THE AUSTRALIAN NATIONAL UNIVERSITY

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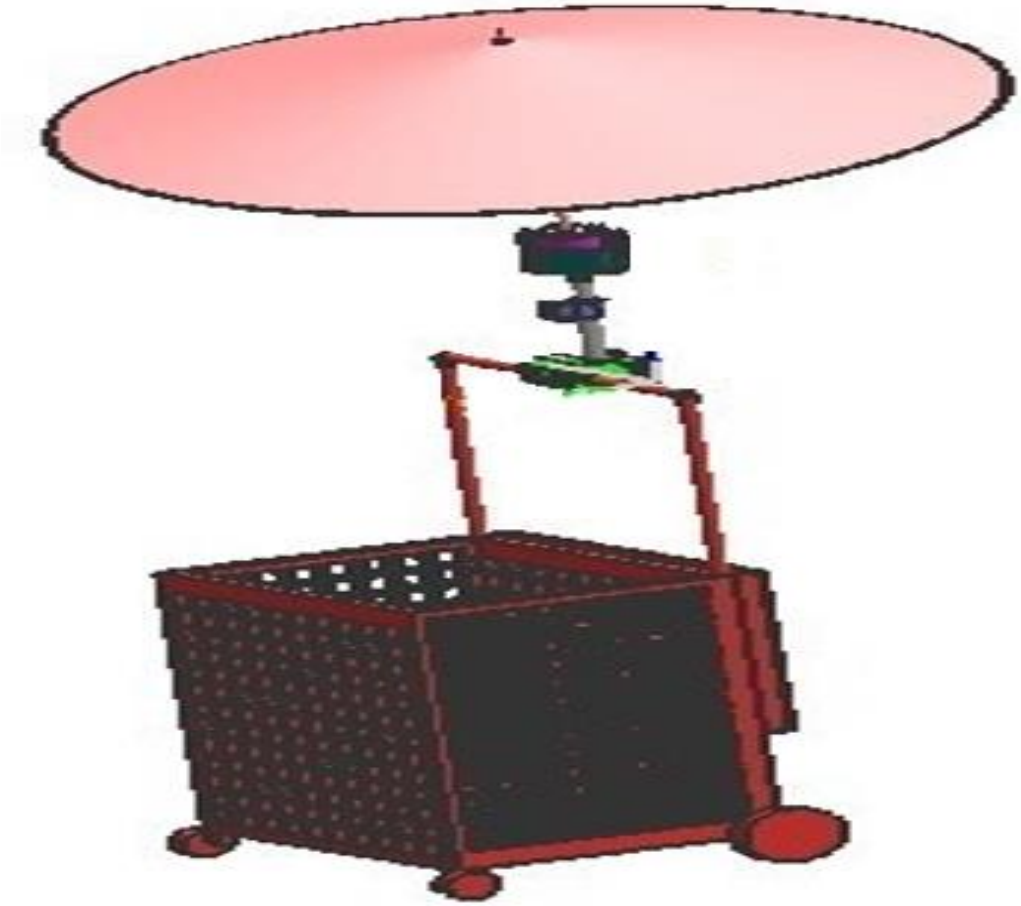
# ENGN2225 Portfolio: Hands Free Brolly Clamp



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# 1. Abstract:

This portfolio focuses on improving a clamp by using system design approaches, which involve in Requirements Engineering, System function definition, Sub-System integration, System Attributes Evaluation &Verification, Design Communication. As a result, a 3D drawing prototype of the solution was produced to convey the idea to the clients involved with the project. The chosen concept is known as the Hands Free Brolly Clamp; a clamp can hold the umbrella and give the users a hand free.

# 2. Introduction

## 2.1 Background

Weather protection is a necessity not a luxury in daily life. And an umbrella is often used to protecting the weather. For the elderly and disables, they may have insufficient strength to hold the umbrella and trolley together when they are shopping. And sometimes the people need a tool to help them hold the umbrella in order to get a hand free to do other thing, especially when they are pushing the shopping trolley, pushchair or riding bicycle (Figure 1).

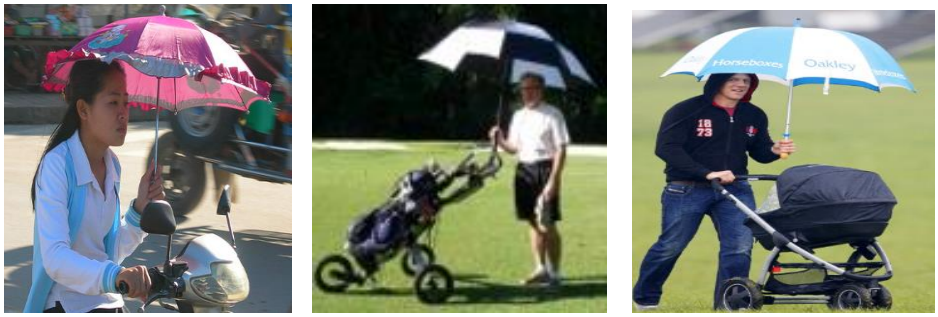



Figure 1: People Holding Umbrella (Google, 2014).

The issues associated with hands free devices throughout society these days are often overlooked. It is evident from researching current solutions on the market today that there is a need to create more efficient and safer hands free devices. Most hands free tools based variants have clamp at the base and a holder at the body, which can clamp the trolley, pushchair and hold the umbrella. In these devices, a relative umbrella are often produced to equip on the clamp in order to implement the hands free feature.

Other techniques that the people commonly implement is using a bag to hold the umbrella which can enhance their burden to carry it.

Figure 2: Existing Hands Free Devices (C1 South, 2013)

To tackle this problem, the design project will be aimed at producing a hands free brolly clamp which is suitable for different kinds of umbrellas and also can be used in a large wide of areas such as pushchair, bike and trolley. It will be very beneficial for lots of people such as housewife, elderly or disables and potentially help them release burden. For the clamp especially, it will be easier to clamp both the umbrella and trolley rather than other approaches.

### 2.2 Client

The main clients for the project are housewife, elders and the organisation 'Technical aid for the disabled, ACT' (TADACT). TADACT is a non-profit organization that creates and modifies equipment that is otherwise unavailable commercially to suit the needs of the user. For example, users whom require hands free clamp to aid them on an everyday basis may benefit.

## 3. System design approach

Systems engineering design approaches will be utilised in designing the hands free brolly clamp. Following such a technique will ensure that the customer requirements are identified and met. The main techniques used during the project are as follows: Requirements Engineering, System function definition, sub system integration, system attribute, verification & evaluation and design communications.

### 3.1 Requirements Engineering

#### 3.1.1 Customer Requirements

Customer requirements is to get a profound understand about the clients' needs and expectations in the design of clamp. It is essential that these are all investigated in detail

as they provide the foundation of the project; all research and decisions will be based on these requirements. For this project, the customer requirements are tough, light, cheap, durable, looks good, reliable, easy to use, clamp ability and weather proof.

### 3.1.2 Pairwise Analysis

The relationships between these customer requirements must be compared to determine which will gain priority. Prioritising these is important to make sure the client is much more satisfied with the outcome, otherwise targeting lesser essential properties will result in a waste of time in an already time constrained environment. Table 1 below shows a pairwise analysis of the customer requirements of the clamp project.

| | Tough | Light | Cheap | Durable | Looks good | Reliable | Easy to use | Clamp ability | Weather proof | Score | Rank | Weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Tough** | | 1 | 1 | 0.5 | 1 | 0 | 1 | 0.5 | 1 | 6 | 3 | 7 |
| **Light** | 0 | | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 6 | 4 |
| **Cheap** | 0 | 0 | | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 8 | 2 |
| **Durable** | 0.5 | 1 | 1 | | 1 | 0 | 1 | 0 | 1 | 5.5 | 4 | 6 |
| **Looks good** | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 9 | 1 |
| **Reliable** | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 8 | 1 | 9 |
| **Easy to use** | 0 | 1 | 1 | 0 | 1 | 0 | | 0 | 1 | 4 | 5 | 5 |
| **Clamp ability** | 0.5 | 1 | 1 | 1 | 1 | 0 | 1 | | 1 | 6.5 | 2 | 8 |
| **Weather proof** | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | | 2 | 7 | 3 |

| | Rank |
|---|---|
| **Reliable** | 1 |
| **Clamp ability** | 2 |
| **Tough** | 3 |
| **Durable** | 4 |
| **Easy to use** | 5 |

Table 1: Pairwise Analysis of the Customer Requirements (CR) Table 2: Rank of CR Result

After the pairwise analysis, the most important five customer requirement are selected (Table 2) and these will be prior analysed during the design.

### 3.1.3 Technical Performance Measures

In the technical performance measures procedure, the selected customer requirements will be translated to the design requirements, which are more suitable terms the designer can work with. And the engineering characteristics are subsequently obtained according to the design requirement, which also known as technical requirements (table 3). The symbols“-”and“+”represent the direction of improvements, which means that the characteristic should be minimised or maximised.

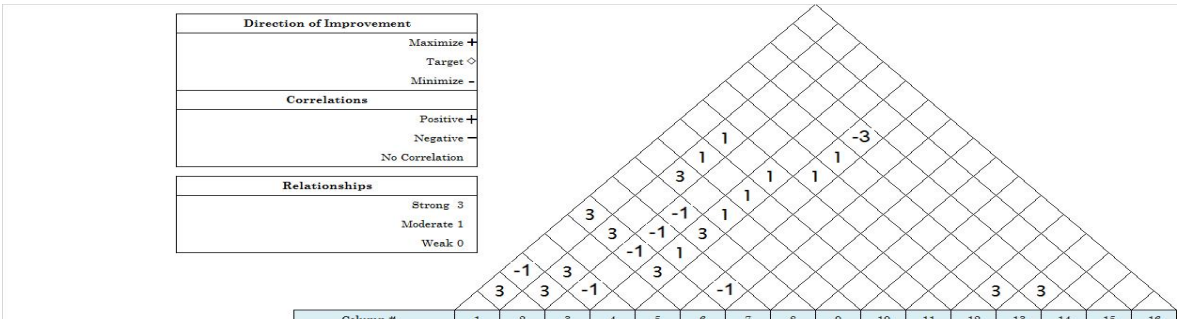
Using customer requirement “Durable” as an example: The customer requirement “durable” can be transferred to design requirement as high quality of parts, strong joint point and weather proof material. And Weather proof material could be measured by water resistant material, UV resistant material and colourfast material. In this project, water resistant material, UV resistant material and colourfast material will be maximised to enhance the relative design requirement.

| Importance | Customer Requirement | ID | Design Requirement/Attributes | Engineering Characteristics | Metric |
|---|---|---|---|---|---|
| 1 | Reliable | DR01-01 | Strong Screws to be used | +Strong materials of screws | kg/m³(Density) |
| | | DR01-02 | High quality of parts | +Strong materials of parts | kg/m³(Density) |
| | | DR01-03 | Stability of functions | -User pushing effect | N(force) |
| 2 | Clamp ability | DR02-01 | Clamp the trolley and umbrella | +Two strong Clamps | number |
| | | DR02-02 | Adjustable clamp | +Adjustable rod | m(Length) |
| 3 | Tough | DR03-01 | Strong materials used | +Strong materials | kg/m³(Density) |
| | | DR03-02 | Withstanding umbrella's weight | +Umbrella holding area | m²(Area) |
| | | DR03-03 | Strong Joint points | +Joint area | m²(Area) |
| 4 | Durable | DR04-01 | High quality of parts | +Strong materials of parts | kg/m³(Density) |
| | | DR04-02 | Strong Joint points | +Joint area | m²(Area) |
| | | DR04-03 | Weather proof material | +Water Resistant material | kg/m³(Density) |
| | | | | +UV Resistant material | kg/m³(Density) |
| | | | | +Colourfast material | kg/m³(Density) |
| 5 | Easy to use | DR05-01 | Easy to equip | -Number of parts to be equipped | Number |
| | | DR05-02 | Minimum set up steps | -Number of parts to be setted up | Number |
| | | DR05-03 | Minimum set up time | -Number of parts to be setted up | Number |
| | | DR05-04 | Simple Mechanism | -Number of Moving Parts | Number |

Table 3: Design Requirements and Customer Requirements for Hands Free Brolly Clamp

### 3.1.4 House of Quality

After the technical performance measures were completed, a House of Quality (HOQ) was made (Figure 3). The house of quality allows the important parts of the design to be surfaced and the dependencies of each part on one another.




| ID | Design Requirements \ Engineering Characteristics | Relative improtance | Strong materials of screws | Strong materials of parts | User pushing effect | Two strong Clamps | Adjustable rod | Strong materials | Umbrella holding area | Joint area | Water Resistant material | UV Resistant material | Colourfast material | Number of parts to be equipped | Number of parts to be setted up | Number of Moving Parts | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Column # | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| | Direction of Improvement | | + | + | . | + | + | + | + | + | + | + | + | + | . | . | . | . |
| DR01-01 | Strong Screws to be used | 6 | 3 | 3 | 0 | 0 | 0 | 3 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | | |
| DR01-02 | High quality of parts | 1 | 3 | 3 | 0 | 0 | 0 | 3 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | | |
| DR01-03 | Stability of functions | 2 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | | |
| DR02-01 | Clamp the trolley and umbrella | 12 | 3 | 3 | 3 | 3 | 0 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| DR02-02 | Adjustable clamp | 11 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| DR03-01 | Strong design | 4 | 3 | 3 | 3 | 0 | 0 | 3 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | | |
| DR03-02 | Withstanding umbrella's weight | 5 | 3 | 3 | 3 | 0 | 0 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| DR03-03 | Strong Joint points | 7 | 1 | 1 | 1 | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| DR04-02 | Weather proof material | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 0 | 0 | 0 | | |
| DR05-01 | Can be handled easily | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | | |
| DR05-02 | Minimum set up steps | 9 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | | |
| DR05-03 | Minimum set up time | 10 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | | |
| DR05-04 | Simple Mechanism | 8 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | | |
| | Metric/TPM | | kg/m³ (Density) | kg/m³ (Density) | N(force) | Number | m (Length) | kg/m³ (Density) | m²(Area) | m²(Area) | kg/m³ (Density) | kg/m³ (Density) | kg/m³ (Density) | Number | Number | Number | | |

Figure 3: House of Quality for Hands Free Brolly Clamp

The design requirements are ranked and the priority of them are clearly showed in the HOQ. The design requirements ‘Stability of functions’ and ‘Clamp the trolley and umbrella’ have the most dependent relationship as they are related to most of engineering characteristics, so these two qualities must be analysed closely and prior during the project. ‘Adjustable clamp’ has the least dependent relationship as it is related to least of engineering characteristic and it can be analysed at last.

## 3.2 System function definition

### 3.2.1 Functional analysis

A schematic diagram (FFBD) is applied to assist in analysing the functions of the clamp after completing the requirements engineer. It shows a procedure of using the clamp and broken into sub- functions (Figure 4).

The top level of the functional flow shows the procedures of using the clamp (Equip it on the trolley as example): Firstly, the user takes out the clamp; followed by equip the clamp on the trolley; open umbrella; equip the umbrella on the clamp; adjust road; keeping walking; arrive destination and keep the clamp on the trolley or take clamp from the trolley.

The function flow second level breaks a vague instruction into more defined series. It clearly shows the steps from take-out clamp to equip the clamp on the trolley. Similarly, the function flow third level, the function flow forth level and the function flow fifth level separately shows the steps from open umbrella step to equip the umbrella on the clamp step; from adjust rod step to keep walking step; from arrive destination step to take clamp from trolley (Appendix A).

The maintenance flow first level is an alternative procedure to find a solution if the clamp were not equipped on the trolley. Firstly it will visually check whether the clamp has been broken, followed by checking the functional parts. The system will be restarted after correcting the problem.

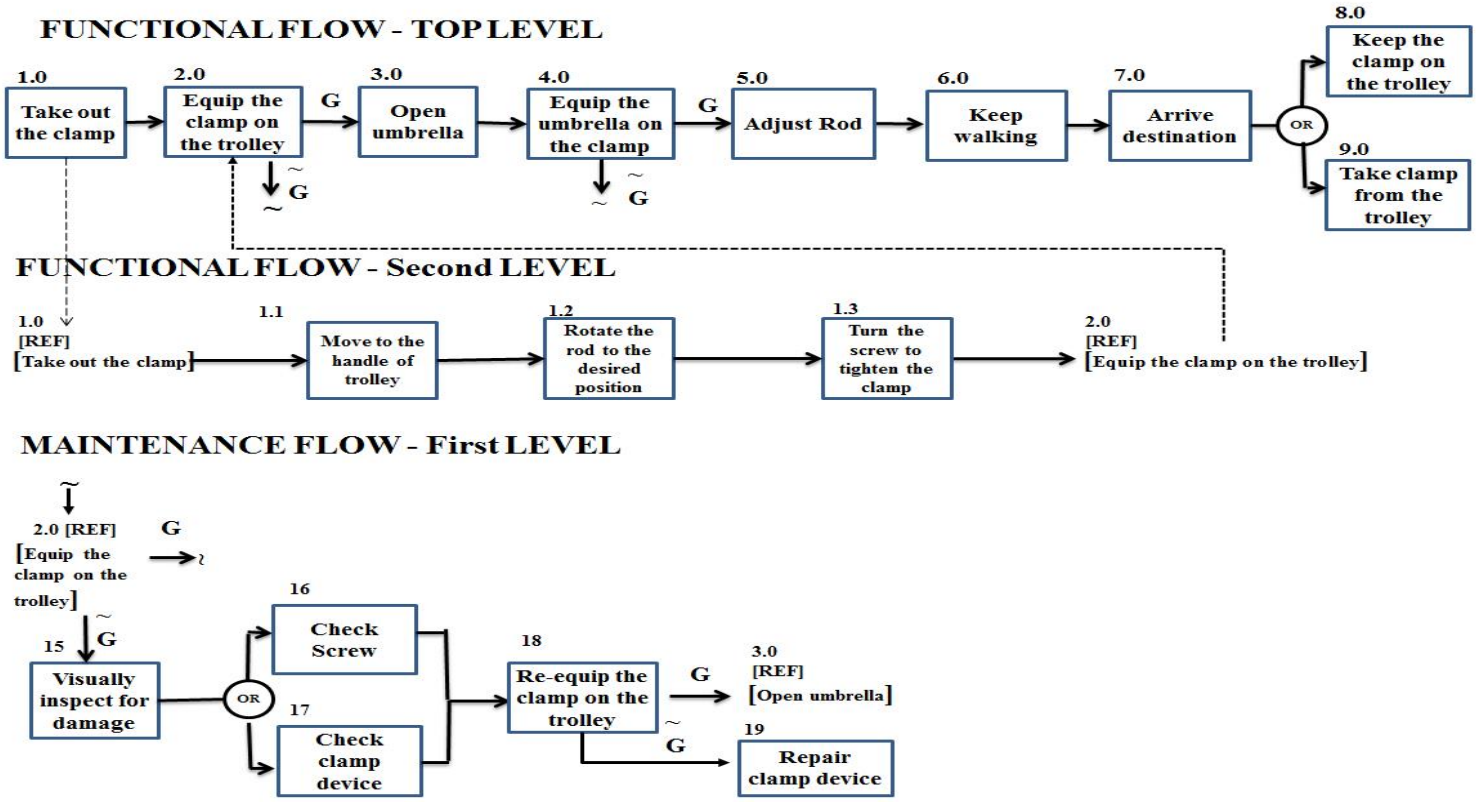



Figure 4: Functional Flow Block Diagram of Hands Free Brolly Clamp

FFBDs are a very useful tool to help analyse or describe the intended purpose of the system. They often break down complex instructions into more easily understood step by step ones in a visual representation, help to highlight the problems in its functioning and giving an idea of how to solve it.

### 3.2.2 Concept generation

After a clear requirements analysis is completed, a concept generation diagram is used to classing all the ideas and relating back to customer requirements. For example, figure 5 shows a concept generation about the stability of functions. After finishing the concept generation, the high density materials, high hardness Martials and the weather proof materials will be considered to be used in the clamp.

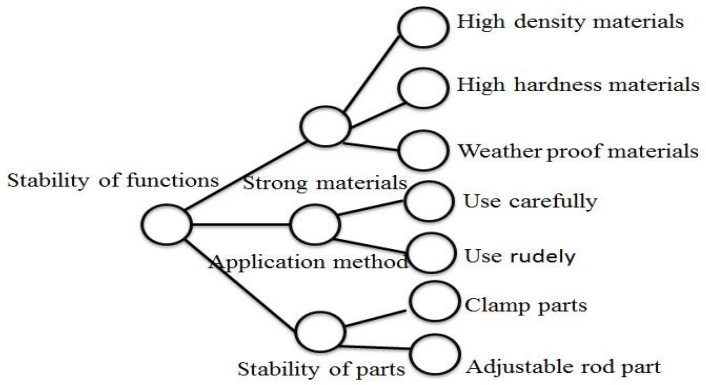



Figure 5: Concept generation diagram

## 3.3 Sub-System integration

To further understand how the clamp works, the design concept was broken down to its system and sub-system. Sub-system integration aids in understanding the inputs and outputs of the clamp system, as well as the relationships between each of the sub systems. Firstly a systems boundary chart was made and is shown in table 4.

| Internal | External | Outside |
|---|---|---|
| • Lower clamp system<br>• Adjustable rod system<br>• Upper clamp system<br>• Holder system | • User<br>• Umbrella<br>• Trolley | • Weather<br>• Temperature<br>• Energy of user |

Table 4: System Boundary Analysis showing Internal, External and Outside

Functional Block Diagram (FBD) of the clamp system was sequentially built up according to the system boundary chart (Figure 6). Sub systems were made up of internal factors, the inputs were made up of the external factors. The Functional Block Diagram displays the relationships between the subsystems and the inputs. For example, the user exerts a force measured in newton to the lower Clamp System to equip the clamp on the trolley. It also shows the relationships between the subsystems such as the lower clamp system and the holder system are fixed each other. In the FBD diagram, the relationships among the Clamp system, sub-systems and the inputs are clearly analysed.

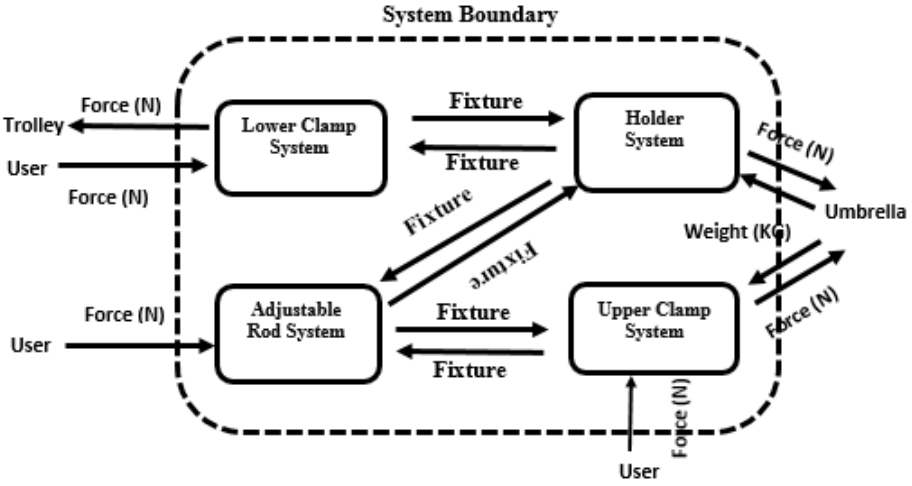



Figure 6: Flow Block Diagram of Hands Free Brolly Clamp

## 3.4 System Attributes

### 3.4.1 Attributes cascade

The attributes cascade was produced in the project to understand the connection between the customer requirements and the qualities of the system clearly. Table 5 was produced by implementing the 5-Hows technique. After the primary attributes were determined from looking at the design requirements, secondary attributes and tertiary attribute were proposed. They were then entered into the cascade in table 5 and the associated sub-systems was included in the last column. This then connects the dependent qualities of the system to a particular sub-systems. Table 6 shows the abbreviation for the Attributes Cascade Sub-system Column.

The attributes cascade plays an important role that if a change in one of the customer requirements is made at any stage during the design process, its impact on the rest of the system can be traced in a more efficient way than the designer may otherwise have to go through.

| ID | Primary Attribute | ID | Secondary Attribute | ID | Tertiary Attribute | Subsystem |
|---|---|---|---|---|---|---|
| A1.0 | Can be Handled Easily | A1.1 | Simple Mechanism | A1.1.1 | Few Moving Parts | ARS,LCS,UCS |
| | | | | A1.1.2 | Few Controls | ARS,LCS,UCS |
| | | | | A1.1.3 | Large Clamp Surfaces | UCS,LCS |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | A1.2 | Lightweight | A1.2.1 | Refined Design | ARS,LCS,UCS,HS |
| | | | | A1.2.2 | Limited Materials Used | ARS,LCS,UCS,HS |
| | | | | A1.2.3 | Low Weight Materials | ARS,LCS,UCS,HS |
| A2.0 | Clamp Trolley and Umbrella | A2.1 | Adjustable | A2.1.1 | Pivoting Points | LCS,UCS |
| | | | | A2.1.2 | Flexible | LCS,UCS,HS |
| | | | | A2.1.3 | Adjustable Clamped Area | LCS,UCS |
| | | A2.2 | Clamp Points | A2.2.1 | Holders | UCS,UCS |
| | | | | A2.2.2 | Forceful Parts | LCS,UCS |
| | | | | A2.2.3 | Multi-Clamps | LCS,UCS |
| A3.0 | Withstanding Umbrella's Weight | A3.1 | Strong Holding Part | A3.1.1 | Large Holding Surfaces | HS |
| | | | | A3.1.2 | Strong Materials Used | HS |
| | | | | A3.1.3 | Good Welding | ARS,LCS,HS |
| | | A3.2 | Strong Upper Clamp Part | A3.2.1 | High Quality Clamp | UCS |
| | | | | A3.2.2 | Strong Materials Used | UCS, HS |
| | | | | A3.2.3 | Good Welding | UCS, ARS |
| | | | | A3.2.4 | Locker Used | UCS |
| A4.0 | Strong Design | A4.1 | Strong Parts | A4.1.1 | Strong Materials Used | ARS,LCS,UCS,HS |
| | | | | A4.1.2 | Appropriate Thickness | ARS,LCS,UCS,HS |
| | | | | A4.1.3 | Appropriate Length | ARS,LCS,UCS,HS |
| | | | | A4.1.4 | Appropriate Design | ARS,LCS,UCS,HS |
| | | A4.2 | Strong Joints | A4.2.1 | Large Joint Area | ARS,LCS,UCS,HS |
| | | | | A4.2.2 | Good Joint Materials | ARS,LCS,UCS,HS |
| A5.0 | Adjustable Clamp | A5.1 | Adjustable Length | A5.1.1 | Controllable Rod | ARS |
| | | A5.2 | Adjustable Upper Clamp Part | A5.2.1 | Adjustable Clamped Area | LCS,UCS |
| | | | | A5.2.2 | Multi-Clamps | LCS,UCS |
| | | A5.3 | Adjustable Upper Clamp Part | A5.3.1 | Adjustable Clamped Area | LCS,UCS |
| | | | | A5.3.2 | Multi-Clamps | LCS,UCS |
| A6.0 | Weather Proof Materials | A6.1 | Water Resistant | A6.1.1 | Plastics | ARS,LCS,UCS,HS |
| | | | | A6.1.2 | Alloys | ARS,LCS,UCS,HS |
| | | A6.2 | UV Resistant | A6.2.1 | Polyethylene | ARS,LCS,UCS,HS |
| | | A6.3 | Colourfast | A6.3.1 | Alloys | ARS,LCS,UCS,HS |

Table 5: Attributes Cascade.

| Related Sub-system | Abbreviation |
|---|---|
| Upper Clamp System | UCS |
| Lower Clamp System | LCS |
| Adjustable Rod System | ARS |
| Holder System | HS |

Table 6: Key for the Attributes Cascade Sub-system Column.

By looking through the attributes cascade, it is important to ensure the product is made of strong materials that could also possess high weather proof characteristics. The dimensions of the clamp are also considered as it affects the strength of the product. It is clear that by establishing the system attributes, the clamp will be produced that primarily utilises weather proof and high strength materials to meet the initial customer requirements.

## 3.5 Evaluation and Verification

### 3.5.1 Design verification

Three testing stages based on Attributes Cascade are used to justify whether the design could meet the customer requirement in the project: Analytical models, Proof-of-concept, System prototypes. In the attributes cascade (Table 5), the tables with orange colour are the attributes can be tested by using analytical testing, which can be quickly analysed and simulated by specified software such as CAD. The tables with blue colour are the attributes tested by using proof-of-concept testing, which are creating a test rig analogous to the attributes and test the attributes. The tables with green colour are the attributes tested by using prototyping as the attributes are associated with several subsystems and cannot be tested using simple model or basic concepts. Some of the test procedures are shown as table 7.

| Which attribute | Who does the testing | Procedure outline | Pass/fail criteria |
|---|---|---|---|
| Can be Handled Easily | Designer | 1. Start to install, and record time. 2. Installation procedure. 3. Finish the install and end the timing. 4. Measure the installation time by subtraction and compare. | Convenience of installing/Time |
| Strong Design | Technician | 1. Start to use 2. Testing under different tensile strengths 3.Record down the limiting strength | Can handle high strength |
| Withstanding Umbrella's Weight | Technician | 1. Start to use 2. Testing by equipping on different umbrellas 3.Record down whether the | Clamp still good |
| Weather Proof Materials | Technician | 1. Start to use these products and record the beginning date. 2. Take photos regular as sampling and evidence, and record the changing. 3. After a long time period, compare the conditions of the product. 4. Get the results of which one have the high weather proof ability | Waterproof ability/colourfast ablity/UV resistant ability |

Table 7: Test Procedures for verification

The verification part of the clamp project plays an important role to understand whether the certain clamp design matches up with the requirements. After the verification test, most parts of the design meet the requirements and few parts of the design need to be improved such as simple mechanism.

### 3.5.2 Design evaluation

The design evaluation part is hence applied to evaluate three designs of the clamps. Clamp A (Figure 7) is an existing design which using a bag to hold the umbrellas. Clamp B (Figure 8) is another existing design, it could be clamped to the trolley and a relative umbrella are often produced to equip on the clamp. Clamp C (Figure 9) is our design to clamp both the umbrella and trolley.

Figure 7: Clamp A

Figure 8: Clamp B

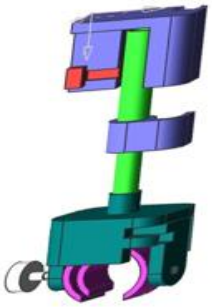


Figure 9: Clamp C

To complete the evaluation, firstly the client requirements and House of quality (Figure 3) are reviewed to produce benchmarks and design alternatives, while using evaluation matrices to evaluate the optimal clamp (Blanchard & Fabrycky 2011). Pairwise analysis (Table 1) and customer requirements are reviewed in order to create a weighted matrix for assisting in the evaluation (Table 8).

| SCALE<br>5 = Exceeds compliance<br>3 = Full compliance<br>1 = Partial compliance<br>0 = Non-compliance<br><br>Customer Requirement | WEIGHTING | | Clamp A | | Clamp B | | Clamp C | |
|---|---|---|---|---|---|---|---|---|
| | RANK | WEIGHTING | RELATIVE COMPLIANCE | WEIGHTED VALUE | RELATIVE COMPLIANCE | WEIGHTED VALUE | RELATIVE COMPLIANCE | WEIGHTED VALUE |
| Reliable | 1 | 5 | 3 | 15 | 3 | 15 | 3 | 15 |
| Clamp ability | 2 | 4 | 3 | 12 | 3 | 12 | 5 | 20 |
| Strong | 3 | 3 | 3 | 9 | 5 | 15 | 5 | 15 |
| Durable | 4 | 2 | 3 | 6 | 3 | 6 | 3 | 6 |
| Easy to use | 5 | 1 | 3 | 3 | 3 | 3 | 1 | 1 |
| | | TOTALS | | 45 | | 51 | | 57 |

Table 8. Evaluation Matrix: Three Designs of Clamp

As we can see from the matrix above, clamp C got the highest score of 57. Clamp B is followed with a score of 51, and Clamp A has the lowest score of 45. Clamp A has the lowest score because of the strong and clamp ability are lower. This due to the facts that the materials of the bag is weak and the lower clamp stability. Clamp B is strong and reliable but it has low clamp ability. Although Clamp C is not easy to use, its high clamp ability and strong design make it meet most of the customer requirements. In summary, it seems that the Clamp C is the most desired design as quantitatively and qualitatively satisfies the customer requirements.

## 3.6 Design Communication

Design communications serve as a significant role in the project, where the ideas are modelled and designs presented to the clients. There are many design communication approaches, whose aim is to present the design to the clients to receive real-time feedback. The prototyping and the mechanism diagram are two effective ways and applied to the clamp project, which assist in showcasing the design to the clients. The designer enables the undesired design details to be rectified based on the feedback and subsequently provides the clients a better product as a result.

### 3.6.1 Prototyping

Firstly, a 3D drawing would be served as a prototype for users (Figure 10). The drawing is the visualization of ideas that allows the users to clearly understand the design conception. The specifications, features, structure and operation of the innovative clamp will be introduced through the prototype. There are two clamp parts in the upper calm system: one is central clamp which can clamp a standard umbrella (made by designer and can be equipped into the rod) and locked by the locker. Other one is a side clamp which can clamp more types of umbrellas by putting them on the side clamp and lock it. A real-time feedback will be provided after the experience. Hence, the undesirable parts of the design will be modified and a better product will be served to the users as a result.

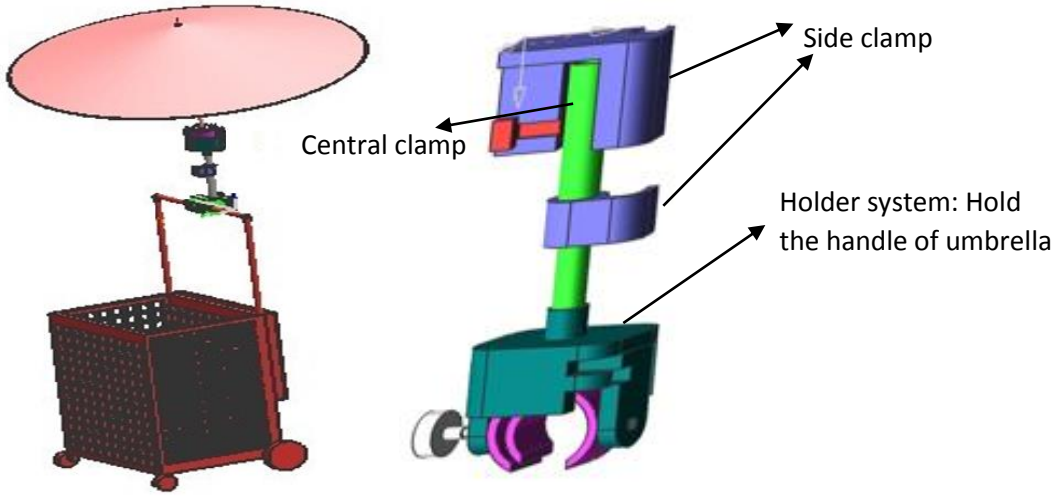



Figure 10: 3D Drawing for Hands Free Brolly Clamp

### 3.6.2 Mechanism Diagram

A mechanism diagram has been developed to assist introducing the structure and operation of clamp (Figure 11). It is the visualization of the inner structure and operation, which could assist the users to profoundly understand the components, structure and operation of clamp. In the diagram, each parts of the clamp has been labelled and three status (Unlock state Normal length, Lock state Normal length and Unlock state long length) has been clearly showcased: When the users tighten the screw, the clamp will be compressed and clamp the trolley. When the user exerts a force to the locker, the locker will lock the umbrella. The users can select different length by adjusting the adjustable points which are controlled by strong springs. Additionally, the durability of the design could be also showed as it based on the durability of the components. Thereby, the group could get feedbacks about the components and the inner structure, and rectify the undesirable parts.

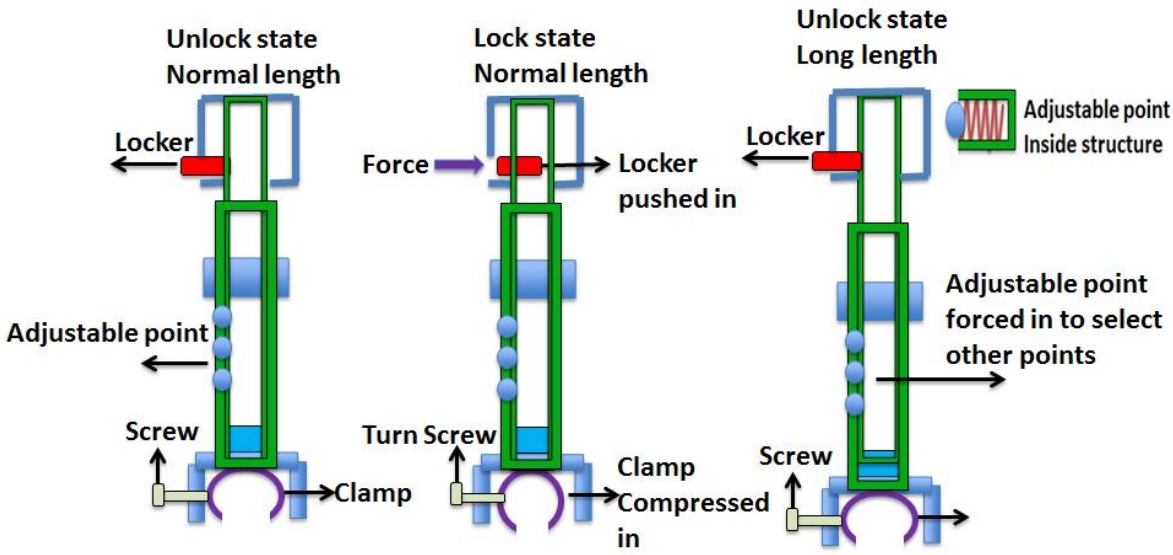



Figure 11: Mechanism Diagram for Hands Free Brolly Clamp

## 4. Discussion

After building up the prototype and gaining the feedback from the users, some components of clamp were suggested to further develop. One is the upper clamp part, which is too complicated for users to clamp the umbrella. The designer decided to change it to an easier clamp which is similar to the lower clamp. Other one is the adjustable rod part (Figure 4), which is not convent to use. The designer will modify the rod and makes it more flexible and easy to use. The colour of Clamp is also be considered based on the clients' requirement. The designer decided to produce multiple colours for users to choose.

## 5. Conclusion

An appropriate solution was designed by using a systems engineering approach. The reason why this is a suitable solution to the problem is due to the results of verification and evaluation. It is stronger, more stable and has higher clamp abilities than other variants. It can be also used in different targets such as shopping chart, chairs, pushchairs, bicycle etc. Finally, a 3D drawing prototype was designed to convey the solution in a more appropriate manner to the client base. In the further, the Hands Free Brolly Clamp prototype would be manufactured to help the people in everyday tasks.

## 6. Bibliography

Shelly Rivoli. 2012. *Pack This! Hands-free stroller umbrella for parents*. [ONLINE] Available at: http://www.travelswithbaby.com/blog/pack-this-hands-free-stroller-umbrella-for-parents/. [Accessed 14 May 14].

Alan Kaufman . 2013. *Finally, the world's first hands-free umbrella has arrived*. [ONLINE] Available at: https://www.kickstarter.com/projects/36197580/finally-the-worlds-first-hands-free-umbrella-has-a. [Accessed 14 May 14].

eddie in Fashion . 2011. *Hands-Free – The Umbrella Messenger Bag*. [ONLINE] Available at: http://www.unfinishedman.com/hands-free-the-umbrella-messenger-bag/. [Accessed 14 May 14].

Oliver Serrat. 2009. The Five Whys Technique, Asian Development Bank, Available from: http://www.adb.org/sites/default/files/pub/2009/the-five-whys-technique.pdf. [Accessed 14 Apr 14].

SlalomTech, Instrumented Whitewater Slalom Gate System, Available from: http://eng.anu.edu.au/courses/ENGN2225/course-files/core_resources/wk08-ANUPDS_AttributesCascade.pdf. [Accessed 14 Apr 14].

Beale, D & Bonometti, J 2014, 'Chapter 2: Systems Engineering (SE) – The Systems Design Processes', The Lunar Engineering Handbook, Auburn University. http://www.eng.auburn.edu/~dbeale/ESMDCourse/Chapter2.htm#ArchitechtureandDesignDevelopment. [Accessed 28 Apr 14].

Blanchard, BS & Fabrycky, WJ, 'Chapter 3: Conceptual System Design', Systems Engineering and Analysis, New Jersey,<http://eng.anu.edu.au/courses/ENGN2225/course files/core_resources/wk07-Blanchard_FunctionalAllocation.pdf>. [Accessed 28 Apr 14].

Browne, C 2014, Week 8: System Attributes, ENGN 2225 Systems Engineering Design, ANU, http://eng.anu.edu.au/courses/ENGN2225/current/content#wk-8-systemattributes. [Accessed 28 Apr 14].

Benner, T. et al., 1995. A prototyping system for verification and evaluation in hardware-software cosynthesis. *Rapid System Prototyping*, 6(1074-6005), pp. 54 - 59.

Blanchard, B. & Fabrycky, W., 2011. *Systems Engineering and Analysis*. Fifth edition ed. New Jersey: Pearson.

Browne, C., 2014. *ENGN2225 COURSE CONTENT*. [Online] Available at: http://eng.anu.edu.au/courses/ENGN2225/course-files/online_classroom/OC-Wk09_Evaluation.pdf [Accessed 29 04 2014].

ENGN2225 COURSE CONTENT, 2014. *ENGN2225 COURSE CONTENT*. [Online] Available at: http://eng.anu.edu.au/courses/ENGN2225/course-files/core_resources/wk09-evaluation_matrices.pdf [Accessed 27 04 2014].

Blanchard, B. & Fabrycky, W. 2011, Systems Engineering and Analysis, 5th edn, Pearson, New Jersey. Testing types, pp. 166-171

Figure is a good way to visualise the alternatives, p.202.Graham, S. 2000, Rapid prototyping: A key to fast tracking design to manufacture, Assembly Automation, vol. 20, no. 4, pp. 291-294 HL, 2013, Personalized Diabetes Self-healthcare, Refined Proof of concept application and Field ,BUTLER, pp.47-49.

Barbara Shwom, Penny Hirsch, Charles Yarnoff, John Anderson. 1999. Engineering Design and Communication: A Foundational Course for freshmen. Available at: http://wac.colostate.edu/llad/v3n2/shwom.pdf. [Accessed 13 May 14].

Maaike Kleinsmann, Anja Maier, 2013. Artificial Intelligence for Engineering Design, Analysis and Manufacturing. AIEDAM Special Issue, [Online]. Vol.27, No.2, Available at: http://web.cs.wpi.edu/~aiedam/SpecialIssues/Kleinsmann-Maier.html [Accessed 12 May 2014].

Cerri, S., 2000, "Effective communication skills for engineers," Engineering Management Society, Proceedings of the 2000 IEEE, pp.625, 629.Jill H. Larkin, Herbert A. Simon, 1987. Why a Diagram is (Sometimes) Worth Ten Thousand Words. Cognitive Science, Pages 65– 99. Available at: http://mechanism.ucsd.edu/teaching/f12/cs200/readings/larkin.whyadiagramissometimesworth.1987.pdf [Accessed 04 May 2014].

# 7 Appendices

Appendix A: Functional Flow third, fourth, fifth level