV module with a dimension of 270*380 mm has a peak PV power of 10W (FVG Energy, 2009):

The optimized inclination for this location is 34° and an azimuth of -2° (European Commision Joint Research Centre, 2008). However, an inclination of 34° has much influence on the look and design of the object. Therefore, the result of energy production is calculated for different inclinations. Because the surface increases with a higher inclination, the peak PV power of a module is scaled to the surface of the roof.

To calculate the energy production of PV modules, the website of (European Commision Joint Research Centre, 2008) the following data is used:

- Location: Rome, Italy
- PV technology: Crystalline silicon (FVG Energy, 2009)
- Estimated system losses: 14% (based on the standard value of the website)
- Azimuth: -2°
- Installed peak PV power (kWp) and inclination: see Table 2.

inclination (°)	r1 (cm)	r2 (cm)	surface (cm^2)	kWp	kWh produced yearly	% of total
0	150	150,0	70685,83	0,689	761	15%
5	150	150,6	70955,84	0,692	793	15%
10	150	152,3	71776,28	0,700	827	16%
15	150	155,3	73179,36	0,713	846	16%
20	150	159,6	75222,29	0,733	905	17%
25	150	165,5	77993,19	0,760	950	18%
30	150	173,2	81620,97	0,796	1000	19%
34	150	180,9	85262,52	0,831	1050	20%

Table 2: calculation of energy production excluding shading factor

This table shows the maximum energy production depending for this location, including weather circumstances throughout the year. However, on the small square, the object will stand in the shade for some time. Using a shading simulation in Google Sketchup, the possible locations of the object on the square with quite little shade are determined, and these are analyzed in the program PVsyst to determine the shading factor. The locations used are shown in figure 7.

The results of the calculations of the shading factor of location 2 are shown in figure ; the shading factors for the three locations are as follows:

Location 1: 0,679
Location 2: 0,712
Location 3: 0,606

With these results, location two is chosen as the best location on the square, and this shading factor will be used in further calculations of the detailed energy production.

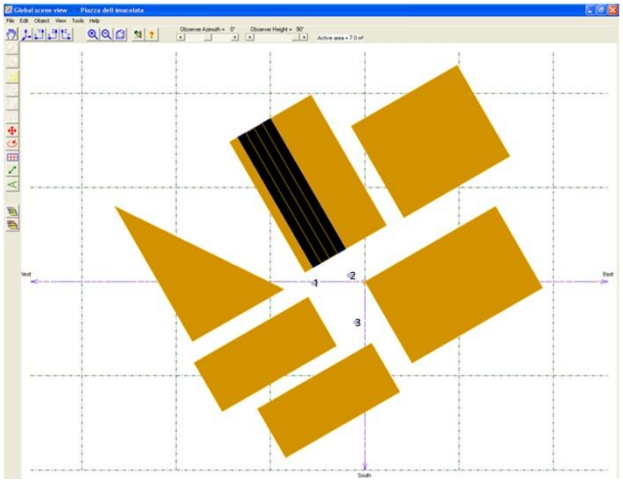


figure 7: model and locations of object during shading analysis

Shading factor table (linear), for the beam component

Azimuth / Height	-180°	-160°	-140°	-120°	-100°	-80°	-60°	-40°	-20°	0°	20°	40°	60°	80°	100°	120°	140°	160°	180°
90°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
80°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
70°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
60°	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.131	0.999	1.000
50°	1.000	1.000	1.000	1.000	1.000	0.882	0.944	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.655	1.000
40°	0.993	1.000	1.000	1.000	1.000	0.066	0.103	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.000	0.000	0.000	0.993
30°	0.987	1.000	1.000	1.000	0.687	0.000	0.000	1.000	1.000	1.000	1.000	0.807	0.458	1.000	0.840	0.000	0.000	Behind	0.987
20°	Behind	Behind	1.000	1.000	0.000	0.000	0.000	0.705	0.715	1.000	0.000	0.000	0.108	1.000	0.840	0.000	0.000	Behind	Behind
10°	Behind	Behind	Behind	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.108	0.000	0.841	Behind	Behind	Behind	Behind
2°	Behind	Behind	Behind	Behind	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.108	0.000	0.842	Behind	Behind	Behind	Behind

Shading factor for diffuse: 0.712 and for albedo: 0.006

figure 8: Calculation of the shading factor on location 2.

Using this shading factor, the final energy production for different inclinations is calculated, and the part of the energy consumption that can be covered. As can be seen in Table 3 maximum 14,3% of the energy consumption can be covered by integrated PV modules in the object.

inclination	energy production (kWh)	% of consumption
0	541,832	10,4%
5	564,616	10,8%
10	588,824	11,3%
15	602,352	11,5%
20	644,36	12,3%
25	676,4	12,9%
30	712	13,6%
34	747,6	14,3%

Table 3: calculation of energy production including shading factor

5.3. Conclusions

With the designed object and the corresponding energy consumption and possible energy production only little amount of the energy consumption will be covered. To create a substantial covering of energy consumption there are two options: To decrease the energy consumption or to increase the energy production.

Decreasing the energy consumption will also decrease the functioning of interaction of the object, therefore this is not a suitable option. Increasing the energy production within the object is hardly possible, most options have a really low profit due to location or other constraints. It is decided not to create an object focused on sustainability, but focused on the users and introducing people to the social and communication aspect of the smart city.

Because the profit is relatively low, within the further development of the concept both options (with PV modules and without) should be taken into account, to also involve the influence on the design and look of the object in the choice of using PV module.

[vii] Depending on functioning, between 60 en 250 watt for basic up to professional desktops (Bray, 2006), for high powered gaming desktops it can be 500 watt (Dell, 2010)

[viii] depending on size: for 55 cm, 48 W, for 106 cm,246 W, in between the changes are about linear (PC Connections, Inc, 2010), (Nextag Inc., 2010)
[ix] (Vergelijk.nl, n.d.)
[x] Hargo Geijbels (personal communication; e-mail, November 5, 2010)
[xi] (PC Speakers, n.d.)

6. Sketches of design of porches

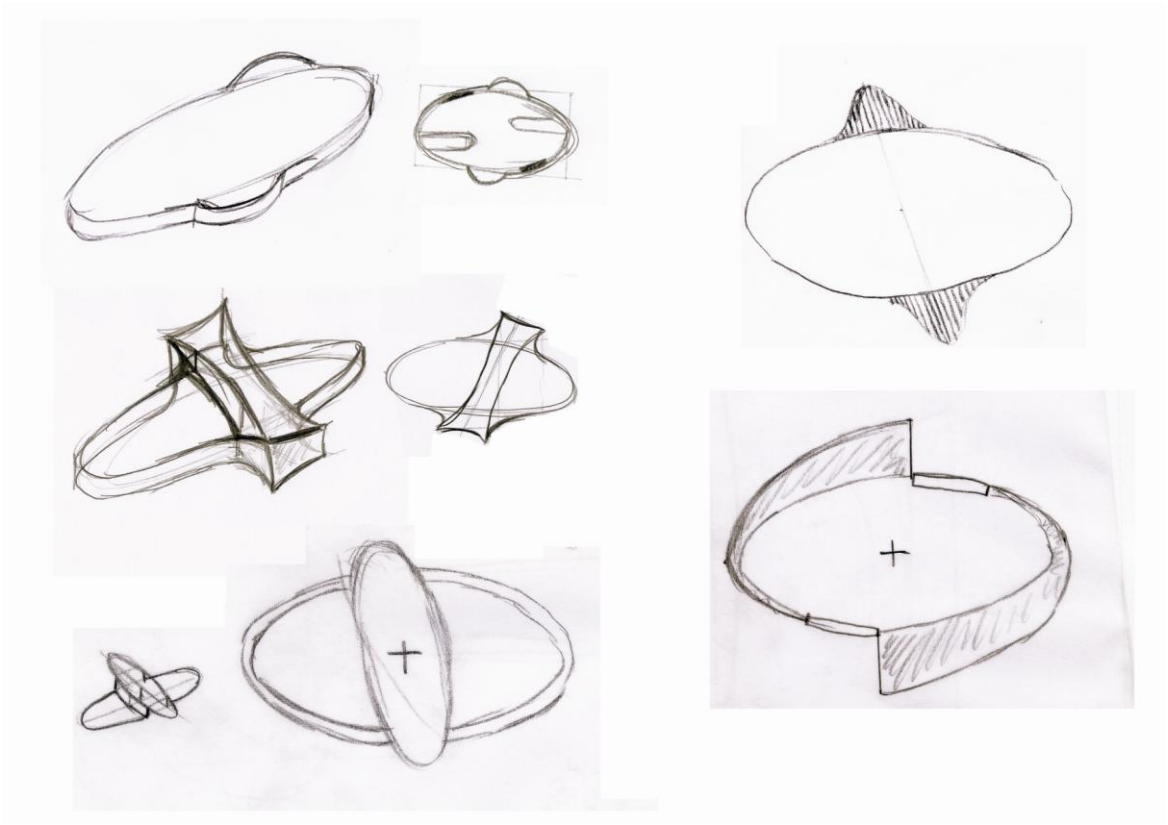


figure 9: Sketches of the development of the design of the porches

7. Estimated dimensions of technical parts

For the internal design of the object, some information about dimensions and connections of technical parts was required. This information is given below:

7.1. Landscape touch screen

Several companies are contacted to get information about the landscaped touch screen, but only one of the companies could provide with information. This company provides touch layers to be placed over other screens (EZScreen, 2010).
For the information on normal screens also several companies are contacted, but no replied. However, Samsung sells a thin 40" LED-TV (Samsung, 2010).

These screens combined give the following dimensions for the landscaped touch screen:

	Length	Width	depth
LED TV (Samsung, 2010)	969,4	582	8
Touch Layer (EZScreen, 2010)	958	570	12,2
Protection Glass (EZScreen, 2010)	-	-	3
Total	**969,4**	**582**	**23,2**

For a functioning screen, the following connections are needed:

- USB cable to connect the touch layer to the computer (EZScreen, 2010)
- Minijack audio in to built in boxes on screen (Samsung, 2010)
- Y-Pb-Pr video input (Samsung, 2010)
- Power cable for TV

7.2. Squared touch screen

EZScreen is able to produce the touch layer and protection glass in any rectangular dimension. Therefore, the same technology can be used for squared touch screens. As squared screens are only produced for industrial use, information on them can't be found on websites. Different producers are contacted for information on dimensions, but no company reacted on time.
However, as Samsung can produce an 8 mm thick LED TV, it is expected that also a squared screen can produced with the same thickness. Therefore the assumed dimensions are as follows:

	Length	Width	depth
Display (assumed based on Samsung, 2010)	969,4	969,4	8
Touch Layer (EZScreen, 2010)	958	958	12,2
Protection Glass (EZScreen, 2010)	-	-	3
Total	**969,4**	**969,4**	**23,2**

For the functioning of the object, the same connections as with the landscaped touch screen are required.

7.3. Horizontal Screen

It is decided to use a squared screen with active dimensions of 48 by 48 cm, which can be fitted into the circular object of 80 cm diameter. The form is maintained circular to create a more dynamic use

around the horizontal screen. As is found in the research on the internet, there are multiple conceptual developments of circular touch screens, and companies are starting to make a first prototype of small round screens. Therefore the development of circular touch screen displays should be closely followed in the future of this project, to maybe implement circular touch screens later.

The dimensions of the squared horizontal screen will be as follows:

	Length	Width	depth
Display	552	552	8
Touch Layer (EZScreen, 2010)	552	552	12,2
Protection Glass (EZScreen, 2010)	-	-	3
Total	**552**	**552**	**23,2**

For the functioning of the object, the same connections as with the landscaped touch screen are required.

7.4. Ticker

Round tickers are manufactured by several companies (i.e. (Outlook Electronics, 2010; Vegas LED Screens, 2010; LEDMAN Optoelectronic Co. Ltd., 2010)), which are contacted for information on the dimensions and implementation of the ticker. However, none of the companies could supply the required information.

To create a ticker readable up to 40 meters distance, the height of the characters should be at least 10 cm (Lichtkrantenshop.nl, n.d.).

As a reference for dimensions the specifications of a 8x8 LED dot Matrix by (LC LED Corporation, 2010) is used. This LED dot Matrix has dimensions of 60.2 mm by 60.2 mm; therefore, two are used to create a height of 120.4 mm.
This matrix has a thickness of 14,8 mm, but to connect the matrix for a functioning ticker, it is assumed more space is needed. Tickers sold by (Lichtkrantenshop.nl, n.d.) have a thickness of 45 mm.

Thus, the space needed for the ticker will be as follows:

	Height	depth
LEDs and technical features	120,4	45
Protection Layer	-	3
Total	**120,4**	**48**

To connect the ticker, the following cables and connections are needed:

- Power cable
- USB cable for programming text (Lichtkrantenshop.nl, n.d.)

7.5. Computer

According to Fabio Moretti, IT engineer and intern at ENEA, the most determining part for the size of space needed for the computer is the motherboard with several parts (graphic card, audio card, ram, cooler etc.) plugged onto it.

The dimensions of a standard motherboard with 7 slots are 325 mm x 267 mm, for the plugged in parts, about 10 to 15 cm of height should be sufficient.
Other parts needed for the functioning of the computer (i.e. adapter, video and audio output, USB and internet ports, hard disks) are smaller, and could easily be fit into the rest of the bench if this has an open space inside.

For the cooling of the computer, it's important to allow fresh air into the bench, therefore a rooster needs to be placed on the side of the bench.

7.6. Wi-Fi and Bluetooth

The wifi router and bluetooth dongle will be placed in the roof. To enhance the range of the router and dongle, they should be placed with only a thin layer of coverage. The dimensions needed are as follows:

	Length	Width	depth
Router (D-Link, 2007)	193	116,8	30,5
Bluetooth (USB Gear, 2010)	49,36	17,99	7,55

To connect both devices, the following connections are needed:

- Power connection for Router
- Internet cable for router
- USB connection for Bluetooth

7.7. USB and SD slots and minijack plugs

For USB slots, SD slots and minijack plugs, only the dimensions of the parts to be inserted can be found. However, these can be used for an estimation of the total space needed. In the table below, the dimensions of the to be inserted parts is listed

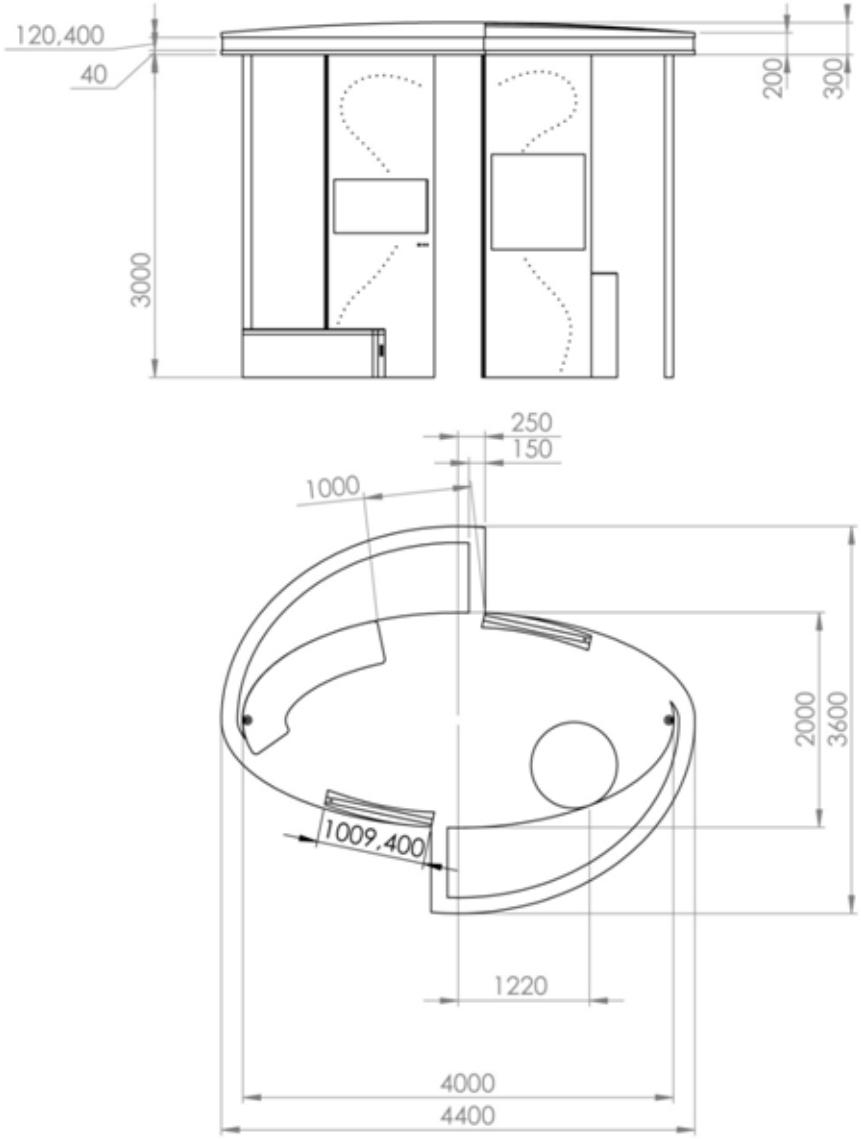
	Length	height	depth
SD card(SD Association, 2010)	24	2,1	32
USB plug (measured)	12	4	13
Mini jack plug	3,5	3,5	15

8. Dimensional charts

In this attachment, the dimensions of the object and the relations between the different parts are shown. After the complete object and relations within the object are shown, the dimensions of different parts are shown.

For the assemblies, also the list of used parts and their material is shown.

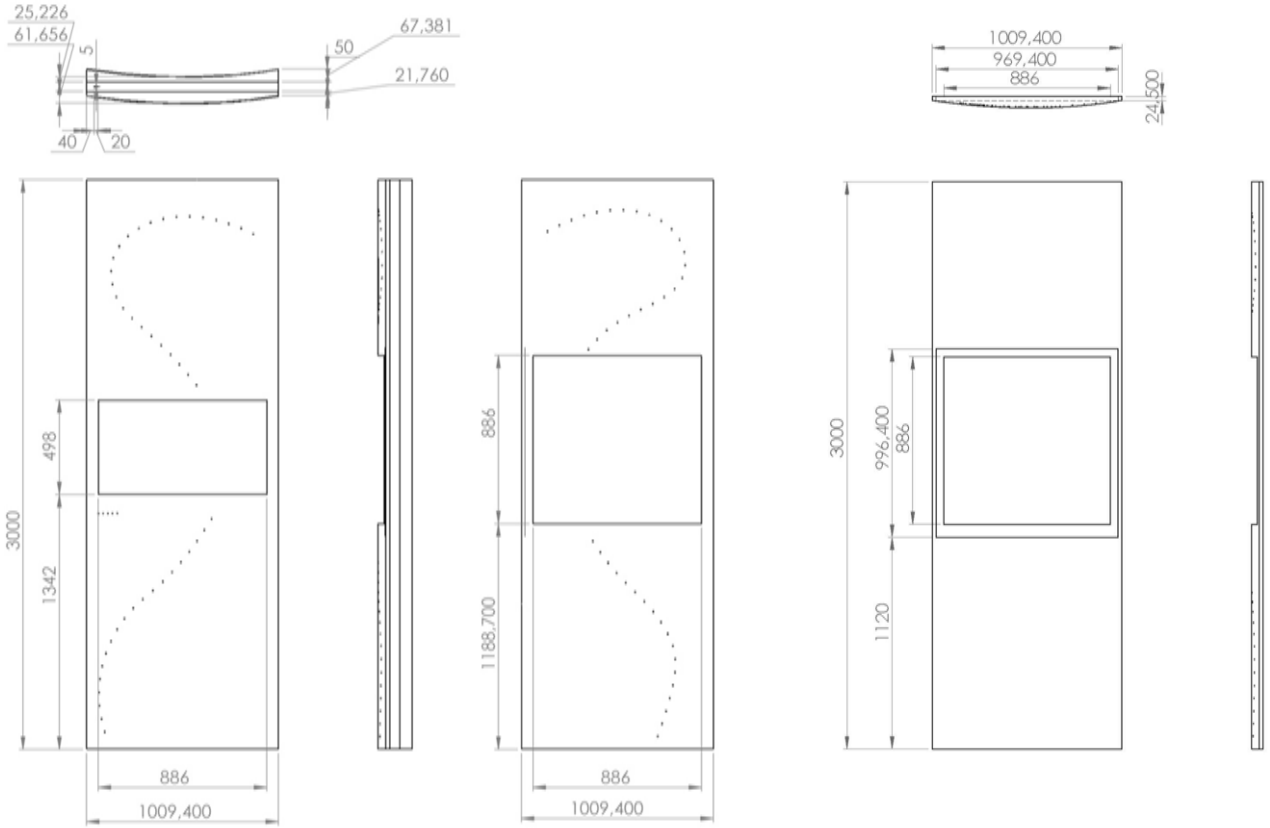
8.1. Complete object



ITEM NO.	PART NUMBER	MATERIALS	QTY.
1	pole	stainless steel	2
2	panelaudio	stainless steel,plastics and technical components	1
3	panelvideo	stainless steel, plastics and technical components	1
4	roof	plastics & technical components	1
5	horizscreen body	plastics	1
6	horizscreen	technical components	1
7	bench	plastics & technical components	1

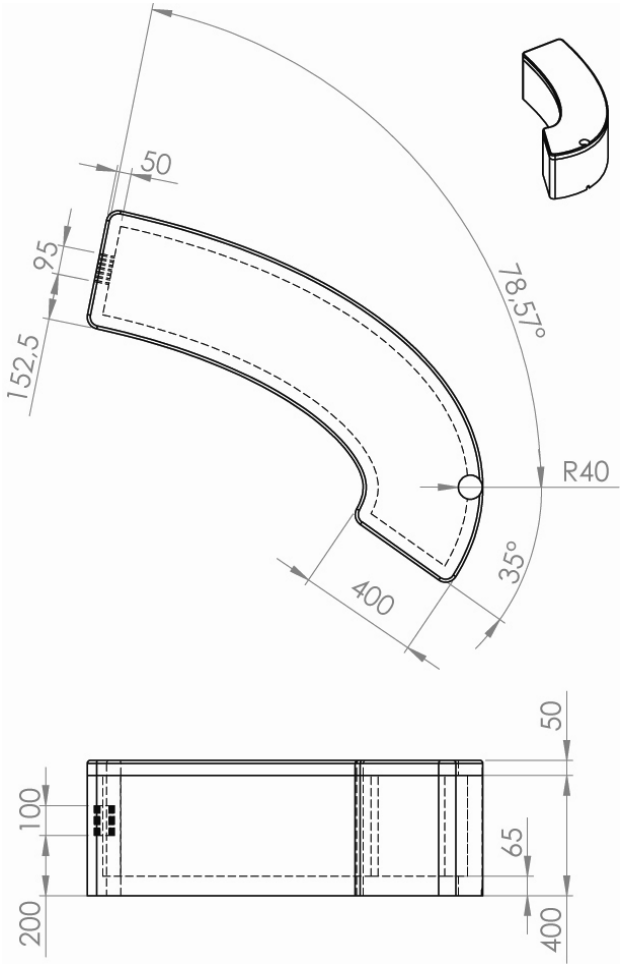
8.2. Panels

The figures below show the dimensions of one panel. In the first figure, the dimensions of the assembly are shown. In the second figure only one outside pane of the panel is shown.

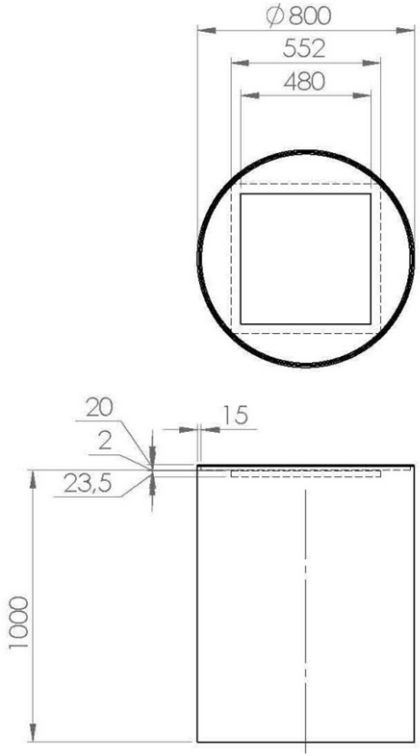


ITEM NO.	PART NUMBER	MATERIAL	QTY.
1	middlepanel	Stainless steel	1
2	outsidepanelaudio	Plastics	1
3	frontpanelaudio	plastics	1
4	landscapescreen	technical component	1
5	squaredscreen	technical component	1
6	led	technical component	206

8.3. Bench



8.4. Horizontal Screen



8.5. Pole