Development of a bedside led light for hotel rooms

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This dissertation was carried out as part of the MSc in Strategic Product Design at the International Hellenic University, and it involves the design of a bedside led light for hotel rooms.

It essentially consists in two main parts, research and design, which are combined in order to lead to the final result; the process continuously alternates between the two, since while the design proceeds, new fields of research are revealed. My intention was to design a product that addresses a real-life problem in an original, fresh, innovative and realistic way, with no exaggerated requirements in materials and production techniques, and I believe that I have achieved it.

By resorting to subtle methods and applying various approaches (design guidelines set, ergonomics, semantics, design for the senses etc.), the final result is a simple but not simplistic object, with its own unique and particular character, which allows the users to create their own experience and way of interaction.

I would like to express my warmest gratitude to my supervising professor, Mr. Sergios Fotiadis, for his guidance and cooperation: being always eager to contribute and open to cooperation, my association with him helped expand my way of thinking.

Special thanks are due to my teachers, Dr. Dimitris Nathanael and Dr. George Liamadis, for their kindness, the time they devoted to me and their valuable contribution to my work, by generously sharing their knowledge and experience upon specialized fields (ergonomics and design for the senses, respectively).

I would be remiss if I did not mention the coordinator of the MSc in Strategic Product Design, Dr. Dimitris Tzetzis, for the assistance and support he provided regarding formal issues of my Thesis.

I must also thank my friends and fellow students for their help and the time we spent together, discussing various relevant issues during the Thesis' progress; last but not least, all the people who answered my questionnaire and allowed me to interview them in order to define the stakeholders' needs.

keywords: design for the senses, semantics, ergonomics, design guidelines, bedside lamp
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1. Introduction

The aim of the dissertation is the development of a bedside LED light for hotel rooms. The idea of luminaire originated from personal preferences and inclinations as well as, from the fact that many existing luminaires have been designed for older, smaller bulbs which have been replaced for energy efficiency with bigger, newer ones, creating a weird aesthetic result. A fresh, simple and innovative design is pursued in terms of form, materials and aesthetics in general. The user's engagement with the object is considered of great importance. Thus, ergonomics and semantics were carefully studied through hands-on, primary and secondary research. Many experiments have been conducted through physical models to find the appropriate solution for each feature and the overall design of the product. The product mainly focuses -in terms of market- on hotels, but it can also be purchased by individuals for domestic use. Thus, a vast audience is targeted and affected. The dissertation's outcome is a fully designed product, developed and based on real-life conditions and market tendencies/circumstances and it could proceed to production.
2. Methodology

The methodology followed in this thesis was a combination of a more rational and a more intuitive one: a “design process” methodology, as it is presented by Mr Fotiadis Sergios, and a “concept/basic form idea” methodology, as it is commonly used in the field of architectural design. In the case of the “design process” methodology, a set of design guidelines is compiled following extensive research, and all concept generation is based on their fulfillment. In the case of the “concept/basic form idea” methodology, a rough form idea is obtained through sketching or other more or less intuitive methods, such as physical model creation, philosophical research etc.; this basic form is then interpreted and developed in the final, fully designed and defined product.

In our case, after receiving the initial brief (theme of the thesis), an extensive research in many fields has been conducted ending up in a set of design guidelines and creating sub-solutions for each of them. At the same time, a “concept/basic form idea” has been obtained through sketching. In this parallel, non-linear process, once a certain point was reached, the two different methodologies were combined by selecting and aligning the proper concept/basic form idea to the design guidelines that have been set.

The next step was further development has followed, including form and features’ development through sketches, drawings and mainly prototypes, ending up in the final product. At this stage, further research in more specific fields (such as semantics, hand ergonomics, senses and haptics etc.) has taken place. The process ended with complete documentation, conclusions and reflections upon the whole process and final result.

3. Research

After deciding to design a bedside lamp, the target group was the first parameter to be defined, followed by the definition of the stakeholders and potential users, as well as their needs. The initial general research consisted in an extensive study of the following elements: light, natural and artificial, and the physical quantities by which it is determined; light bulbs and their characteristics; human physiology related to light and how it is affected by: light ergonomics; similar products. Further research on specific fields (semantics, hand ergonomics etc.) has been conducted at the stage of the product’s further development in order to acquire specific knowledge and refine the product’s features. All research was carried out using the hands-on method -primary research- and through literature -secondary research.

3.1 Target Group

Market research revealed that many hotels are renovating because their clientele has decreased and so has their income. The most obvious reason is the emergence of other accommodation possibilities (e.g. Airbnb). Thus, hotels are trying to increase the level of their premises and services. Three-star hotels are the ones that have been most affected, since they are competing mainly based on their price. Higher level hotels have suffered less, since their customers’ main criteria are the level of service, convenience and luxury. As a result, a lot of three-star hotels are under renovation and that was the reason why three-star hotels have been defined as the main target group for the product, since this could greatly facilitate the product’s launch in the market.

A research on three-star hotels has followed, focusing on standards established by hotel rating organizations, such as the Greek Tourism Organization (EOT), the European Hotelstars Union etc., as well as common practices, amenities and facilities. The product does not focus only on the Greek market; standards from international organizations have been studied as well, revealing that most requirements are universal.

Typical three-star hotel rooms have been examined in terms of their layout, equipment, furnishing, facilities, as well as general character and aesthetics. Most of the times, a typical three-star hotel room furnishing consists of the bed(s) -number and type depends on the room type-, night table(s), one seat for each guest, a wardrobe, a luggage rack and quite often a console table -even though the latter is not mandatory. Concerning lighting in three-star hotels, adequate general ceiling lighting is mandatory, as well as bedside lamps, but a central switch for the room lights is optional.

### Table 3.1 Hotels’ standards established by the Greek Tourism Organization (EOT)

<table>
<thead>
<tr>
<th>No.</th>
<th>CRITERIA</th>
<th>GRADE 1*</th>
<th>GRADE 2*</th>
<th>GRADE 3*</th>
<th>GRADE 4*</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Single room minimum area (m²)</td>
<td>16</td>
<td>13</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>3.2</td>
<td>Double room minimum area (m²)</td>
<td>18</td>
<td>15</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>3.3</td>
<td>Triple room minimum area (m²)</td>
<td>22</td>
<td>18</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>3.4</td>
<td>Suites (2 min requirement)</td>
<td>14</td>
<td>11</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>

R : Required, O : Optional

Source: GG 09.01.2015/Volume 10

Pict 2.1 “Design process” methodology by Sergios Fotiadis.
4. COMMON SPECIFICATIONS FOR ROOMS AND STUDIOS

<table>
<thead>
<tr>
<th>No</th>
<th>CRITERIA</th>
<th>GRADE</th>
<th>5*</th>
<th>4*</th>
<th>3*</th>
<th>2*</th>
<th>1*</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Bed with a modern and well-maintained matress</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td>Minimum dimensions for single beds 0.90m x 1.90m and for double beds 1.60m x 2.00m</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.3</td>
<td>Bed dimensions larger than the minimum ones according to criterion 4.2</td>
<td>150</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>4.4</td>
<td>New technology TV at least 24&quot;</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>New technology TV at least 29&quot;</td>
<td>100</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>4.6</td>
<td>Internet connection</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.7</td>
<td>Empty refrigerator (mini fridge) or Mini bar</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.8</td>
<td>Wardrobe</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.9</td>
<td>One seat for each guest staying in all rooms.</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.10</td>
<td>Coffe table</td>
<td>50</td>
<td>R</td>
<td>R</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>4.11</td>
<td>Table or office or other working surface</td>
<td>50</td>
<td>R</td>
<td>R</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>4.12</td>
<td>Night tables or other similar surface</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.13</td>
<td>Console table with mirror</td>
<td>50</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>4.14</td>
<td>Lighting suitable for reading in bed which can be operated from either side of the bed</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.15</td>
<td>Central switch for the lighting at the entrance</td>
<td>50</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>4.16</td>
<td>Central switch next to the bed to operate the general lighting from the bed</td>
<td>50</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>4.17</td>
<td>Unused power points in room (at least 2)</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.18</td>
<td>Possibility for complete darkness in the room</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>e.g. shutters, opaque curtain</td>
<td></td>
</tr>
<tr>
<td>4.19</td>
<td>Luggage rack or similar provision</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.20</td>
<td>Pouf</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R : Required, O : Optional

Table 3.1 Hotels' standards established by the Greek Tourism Organization (EOT) (Continuation from previous page)
Source: GG 09.01.2015/Volume 10
3.2 Stakeholders and their Needs

The product’s stakeholders include mainly hoteliers and room tenants, with hoteliers being its primary market and the public the secondary one, since the luminaire can be used in a domestic context as well. Personal interviews with frequent travelers (lead users) were conducted in order to extract important conclusions related to their needs, as well as to define a questionnaire for gathering extra information. A questionnaire was used in order to, first, test how close the interviewed lead-users’ needs are to the average users’ needs and, second, to gather information related to tasks carried out in a hotel room by its tenants, as well as to their personal taste as regards lighting conditions. As it can be seen from light ergonomics, the range of luminous flux for each task is quite wide and the users have their own personal preferences.

1) How often do you stay in a hotel?
- up to twice a year
- 3-4 times a year
- 5-6 times a year
- more than 7 times a year

2) What is the usual purpose of your trip?
- business
- recreation
- education

3) Which hotel class do you usually select?
- Hostel
- 2***
- 3****
- 4*****
- 5******

4) With whom do you usually travel?
- nobody
- with my companion
- with friends
- with a colleague(s)
- kid(s)

5) What time do you usually wake up during your trip?

6) What time do you leave your hotel room?

7) During which hours do you sleep?

8) During which time are you usually in your hotel room? (please select all the answers that match your case)
- 00.00 - 07.00
- 07.00 - 09.00
- 09.00 - 12.00
- 12.00 - 15.00
- 15.00 - 18.00
- 18.00 - 21.00
- 21.00 - 00.00

9) How do you spend your time in the hotel room?

<table>
<thead>
<tr>
<th>Activity</th>
<th>in bed</th>
<th>at the desk</th>
<th>no time at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>I read literature books/magazines/newspapers (casual reading)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I read literature books/magazines/newspapers on my tablet (casual reading)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I surf on the Internet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I work, read/write on paper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I watch TV</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10) Which lighting conditions do you prefer per activity?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Strong</th>
<th>Soft</th>
</tr>
</thead>
<tbody>
<tr>
<td>I read literature books/magazines/newspapers (casual reading)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I read literature books/magazines/newspapers on my tablet (casual reading)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I surf on the Internet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I work, read/write on paper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I watch TV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11) Which lighting conditions do you usually prefer in your hotel room?

Strong lighting
Medium lighting
Soft lighting

12) In case you share your hotel room with other people, do you follow a common schedule?

- identical
  - we wake up at the same time
  - we go to bed at the same time
  - we stay in the room at the same time
  - we follow common activities

This question was quite difficult to phrase and the answers did not allow for clear results and conclusions.
1) How often do you stay in a hotel?
- up to twice a year: 54.1%
- 5-6 times a year: 13.5%
- more than 7 times a year: 8.1%
- 3-4 times a year: 24.3%

2) What is the usual purpose of your trip?
- recreation: 75.7%
- business: 16.2%
- education: 8.1%

3) Which hotel class do you usually select?
- Hostel: 40.5%
- 4****: 16.2%
- 3***: 37.8%
- 2**: 5.4%

4) With whom do you usually travel?
- with friends: 39.1%
- with my companion: 16.6%
- nobody: 8.1%
- with a colleague(s): 4.1%
- kid(s): 2.2%

5) What time do you usually wake up during your trip?

6) What time do you leave your hotel room?
First of all, considering that 14 and 15 -out of 37- individuals who answered the questionnaire use three-star and four-star hotels respectively, we can consider that the provided answers are valid and relevant. Since 28/37 are travelling for recreation and only 6/37 for business, it is quite logical that 18/37 are doing paperwork (5/37 in bed and 13/37 on the desk) and 19/37 are working on screen (tablet/laptop) (12/37 in bed and 7/37 on the desk). Paperwork and working on screen, as well as casual reading on paper and on screen, were diversified, since their lighting requirements are totally different. Given that only 5/37 are doing paperwork in bed, there is no actual need for the light to always come from the left side for right-handed users and from the right for left-handed users. Since 30/37 are accompanied by one or more fellow travellers-companions, friends, colleagues, children- the luminaire should be operating in a way to avoid disturbing other guest, even though most individuals answered that they share a common schedule with other tenants. The 24-hour day has been split in time zones based on a typical use scenario and the lighting needs related to each zone. The hours with the highest needs for artificial lighting is mainly 18.00-09.00, when actually most tenants are in the room (00.00-07.00 for 37/37, 07.00-09.00 for 31/37, 18.00-21.00 for 14/37, 21.00-00.00 for 13/37); for the rest, artificial lighting is only needed with the blinds closed.

Google forms were used for the survey. Answers were provided in an Excel file, allowing to view each individual’s answers separately and to combine the answers of different questions. That was very useful for conclusion extraction. Combining answers from questions 9 (tasks carried out in the room) and 10 (light preferences for each task), conclusions can be extracted for the users’ lighting requests per task from a bedside lamp.

- 22/37 are doing casual reading on paper in bed, with 14/22 asking for soft lighting and 8/22 for strong lighting.
- 15/37 are doing casual reading on screen, with 11/15 asking for soft and 4/15 for strong lighting.
- 33/37 are doing Internet surfing in bed with 28/33 asking for soft and 5/33 for strong lighting.
- Out of 18/37 who are doing paperwork, only 5/18 are working in bed, with 3/5 asking for soft and 2/5 for strong lighting.
- Out of 18/37 who are working on screen, only 12 are working in bed, with 8/12 asking for soft and 4/12 for strong lighting.
- 18/37 said that they are watching TV in bed, with all of them asking for dim lighting.

Based on these results -2/3 of the answers related to bedside lamp asked form soft and 1/3 for strong lighting - and considering the different lighting requirements of each task - mainly on screen and on paper- it is concluded that the luminaire should provide from a strong to a dim light and it should be possible for the light to come both from behind the user (for paper) and from their surroundings (for screen).

At this stage, an attempt to gather statistical data related to hotels’ needs and common practices, as well as their customers’ needs and practices, was made by resorting to the Hellenic Hoteliers Federation (HHF), the Institute of Greek Tourism Confederation – SETE (INSETE) and the Athens-Attica &amp; Aegean Hotel Association; Unfortunately this attempt was fruitless, since the only available data strictly refer to bookings.

Thus, data on hoteliers’ needs have been gathered through interviews and literature. It is common practice, especially for middle-class hotels such as three-star ones, to provide their clients with facilities mandatory for hotels of higher classes, in order to upgrade the overall quality of their services and maximize client satisfaction. Thus, lighting dimming, even though not mandatory for three-star hotels, is a very welcome extra facility. Maximum flexibility in the room’s layout, minimum wall modification and low energy consumption –leading to low running costs- were considered as very important needs by the hoteliers.

Osram, one of the biggest bulb manufacturers worldwide, quotes in its website “Perfect hotel room lighting should give a sense of comfort and security. Guests should feel welcome and at home as soon as they enter the room. Good lighting also means no annoying glare and no heavy shadows. Ideally guests should be able to adjust the lighting to suit their needs and their preferences so they can read, relax or work in peace. And the lighting must complement the style of the hotel.”

Chelsom, a UK lighting manufacturing company, hosts a very interesting article on its website related to hotel lighting: “Designing good lighting for hotels is about more than creating stylish products that are on trend and look the part. It’s about top quality products that provide efficient lighting and enhance the guest experience [...] recent extensive research conducted by Osram suggesting that of 10,000 recent hotel reviews in London most guests complained about the dim, bad and sparse lighting in their rooms. [...] One of the biggest complaints toconcierges is that guestrooms are insufficiently lit to work, put make up on or to simply see […] A hotel room is no longer just a room to sleep in, it has become multifunctional, a place to eat, sleep, work and relax [...] Products need to be designed to withstand frequent and often forceful handling because those of domestic quality aren’t going to last 2 minutes in the hotel environment. [...] most guests have dimming functionality at home and expect it in hotels, but they want it to be clearly visible on the product and most of all usable. I have lost count of the number of times I have heard stories of the concierge being called up to the room to explain how to dim the lights, illustrating there needs to be a distinct balance between design and functionality.”

3.3 Light as a Phenomenon

“Light has empowered us to experience the world, brought color into existence, and above all, it is the light within that liberates us.” Light is a phenomenon with many extensions, from philosophical and spiritual to totally pragmatic ones. It is the light that allows us to perceive the world through our eyes, that makes things revealed in our perception. In many traditions, light is considered equal to the divine and the truth. In physics, light is an electromagnetic phenomenon. Visible white light is a combination of electromagnetic waves with different wavelengths and it can be analyzed into them. Natural light on Earth mainly originates from the Sun (some animals and plants can also produce light through chemical reactions) and it is considered ideal in terms of its spectrum and color rendering.

**Sadhguru quote**

> Light has empowered us to experience the world, brought color into existence, and above all, it is the light within that liberates us. “Light is a phenomenon with many extensions, from philosophical and spiritual to totally pragmatic ones. It is the light that allows us to perceive the world through our eyes, that makes things revealed in our perception. In many traditions, light is considered equal to the divine and the truth. In physics, light is an electromagnetic phenomenon. Visible white light is a combination of electromagnetic waves with different wavelengths and it can be analyzed into them. Natural light on Earth mainly originates from the Sun (some animals and plants can also produce light through chemical reactions) and it is considered ideal in terms of its spectrum and color rendering.

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3. Sadhguru quote

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**Pict 3.6 Visible light**
The additive color model applies to the light. In other words, by mixing red, green and blue light, white light is produced, and the more you add the brighter the result, because they are emitting elements. Thus, all light emitting devices follow the RGB color model. It is interesting, though, that all colors are produced by mixing red, yellow and blue and that happens because the subtractive color model applies to paints. That means that the more you add the darker the result, because they are reflecting elements.

Artificial light came along with the fire discovery, as early as 400,000 BC. In the beginning campfires or torches were used, then oil lamps were produced using natural materials (rocks, shells, horns and stones were filled with grease and had a fiber wick); later on, candles, glass and pottery lamps were invented. As time went by, different fuels (whale oil, kerosene, gas) were used to produce light through burning, but fire still was the actual source of light. Electric lamps started to appear in everyday life as late as in the 1880s. Since then, artificial lighting has been a commodity, and a large variety of different electric light sources has been invented. Some of the most common ones are presented below.

### 3.4 Artificial Light and Electric Light Sources

- Incandescent light bulb, a heated filament inside a glass envelope
- Halogen lamps are incandescent lamps that use a fused quartz envelope filled with halogen gas
- LED lamp, a solid-state lamp that uses light-emitting diodes (LEDs) as the source of light
- Arc lamp
- Xenon arc lamp
- Mercury-xenon arc lamp
- Ultra-high-performance lamp, an ultra-high-pressure mercury-vapor arc lamp for use in projectors
- Metal-halide lamp
- Gas-discharge lamp, a light source that generates light by sending an electrical discharge through an ionized gas
- Fluorescent lamp
- Compact fluorescent lamp, a fluorescent lamp designed to replace an incandescent lamp
- Neon lamp
- Mercury-vapor lamp
- Sodium-vapor lamp
- Sulfur lamp
- Electrodeless lamp, a gas discharge lamp in which the power is transferred from outside the bulb to inside via electromagnetic fields

Thermal sources of light are most prevalent, since a distinctive spectrum of black-body radiation is emitted from a body with a given temperature. The most common example is the Sun, which in fact closely approximates a black-body radiator. Its surface temperature is around 6000K, emitting a vast spectrum of electromagnetic radiation, part of it being visible to the human eye.

In case of artificial lighting, the color temperature of a light source is defined as the temperature of an ideal black-body radiator emitting light of a similar color to that of the light source. Color temperature makes practical sense only in case of light sources that actually resemble the radiation of a black body, namely those ranging from reddish/orange via yellow and more or less white to bluish white. Therefore, color temperature makes no sense in case of a green or purple light. Color temperature conventionally uses the same unit used for absolute temperature, i.e. kelvins (symbol: K).

An ideal black body that emits electromagnetic radiation has a color temperature defined as its surface temperature, measured in kelvins. This is used as a reference of comparison for light sources.

A hot surface may well emit thermal radiation, but its light temperature does not equal its actual surface temperature, as long as it is not an ideal black body radiator. Instead, the bulb of an incandescent...
A color rendering index (CRI) is a quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with an ideal or natural light source. The CRI of a light source does not indicate the apparent color of the light source; that information is under the rubric of subjective color rendering quality in practice—particularly for light sources with spiky emission spectra for some light sources. Criticism on CRI model has arisen, since it is not always correlating well with daylight or a black body (incandescent lamps are effectively black bodies), dropping to negative values ly, the highest possible CRI value is 100, and would only be given to a source identical to standardized correlated color temperature (CCT). The CRI is determined by the light source’s spectrum. Numerical, the highest possible CRI value is 100, and would only be given to a source identical to standardized daylight or a black body (incandescent lamps are effectively black bodies), dropping to negative values for some light sources. Criticism on CRI model has arisen, since it is not always correlating well with subjective color rendering quality in practice—particularly for light sources with spiky emission spectra such as fluorescent lamps or white LEDs—because of the process through which CRI values are defined (description, analysis and flaws of the process were considered outside the scope of this thesis).

The amount of light produced by a lighting source is called brightness or luminous flux and it is measured in lumens (lm). In the past, it was quite common to use watts to describe the bulb brightness, but watts actually measure the amount of energy consumed by the bulb and not its brightness. This originated from the fact that almost all commercial bulbs were of the same technology (incandescent), producing more or less the same amount of light for a certain power consumption. This does not apply any more, since there are at least three different categories of commercial bulbs (LEDs, CFLs and incandescent/halogen ones) with a big difference in the brightness generated for the same amount of power (lm/w), ending up as a critical factor upon their selection. While lumens measure the total quantity of visible light emitted by a source, lux (lx) measure illuminance, meaning luminous flux per unit area lm/m². Experiments were conducted with certain bulbs in order to relate the number of lumens with the actual lighting effect.

Table 3.3 Color temperature and lighting sources
Source: https://en.wikipedia.org/wiki/Color_temperature

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1700 K</td>
<td>Match flame, low pressure sodium lamps (LPS/SODX)</td>
</tr>
<tr>
<td>1850 K</td>
<td>Candle flame, sunset/sunrise</td>
</tr>
<tr>
<td>2400 K</td>
<td>Standard incandescent lamps</td>
</tr>
<tr>
<td>2550 K</td>
<td>Soft white incandescent lamps</td>
</tr>
<tr>
<td>2700 K</td>
<td>&quot;Soft white&quot; compact fluorescent and LED lamps</td>
</tr>
<tr>
<td>3000 K</td>
<td>Warm white compact fluorescent and LED lamps</td>
</tr>
<tr>
<td>3200 K</td>
<td>Studio lamps, photofloods, etc.</td>
</tr>
<tr>
<td>3350 K</td>
<td>Studio &quot;CP&quot; light</td>
</tr>
<tr>
<td>4100 – 4150 K</td>
<td>Moonlight</td>
</tr>
<tr>
<td>5000 K</td>
<td>Horizon daylight</td>
</tr>
<tr>
<td>5000 K</td>
<td>Tubular fluorescent lamps or cool white/daylight compact fluorescent lamps (CFL)</td>
</tr>
<tr>
<td>5500 – 6000 K</td>
<td>Vertical daylight, electronic flash</td>
</tr>
<tr>
<td>6200 K</td>
<td>Xenon short-arc lamp</td>
</tr>
<tr>
<td>6500 K</td>
<td>Daylight, overcast</td>
</tr>
<tr>
<td>6500 – 9500 K</td>
<td>LCD or CRT screen</td>
</tr>
<tr>
<td>15,000 – 27,000 K</td>
<td>Clear blue poleward sky</td>
</tr>
</tbody>
</table>

These temperatures are merely characteristic; considerable variation may be present.

Table 3.4 Specifications of different lighting sources
Source: https://en.wikipedia.org/wiki/Electric_light

<table>
<thead>
<tr>
<th>Name</th>
<th>Optical spectrum</th>
<th>Nominal efficacy (lm/W)</th>
<th>Lifetime (MTTF) (hours)</th>
<th>Color temperature (Kelvin)</th>
<th>Color</th>
<th>Color rendering index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent light bulb</td>
<td>Continuous</td>
<td>4 – 17</td>
<td>2-20,000</td>
<td>2,400–3,400</td>
<td>Warm white (yellowish)</td>
<td>100</td>
</tr>
<tr>
<td>Halogen lamp</td>
<td>Continuous</td>
<td>16 – 23</td>
<td>3,000–6,000</td>
<td>3,200</td>
<td>Warm white (yellowish)</td>
<td>100</td>
</tr>
<tr>
<td>Fluorescent lamp</td>
<td>Mercury line + Phosphor</td>
<td>52 – 100 (white)</td>
<td>8,000–20,000</td>
<td>2,700–5,000</td>
<td>White (various color temperatures), as well as saturated colors available</td>
<td>15–85</td>
</tr>
<tr>
<td>Metal halide lamp</td>
<td>Quasi-continuous</td>
<td>50 – 115</td>
<td>6,000–20,000</td>
<td>3,000–4,500</td>
<td>Cold white</td>
<td>65–93</td>
</tr>
<tr>
<td>Sulfur lamp</td>
<td>Continuous</td>
<td>80 – 110</td>
<td>15,000–20,000</td>
<td>6,000</td>
<td>Pale green</td>
<td>79</td>
</tr>
<tr>
<td>High pressure sodium</td>
<td>Broadband</td>
<td>55 – 140</td>
<td>10,000–40,000</td>
<td>1,800–2,200</td>
<td>Pinkish orange</td>
<td>0–70</td>
</tr>
<tr>
<td>Low pressure sodium</td>
<td>Narrow line</td>
<td>100 – 200</td>
<td>18,000–20,000</td>
<td>1,800</td>
<td>Yellow, no color rendering</td>
<td>0</td>
</tr>
<tr>
<td>LED lamp</td>
<td>Line plus phosphor</td>
<td>10 – 110 (white)</td>
<td>50,000–100,000</td>
<td>Various white from 2,700 to 6,000</td>
<td>Various color temperatures, as well as saturated colors</td>
<td>70–85 (white)</td>
</tr>
<tr>
<td>Electrodeless lamp</td>
<td>Mercury line + Phosphor</td>
<td>70–90 (white)</td>
<td>80,000–100,000</td>
<td>Various white from 2,700 to 6,000</td>
<td>Various color temperatures, as well as saturated colors</td>
<td>70–85 (white)</td>
</tr>
</tbody>
</table>
Nowadays, since energy consumption has turned into a critical factor, LEDs and CFLs are the most commonly used, with halogen lamps (type of incandescent lamp that use a fused quartz envelope filled with halogen gas) being still in use due to their low price and dimming possibility.

LEDs today are superior over all other bulbs in brightness, life span and efficiency (lm/watt) and thus have been selected as the luminaire’s lighting source. Thus, LEDs have been studied further through literature and hands-on research in order to understand their working method, strengths and weaknesses. The LED - light-emitting diode - to put it simply, emits light through electron movement and change in their energy status, which release photons. This phenomenon is called electroluminescence, and the light color (which corresponds to the photon energy) depends on materials’ type and technical aspects of the circuit.

The first LEDs were invented in 1962, producing low-intensity infrared light. After further development, the first visible-light LEDs were produced, also with low intensity and limited to red light. Blue LEDs appeared in 1972 and white ones shortly afterwards. From that stage onwards, LEDs have greatly developed, achieving high brightness and color rendering with very low energy consumption.

<table>
<thead>
<tr>
<th>Incandescent</th>
<th>Lumen</th>
<th>Halogen</th>
<th>CFLs</th>
<th>LEDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>40W</td>
<td>~450</td>
<td>29W</td>
<td>9-13W</td>
<td>4-5W</td>
</tr>
<tr>
<td>60W</td>
<td>~800</td>
<td>43W</td>
<td>13-16W</td>
<td>6-8W</td>
</tr>
<tr>
<td>75W</td>
<td>~1100</td>
<td>53W</td>
<td>17-23W</td>
<td>9-11W</td>
</tr>
<tr>
<td>100W</td>
<td>~1600</td>
<td>72W</td>
<td>23-30W</td>
<td>11-15W</td>
</tr>
</tbody>
</table>

Table 3.5 lm/w for the three most commonly used lighting bulbs’ types.
Typical LED bulbs have been studied through hands-on research to define their components, construction method and behavior during operation. Since LEDs are working in low voltage, a current transformer is inserted in the circuit (visible or not, depending on the LED type). In common LED light bulbs (as the own shown below), electronics are embedded in a non-visible way. LEDs produce very low heat compared to other bulbs, such as incandescent ones, due to their functional principles (they are not thermal sources). Still, some heat is produced mainly by the electronics, due to current transformation. Thus, heat sinks are a common feature of all LED applications.

<table>
<thead>
<tr>
<th>high brightness</th>
<th>energy efficiency - high lm/w</th>
</tr>
</thead>
<tbody>
<tr>
<td>long life span 20,000h - 50,000h</td>
<td>shockproof</td>
</tr>
<tr>
<td>low heat</td>
<td>no mercury included</td>
</tr>
<tr>
<td>CCT 2700K - 6000K</td>
<td>small size</td>
</tr>
<tr>
<td>low voltage</td>
<td>need for transformer</td>
</tr>
<tr>
<td>dimmable (some of them)</td>
<td>CRI ≤ 85</td>
</tr>
<tr>
<td>high price</td>
<td>non-recyclable</td>
</tr>
</tbody>
</table>

Table 3.6 LEDs characteristics.
With LED technology, lighting sources of very small dimensions have been achieved. Especially OLEDs (organic light-emitting diode), a certain type of LEDs, come in the form of flexible and transparent films, as thin as 0.6mm. OLEDs nowadays are mainly used in digital displays, but attempts to incorporate them in luminaires have already been made. Their main weakness is their high cost, as well as their shorter life span and lower efficiency (lm/w) compared to common LEDs. LED panels produce more or less the same result as OLEDs, the difference being that they are not flexible and are significantly thicker (about 7-10mm) but still slim enough. LED panels use common LED strips combined with certain filters in a certain way, resulting in all emitted light coming through refraction and providing a smooth and uniform light. LED panels have been meticulously studied through hands-on research and, since the very beginning have been considered a very good option.
3.5 Human Physiology and Circadian Rhythms

Human eye is the organ which allows vision. Light reception activated certain cells (rod and cone cells) in the eye and, through chemical reactions, light is converted into chemical-electrical signals which is transferred to the brain through the optic nerve. The signals are being processed by the brain and image perception is created. The human eyes facilitate the creation of a three dimensional, moving image, with normal color in daylight. Rod and cone cells in the retina permit conscious light perception and vision with different colors, as well as the perception of depth.

Light reception through the eyes is also related to hormones production in the human body. The body has its own internal clock and cycle which regulates the timing of biological processes in a periodical base. This phenomenon is known as circadian rhythms. Although these rhythms are self-maintained, there are slight variations in terms of length for each individual (for some people they are longer than 24 hours and for others shorter). Therefore, external factors are used to realign the individuals’ internal clock with a 24-hour day/night cycle. Eyes exposure to light is probably the strongest realignment factor. Melatonin is an important hormone for circadian rhythms and its production is strongly affected by light exposure. Certain wave lengths -mainly blue- that appear in early daylight suppress melatonin production, creating an activation state for the body. Warmer light, like during sunset, includes less blue in its spectrum and allows melatonin production, preparing the body for rest and sleep. Melatonin is also considered an important hormone for a lot of metabolic activities in the human body, some of them still unknown. Its suppression has even been correlated to cancer appearance.

Thus, it is important to protect both its production and suppression cycle, as well as circadian rhythms in general. Artificial light creates an intensive disturbance in circadian rhythms, since the body cannot understand the actual time based on light exposure, ending up in a “constant day” effect. Especially electric light sources, such as LEDs and CFLs, which produce a light spectrum rich in blue light, and digital screens intensify this effect. Thus, bulb production companies, such as Philips, LG and others, have been experimenting in the production of bulbs that can create light of a different color during the 24-hour cycle, in resonance with the melatonin production and suppression cycle.

Moreover, software has been developed and embedded into many electronic devices (smartphones, tablets, computers etc.) to adjust screen color and reduce the blue light percentage in the emitted light.
3.6 Lighting Requirements and Ergonomics

Lights requirements mainly depend on the task at hand and the user's particular needs and preferences. A basic rule is that the more precision the task requires the more brightness is necessary. As people get older, their need for brightness increases for the same tasks, due to eye sensitivity reduction. Moreover, personal preferences and taste indicate different amounts of light for the same task and age. Thus, lighting ergonomics recommendations provide a significant range of the light required for each task.

<table>
<thead>
<tr>
<th>Illumination</th>
<th>lux, lumens/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedroom, Dormitory</td>
<td>200-300</td>
</tr>
<tr>
<td>Reading</td>
<td>300 - 500</td>
</tr>
<tr>
<td>Workshop or Intensive reading</td>
<td>500 - 1200</td>
</tr>
<tr>
<td>Work on screen</td>
<td>300-500 - 750</td>
</tr>
<tr>
<td>Watch TV</td>
<td>50-100</td>
</tr>
<tr>
<td>High detail work</td>
<td>1000 - 2000</td>
</tr>
</tbody>
</table>

Table 3.7 Light required for each task

3.7 Luminaires and Market Research

The simplest luminaire form is an electric circuit which provides the necessary electricity to the lighting source in order to create artificial light. The lighting source may vary; a switch is commonly used to control the device activation-deactivation, permanent lighting may be directly wired, moveable lamps may have a plug, while reflectors for directing the light may be used.

An extensive market research has been conducted to identify different kinds of available luminaires. Luminaires usually are organized in two main categories, indoor and outdoor, plus a few other basic subcategories (without this being a rule), based on their position and placement method, i.e. suspension, floor, table, wall (mounted & recessed), ceiling (mounted & recessed). Research included all these categories and focused on table and bedside lamps.

Especially for hotel rooms, there is an upcoming trend in bedside lamps, consisting in combining two lamps in one, providing both ambient and task light. Most of these products are wall-mounted and feature two light sources with two outer shells, merged rather awkwardly, with a single switch to alternate the active lighting source.

Table lamps present a significant variety with great results in terms of functionality and aesthetics. This subcategory served as a great ideas bank and inspiration source for the concept development phase.
The position and placement method in bedside lamps vary a lot. They can be suspended from the ceiling, wall-mounted, placed on the night table or, less commonly (due to functional reasons), placed on the floor. Each of these methods differs on several aspects, such as wall/ceiling modification, flexibility of room layout, electric wiring requirements, useful surface and space occupation and, of course, lighting result.
4. Personal Perspective

In my point of view, a functional object first of all should fulfill the function it is meant for, in the best possible way. Its form, features, details and overall design should be aligned with its functional purpose. In an era of modernism that was stated as the “form follows function” approach⁴ to distinguish it from other approaches, which focus more on the object’s form, while function comes second. When something is being created to fulfill a real need and its form is aligned with the purpose of its existence, it has an inherent sincerity and beauty. Throughout humanity’s pursuit of the truth and real substance of things, notions of beauty, goodness and truth have been mentioned in many cultures from early on, even before Classical Greek philosophy. This set of highest values is often attributed to Plato, even though nowhere in his works are these values referred as a specific group, because he mentions them in several of his works.

An object that incorporates truth is somehow self-sufficient. The way in which that object expresses its existence is of major importance to the user’s experience. My aim is for the object to invite the user to engage with it and discover its inner reality. It should be self-sufficient but not strict and distant. It should feel “open”, receptive and accessible, giving and receiving opportunities for interaction. The development of a rich user sensory experience, full of stimuli directly received through physical senses, can create emotions and an overall memorable experience. Most of the times, it is our feelings and emotions that we do remember rather than the facts. The objects’ overall design (form, materials, finishing, etc.) offers a sensory stimulus and invites the user to discover it through his senses. The object should indicate a way of interaction, but not too loudly, allowing users to find their own way of interaction and build their own experience. My intention is for the users to take the object in their hands and to inspect it.

When we talk about object design, the senses mainly involved are sight and touch, followed by smell, hearing and taste, but all of them are involved. Actually, the more senses and the more strongly they are involved, the richer the user’s experience. According to Roland Barthes, sight is the most magical of all senses and touch the most demystifying⁵. Indeed, sight is the sense that in a way makes first contact with our farther surroundings, even though touch is always in contact with our closer environment (floor, clothes, etc.). It is sight that provokes the will to come closer and interact through touch. But it is only when you approach and touch something that you start discovering it; until then, you might be really far away from the object’s reality. Until then, it is our projections of what we are seeing that we perceive. Even when we touch something, we are not able to “touch” its truth, but still we are a step closer to it.

Sight is much more of an intellectual sense. Even emotions arising from sight, such as astonishment and admiration, are somehow intellectual ones. Touch, on the other hand, is more related to the body and sensory experience, and it can create “deeper” emotions, such as affection, euphoria, joy, pleasure, tenderness, etc.

In our era, sight seems to rule more and more our everyday life and experience. It is actually “the only sense that is fast enough to keep pace with the astounding increase of speed in the technological world. But the world of the eye is causing us to live increasingly in a perpetual present, flattened by speed and simultaneity.”⁶ “The dominance of the eye and the suppression of the other senses tends to push us into detachment, isolation and exteriority.”⁷ “Our society is characterized by a cancerous growth of vision, measuring everything by its ability to show or be shown.”⁸ Especially with the use of smartphones and social media, our life is getting more and more seen and shown rather than lived. All these have raised a lot of speculation around senses, sensory experience and design. Renault’s concept car Talisman presented in 2001 (launched by Patrick Le Quément), which introduced the notion of “Touch Design” in automotive industry, is part of this movement, as well as Juhani Palasmaa’s book “The eyes of the skin” and many other examples. Design nowadays can play a significant role in the user’s sensory experience and the equal participation of the senses in this experience.

The object should adjust to the users’ needs and provide them with both the necessary clues and the freedom to build their own experience, way of interaction and self-expression. An over-defined object suppresses the user’s creativity and imagination, imposing a certain way of use and interaction. On the other hand, an under-defined object doesn’t provide the user with sufficient information on how to interact with it and may create an unpleasant and confusing experience.

Sustainability is also of great importance, especially nowadays, given that the planet’s equilibrium is getting more and more fragile, putting Man’s survival at risk. If a product does not fulfill the purpose for which it was bought, sooner or later it will end up in the trash or, at best, in a dusty attic. This means a huge waste of resources, energy and money, plus environmental pollution. Thus, the most sustainable design is good design. Good design, besides being functional, lasts for a long time. To make this possible, objects should be robust and durable enough in constant use and strain, repairable and embody timeless aesthetics. Of course, recyclable and renewable materials are also very important. Natural materials are a very good solution, since most of them are renewable and they do not cause any environmental pollution, especially considering the fact that recycling cannot be guaranteed.

In general, I adopt Dieter Rams’ ten principles for ‘good design’ and consider them very useful tools in the design process.

1. Good design is innovative
2. Good design makes a product useful
3. Good design is aesthetic
4. Good design makes a product understandable
5. Good design is unobtrusive
6. Good design is honest
7. Good design is long-lasting
8. Good design is thorough down to the last detail
9. Good design is environmentally-friendly
10. Good design is as little design as possible⁹

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⁴Roland Barthes (1957) The New Citroen - extract from Mythologies
⁶1Louis Sullivan quote
⁷Roland Barthes quote
⁸Juhani Pallasmaa (1995) Eyes of the Skin, John Wiley & Sons, p. 21

...
5. Design Guidelines Set

Based on the initial research and my personal perspective, a set of design guidelines was compiled and placed in hierarchical order.

- Form follows function approach
- Object adjusts to user’s needs
- User engagement through senses and mainly touch – user takes the object in hand
- Bedside lamp
- 3* hotels
- Aesthetics (moodboard)
- Environmentally sustainable (obviously)
- Maximize energy efficiency (obviously)
- Incorporates LED lighting source
- Provides ambient light
- Operates as task light
- Durable and robust
- Long-lasting
- Fits in different aesthetic environments and interior design styles
- Provides flexibility in room layout
- Requires minimum wall modification
- Provides self-explanatory use
- Easy to clean
- Easy to remain clean
- Creates soft light
- customizable
customizable
- neutral
- wall
- ceiling
- table
- floor
- multiple
- mechanical
- electrical
- 220V
- 12V
- electric plug (higher flexibility in room layout & minimum wall modification)
- wall-mounted wiring
- 360° (the luminaire can provide both ambient and spot light with one source)
- Lighting source easy to obtain
- Lighting source easy to replace
- Use of natural materials (metal, wood, clay, ceramic, glass, fabric, paper, rubber etc.)
- Easily CE certifiable
- Eliminate emitted blue light

In cases with multiple possible solutions, decisions were made based on further research, technical characteristics and personal preferences.

A customization possibility in aesthetics, by selecting from a certain variety of solutions, was chosen over a neutral aesthetical character, since this could provide hoteliers with a sense of exclusivity. Moreover, in combination with small production quantity (from 50 pcs), even small hotels can obtain this option.

Multiple positioning was selected to increase the users’ engagement with the object and to provide them with a higher variety of lighting results and options, thus fulfilling their needs in the best possible way.

The mechanical dimming option was selected to increase the users’ engagement with the object and provide higher flexibility in the lighting source selection, since the majority of LEDs are not dimmable and the ones that are cost more and are more difficult to find.

A lighting source of low voltage was selected for safety reasons and because it makes the CE certification process easier.

Energy supply through common electric plug was chosen, to provide hoteliers with higher flexibility in room layout and minimize wall modification requirements, making the whole process easier and thus increasing the possibilities to obtain the product.
6. Concept Generation

In this phase, sub-solutions for each one of the design guidelines have been created. At the same time, various concepts have been approached through sketching in order to find the most suitable one for the occasion. At the end of this phase, a certain concept has been chosen based both on intuitive criteria and the design guidelines.

- Ambient to task light subsolutions

- Luminaire’s possible position options subsolutions
- Mechanical dimming possibilities subsolutions

- Direct light beam subsolutions

- Lighting source movement subsolutions
Luminaire's concepts
7. Further Development

The selected concept has been aligned with design guidelines through further development. Further primary and secondary research has been conducted, to acquire specific knowledge on certain fields. Semantics have been studied in order to find out how the object can indicate its way of use and features. The object itself needed to imply the following ideas: inviting the users to engage with it through their senses and mainly touch, manipulating the lighting effect by turning the luminaire upwards or downwards, dimming by twisting and placing the luminaire on the wall, and transforming it from an ambient to a task light.

It was the luminaire’s cylindrical silhouette and its hand interaction that led to the idea of twisting as a feature of its operation. Polarizing filters combined with twisting could provide extra features, offering different lighting and creating a rich user experience. Their function, capabilities and characteristics have been studied to find out how they could be incorporated and enrich the overall result.

Hand dimensions have been specified through anthropometrical data, and common objects designed for hands, such as water bottles, have been studied, in order to define the luminaire’s diameter. Physical models have been built and tested, as well, for further exploration of the object’s interaction with the user’s hand.

This study has concluded that for the luminaire to fit better into the users’ hands and allow them to experiment with it, an overall diameter of around 90 mm is most suitable (the diameter of most large water bottles is about 80-85 mm).

Even though a 90 mm overall diameter seems optimal for hand operation, a compromise to 95 mm has been done, considering the fact that the object’s primary function is to provide light and not hand operation. First of all, the larger the diameter, the more the emitted light. Secondly, with a 90 mm overall diameter and selected proportions, the luminaire didn’t look big enough in relation to the room’s context. Last but not least, it was not possible to find any available led panel providing adequate lighting result for 90mm.

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This study has concluded that for the luminaire to fit better into the users’ hands and allow them to experiment with it, an overall diameter of around 90 mm is most suitable (the diameter of most large water bottles is about 80-85 mm).

Even though a 90 mm overall diameter seems optimal for hand operation, a compromise to 95 mm has been done, considering the fact that the object’s primary function is to provide light and not hand operation. First of all, the larger the diameter, the more the emitted light. Secondly, with a 90 mm overall diameter and selected proportions, the luminaire didn’t look big enough in relation to the room’s context. Last but not least, it was not possible to find any available led panel providing adequate lighting result for 90mm.

An extensive literature and hands-on research has been conducted on objects designed for hand operation and not only, to define what invites individuals to engage with objects through touch, as well as what fits and feels better in the human hand. Through literature, personal experience and earlier studies on architecture, an attempt was made to define factors appealing to touch. First of all, the object’s overall form and individual form details can affect the users’ will to take it in their hands. If the overall form looks too geometrical, minimal and strict, this may cause the users to feel “look but do not touch”. Thus, more organic forms and proper form details (curves, round edges, etc.) can make an object look more accessible. The object’s dimensions and perceived robustness also play an important role. If something looks too big or too small or fragile, this will discourage the user from tactile engagement. Materials and their finishing can appeal to the user’s engagement and create totally different tactile experience. Some materials feel cheap, others unpleasant, while some can generate very pleasant feelings and so on. Last

Table 7.1 Ergonomics of the human hand.

<table>
<thead>
<tr>
<th></th>
<th>5th percentile</th>
<th>50th percentile</th>
<th>95th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand length</td>
<td>17.9</td>
<td>19.3</td>
<td>20.6</td>
</tr>
<tr>
<td>Hand breadth</td>
<td>8.2</td>
<td>8.9</td>
<td>9.6</td>
</tr>
<tr>
<td>female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand length</td>
<td>15.8</td>
<td>17.2</td>
<td>18.7</td>
</tr>
<tr>
<td>Hand breadth</td>
<td>6.9</td>
<td>7.8</td>
<td>8.6</td>
</tr>
</tbody>
</table>

Source: https://msis.jsc.nasa.gov/sections/section03.htm
but not least, the object’s weight can play an important role in the user’s experience and perceived quality. Something too light may feel cheap and of low quality, whereas something too heavy may feel bulky. The most important conclusion, though, is the fact that the most appealing factor for tactile engagement is mystery, namely when what stands before us seems impossible to perceive and understand through sight. The inability may refer to its identity, function, material, history and so on. Any of these is enough to provoke the user’s engagement.

Handles, kitchenware, pans, kitchen hand blenders and other tools and small devices have been studied through hands-on research and experimentation in terms of their overall form, materials and finishing, how they invite the user to interact with them and how they feel. Organic forms look more inviting than geometrical ones. A slightly mat finishing looks and feels more premium. Metal may look premium and expensive, but at the same time so strict that it doesn’t invites the user to touch it. Moreover, it feels so slick and cold that, most of the time, it creates a poor and unpleasant tactile experience. Paint and coatings may affect its overall result, depending on the added material. An interesting finding was that rubber looks very inviting and fulfills the user’s expectations for a rich tactile experience, compared to some plastics that may look tempting but feel cheap because of their texture and weight. Additionally, rubber creates a subconscious feeling of adjustability and durability.

The luminaire’s proportions have been explored through sketching and physical models. Based on the selected diameter and proportions, the overall dimensions have been defined based on aesthetical criteria, overall lighting result, lighting sources availability, plus the object’s appearance in space. 95 mm have been selected as the external (and 90 mm for the internal) diameter, so that the luminaire can provide better lighting and look big enough compared with other objects in the room.

At this point, extra research took place to find alternatives solutions on lighting sources that would fit in a 90 mm luminaire’s internal diameter, since the initially selected LED panel (Theron 840R 8W) required a slightly larger internal diameter. Products with smaller diameter, thus wattage, and equal or higher luminosity were sought. Even a bare LED strip was tested, but unfortunately its output for the same length was around 260 lm, providing inadequate light. Smaller panels with 3 w power (300 lm) and an 85 mm overall diameter were tested, but the lighting result was poor, since they didn’t provide enough light and they were creating weird shadows because the luminous surface’s diameter was about 50 mm. Eventually, ‘Spot Light 5471’ was discovered, with a 90 mm overall diameter and 75 mm luminous surface diameter. Moreover, its brightness is around 900 lm (even though its specifications mention 1120 lm) and it comes with an embedded controller requiring no modification during the luminaire’s production.

Pict 7.15 Different lighting sources that have been tested.
Pict 7.16 - 7.19 Lighting effect of different sources. Photo shooting with identical settings to compare lighting result.
LED strip 900lm/m 0.29m aprox. 260lm,
Spot Light 5236 LED panel 3W 300lm,
Theron 840R LED panel 8W 500lm,
Spot Light 5471 LED panel 8W 900lm (from left to right)
The luminaire's cable should be long enough to allow multiple positioning but at the same time it should stay away from the bed and the user's feet, as this could cause inconvenience or even an accident. Thus, a series of solutions were investigated, concluding that the optimum and simplest option would be a cable with the right length. Based on the typical night table's height, electric plug location and collected anthropometrical data from hands-on research, the cable's length has been defined through a series of experiments at 135 cm, to serve both luminaire's potential positions. In case of marginal scenarios with extremely different night table dimensions or electric plug locations, the cable length could be easily adjusted during production.

In this stage, luminaire's form and features have been refined through sketching, physical models' creation and use of parametric design (Solidworks software).
8. Final Product

Evidence of use scenarios is provided to the users through subtle features, to allow them to form their personal experience without imposing a certain way of interaction. A little mystery is used to provoke the user’s attention and will for interaction. The luminaire’s multiple positioning with two predefined places - on the night table and over the bed - and at least one more possible one - on the floor - was a decision made to better serve the users’ need and engage them more in a sensory experience since they would take the object in their hands in order to move it around.

The luminaire’s form is almost totally symmetric (except from the concave recess on the one side and the opening on the one cylinder’s flat surface) to imply the fact that it can face both upwards and downwards or even sideways, in order to create different lighting results. The cable is positioned in the middle of the cylinder and both of its edges are slightly round. One of the two cylinder’s flat surfaces together with its rounded edge is rotatable, in order to switch the luminaire on and off, and to provide a dimming option.

Pict 8.1: Luminaire’s multiple positioning and possible places.

Pict 8.2 - 8.4: Luminaire’s different aspects (facing upwards, downwards or sideways).

Pict 8.5: The luminaire when facing upwards.

Pict 8.6: The luminaire when facing downwards.
The dimming effect is achieved through the use of two polarizing filters. One is stable and the other rotates together with the rotatable cylinder’s flat surface. When the filters’ orientation is vertical, all the emitted light is blocked. Thus, in the starting position the filters are almost perpendicular, allowing very little light to escape, and in the final one parallel, blocking almost none of the emitted light. Marks can be imprinted on the rubber surface to guide the users and simplify their interaction.

Even though, conducted survey concluded that there was no strong need for the luminaire to operate both as an ambient and a task light, or to provide the user with the ability to direct the light beam, it was considered as a nice extra feature, plus as a safe solution in case there was a flaw in the survey. In this way, the final product consists of two main parts, the luminaire and a wall-mounted base, which is used to attach it on the wall over the bed in order to serve as a task lamp. Both the luminaire and the base are made of the same materials, have the same colors and their form looks complementary, in order to provide the user with clear evidences that these two objects can be combined. The luminaire’s initial position is considered to be on the night table, because if it is already attached on the wall-mounted base, the incautious users may not realize that they can detach it from there. A spherical magnet is used to achieve the temporary attachment of the luminaire onto the base, providing the ability to rotate the luminaire in order to direct the light beam and create different lighting results.

Both luminaire and base are made of metal, coated with a thin layer of rubber. The use of metal also allows the use of a magnet and offers the necessary robustness, actual and perceived. At the same time, it provides the necessary overall weight to create a feeling of a premium object (the weight is estimated at around 500 gr through the Solidworks software). Rubber serves to create a misty visual impression and provokes the user to touch the object in order to define its materiality. It is also used because it provides a rich and pleasant tactile experience. Moreover, bare or even painted metal would not look very tempting and would also discourage the user from touching it, according to the popular belief that a luminaire made of metal is too hot, even though this is not the case, since LEDs produce very little heat. Rubber is also providing significant friction, maximizing the luminaire’s stability and allowing one-hand rotational dimming. Both of these materials are durable, long lasting, recyclable, become and stay clean easily, thus fulfilling the required design guidelines.

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The rubber-and thus product-color can vary within a certain palette to provide hoteliers with the ability to select the color that better matches the room’s interior design and offers a feeling of exclusivity.
Pict 8.15 The luminaire placed over the bed, facing downwards.

Pict 8.17 Potential hotel room.

Pict 8.16 The luminaire placed over the bed, facing upwards.

Pict 8.18 The luminaire in different colors.
The luminaire incorporates a ‘Spot Light 5471’ LED panel that provides around 900 lm, with 8 W power, 50,000 h lifespan, 180° beaming angle, 12 V DC power supply, 4,000 K CCT. This lighting source is actually a readymade luminaire for recessed ceiling or wall placement that can be easily obtained. Since it is used with no modification, it can be easily replaced after the end of its life-span (even though it lasts quite long -50,000 h equal around six years of 24/7 use); combined with the 12 V DC power supply, it simplifies a lot the CE certification process. The lighting source’s long life and replacement possibility, combined with the materials’ robustness and durability guarantee a long-life span for the overall product. The power supply through a common electric plug maximizes flexibility in the room layout and minimizes wall modification regardless of an wall-mounted electric installation.

Sheet metal is proposed for the production method. The cylinder’s lateral surface is made from a flat sheet metal, after making the openings with laser cutting and rolling it. The concave recess and the cylinder’s flat surfaces with round edges are produced with metal spinning or metal drawing, depending on the size of production and the available financial resources for producing the required molds. At the end, all pieces are welded together, except the rotatable surface which is assembled with another method, probably by using screws. The required internal mechanism for keeping the light source and polarizing filters in position and allowing them to rotate is probably is made from solid aluminium, formed through milling.

9. Discussion of Process and End Result

The overall process, acquired knowledge and end result are considered more than adequate in terms of the Thesis’ scope, requirements and available time. Systematic and methodical - primary and secondary- research has been conducted using a variety of research techniques. Reflection upon the findings, critical analysis and interpretation led to important and necessary conclusions for the progress of the process. A synthesis of the conclusions and acquired knowledge, in combination with innovative thinking led to the end result. The end product addresses a real-life problem, providing concrete and viable solutions in many sub-problems. Through adjustability and flexibility, it can meet a variety of users’ needs with original, innovative, simple and realistic design, and no exaggerated requirements in materials and production techniques.

Ideally, more prototypes should have been built in order to conduct group tests for the further development and refinement of the product. This was not possible due to the lack of financial resources and, mainly, time constraints. It has been estimated that a working prototype would need around 250€ and a couple of months to be produced. Especially for the polarizing filter, extensive research came up with a single shop where it could be obtained and, in fact, upon special request and import from England. Thus, it was not possible to experiment on it, even though it was my original intention, since it was actually ordered but did not arrive on time.

Further experimentation on how to eliminate the emitted blue light should take place, since the initial idea of using filters did not meet with success, because that there are no available filters absorbing blue light in the lighting industry. Existing filters have been designed mainly to produce special lighting effects for shows and events, movie and photo shooting, and in these cases, there is no need to block blue light. During experimentation with physical models made of cardboard, it was observed that the color and texture of the model-luminaire’s internal surface had a significant impact on the amount and color of the emitted light. Experimentation with different type and color of internal coatings could probably provide a solution for this aspect.
Another issue for further investigation is the fact that when the luminaire is facing upwards and it is dimmed to full brightness, a potential glare may occur if the user is standing over or close to it. This probably will not happen when polarizing filters are placed, but this was impossible to test, since the filter has not yet been obtained. In any cases, if a glare still occurs in the position facing upwards, the filters’ relative position may not be parallel to their final angle, blocking a necessary amount of emitted light to prevent a glare.

Last but not least, concerning the research stage, more interviews with or a questionnaire filled in by hoteliers would be useful in order to verify the opinions already gathered through the small sample and literature research.

Thoughts and reflections upon the creation of a series of luminaires of different types, such as suspended, floor or free-standing, have occurred and were taken into consideration during the luminaire’s development process, but mostly remain a future plan.

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