GU J Sci, Part A, 4(4): 125-143 (2017)

Gazi University

Journal of Science

PART A: ENGINEERING AND INNOVATION

http://dergipark.gov.tr/gujsa

# Conceptual Design of a New Buoy

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**Article Info**

*Received: 15/11/2017*
*Accepted: 15/12/2017*

**Keywords**

*Oceanographic buoy,*
*Meteorological buoy,*
*Acoustic buoy,*
*Systematic design approach,*
*Conceptual design*

**Abstract**

Known as navigational aids, buoys are used for locating, pointing to a dangerous area or showing cruising routes. It is important that the scientific, commercial or military oceanographic, meteorological or acoustical data are collected, processed and valued in our country, which is surrounded by the sea on three sides. Within the scope of this paper, the conceptual design of a new buoy that will answer this need is introduced. This design process is based on the systematic design approach of Pahl and Beitz. The method applied includes problem definition, formulating (function diagram), creating and selecting options. The conceptual design of the buoy will ensure that changes in the ecosystem are tracked in real time or recorded. The collected data will be valued and made available for long-term estimates.

## 1. INTRODUCTION

Generally, buoys used as navigational aids due to seafloor are floating bodies with shells of different shapes and sizes. Indicating a position in the sea is used to indicate a dangerous area, such as a shallow, rocky or sunken area, or to indicate a transit route that must be followed.

In parallel with the developing technologies in recent years, the usage areas of the buoys are also increasing. In addition to marking functions in the sea areas, buoys also serve the fields of marine science, climate science, defense industry by monitoring and analyzing the meteorological, oceanographical and acoustic changes of the marine environment.

In this study, a sample design application is described using Pahl and Beitz's conceptual design approach [1] to develop a buoy that collects data with underlying underwater and meteorological sensors, evaluates data with signal processing algorithms, and distributes valuable data with communication units.

## 2. CONCEPTUAL DESIGN OF AN INNOVATIVE BUOY

In this section, a conceptual design of a new and innovative buoy constructed using a systematic design approach will be introduced. Buoys can be placed in a fixed area or moving (non-anchored) in sea, lake or river. Buoys are usually used to create a marking in marine areas where they are placed, to make oceanographic, meteorological, acoustic observations and records, or to protect the sensors or structures positioned at the bottom of the sea from physical effects and indicate their location.

There are studies in the literature which outline structural design techniques and productions of buoyant systems. For example, the reference [5] includes information about buoys classification, design logic, buoy hulls and the float materials, anchors and production.

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The buoys are equipped with various sensors and devices according to their intended use. These sensors and devices are generally used to observe sea water and weather conditions, determine the buoy position and transmit data to the coastal unit.

There are studies to transmit the results to the center via acoustic and radio data links, with buoys equipped with sensors and communication devices and special ecological areas underwater or watching target sea platforms in the water [6, 7].

It is expected that the buoy system will be able to measure the wind stress on the scene [8]. A buoy of 10 m in diameter was used to record the current speed and direction in a vertical profile for one year in a river with an average water depth of 46 m [9]. The reference [10] overviews characteristics and test results of the oceanographic observation buoy developed in the field study.

A solution is provided in the communication and information network of these systems, how to communicate with minimum energy expenditure without jumping and / or other problems [11].

Along with the rapidly developing technology, it is possible to make more capable hardware designs for such buoys. There is a study of hardware design, including a buoy data acquisition, communication and data storage systems, that provide platform real-time data at work [12].

In this study, the conceptual design of a new / innovative buoy to be used in the sea environment is introduced by systematic approach of Pahl and Beitz.

The systematic method for the conceptual design of a new product was introduced in 1977 by Pahl and Beitz as a comprehensive design tool [1]. The new technologies that have evolved have been expanded with the introduction of processes and new techniques and tools by Pahl and Beitz to make this method more specific and more focused.

The applicability of the model is explained on an event using the conceptual design model of Pahl and Beitz, while emphasizing the application and detail design, which is usually the last two phases of the engineering design process, as well as the importance of the conceptual design phase leading designers to find more innovative and innovative solutions [2]. A model of an innovative conceptual design process was created by systematically incorporating TRIZ and QFD into the conceptual design approach of Pahl and Beitz in order to come up with some important issues, such as practicality in high-level work, finding high innovative solutions [3]. The conceptual design model developed by Pahl and Beitz in the workshop was developed and new tools were added to the design methodology called Integrated, Customer Focused, Conceptual Design Methodology [4].

In this study, an application on the use of Pahl and Beitz's Conceptual Design Model is given. The conceptual design consists of six stages: (1) Requirement list, (2) Functional diagram, (3) Sub and general designs, (4) Preliminary evaluation, (5) Important designs and (6) Additional selection procedures. The design will be described below under these headings.

### 2.1. Requirement List

A sample requirement list (design specification) prepared for the conceptual design of the marine surveillance buoy is shown in Table 1.

On the requirement list, the buoy to be designed; geometric size, fixation in a specific area, water-safe and functioning properly, energy source, environmental conditions, materials to be selected for this purpose, preventive measures, collecting / measuring data and their transmission, maintenance and cost.

In the process of determining the requirements, the necessary requirements are generally given for the conceptual design process. If necessary, these requirements can be flexed / modified depending on the development of the design.

The requirements on the list are organized as Demands (D) and Wishes (W). These “Demands” must be fulfill absolutely by the design solution and the “Wishes” must be fulfill to the extent that technological and economic conditions permit.

***Table 1.*** *Requirements list of marine surveillance buoy requirements to be designed (Desires as (A)).*

| **Nu.** | **Requirements (Demands or Wishes)** |
|---|---|
| **1** | Buoy; ≤ 70 kg weight, ≥ 3 m height (excluding antenna) and ≤ 0,5 $m^2$ area. |
| **2** | The buoy must be fixed in a region of water and automatically removed from it if necessary. |
| **3** | (A) The buoy must have the transport pad and the side rubber bumpers. It must be activated automatically. |
| **4** | (A) The buoy must have a battery unit that will provide 48 hours of energy |
| **5** | (A) The buoy lamp must operate with renewable energy. This energy must also be used for battery charging. |
| **6** | (A) Power consumption must be at minimum level. |
| **7** | Hull Aluminum material, Hull buoyancy clamp made from composite material. This clamp must be covered with gelcoat. |
| **8** | The rest of the water must be covered with a protective (poisonous) paint from the possible effects of sea water and its creatures. |
| **9** | (A) It must be fairly noticeable (orange / yellow) and be a flashlight. Deployment/Collection time should be ≤ 30 min. |
| **10** | Buoy, sea water temperature, depth, conductivity, such as values can be measured. |
| **11** | The buoy should be capable of meteorological measurements. |
| **12** | (A) The buoy may measure underwater acoustic noise |
| **13** | The buoy should have a GPS receiver unit and antenna. Wireless communication is ensured. |
| **14** | Data transmission should be done by wireless communication. |
| **15** | Other units should not be affected during data transfer. The data recorder should clean itself at regular intervals. |
| **16** | Buoy sea condition should be 0-1-2 and should be at least 3 m deep. |
| **17** | (A) Hull painted for protection every 6 months (against corrosion). Bataries need to be renewed every 2 years. |
| **18** | Production cost should be ≤ 300 thousand TL. |
| **19** | Operating cost should be low |
| **20** | Easy maintenance |
| **21** | Must be expandable with new sensors |

## 2.2. Function Structure

Figure 1 shows the general functional structure of a marine surveilance buoy according to the requirement list given in Table 1. System E (electricity and / or mechanics), S (ignal) and M (aterial) enter the system and emerge as E (nergy), S (ignal) and M (aterial) in different levels as a result of the main and sub functions of the system. The main subfunction blocks on the schematic are the deployment of the buoy, the activation of system sensors and processor units, the sense of underwater and surface environments with sensors, the acquisition, recording and transmitting of raw data received by the processor units [1].

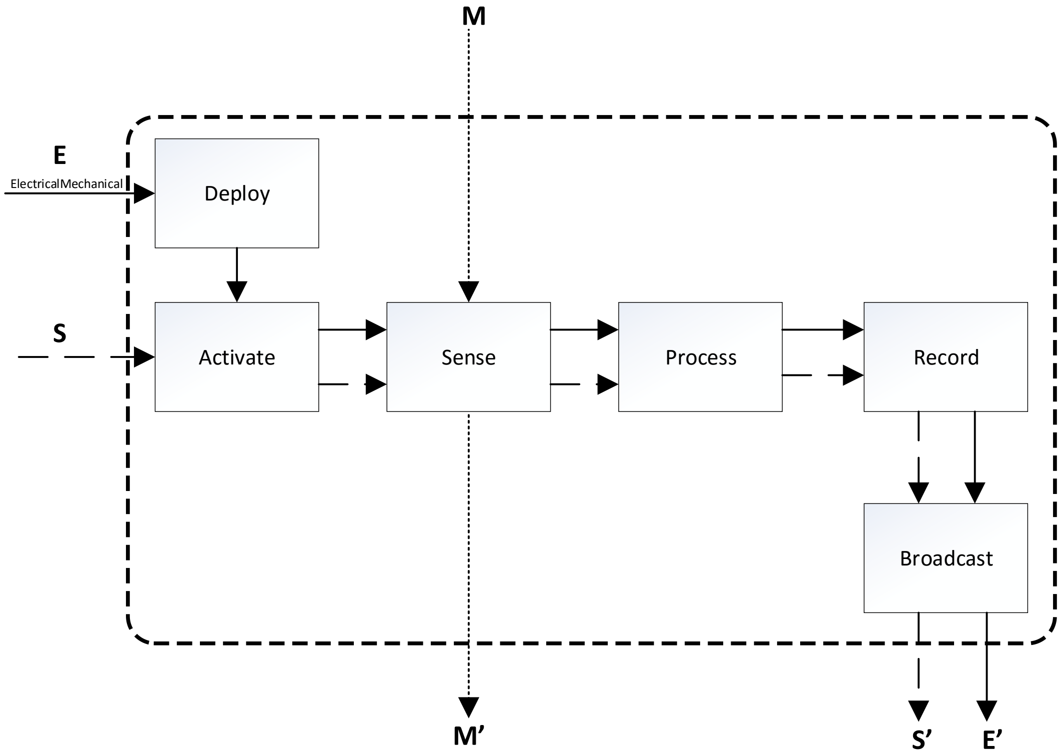


***Figure 1.*** *A sample function structure of the marine surveilance buoy.*

### 2.3. Sub and General Designs

The function structure in Figure 1 divides the conceptual design of the buoy into functional sub-parts. In addition, these inter-component relationships and data flows (in E, S, and M) can be seen in this structure.

Sub-designs have been obtained (ie, using a morphological card / matrix) by fitting the major / main functions (hull design, deployment, sensor, processor, communication) of the function structure to the matrix rows shown in Figure 2 and their possible solutions.

Possible sub-solutions for these functions are shown in the cells in the same row. Lastly, preferences were made between these solution principles and 5 different solution variants (alternative general solutions) were created for the entire system.

| Solution Path / Sub Units | | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| **A** | **Hull** | (Disk) | (Spar) | | |
| **B** | **Fixing** | (Without anchor) | (Anchor) | (Anchor with release mechanism) | |
| **C** | **Sensors** | Meteorological | Meteorological - oceanographic | Meteorological - oceanographic acoustic | |
| **D** | **Processor** | mProc | FPGA | | |
| **E** | **Communication** | GSM | RF | SAT | |
| **F** | **Battery** | Ni-Cd | Ni-Mh | Li-Ion | Li-Fe-Po4 |

***Figure 2.*** *Morphological card of a marine buoy (sub-design solutions).*

The general solutions for the subfunctions given in Fig. 2 are given below.

- **Hull:** The hull design should make it possible for the system to float and be stable. If the marine traffic is used as a sign for busy places, it should be difficult to detect if it is used for observation and recording purposes in a hidden mission. The hull must provide lightweight and easy to assemble/disassemble requirements. In addition, effects such as wind, wave, and air that will impact the buoy should be considered in design. The housing should provide adequate sealing and corrosion resistance (num of connection must be low). Power supply / sensor replacement, adjustment and other maintenance / repair activities should be easy. Different sensors, communication and measuring devices should be installed in the hull. The buoy hulls are classified into two types, disc and spar. Their radii and lengths may vary as needed. The hull and trunked spark will carry all the sub-units mentioned below.

- **Fixing Unit:** The buoy is positioned by pouring over the sea platform with the aid of a crane and / or human. If the buoy is not required to float on the sea surface, the buoy is thrown together with the anchor (weight) from the sea platform. The anchors can be fixed to the buoy with a chain or designed to be separated from the buoy by an electromechanical system. There is a difficulty in collecting if it is a fixed anchor. Separable systems will require a technical solution to trigger the system.

- **Sensor Unit:** Different types of sensors can be added to the buoy according to the need of data. The sensors to be evaluated in this design are as follows and one or all of them can be used.
  - Acoustic Sensor: Passive or active / passive methods are used for underwater signal measurement. There may be one or more acoustic hydrophones to be used for listening to the underwater noise. In active / passive methods, a sound signal is sent to the water by the pinger, which is the sound source, and then the reflection is taken. With this sensor, you can have information about marine traffic and underwater life.
  - Oceanographic Sensor: CTD (Conductivity, Temperature, Depth) sensors are used to obtain oceanographical information. Temperature, pH, dissolved oxygen, electrical conductivity, turbidity, salinity are measured with this sensor. These measurements and some other parameters (chlorophyll-a, light transmittance, sigma-t) can be measured with a CTD probe in the sea environment at intervals of 1 meter or less up to 500 meters in depth.
  - Meteorological Sensor: The meteorological unit to be placed at least 3 m above the water surface usually includes air temperature, relative humidity, rainfall type and intensity, precipitation amount, air pressure, wind direction and wind speed sensors.

- **Processor Unit:** It is the unit from which the data coming from the sensors are processed, stored and communicated with the interfaces. As a processor, FPGA or ready microprocessor solutions can be used. The most important advantage of FPGAs over other solutions is that they are programmable to the application rather than a fixed hardware. The processors have a fixed unit (transistor, memory, peripherals and connections). The processor can perform various arithmetic and logic operations. The FPGA logic cells are fixed, but their functions and relationships are determined by the user. They can do parallel processing. FPGAs can be used for performance-critical tasks. Also, the processors can be embedded in the FPGA. Thus, it is possible to define and use both processor and user-specific hardware functions in a single chip using FPGA.

- **Communication Unit:** It is a unit sharing meteorological, oceanographic, acoustical data and GPS data with all platforms on the frequencies determined by the standards. Alternatively, different communication lines such as GSM, Wi-Fi, RF and Satellite can be used. In terms of cost and data security, these methods have some advantages and disadvantages. At least two of them can be used to ensure safety.

- **Power Unit:** The power unit that supplies energy to the system will be powered by a rechargeable battery. In battery selection, characteristics such as energy density / capacity, working time, load characteristic, safety, cost, discharge with time, environmental effect, maintenance, recycling will be taken into consideration. Alternative batteries are as follows.

  **Nickel-Cadmium (NiCd)** batteries are well known, long lasting, capable of operating at extreme temperatures and providing high discharge currents.

  **Nickel-Metal-Hybrid (NiMH)** batteries have been replaced by nickel-cadmium (NiCd) batteries due to environmental influences. They deliver high power, long life. They can be used comfortably at low temperatures.

  **Lithium-Ion (Li-Ion)** batteries are widely used. It is more expensive and requires safety precautions. There are many different types.

  **Lithium-Iron-Phosphate (LiFePo4, LFP**) batteries are resistant to short-circuit, high temperature and overcharging. It will not drain when you expect (maintain 80% per year) and the aging effects are very low. It has superior and important features.

  All these batteries can be filled with renewable energy (sun / wind / wave).

Design variants (alternative designs) were created from the sub-solutions presented in Figure 2 on the morphological card. The 5 different design variants given in Figure 3 are chosen from logical sub-solutions, which ara:

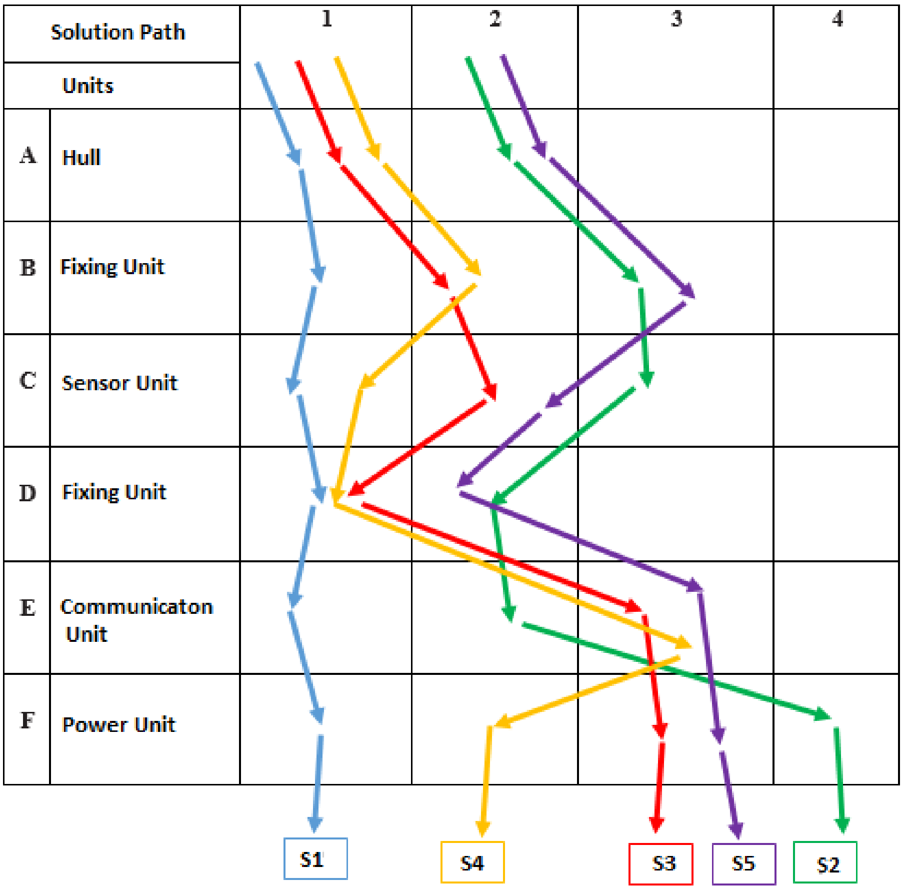


***Figure 3.*** *Concept variants of the buoy design (general designs).*

S1 (A.1-B.1-C.1-D.1-E.1-F.1) conceptual design variant consists of the following units:

- A disc-shaped hull that is not attached to the anchor
- A sensor unit having a meteorological sensor
- The processor unit having the microprocessor
- Communication unit with GSM interface
- Power unit consisting of a Ni-CD battery block.

S2 (A.2-B.3-C.3-D.2-E.2-F.4) conceptual design variant consists of the following units:

- A spar-shaped hull attached to a releasable anchor
- A sensor unit having acoustic, oceanographic and meteorological sensors
- Processor unit with FPGA-based processor
- Communication unit with RF interface
- Power unit consisting of a Ni-FE-PO4 battery block.

S3 (A.1-B.2-C.3-D.1-E.3-F.3) conceptual design variant consists of the following units:

- A disc-shaped hull attached to a fixed anchor
- A sensor unit having oceanographic and meteorological sensors
- Processor unit with microprocessor
- Communication unit with satellite interface
- Power unit consisting of a Li-Ion battery block.

S4 (A.1-B.1-C.2-D.1-E.3-F.2) conceptual design variant consists of the following units:

- A disc-shaped hull attached to a fixed anchor
- A sensor unit having a meteorological sensor
- Processor unit with microprocessor
- Communication unit with satellite interface
- Power unit consisting of a Ni-Mh battery block.

S5 (A.2-B.3-C.2-D.1-E.3-F.3) conceptual design variant consists of the following units:

- A body in the form of a pole attached to a releasable tonosa
- A sensor unit having oceanographic and meteorological sensors,
- Processor unit with microprocessor,
- Communication unit with satellite interface
- Power unit consisting of a Li-ion battery block.

### 2.4. Preliminary Evaluation

When solutions for each sub-function are evaluated separately, a number of solution options are available. Solutions that are not suitable for the morphological card should be eliminated by the expert designer. A preliminary evaluation process is performed to reduce the number of conceptual design options in Figure 3. The selection card is used for this purpose (Table 2). At this stage, (eg, +, -, ?, !) are applied to each design option in order, and a decision is made in the last line, in order for the design firm to provide reasonable safety and security precautions. The result of this process was chosen as the appropriate designs in Table 2 with the signs +2, -3 and -5. With this preliminary evaluation, reducing the number of design variants, there are still 3 different design variants to achieve. It should be determined which is the best and most valuable solution. This will be done with the following second and third evaluation and selection procedures [1].

*Table 2. A selection card for the preliminary evaluation of buoy design variants.*

| Evaluation criteria | Compatibility assured | Fulfils demands of requirements list | Relisable in principle | Within permissible costs | Incorporates direct safety measures | Preferred by designer's company | Yeterli bilgi | **Selection Criteria;**<br>(+) Yes<br>(-) No<br>(?) Lack Of information<br>(!) Check requirements list<br>**Decision Options;**<br>(+) Pursue solution.<br>(-) Elminate solution.<br>(?) Collect information and re-evaluate solution<br>(!) Check requirements list for changes | |
|---|---|---|---|---|---|---|---|---|---|
| **Solutions** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **Remarks (Indications, Reasons)** | **Decision** |
| **$S_1$** | + | - | + | ! | + | + | - | Due to its weight, it does not fulfil the requirement list. | - |
| **$S_2$** | + | + | + | + | + | + | + | Difficult design | + |
| **$S_3$** | + | - | + | + | + | ! | + | Size and cost should be re-evaluate. | + |
| **$S_4$** | - | - | + | - | + | - | + | Missing function | - |
| **$S_5$** | + | + | + | + | + | - | + | The number of sensors is less. | + |

### 2.5. Alternative Designs

The designs that meet the needs in the selection card for concept variants are given below.

In Solution-2, a spar-shaped hull design was used. All electronic units and battery will be installed in the hull. The acoustic and oceanographic sensor is located below the hull, and the meteorological sensor is located on the spar.

The data collected by the sensors will be processed in a low-power FPGA-based processor unit. This data will be stored for transfer after process. Communications with coastal or maritime platforms will be periodically carried out over RF. A releasable anchor unit will be used to stabilize the buoy on the sea. The release system, which will allow easy collection of the buoy, will consist of an electromechanical structure. A GPS unit that receives position information from the satellite on the buoy and a radar reflector with a flashlight to enable awareness on the sea surface will be found. As the battery group, high performance "Li-Fe-Po4" will be used. Figure 1 gives a schematic representation of *concep variant-2 of the buoy design* (Design solution-2).

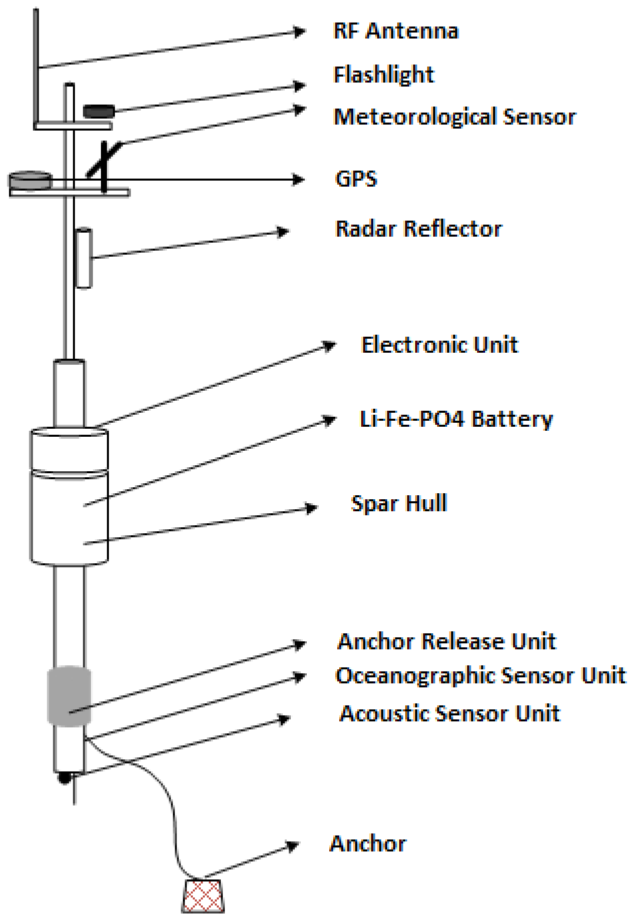


***Figure 1.*** *Concep variant-2 of the buoy design.*

In Solution-3, a disk-shaped hull design was used. All electronic units and battery will be installed in the hull. The acoustic sensor and the oceanographic sensor are located below the hull, and the meteorological sensor is located above the hull. The data collected by the sensors will be processed in the COTS (Commercial Off-The-Shelf) microprocessor unit. This data will be stored for transfer after process. Communications with coastal or maritime platforms will be periodically carried out over RF. The anchor will be used to fix buoy on the sea. On the buoy there will be a GPS unit that receives position information from the satellite. High performance "Li-Ion" will be used as the battery group. In Figure 2, a schematic representation of variant 3 (Design solution-3) is given.

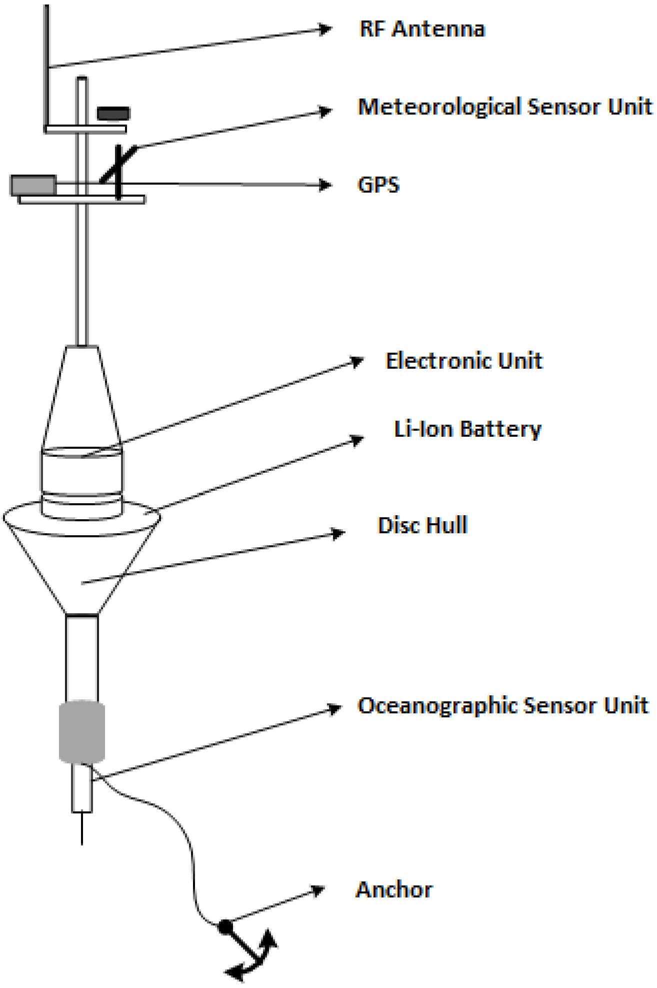


***Figure 2.*** *Concep variant-3 of the buoy design.*

In variant 5 (Design solution-5), a spar-shaped hull design was used. All electronic units and battery will be installed in the hull. The oceanographic sensor are located below the hull on the spar, and the meteorological sensor is located above the hull on the spar. The data collected by the sensors will be processed in the COTS (Commercial Off-The-Shelf) microprocessor unit. This data will be stored for transfer after process. Communications with coastal or maritime platforms will be periodically carried out over satellite. The anchor will be used to fix buoy on the sea. A GPS unit that receives position information from the satellite on the buoy and a radar reflector with a flashlight to enable awareness on the sea surface will be found. The use of common "Li-Ion" will be used as the battery group. In Figure 3, a schematic representation of the concept variant-5 is given.

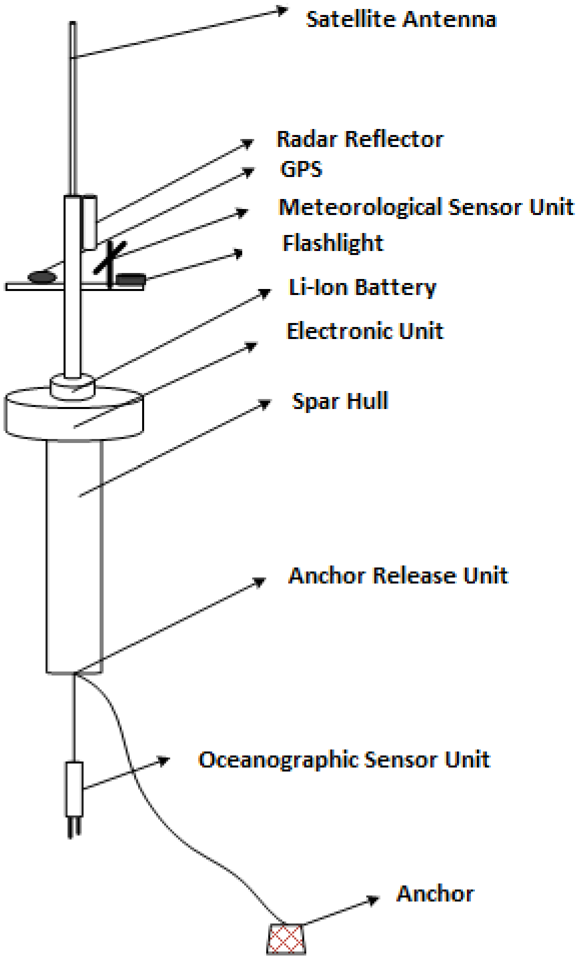


***Figure 3.*** *Concep variant-5 of the buoy design.*

## 2.6. Additional Selection Process

The number of conceptual design solutions were reduced to 3 variants by using the selection card found in Table 2. In this phase, the three variants that have passed the preliminary process have been subjected to a more detailed selection process and the best (most optimal) design has been chosen. For the detailed selection process, an objectives tree was created as shown in Figure 4 and an evaluation chart was prepared using criteria and values (Table 3). In the evaluation chart; the criteria were converted into technical parameters and three variants were awarded accordingly. The variants 2 and 5 seems to have a higher total score than variant 3, and the number of design variants is reduced to 2. Finally, the number of design variants is reduced to 1 using the value profile diagram (see Figure 5). If the value is less than what is missing in the profile diagram, then that variant is the best one [1].

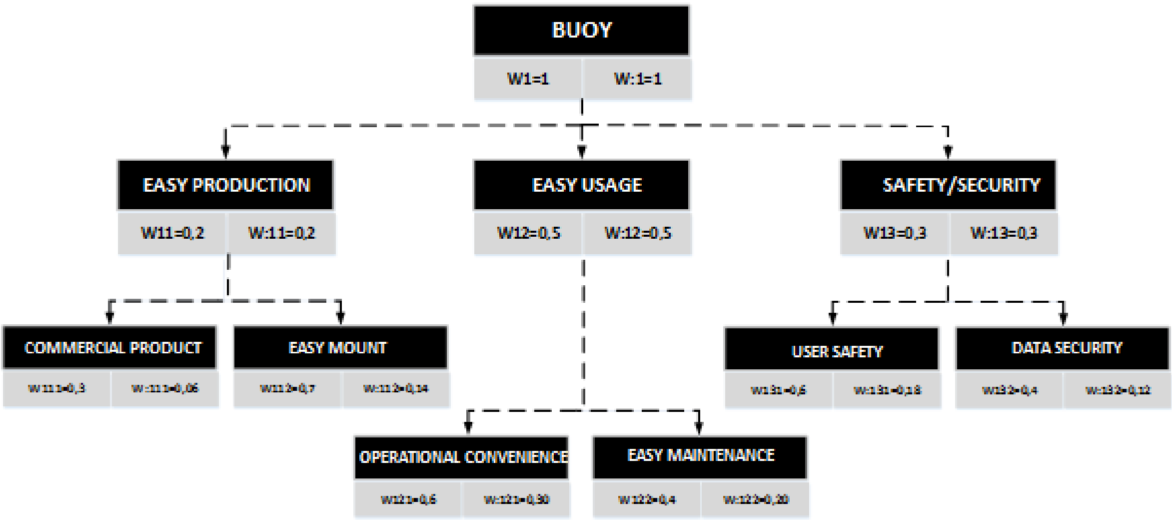


***Figure 4.*** *Objectives tree of the buoy design (additional selection process)*

***Table 3.*** *Evaluation chart for the concept variants of buoy design.*

| Evaluation Chart | | W | Variables | Variant-2 | | | Variant -3 | | | Variant -5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Rate** | **Value** | **Weight** | **Rate** | **Value** | **Weight** | **Rate** | **Value** | **Weight** |
| 1 | Commercial. Off-The-Shelf Product | 0.06 | Easy Supply | Medium | 6 | 0.36 | Medium | 6 | 0.36 | Medium | 7 | 0.042 |
| 2 | Easy Mount | 0.14 | Easy Supply | Over | 8 | 1.12 | Medium | 7 | 0,98 | Over | 9 | 1.26 |
| 3 | Operational Convenience | 0.30 | Complexity | Over | 9 | 2.7 | Medium | 6 | 1,8 | Medium | 7 | 2.1 |
| 4 | Easy Maintenance | 0.20 | Complexity | Over | 9 | 1.8 | Medium | 7 | 1,4 | Fazla | 8 | 1.6 |
| 5 | User Safety | 0.18 | System Complexity | Medium | 7 | 1.26 | Medium | 7 | 1.26 | Medium | 7 | 1.26 |
| 6 | Data Security | 0.12 | System Complexity | Over | 9 | 1.08 | Over | 9 | 1.08 | Medium | 7 | 0.84 |
| ∑Wt = 1 | | | | ∑d = 48 | | | ∑d = 42 | | | ∑d = 45 | | |
| | | | | **∑Ad = 8.32** | | | ∑Ad = 6,88 | | | **∑Ad = 7.102** | | |

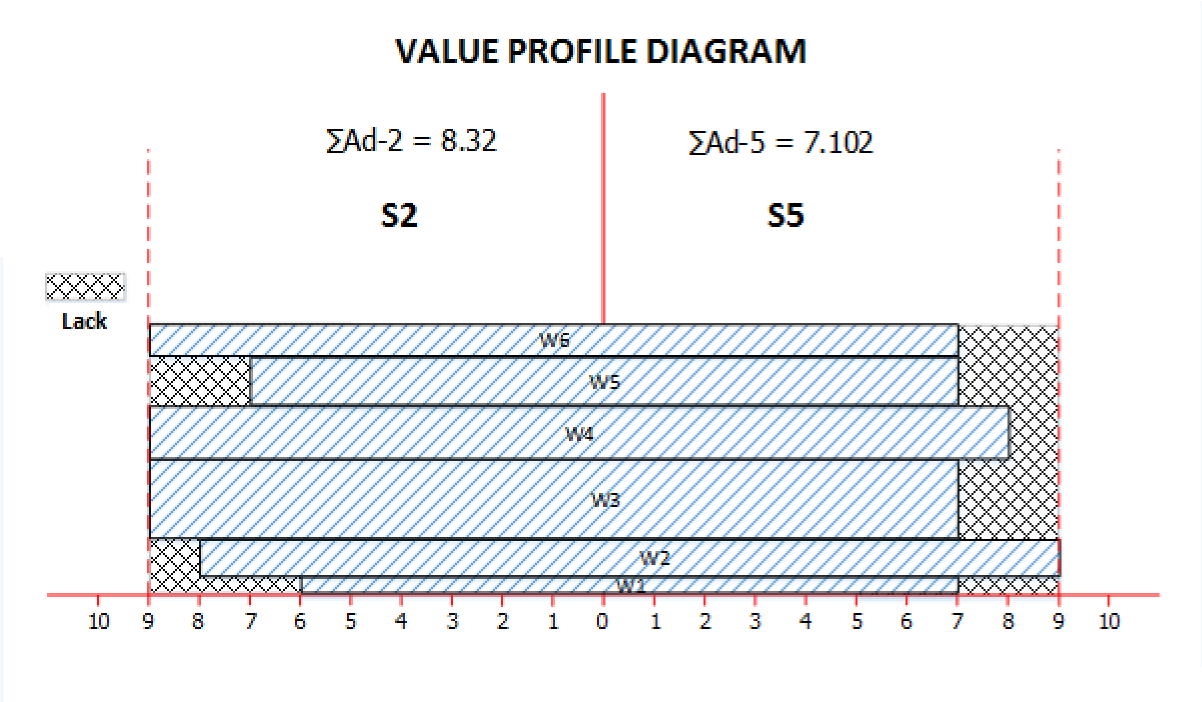


***Figure 5.*** *Value profile diagram for the buoy design.*

In order to re-evaluate the important concept variants with the defined criteria and weights, a hierarchical objectives tree, as shown in Fig. 4, is prepared. According to total values of criteria score points of variants as given in Table 3, it can be clearly seen that S2 has the hights value (the best variant) and then S5 has the the second value (the following variant). In addition, a value profile diagram was also prepared to identify the weak spots (Figure 5). With this diagram, it was determined that the best/optimum design solution is the variant S2 (Figure 6).

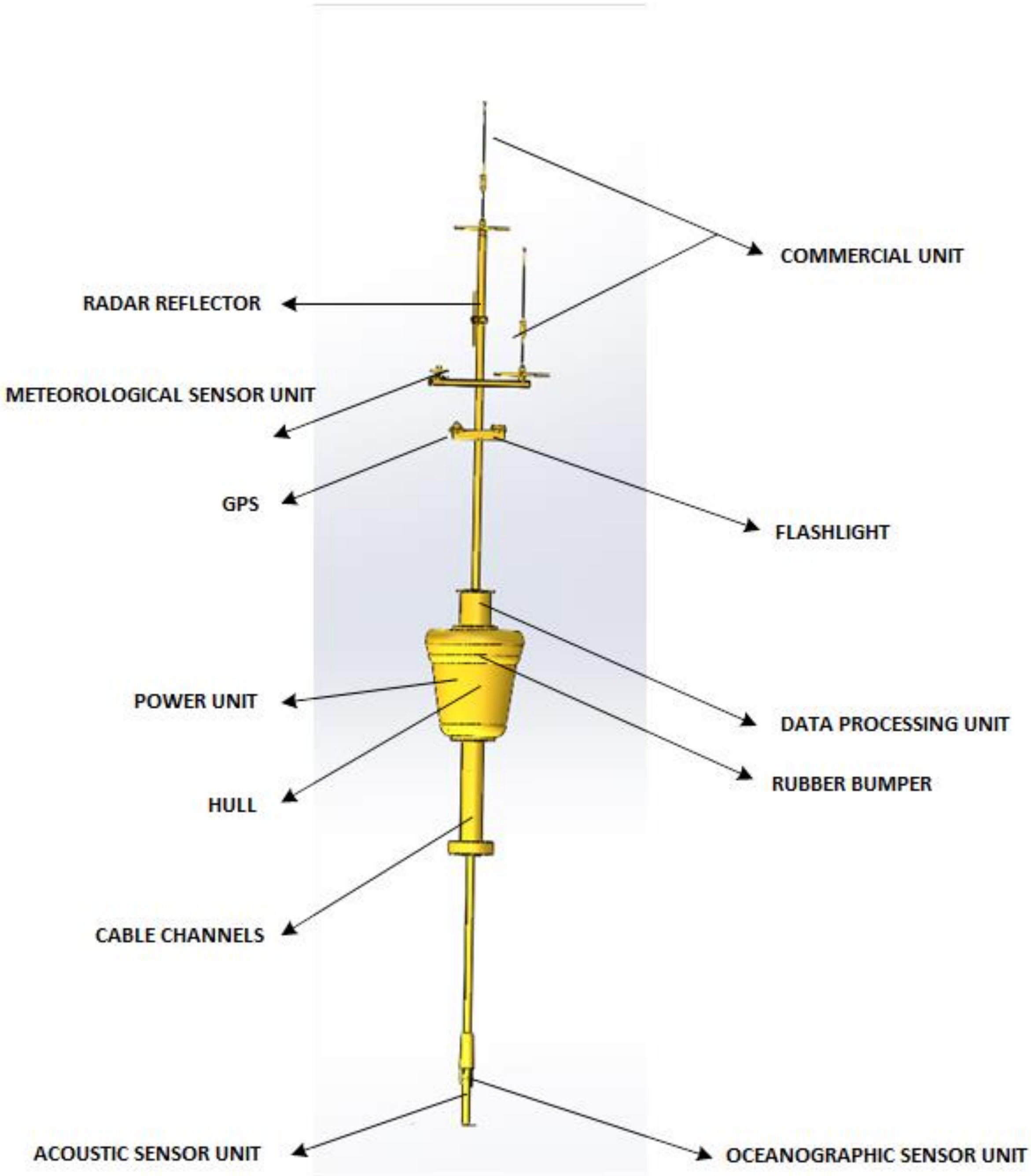


***Figure 6.*** *The chosen as the best design variants of buoy concepts.*

Figure 6 shows a conceptual design of a buoy that meets the requirement list, consisting of a communication unit, a positioning unit, a data processing unit, a power unit, a meteorological sensor unit, an oceanographic sensor unit and an acoustic sensor unit. The buoy can monitor the underwater nature with the sensors integrated into its hull, can detect and classify the sea platforms in the environment, can predict for the clime and transmit these data to the nearest station. The buoy can be clearly seen and noticeable by external platforms with radar reflector and flashlight attached to the spar. With the developing technology, the buoy can be designed and developed with much more and superior features with special solutions for civil and / or military use.

### 2.7. Comparison with Available Designs

Some designs available in the literature regarding the conceptual design variants are listed below. Figure 7 shows an observation platform (buoy) collecting meteorology, oceanography and water data from the National Oceanic and Atmospheric Administration (NOAA) and transferring this data to various users using wireless technology.


***Figure 7.*** *Available Designs-1 [13] .*

In Figure 8, an Envirtech Tsunami Detection Buoy designed and developed to measure tsunami waves, which is the long periodic sea wave generated by the tsunami event such as earthquake, is given as an example design at the bottom of the ocean or sea.

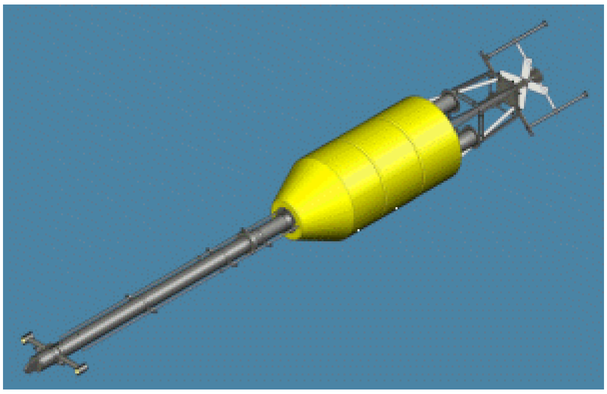

***Figure 8.*** *Available Designs-2 [14] .*

In Figure 9, a Coastal Climate Buoy designed and developed by South Florida University for meteorological data identification is given as an sample design.


***Figure 9.*** *Available Designs-3 [15]*

In Figure 10, the APB5 Automatic Profile Buoy designed to monitor water quality in lakes, sea or fish farms is given as an sample design.

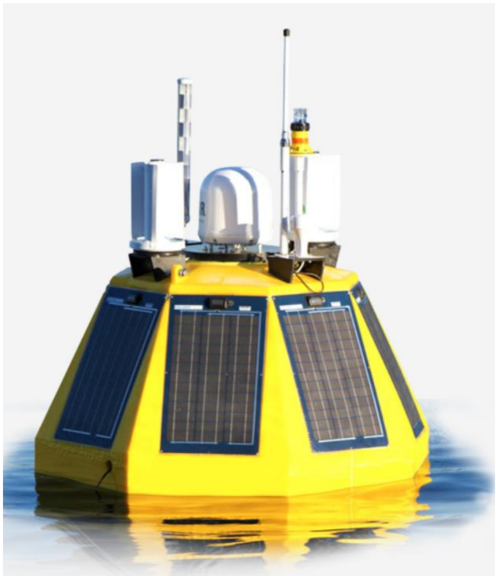

***Figure 10.*** *Available Designs-4 [16]*

In Fig. 11, the "Teledyne Gateway Buoy" used for real-time data monitoring in nearest coast is given as a sample design.

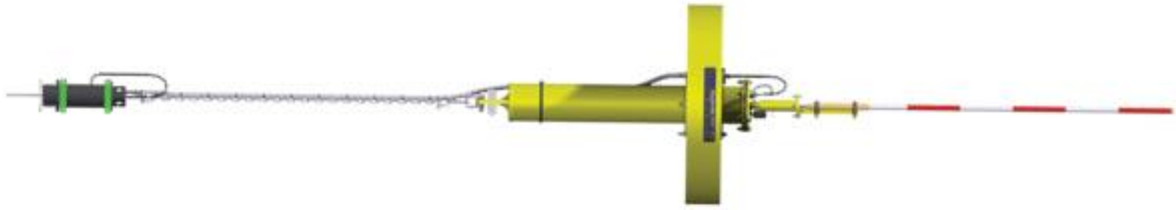

***Figure 11.*** *Available Designs-5 [17]*

Available products are designed for a specific purpose as mentioned above. The conceptual designed buoy is designed for multipurpose use. The buoy allows sensors and surveys in the marine environment in the military and civilian sectors, and can transfer the sea status (traffic, air condition, sea water) to the coast and ship platforms. A spar hull design is used for operational convenience. Due to the rapidly evolving technology, the system has been designed to be extensible so that different types of sensors can be integrated into the system. The system architecture is made up of elements that will consume the least amount of energy so that the buoy can function for a long time. The buoy will process the data it collects and will transfer it by valuing it. Therefore, there is no need for an operator to interpret the data.

## 3. CONCLUSION

In this study the conceptual design process of an innovative buoy, based on Pahl and Betiz’s Systematic Design approach, was conducted. Various design variants (alternative solutions) that meet design requirements have been developed, evaluation criteria have been established, design variants have been evaluated according to these criteria and a promosing desig variants has been chosen. In this design study, it is seen that there are many alternative solutions (design variants) to the main / sub functions based on the conceptual design model, and more than one solution can be used for the functions in the product development process. This study has shown that the Systematic design approach is very effective in identifying, solving and developing products, especially in the preliminary design process.

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