Product Design in the Smart City

Investigation of priority needs in terms of human interaction in the Smart City

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***Abstract*—The concept of Smart City refers to a developed city, which incorporates the required infrastructures and available technology to increase its economic and environmental sustainability, as well as the quality of life for its inhabitants. It involves a city equipped with the latest communication technologies in order to "function" by providing "intelligent" solutions to multiple issues. This control of technology in the management of resources, services and information in the city can increase the risk of threatening the interaction between people and the environment. In order to get feedback about people's concerns and priorities as future users of this Smart City, a preliminary research has been developed. This paper presents the study carried out at the School of Design Engineering, whose objective is to look for design concepts for the city, which increase the relationship of citizens with products and services intended for public use, and the "potential benefits" of the "smart city". The first results reveal that it is a priority to work on the urban elements which show citizens the contributions of technology to the care and welfare of the environment in which they operate.**

Keywords-Smart City; Shared Artefacts; Product Design; Smart products; Technology Design

I. INTRODUCTION

The Smart City is an emerging concept with a broad and diffuse scope, whose limits have yet to be defined, and where many initiatives are in the project phase. We highlight, as an essential feature, the implementation of Information and Communications Technologies (ICTs) in multiple existing products and services, and the connectivity of objects [1]. This development will make it possible to manage and control energy resources with greater efficiency, and provide a faster response to the constant maintenance requirements. It is understood that a digital platform will be constructed, which will make it possible to improve the society, environment and welfare of cities in a sustainable manner, and in accordance with the degree of "CONTROL" which technology allows. Everything offers controllable information in real time and, which will foreseeably result in a better response to citizens' needs. Public spaces have been transformed into more interesting and entertaining sites where many topics are shared and where everything is recorded [2].

The public space, which historically has been a meeting place open to all citizens, is now undergoing smart, as result of the implementation of the new communication technologies and their application in personal use devices. These devices have transferred part of the interaction that took place in the physical space, to a new public domain, which is partly physical and virtual, and is modifying many social habits and individual behaviours.

According to the European Smart Cities initiative, the six main elements, which constitute a Smart city [3] are: *Smart Mobility*, which gives priority to public transportation and "soft" transportation services. *Smart people*, which includes services that have an impact on comfort, health and safety, permanent learning and training, care for senior citizens, meeting points and leisure, etc. *Smart economy*, which relies on decentralized work areas, mobile offices and teleworking, entrepreneurship, development of co-working, etc.
Smart living, which focuses on the use of intelligent sensors that control confort and safety in buildings, sustainability, pollution and their remote management. *Smart Environment*, which focuses on optimising the smart grids through sustainable electricity production and management systems, controlling public and household lighting, integrating home automation systems, and through the coexistence of clean energy cogeneration processes. Finally *Smart Governance*, which involves communication and participation in the city's management, managing its employment, relations with the public administration, etc.

Furthermore, the European Commission has set a challenge and priority for these smart cities, to make it viable to reduce pollution by 40% in the short term, and thus improve the economy and the quality of citizens' lives. This approach prioritises investing in buildings, energy and transportation [4]. The role of ICTs is also essential for the development of these concepts, since they require the implementation of powerful infrastructures and communication systems, which permit data exchange and storage, as well as its analysis, in order to improve the processes, which have a repercussion on the citizens. Major investments are required to carry out this technological upgrade of our cities that, in 2020, will have billions of devices connected to Internet [5].

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Faced with this highly technified, automated and virtual environment, we must address the need for tangible interaction with these concepts proposed and developed in the Smart City. We strongly believe in the pertinence of designing products for the environment, which have a physical presence, and with which, citizens directly become users.

This paper presents in Section II the Smart City as context for product design, and the need for interaction with users. In Section III, we point out the relevance of the *augmented city* concept and some projects that influence people's demands and expectations. The Research Methods and materials used in this local research are presented in Section IV, followed, in Section V, by some of the results from the research made. These results have allowed us to define in Section VI the scope of a design project, and to draw some specific proposals for the Smart City.Finally, some general conclusions are given.

II. PRODUCT DESIGNS FOR THE "USE" OF THE SMART CITY

As claimed in the report *Smart City Trends* [6], there is no doubt that Smart Cities are a fertile sector for innovation, an open space where proposals and categories of services and products arise. This field opens up opportunities and new market challenges for industrial design and for companies, and it constitutes an enormous space for innovation. Based on the elements of the Smart City listed above, this prospective study features some areas of urban innovation. We are interested on some of them, such as products on a human scale, bicycles first, predictive systems, flexible furniture, outdoor offices, sustainable lighting and access to energy.

Coming from the Design Engineering sector, and having had experience in the development of projects for the public space [7] since 2001, the concept of Smart City has made it necessary, to devote a specific line of work to enhance the role of design in the development of elements for the users of this technological and sustainable city. The exhibition *Smart City, Design, Technologies and Services for the Citizens*, was the first outcome regarding the state of art of this sort of product design. Pioneer applications at present time, which merit attention to interrelate connectivity, energy efficiency with products for public use, power charge and generation systems for the citizens and pollution reduction by means of innovative devices [8].

In the framework of Smart Cities multiple developments can be integrated responding the new needs and the integration of communication technologies, which provide new services and knowledge for citizens. In particular, from the design sector dedicated to urban elements, five action areas were outline, at the Smart City Expo World Congress. These action areas are related to each other, and priority has been given to those, which have the greatest potential as innovative objects for the public space [9].

These five areas are planned to be thoroughly permeable with each other, and they focus on:

- Data processing systems for society, communication and information services and participation. Education, welfare, commitments, ideas, entrepreneurship, etc.
- Launching technologies and access to platforms and urban media.
- Sustainability and clean energies, fair water consumption, increase of green areas, etc.
- Products for welfare and leisure.
- Clean mobility, bicycles, car sharing and participation in energy generation.

The goal of our research is planning a practical design project for the city of Valencia. Since previous works have been realized analysing the urban elements and services, technologies to be implemented, materials, and systems of energy, we have made a prospective research of the potential target of users, attempting to know their needs and expectations. The outcome of this ethnographic research is to find out new possibilities and values for designing and innovation at the contemporary city.

III. THE AUGMENTED CITY

Closely linked to communication technologies in the urban scope and, consequently, to the Smart City, we highlight the "augmented city", which involves the new physical space, expanded by the supply of graphic formats and information generally derived from Internet.

Augmented Reality (AR) applications in the public space are creating a new dimension within the city, an overlapping layer consisting of information, which augments the experiences in real time of the individuals who interact simultaneously in their urban environment [10]. To cite several examples of these technologies in dynamic situations, we highlight the application for cell phones GeoTravel, the project proposed by architect Keiichi Matsuda, in which the virtual and the real form a continuum offering amazing possibilities, while also controlling the way we understand the world (Figure 3). In the same way the famous Google Glass proposes a dynamic and constant individual visual connection with the on-line information and the environment It will be the glue between every interaction and experience everywhere [11] -[13].

Figure 1. Some technologies provide individual experiences of Augmented Reality outdoors. Google Glass and Domesti/City The Dislocated Home in Augmented Space.

In augmented city, the physical space and the virtual space are not separate, but two spaces, which constitute a whole. Real is combined with the digital environment, so that concepts such as public space, identity, knowledge, citizenship, and public participation are inevitably affected

by technology, by mobile communication, which modifies the enjoyment of the public space and the way in which the users relate to the environment and with the activities that take place in these environments. With the implementation of this technology, surprising and immediate results have been obtained within the scope of wayfinding. Orientation and location of spaces and places make the urban environment more attractive for users because it allows them to expand and express their own identity and experiences [14].

IV. RESEARCH METHODS

With the aim of getting information of products and citizen's expectations, this research focused four areas:

A. Urban scenario and field research

Ethnographic methods were used; walking and visiting the city to get information about what already exists, the potential lack of aspects or things which could be improved, and observe where most people spend their time outside. This part leads us to a favourite place in the city of Valencia: the Turia Park, a riverbed transformed into an urban park in the nineties.

Nowadays, as it passes through the city of Valencia, the old Turia riverbed is a big urban park that allows for different leisure activities, consistent with the contemporary concept of sustainable city that is active, healthy and participative. In this longitudinal space that runs through the city, natural elements play a key role in connecting leisure, mobility (walking or cycling) and a variety of uses (recreational, sportive, cultural, touristic).

B. Desk research

This involved information about Valencia's plan to become a Smart City. We made an inventory of street furniture elements and classified it in categories pertaining to their contribution to this aim.

C. Interviews

The survey had the aim of verifying which existing facilities were highly valued, and what the interviewees found to be lacking in an urban environment very frequented by multiple users. These interviews performed 3 times per week at different times of the day, in September 2015 and, again in May 2016. We choose people randomly, trying to cover different user profiles.

We interviewed a range of 25-30 people from each of the four different groups, who are relevant users of this site: citizens, young athletes, elderly people and tourists/visitors.

D. On-line Survey

Simultaneously, a short public-opinion poll was conducted online to complement the previous one, about preferences regarding services and design. This online survey targeted to people who live in Valencia or have been living in the city, such as exchange students or foreign workers (short-term residents).

V. RESULTS OF THE LOCAL RESEARCH

The city of Valencia has an action plan to become a Smart City and it has a major potential as an urban environment, due to its socio-demographic and environmental features. However, the first field research realized shows only ten public facilities, currently identified as Smart products in the city:

1) Information panels, with real-time traffic information throughout the city.

2) App-Valencia, car park information, also in real time

3) QR codes for disabled people, so they can reach things, such as a parking meter

4) E-card, an electronic public transport card (4,000 passengers per day)

5) Municipal bicycle rental service (*Valenbisi*): 2,750 bikes, 5,500 access points, 75,114 daily bike journeys.

6) Monitoring Valencia through cameras

7) Intelligent lights throughout the city

8) EMT bus service, 100% ecological

9) Online City Council administration services (100% paperless)

10) VLCi Platform for urban information

This list summarizes the answers to the open question: "Give an example of the Smart City concept in Valencia" in On-line interviews conducted and the inventory made on the desk research.

What we observe overall in terms of participation is that both, the interviews and the surveys show, from a sample of 100 individuals distributed equally as users, that young people have been more interested in this research.

The two graphs (the Figure 2) illustrate the age of the participants in the study, and the main areas of changes that they perceive as part of the Smart City. The first graph shows clearly the prevalence of young people (18-29) over the different groups of the answers, while the second one describes the value given to the changes perceived at the city as context of public life. So the graphs clearly illustrate the relation between people age and the tendencies on what they expect from the city places nowadays.

In terms of participation, both the interviews and the surveys show, from a sample of 100 individuals distributed equally as users, that young people have been more interested in the research presented. This result is not surprising, as, compared to other groups, young people tend to go out more often and furthermore, they find easier to participate in on-line applications such as this interview and what is more, they prefer this way. Young people like to share places outside even when they are using their own personal devices. They usually mentioned the quality of the environment as place to rest and stay. They ask for urban elements and services, which involve spending time (charge a mobile phone, to use a computer, information in real time, social areas…).

It's worth observing that de second group of participants more relevant (45-64), represents people situated as professionals, workers who have more time in front of the

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computer and who practice sports and healthy habits. On the contrary, the group (30-44) years corresponds to a group affected by the economic crisis that shows a more sceptical and slightly participative attitude.

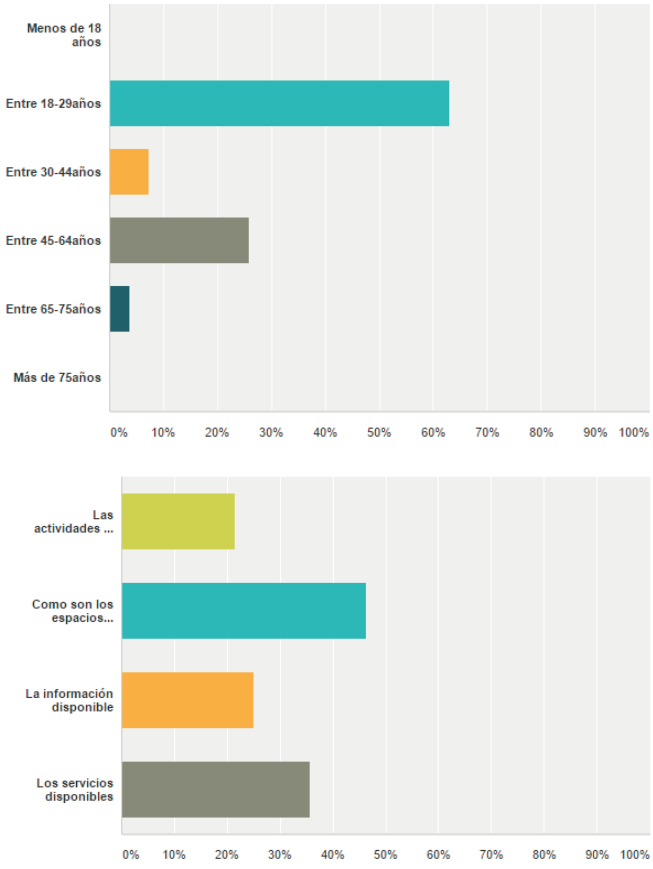

Figure 2. Participation by ages. Activities and changes in the city

What is perhaps more significant for design is that on the second graph, how are the places and the facilities provided, got more percentage than the access to information and other activities that people do outdoors. It is relevant to point out that image appreciation raise almost a 50% getting the double than the others.

Research also suggests that people much concentrate attention on the place they are. Through the outdoor interviews, we found what was missing, and what people would like to improve in Valencia, both from the local and from the tourist perspective. One complaint was about dim lighting at night when using urban elements (which makes people feel unsafe and scared).

Tourists pointed out that there are not enough signs, they are often poorly located and only in Spanish. They also ask for more areas in the shade with rest elements. Young people would like to have Wi-Fi zones in order to recharge or use devices comfortably. Elderly citizens would like screens to display events or beautiful sites to visit in the city.

The analysis of these ethnographic data shaped ideas and requirements for some new smart products. These elements have to include in their features those needs: simplicity, interaction, light, be sustainable, provide energy, easy information displayed, etc. Design has to provide the city with elements with a clean image adapted to the current needs.

Following these considerations, we define the scope of this project as the conceptual design of an urban services booth, which combines sustainability and communication. This urban element has to integrate the principles of the Smart City, linking technology with a pleasant interface, inviting the citizens to use it and participate in social public life.

The service booths are more or less enclosed structures, located in the public space, whose aim is to permit the use of different types of installations; electricity, voice and data are the most common. These cabins have a direct antecedent in phone booths and share with them some characteristics. These sort of elements need to have sufficient space for an individual to carry out the required actions; lighting that facilitates both, their location and use at night; an enclosure system, or a partial or total roof to protect the technological elements; and specific insulation to create the suitable conditions for its possible function as an oral/audio communication terminal.

VI. Design Proposals For The Smart City and Further Work

The methodology followed corresponds to the general design process, which starts with the definition and conceptual design phases. Using creativity, design and the principles of the green engineering in an innovative way can be a force for positive change, in the cities of the future. From the social view of the product, that involves with the community and the public space, sustainable design gains added interest: The street furniture can be an active support in public and political life of the community enabling new forms of participation and civic engagement.

The objectives of this proposal are two:

- Suggest an ecological solution for an innovative public use product, owing to the offered services, which will be determining the optimum implementation of materials and sustainable processes.

- Design a product of public use evidencing this ecological efforts contributing to ecological social awareness.

Assuming the range of available technologies allow to create truly “ecofriendly” products that actively contribute in a responsible and respectful use of the community environment. This raises interest in technology, renewable energy and design, as key aspects for generating futuristic, attractive and fully viable street furniture.

In this direction this proposal also focus on looking for new solutions to be incorporated in elements of collective use, making use of current and low cost communication technologies, which are materialized in a self-sufficient infrastructure that also clearly demonstrate this vocation. Following these ideas, ten projects were developed in detail

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in the workshop Designing Products for Collective Use at the Technical School of Design Engineering UPV.

They propose different ways of using the contemporary public space in a sustainable, aware, useful and attractive way. It is important to note that, the element/topic proposed, involves complex urban elements, which have a direct contact with the user and require a specific interactivity to be efficient. Consequently, they require immediate comprehension by the user, and the dimensions of their components must ensure the accessibility.

The two projects presented in this paper, show different design solutions based in the *10 principles of Green Engineering* [14]. In the case of *Algui* focuses on the awareness and communication of its energy system: the biomass, and its visual-natural qualities. While in *Eco cabin*, the main values reference to the experience of nature and domestic comfort.

Algy (Figure 3) is an urban booth for services and information with a lively and fresh appearance. A self-sufficient design that employs the developed technology for the BIQ house, located in Hamburg. The project inquires into the combination of new technologies, like augmented reality (AR) and biomass energy, in a product for public use designed as an ecological, attractive and functional element. This piece of street furniture reduces environmental impact and has as further goal: the communication of these values. With this aim, the central element in the design is the bio-reactor itself. In this way the booth is a vertical element of simple geometric shapes that works independently or accompanied by other strategically located, generating a comfortable micro-climate that provides certain soundproofing and insulation, suitable for some of its functions. As a street furniture, at dimensional level this universal and ergonomic design incorporates a floating screen that adjusts to the height of each individual by means of a sensor, without the need for direct tactile contact. Also, one can interact with the booth by voice. All of this with all the necessary accessories to fulfil the offered services satisfactorily, highlighting among them AR applications, and supported by intuitive and very accessible interface

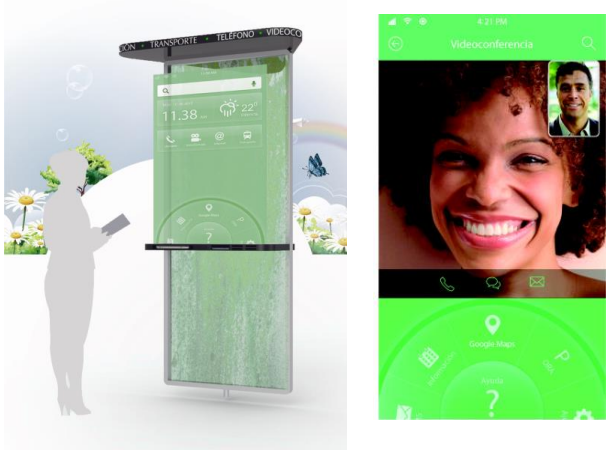

Figure 3. Algy is a service booth inspired in the management of energy with biomass processes. Projected by Marta Jiménez.

Figure 4. Eco Cabin Project allows users to work outdoor in a pleasant environment. Provides energy and plants are watered. Projected by Greta Gulienetti

EcoCabin (Figure 4), provide the city with a comprehensive urban design element that offers a pleasant place for busy people to stop for a while.

Two walls and a cover form a stay zone. One of the two walls is a vertical garden that takes the water needed for drip irrigation from a small container lodged at the top, which stores water from the rain. This allows the irrigation of the plants in perfect autonomy. As far as lighting is concerned, the use of LEDs and its photovoltaic cells installed on the cover, reduce by 50% the power consumption. Plants, water and sun energy also reduce pollution all around this urban element.

In the interior, this cabin has different facilities, such as a table with electrical outlets fed by a few photovoltaic panels installed in the cover. The height of both the work surface and the seats, are adjustable to adapt to different users, in particular to people using wheelchairs. There is a tactile LCD screen on the opposite wall, which presents information of interest (itineraries, transport, etc.), surveillance camera and SOS button.

VII. CONCLUSIONS

It is unquestionable that the development of the Smart City will result in the improvement of the quality of city life. However, it is a true challenge to make people aware of the real changes and participate in their benefits. In this sense, the contribution of this particular research paper is bridging the gap between new concepts and design methods, ideas and smart products.

Coinciding with other authors, the study carried out in the city of Valencia also states clearly that the "Smart" concept seems rhetorical and overvalued, especially when specific products already implemented are observed in operation [15]. It can be state, that it is a priority to gather more information about the needs and expectations of citizens and how they enjoy collective facilities. The parking meters, public transportation, ticket machines or the bicycle

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rental system, are examples of this product concept, regardless of how intelligent they are.

A strong point of public use elements is their availability and acceptance by the users. This is a great advantage for social communication of new habits at the public space. These products are suitable for communicating contents, which can reinforce information and training strategies linked to the opportunities and improvements of the Smart concept itself. The new materials and lighting applications based on the design make it possible to offer low consumption solutions and greater energy efficiency to face the new urban requirements and the growing environmental sensitivity. Several urban applications such as digital lighting and signage, adds multiple attributes and utilities to the urban experience by combining technologies, architectural integration and design of more interactive contents." [16]

The design projects described show the suitability of the service booths as first-class elements of interactive urban furniture for the Smart City, since they allow integrating conventional analogical uses (rest, protection, safety, etc.) and connectivity and augmented reality systems. Furthermore, these products promote user interest and participation. In addition to communicating the technologies applied to the city, they encourage their use by all types of audiences who are already familiar with these types of interfaces, thanks to the multiple applications in other mobile devices. Thanks to the great versatility of technology and its progress, creativity and multidisciplinarity, viable projects can be developed.

These projects allow monitoring how well paired is the implementation of new technologies and sustainability, which may lead to very interesting products with applications that today are still unimaginable. Society is becoming increasingly receptive to ecological policies; therefore, it is of great interest to take the utmost advantage of the opportunities that technology can bring to really competitive design.

Future work may include usability analysis and the evaluation of these design projects, when used by different people and circumstances.

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REFERENCES

[1] N. Vidal, "The smart city: smart cities of the future", Barcelona: Editorial UOC, D.L. 2015, ISBN 9788490649053.

[2] L. Verweij, "Public Spaces More Public or Private than Ever?", Experimenta, vol. 55, pp. 67-73, April 2006, ISSN: 1133-9675.

[3] C. Manville, et al. "Mapping Smart Cities in the EU", Policy Department A Economic and Scientific Policy, pp.21, January 2014. http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf , Accessed: November, 2016.

[4] European Initiative on Smart Cities, https://setis.ec.europa.eu/set-plan-process. Accessed: November, 2016.

[5] N. Vidal, "The smart city: smart cities of the future", Barcelona: Editorial UOC, pp.29–30, October 2015, D.L. ISBN 9788490649053.

[6] M.G. Casado, C. Revert, V. Sales, and S. Veral, "Smart Cities Trends: Trends in smart cities and opportunities for sectors habitat", ITC y ADIMA, pp.3–4, March 2015, ISBN: 978-84-941029-3-6.

[7] M. Puyuelo, et al. "Street furniture. Design and Accessibility", Valencia: Editorial Universitat Politècnica de Valéncia, 2010.

[8] F. Domínguez and U. Fogué, "Technifying Public Space and Publicizing Infrastructures: Exploring New Urban Political Ecologies through the Square of General Vara del Rey" International Journal of Urban and Regional Research, vol. 37, Urban Research Publications Limited, pp.1035-1052, April 2013.

[9] M. Jiménez, M. Puyuelo, and L. Merino "Urban furniture for Smartcity. Augmented Reality and sustainability for public use" Information Systems and Technologies (CISTI), 2014 9th Iberian Conference on, IEEE, pp. 100-105, June 2014, doi:10.1109/CISTI.2014.6876969

[10] http://www.todoiphone.net/geotravel-un-guia-turistico-en-tu-iphone-con-realidad-aumentada Accessed: November, 2016.

[11] K. Matsuda, "DOMESTI/CITY The Dislocated Home in Augmented Space", Keiichi Matsuda / Unit 15 / Year 5 Diploma/March Thesis. http://km.cx/projects/domesticity-the-dislocated-home-in-augmented-space/. Accessed: November, 2016.

[12] Project Glass of Google develops an augmented reality device that allows individual use Internet to interact with information via voice. Wikipedia: the free encyclopedia [Wiki a Internet]. St. Petersburg (FL): Wikimedia Foundation, Inc. 2001. Available from: https://es.wikipedia.org/wiki/Google_Glass. Accessed: November, 2016.

[13] Smart City Expo World Congress, Fira Barcelona, Noviembre 2015, http://www.smartcityexpo.com/en/program. Accessed: November, 2015.

[14] P. T. Anastas and J. B. Zimmerman, "Design through the 12 principles of Green Engineering", Environmental Science & Technology pp. 94A, 2003

[15] T. Paris, "Desirable intelligence", diid disegno industriale/industrial design, vol.58, Rdesignpress, pp.124, 2014.

[16] G. Flore and A. Pozzoni, "Smart cities, smart lights. Digital signage and urban experience", Elisava Temes de Disseny, vol. 28, pp.39, 2012, eISSN: 2385-7951.