Urban Node Project

Team members:

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Abstract: The world is continuously facing the evolution of technologies and environmental issues. The Universitat Politècnica de Catalunya and more precisely la Escola Politècnica Superior d’Enginyeria de Vilanova i la Geltrú and a local company Neàpolis decided to initiate a project called Urban Node in 2013. The idea and focus was to develop an innovative urban element that could gather information and interact with users whilst creating renewable energy. In 2013, two student groups worked on this project during their European Project Semester (EPS) and International Design Project Semester (IDPS). Given the size of the project, the previous year project team could not complete the project. So during the 2014 spring semester, an EPS group of student were assigned to continue this Urban Node project.

The main academic objectives for this project were to complete the construction parts of the Urban Node, materials and dimensions, to start on the manufacturing processes in order to finally make a cost benefit analysis with a marketing study to deliver a full work on the project. During the realisation of those objectives, we found that studying other scopes were interesting and even essential for some of them. That is why we also studied how to guarantee the efficiency of a product that is specifically designed for user interaction, for example adding special features such as lighting and sensors, producing energy using Solar Panels and Wind Turbines as well as them being for a social and educational benefit. The design will also be used to encourage the development of smart cities through the implementation of smart designs. Finally, we realized that printing in 3D a prototype of the Urban Node would be necessary to exhibit a full work of our project.

Key words: innovative construction materials, manufacturing processes, modern urban element, smart cities, Urban Node

I. INTRODUCTION

This project is produced from mutual work between international engineering students, the local company Neàpolis and a Universitat Politècnica de Catalunya. The main purpose is to continue developing design of a new architecture furniture element, The Urban Node, which combines elements of: street lantern, informative point with interactive screen and as a additional part: generator of electric power from renewable sources. It allows the placing of a new generation antenna and sensors inside. Characteristics of the Urban Node are: modular, sustainable and easy to maintain.

Information about Neàpolis

Neàpolis is an agency for technology focused on innovation, design, and entrepreneurship. They are providing education programming, space, and support to help collaborative practices and learning opportunities across a society stimulated by the entrepreneurial experience. As Public Innovation Agency for ICT and Multimedia, Neàpolis has been supporting Vilanova i la Geltrú and its region as a business location for IT, media and creative industries for last 8 years. Neàpolis improves local innovation and competitiveness including the endorsement of regional, national and international teamwork. Neàpolis is focusing on support of successful entrepreneurship especially in small and medium-sized companies, as well as involving them with application-oriented research and public funding programmes.

II. SWOT ANALYSIS

A SWOT analysis was carried out using the reports from the two previous project groups, The EPS and The IDPS. This ensured that there was a clear understanding of the project before it was started allowing us to have background knowledge of the project and the thought process in which the work had been under taken. Using the information collated it allowed us to implement the strengths of the Urban Node, which were: Ergonomics – Having a large number of user profiles, the use of anthropometrics for the design and the shape being designed with the incorporating on the anthropometrics. Aesthetics – The shape, which is innovate resembling a ‘smart city’. The positioning of the solar panels being high is not visible to passers-by; The wind turbine as the chosen colour is bright and attractive as well as the use of LED’s for the lighting. Function – The use of LED’s as they are up to twenty times more efficient than a standard bulb. User interaction, the Node’s ability to interact with its users for the use of technology. Energy Generation, which gives a social and educational as well as economical benefit. The internal structure incorporating sensors and the features that it provides for its users.

The research gave us the opportunity to work to eliminate the weaknesses, which were; Ergonomics - reducing user profiles slightly. Anthropometrics only take the average and in effect it will not meet all users needs so it was only taken into consideration. Aesthetics – Shape may not suit the architecture of the town. The positioning of the lighting was not innovative enough for the design. Function – Lighting, observing the weakness of LED’s. Interaction, which could have been too complicated for users if not in different languages. Energy generation, the node is not able to make enough energy to product profit. Although some of the strengths and weaknesses clashed it was clear that for certain aspects of the design the strengths outweighed the weaknesses of the product. The previous reports then allowed us to develop the opportunities which included; Locations, tourism, smart cities, internationalisation, globalization and maintenance. It also helped identify the threats and eliminate them, which included; Competitors, cost, maintenance and smart cities.
III. PROJECT MANAGEMENT

In order to manage at best our project, the use of simple management tools was required.

The Work Breakdown Structure (WBS) is used to structure the project in different categories to have a quick overview of the project main characteristics, generally at the beginning of a project.

The Gantt Chart was one of those tools which allows to know how progresses the project, if we are respecting our time limits for each steps and if the project goes on correctly. Listing all our steps was for us a way to keep a guideline, to know exactly what we have to do on this project.

The Responsibility Matrix allows listing all the tasks that should be done and all the project members in a table. One member is responsible of one or several tasks and is supported by one or two members.

The Communication Plan was useful because it facilitate the sharing of information between two or more individuals or groups to reach a common understanding is probably the main asset for the success of a project.

V. MATERIALS

For the urban node a comparisation between 4 materials was made for the main structure: steel, reinforced concrete, fibreglass, vubonite [1]. The following table presents the different characteristics that are important for this project:

<table>
<thead>
<tr>
<th>Density (kg/m^3)</th>
<th>Steel</th>
<th>Concrete</th>
<th>Glassfibre</th>
<th>Vubonite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td>Strong</td>
<td>Ok</td>
<td>Strong</td>
<td>Very strong</td>
</tr>
<tr>
<td>Thickness</td>
<td>Thin</td>
<td>Thick</td>
<td>Thin</td>
<td>Thin</td>
</tr>
<tr>
<td>Cost</td>
<td>Cheap</td>
<td>Cheap</td>
<td>Expensive</td>
<td>Very expensive</td>
</tr>
<tr>
<td>Production</td>
<td>Easy</td>
<td>Easy</td>
<td>Difficult</td>
<td>Difficult</td>
</tr>
</tbody>
</table>

Vubonite scores the best on strength characteristics so this seems a good solution for the urban node. But the disadvantage of this is the total cost. They should try to make the urban node as cost efficient so this material is not good for this project. Also fibreglass has good strength characteristics but it has the same problem as the vubonite. It is not cost efficient.

Steel and concrete don’t have the problem of this high total cost. So these materials seem more useful for this project then the others. The problem with concrete is the thickness that we need to maintain. Because the urban node needs to be 14 centimetres at its smallest this material is also not the best to use, especially because there also needs to be place to put sensors and wiring.

With steel this problem will not be there. The thickness of the plates can still be very thin so there will be still be place enough to put the sensors. And the strength characteristics of this material are good enough for this project. The only problem with this material is that there can be corrosion. For this problem there are solutions like: galvanization, coatings, cathodic production, rust-resistant alloy.

Rust-resistant alloy, galvanization and cathodic protection are all very good to protect the steel from corrosion but coating and painting have an extra advantage. The urban node needs to be painted anyway because it will not have the colour of the raw steel. The paint will isolate the steel from the environment. A disadvantage of this is that it needs to be maintained (a paintjob every year or every couple of years). But this needs to happen anyway so it seems like the perfect solution.

VI. STRENGTHS ANALYSIS

Eurocode 3 [2] is the calculation method that is used for the calculation of the steel structure. At first the classification of the cross-sections is made. First a simplification of the cross-section of the urban node is made. The simplification is a hollow rectangular profile with a thickness of 5 millimetres like seen on the following picture:
The classification of the cross-section is made by using next table [3]:

<table>
<thead>
<tr>
<th>Door/section</th>
<th>Belast op buiging</th>
<th>Belast op druk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>c/t ≤ 72 kN</td>
<td>c/t ≤ 33 kN</td>
</tr>
<tr>
<td>2</td>
<td>c/t ≤ 83 kN</td>
<td>c/t ≤ 38 kN</td>
</tr>
<tr>
<td>3</td>
<td>c/t ≤ 124 kN</td>
<td>c/t ≤ 42 kN</td>
</tr>
</tbody>
</table>

After calculation it is decided that classification 1 is used. So the following calculation will continue with the formulas used for classification 1.

Now a control on buckling, compression load and bending load should be done.

Control on buckling:

\[
X = \frac{1}{\phi + (\phi^2 - \lambda^2)^{0.5}} = \frac{1}{6.1163 + (6.1163^2 - 3.13^2)^{0.5}} = 0.08 \leq 1
\]

Compression load:

\[
N_{X,rd} \leq N_{X,t} = \frac{A_f}{f_{yd}} = 2400 \cdot 235 \frac{1}{1.1} = 41018 \leq 41080N
\]

Bending load:

\[
M_{pl,rd} = W_{pl} \cdot f_{z} = 61000 \cdot 235 \frac{1}{1.1} = 13031818Nmm = 13031Nm
\]

\[
M_{pl,rd} = 81000 \cdot 235 \frac{1}{1.1} = 17304545Nmm = 17304Nm
\]

\[
M_{sl,rd} = 500 \cdot 0.3m = 15Nm
\]

\[
M_{sl,rd} = 500 \cdot 0.75m = 375Nm
\]

So in total the Urban Node is strong enough for the different kind of forces that come on to the Urban Node. Calculated with the formulas given in Eurocode 3 the Urban Node is strong enough with steel plates of 5 millimetres and a quality S235.

VII. DESIGN

The dimension and the design of the Urban Node are probably the main aspect of our project because it will give the final appearance of our product. It needs to give the wish for the citizens to interact with this product using all its functions. That is why an attractive and designed aspect must be considered as a main objective.

The design of urban node is modern and eye-catching. Shape of it is streamlined that enable air to flow without any obstacles and go through turbine in most effective way. Urban node is made of steel ‘spine’ that can be connected with semi transparent lighting part. This part provides warm light on whole height of urban node, in contrast to usual street lantern light is not only delivered from above.

After choosing materials of urban node it was decided to use paint as a protective layer. Urban Node can match architecture nearby and colour of one Urban Node is not dependent to others. Modern design and freedom of choosing colours will enliven the perception of Urban furniture in Vilanova i la Geltru, but at the same time will not stand out enough to disrupt the uniform character of public spaces.

It was decided which sensors should be put inside Urban Node. Data obtained from sensors will be source of income. To make it easier to maintain all sensors and computer would be placed in box in back part of Urban Node.

Moreover, on the top we would like to place new generation antenna (4G) that would be responsible for Wi-Fi transmission. The adoption of smart antenna techniques in wireless systems is expected to have a significant impact on the efficient use of the spectrum, the minimization of the cost of establishing new wireless networks.

Elements of Urban Node

- solar panel
- wind turbine
- led lighting
- interactive screen
- temperature sensor
- barometric pressure
- humidity sensor
- light sensor
- infrared sensor
- decibel sensor
- anemometer
- air quality sensor
- CCTV camera
- 4G antenna
VIII. TECHNICAL DRAWINGS

When Engineers are working on the research and the development of a new product or a new device, all the time, drawings are created, done by hand thanks to a modeling software. Consequently, we realize all the technical drawings needed to guaranty the future production of Urban Node by Abertis.

IX. 3D PRINTING

As in every project of Research and Development, the realization of a prototype is necessary to test our product and to how it look like in real scale or in a smaller scale. Thanks to Neapolis and its 3D Printing department, we managed to develop a model in a scale 1:10. The material used for this model is ABS, a thermoplastic polymer. It is a material stiff, light and easy to be molded.

To make this prototype, we transformed the 3D model in the special extension allowing the reading and the understanding of the document by the 3D printer. We cut our 3D model in 10 sections because the size of that printer was small. Indeed, Neapolis’s printer can only print objects of 13x13x13cm. The 3 colors used for our prototype are blue, for the main part (column) of the node, red for the wind turbine and white for the modular plastic part.

At least, the prototype was made in one week. Then we assembled the different parts sticking them with a special product composed of plastic and acetone.

The pictures below show respectively on the right and on the right some of those pieces assembled.
X. MANUFACTURING PROCESS

Manufacturing process is defined by set of operations for modifying characteristics of raw materials until selling the product. So for getting Urban Node will be required to follow these steps on assembly line:

![Schema of manufacturing process](image)

The important steps in assembly line for Urban Node are bending, wiring electronic components and welding. [4]

The bending method has been thought for first productions because it is too cheap for Urban Node materials. But when Urban Node will have a lot of demand, the first step will be changed for casting and molding because is faster than previously mentioned.

About wiring electronic components it is the most important step because almost functions of Urban Node depends of electronics. So workers have an important job here for developing it.

The last important step on assembly line is welding because for wiring electronic components, it is easier for workers have the Urban Node in different parts. For this reason after wiring electronic components, workers have to join every part of Urban Node by welding method.

To conclude the manufacturing part, Urban Node has a quality control about every situation that the product might can find in the streets. Also workers test all functions of Urban node, specially electronic components because these kind of objects usually have fail. [5]

X. COMPANY RESEARCH

The first step of the process of the company research has been focused to the development of the Urban Node. This is one of the main objectives for this project.

Different companies have been taken into consideration focusing on which one would be better to develop the project. These kinds of companies are Manufacturers as well as Infrastructure.

Contact with companies it was completed in two different ways: Letter and presentation.

The letter was written to companies for contact with them first time by email. In this letter it explained everything about Urban Node (who composes, objectives, university of the project ...). The main objective of the letter is to have a meeting with managers of the company.

The presentation was done by PowerPoint. It has two objectives: First one is to show the Urban Node and explain every part detailed of the project. The other one is to convince the company for developing Urban Node.

To conclude Urban Node team have to say that only one company has answered our email about Urban Node project. This company is Abertis. Following it can read a little introduction of Abertis:

Abertis telecom is positioned as the market leader in the segment of infrastructure and services terrestrial telecommunications operator in Spain and International reference in the field of satellite transmission, after becoming a member reference operator Hispasat (57%). [6]

XI. MARKETING PLAN

A marketing plan was produced with the aim to provide a detailed outline as to how the Urban Node will be launched into the market place. This was essential as without a strong marketing plan, the product will fail to reach its full potential and the project will ultimately result in failure. Extensive research has been carried out to ensure the plan has depth and covers all the necessary areas for a successful launch to market. The plan will act as a formatted strategy that identifies the steps that will be completed to successfully launch the Urban Node into the marketplace and contribute to the achievement of the objectives set.

The plan incorporates the use of the marketing mix, covering, the background of the project, stating that it is a continuation of two previous project groups. Our vision, this is highlighting what we want to achieve. People, stating who is involved with the project. Product, explaining what the Urban Node is and how it functions. It provides a detailed outline of our 4 key objectives. It states the unique selling point/proposition (USP) of the product. States the target users and the target market. The price, which will be further defined through a cost analysis. The market position of the Urban Node. It highlights the competitors. Explains in detail the promotion strategy and the use of marketing mix and then goes on to explain the distribution plan.

XII. COST BENEFIT ANALYSIS

As the urban node is a new innovative urban element, it was necessary to conduct a cost benefit analysis. This analysis is divided in three parts.

First there are the expenses. The expenses cover the cost of raw materials and electronic parts, the salary of the workers such as operators for the manufacturing, logisticians and quality controllers, the cost of machines to manufacture the product, the packaging and finally the maintenance cost. Since those costs are the most important ones in the distribution the ROI is strongly impacted by the model chosen. We will see in the last part the impact the model has on the ROI.
Secondly, an analysis of the possible incomes was necessary. Thanks to its design, the urban node has many features that are sources of income, the energy produced by the wind turbine and the solar panels, the 4G antenna, the users payments, the advertising where several models where proposed and the cell of data since there are no state of the art in this field.

Finally a return on investment study was done. Using the two previous parts, the balance between expenses and incomes was studied. It allowed the group to have a clear overview of the economic aspect of the project. Once we had the balanced it was only for the first year.

So we were loosing money on the first year. Then a ROI study was conducted. The idea was to have the evolution of the ROI to see the acceptable models. The next table shows this evolution. The X-axis is the manufacturing time variable and the Y-axis is the ROI time. Each line represents an advertising model.

XII. CONCLUSIONS

The Urban Node is an innovative, evolutionary project. This is because the project was first launched last year in 2013, with the students from the IPDS and EPS groups, which had the focus to design and develop the Urban Node concept. Their task was to create a futurist node, which could couple several renewable energies such as the sun power and the wind power. This node had also to be an information point with a touchscreen which could provide information about the city, the weather, the time and things interesting to do in Vilanova I la Gueltru, as a virtual tourism office.

The project has progressed immensely. We have succeeded to define that the Urban Node composed of two parts, which will be easier for the production and also for the material definition. The materials have been defined, we realized that using simple materials, as steel alloy would be cheaper and more efficient for the weather resistance, particularly against the corrosion effect caused by the salt of the sea, more present in the atmosphere of Vilanova. We have also carried out in depth research that indicates that using steel would not create interference, especially for the WI-FI waves.

The Urban Node project is a large-scale project, which requires the common investment of all the different members of the team to produce a considerable amount of work. Although the Node is a lot closer to entering the market that it previously was there is still a lot of work needed in regards to the electrical part. The next EPS groups would ideally complete this next year. Who should focus on the electrical part including all the sensors.

XIII. REFERENCES