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Toolbox Redesign for Flight Engineer

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Abstract.
Toolbox is a tool rack made with the aim that service tools are arranged according to the tools that are often used by technicians and the tools are safer when not in use by Flight Engineers. Flight Engineer is part of aviation safety which is closely related to the physical plane and aspects of maintenance so that Flight Engineering requirements are met. When carrying out their work, Flight Engineers need a container or facility as a place to put Flight Engineer equipment that can contain a lot of work equipment, is efficient, easy to carry and move. The toolbox redesign process is carried out to make changes and add functions from the existing toolbox design and use at that time. This study uses a mixed method with qualitative and quantitative approaches. Qualitative data obtained from interviews and photo documentation obtained from Flight Engineer sources. Quantitative data obtained by observing the measurement of toolbox dimensions at the Juanda Navy Aviation Center and Biak Air Base. The design concept applied to the design of the equipment box is functional. The results of this research are work equipment icon designs, equipment placement layouts in the toolbox, 10 initial toolbox design sketch designs, five alternative toolbox designs, and one selected toolbox design. The two selected toolbox designs will be developed into a final product design.

Keywords: *Flight Engineer, Redesign, Toolbox*

INTRODUCTION

Air transportation is transportation that requires a lot of money to wear it. Apart from having more advanced technology, air transportation is the fastest means of transportation compared to other means of transportation. (Japri., et. al. 2021). Flight Engineer is a part of flight safety which is closely related with aircraft body and maintenance aspects for the aeronautical engineering requirements. However, maintenance work needs to be done with the most efficient and effective time so that not much time is wasted and the condition of the machine remains stable so that it can be used on time. Flight safety aspect also related to the human resource factor involved in flight activities (Sihombing. 2021). A Flight Engineer has a role to watch some aspects that support flight operation, such as the electricity system, fuel, pneumatic, and hydraulic system. Flight engineers should also do some checking before the plane takes off. This is to make sure whether the plane is good to fly or not. Flight engineers use mechanical tools to do their job in doing maintenance or repair of the plane. Some of the tools are pliers, screwdriver, saw, hammer, and solder with various sizes and kinds.

All the mechanical tools are placed in storage. The mechanical equipment is a construction tool which uses motion power (mechanical) from humans or non-human. The toolbox for the mechanical tools has various designs from a hand-carry design to trolley design Toolbox can be interpreted as a box that contains tools or equipment that serves for storage of tools. (Jatmiko, 2020).

Based on the research, it was found that there is a need for a toolbox for flight engineers which can accommodate a lot of tools, efficient, and easy to carry or move. The problem with the current toolbox is it cannot carry enough tools so there is a need for a better toolbox design which can carry all the tools needed by the flight engineer. There is also a problem when the flight engineer is laying down under a training aircraft which has a smaller size compared to another plane. They are struggling to reach the tools when they are laying under the training aircraft doing some repair. There is also a problem when flight engineers need to repair the top part of the plane. They need another air crew to help pass the tools to do the work.

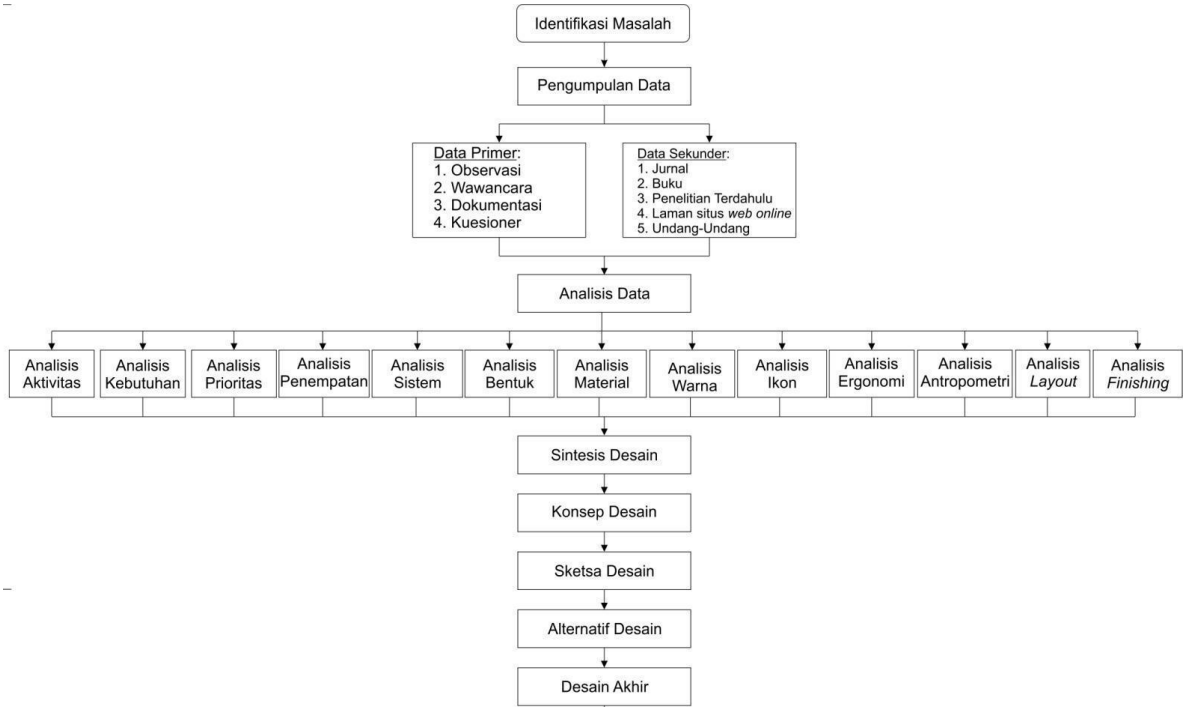
Therefore, the researcher wants to redesign the toolbox for flight engineers. The form of redesign in this study will focus on structure change and function, building, or system in order to give a better user experience or develop a different function from the previous design. The result of early interview and observation shows that the current toolbox used by flight engineers cannot carry all the tools needed to do the work. It found that there are more than one toolbox used by flight engineers to bring all the tools. The toolbox used by flight engineers at Naval Aviation Center is a toolbox that is commonly used by all the mechanic workers, not specifically for flight engineers, or like the stacked rack toolbox as “Stahlwille” brand. Therefore, this study was done to redesign a specific toolbox for Flight Engineers.

METHOD

This study used a mix method approach. Mix method research is a research method that combines quantitative and qualitative methods in the research. Data collection instrument used in this study was observation and questionnaire. The observation was done by observing the activities of flight engineers and measuring the current toolbox used in Juanda Navy Aviation Center and Biak Air Base. The questionnaire was then given to both flight engineers in Juanda and Biak. The

quantitative data instrument was measuring observation (Harvey et.,al. 2010). While the qualitative data instrument was interview transcript, photo documentation, literature media, and online media. (Degner, 2022).

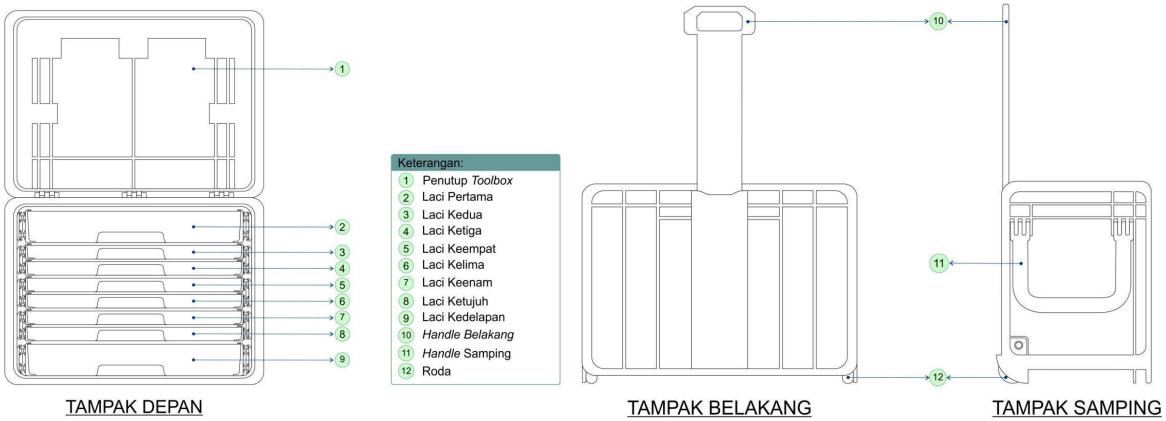
Research Framework



Data Collection

Case study was done in Juanda Navy Aviation Center and Biak Air Base. The location was in Skuadron 200 Unit, Wing Air 2. Skuadron 200 is in charge of flying training. The researcher was visiting the location to observe the current toolbox used on the training plane shelter of Skuadron 200.

Based on the observation, the layout of the toolbox used in this place is:(picture 1)

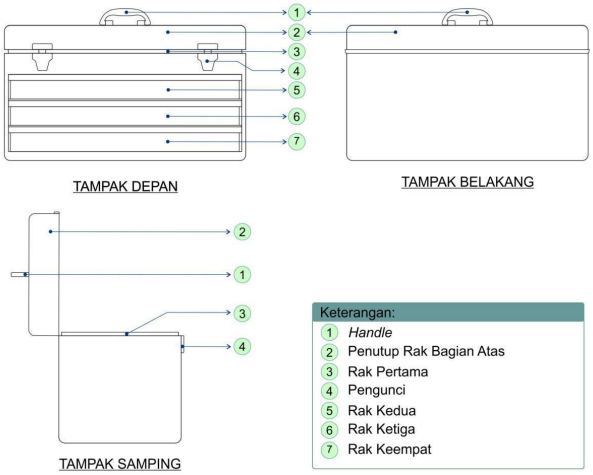


Picture 1. Toolbox Layout used in Juanda Aviation Center

Biak Air Base is a regional work unit under the Indonesian Navy's Central Aviation

Command. Lanudal Biak is the main base for elements of the Indonesian Navy's aircraft carrying out operational tasks in the 3rd Fleet Command area of the Indonesian Navy, its operational working area covers almost all of the provinces of Papua and West Papua.

Here is the toolbox layout used in Biak Air Base: (picture 2)



Picture 2. Toolbox used in Biak Air Base

RESULTS AND DISCUSSION

Results

Activities Analysis

Activities Analysis that has been done.

1. Work equipment inside the toolbox was stored based on the type of the equipment.
2. Work equipment inside the toolbox was arranged based on the cleanliness of working conditions when flight engineers were doing maintenance and repair of the plane.
3. The corner protector can be made using silicone-based material, rubber, and EVA sponge. The shape of the protector is square, oval, and roll. The corner protector that applied to the final design is using silicon-based material with a square shape because silicone is transparent so it can show the color of the toolbox surface.
4. The toolbox was designed using a flexible construction so that it can be moved easily.
5. There will be wheels applied to the toolbox design so that it can be moved easily.
6. The toolbox will be designed to have an additional work area that can be used for workbench.
7. Light and magnifying glass are applied to the toolbox to help flight engineers when they need additional vision.

Needs Analysis

Needs analysis for *Flight Engineer*:

1. Work equipment inside the toolbox can be placed based on the type of the tool.
2. Work equipment inside the toolbox was arranged based on the cleanliness of working conditions when flight engineers were doing maintenance and repair of the plane.
3. The corner protector can be made using silicone-based material, rubber, and EVA sponge. The shape of the protector is square, oval, and roll. The corner protector that applied to the

final design is using silicon-based material with a square shape because silicone is transparent so it can show the color of the toolbox surface.
4. The toolbox was designed using a flexible construction so that it can be moved easily.
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7. Light and magnifying glass are applied to the toolbox to help flight engineers when they need additional vision.

Priority Analysis

The result of priority analysis based on the needs of flight engineers.

1. The most used equipment by flight engineers is wrench set, screwdriver set, and pliers.
2. The placement of the tools mentioned before need to be placed closely and easily reached.

Placement Analysis

The result of placement analysis of work equipment in the toolbox.

1. Ratchet set categorized as medium working condition (clean and dirty).
2. Wrench set is categorized as medium working condition (clean and dirty).
3. Screwdriver set categorized as medium working condition (clean and dirty).
4. Drip pen sets are categorized as dirty working conditions.
5. Pliers categorized as medium working condition (clean and dirty).
6. Hammer categorized as medium working condition (clean and dirty).
7. Inspection glass, ruler, arc, flashlight categorized as clean working condition.
8. Saw, iron brush, iron file categorized as dirty working conditions.

System Analysis

Systems are interrelated elements and influence each other in doing some activities to achieve certain goals (Ahmad, 2015). The result of system analysis used in this toolbox redesign is:

1. The toolbox uses a knockdown construction system so that it has a strong structure.
2. The toolbox uses a mobile construction system with wheels to make it easier to maneuver and move.
3. The toolbox uses an inflatable construction system to expand the workbench that can be used for engine and propeller repair of the plane.
4. The toolbox uses a transformable construction system to integrate two toolbox functions to be a storage of working tools and workbench for engine and propeller repair.

Form Analysis

The form analysis result used in this toolbox redesign was beam shape. Beam shape was applied for the drawer part of the toolbox. It is used for keeping the equipment. Beam shape was chosen because it can maximize the storage space.

Material Analysis

The materials used in the toolbox redesign are:

1. Steel used for wall surface of the toolbox because of its strong and heavy characteristic so that it can hold heavy items on the toolbox
2. 4x4cm Hollow iron used as the structure framework of the toolbox because of its strong and heavy characteristics. But it should be coated with rust-free paint to prevent rust.

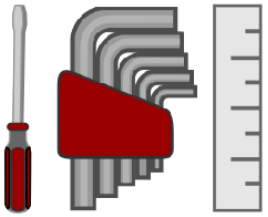
Colour Analysis

1. Work tools arrangement on the drawer started with light color from the top and became darker to the bottom of the drawer. The order of the colors started from the top are yellow, green, blue, purple, and black.
2. Yellow color was used for the first drawer to show the tools with clean working conditions.
3. Green color was used in the second drawer to determine the tools used in clean working condition.
4. Blue color was used for the third drawer to store medium working condition tools (a little dirty).
5. Purple color used in the fourth drawer to show tools with medium working condition.
6. Black color used in the bottom drawer to indicate most dirty working condition tools.

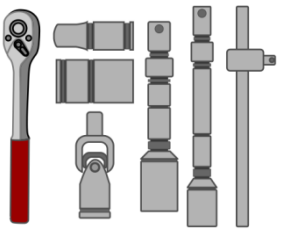
Icon Analysis

Icon design was used to give information on tools placement in the toolbox (picture 3-7).

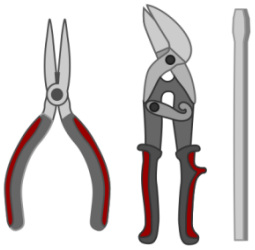
Picture 3. Wrench , power outlet, magnifying glass Icon



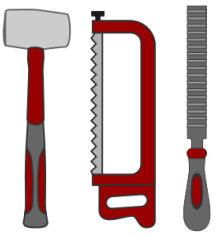
Picture 4. Screwdriver, Hex key, dan Ruler Icon



Picture 5. Ratchet key Icon



Picture 6. Pliers, Scissor and Drip Pen Icon



Picture 7. Hammer, Saw, and File Icon

Ergonomy Analysis

Ergonomics is a study to learn the human's ability to interact with their physical environment. Ergonomics study the relationship between human and tools (human-machine system) based on the research of physical and psychological ability and also human limitation in facing the system or tools (Lin, S., et. Al.2022). The ergonomic aspects applied in the toolbox redesign were:

1. Wrench set, screwdriver set, and ratchet set were arranged sequentially in the first, second, and third drawer because they should be easily reached by the flight engineers.
2. Vision aids like magnifying glass were put together with wrench set in the first drawer, while measurement aids were put together with screwdriver set
3. Lighting sets were placed near the workbench to give additional light when needed.

Anthropometry Analysis

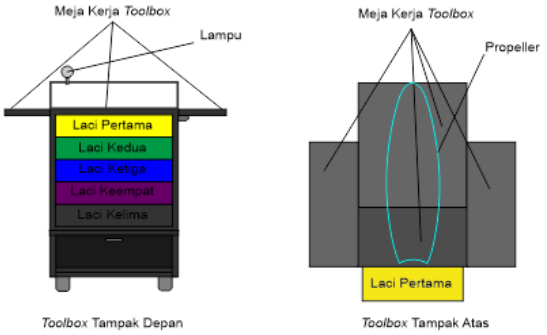
Anthropometry study the human body dimension in every position when doing various activities in their physical environment, from condition and characteristic of the physic, such as linear dimension, volume, weight (Koley, S., 2011) The anthropometry aspects applied in the toolbox redesign were:

1. Toolbox height is 105 cm. This was decided based on Wardani (2003) which stated that the height of the workbench for a working condition that needs precision is between 100-110 cm. The decision to make it 105 cm was because it is the middle value between 100 and 110 cm.
2. Length and width of the toolbox is 80 cm x 50 cm. This value was obtained from a Ruitengtool toolbox that has 78x48 cm.
3. Length and width of the workbench is 170 cm based on the consideration of the propeller length is 150 cm with additional 20 cm for putting lighting and tools.

Layout Analysis

Placement layout used in this study was the second layout. The second layout has drawer arrangement from light color and becomes darker to the bottom drawer. The size of the workbench on the upper part of the toolbox is the extension to the back part, right part, and left part of the

toolbox that extended to the back part. In the bottom of the toolbox, there is a storage. The extension part of the workbench was using hinges (picture 8).



Picture 8. Toolbox Layout

Finishing Analysis

The finishing chosen is duco paint considering the smooth and even finish with more various colors which can be mixed to create desirable color.

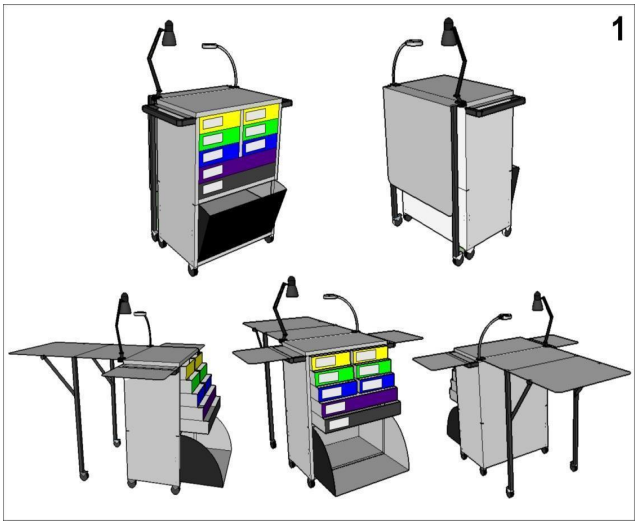
Design Concept

The Design Concept taken by the researcher for this toolbox is “functional”. Utomo (2011) explained that a functional product is a product that is used and created for the purpose of practicality and functionality, especially for daily use. Functional concepts generally have specific or varied uses, where each product emphasizes practical aspects and optimal and efficient functions.

Design Result

There are 5 alternative design results that have been designed based on the analysis that have been done by the researcher.

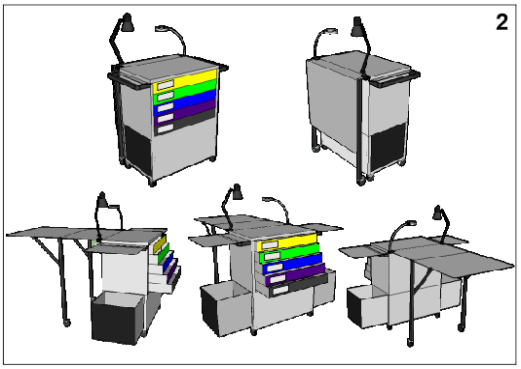
Toolbox Design 1



Picture 9. Toolbox Design 1

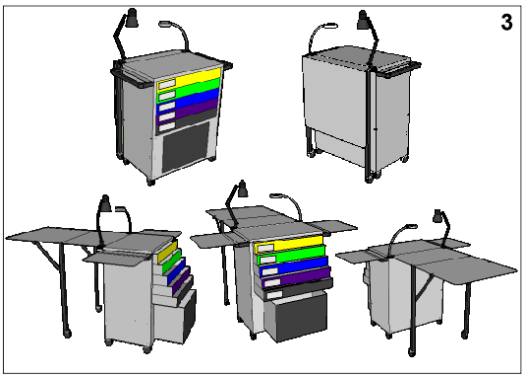
There are 8 drawer levels and 1 storage room in the bottom drawer that has a round-shaped opener. The upper part of the toolbox can be a workbench that is adjustable. The advantage of this toolbox is it has a lot of drawers to put away enough tools. The front-faced drawer also makes it easier to pick up the tools.

Toolbox Design 2



Gambar 10. Desain *Toolbox* 2

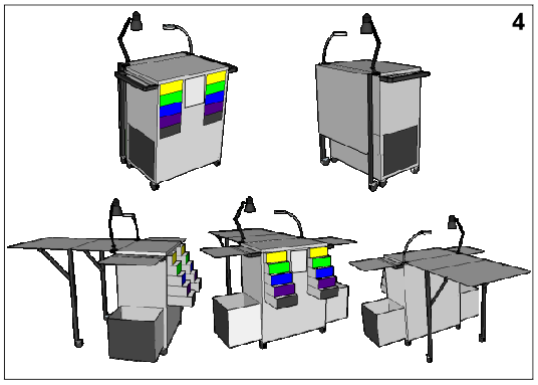
The toolbox in Biak Air Base consisted of 5 stacked drawers and 2 storage rooms on the left and right side of the bottom drawer. The upper part of the toolbox can be used as an adjustable workbench. The advantage of this toolbox design is the storage position that is divided into two parts (left part and right part) so that there are two storages that can be divided to put large tools (Picture 11).



Picture 11. Toolbox Design 3

This design has 5 level drawers and one front storage. The surface of the toolbox could be used as an adjustable workbench. This toolbox design is the simplest one with the advantage that the tools position in every level can be in one place at a time when the drawer is pulled. The storage is positioned in the front with a large size (picture 12).

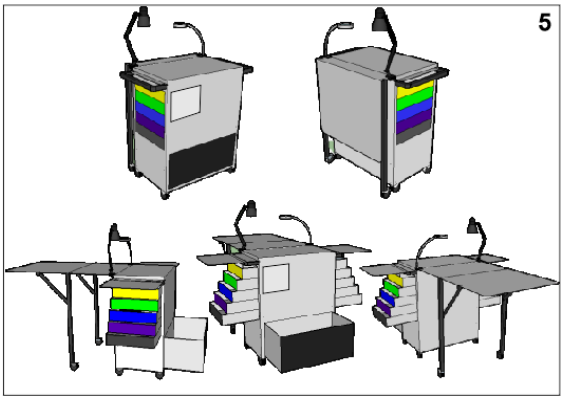
Toolbox Design 4



Picture 12. Toolbox Design 4

The Toolbox Design 4 consists of a 10 level drawer and 2 storage rooms in the bottom left and right. Like other designs, the top part of the toolbox can be used as an adjustable work bench. The strength of this design is in the middle part of this toolbox, there is an empty space when the drawer is in the pull position. This empty space can make it easier for flight engineers to fix the parts on the top of the toolbox. The storage room that is divided into two parts makes it easier to sort out the large tools and put it in the storage as you want (Picture13).

Toolbox Design 5

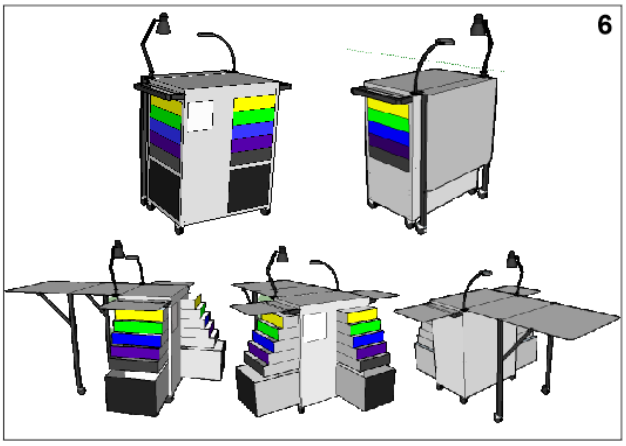


Picture 13. Toolbox Design 5

In this design, there are 10 drawers with 1 storage room in the front. The top part can be used as a workbench. The strength of this design is in the middle part of this toolbox, there is an empty space when the drawer is in the pull position. The front storage room also has a large size.

Final Design

The final design was the result of the improvement from all of the five alternative designs with the consideration from input and suggestion taken from the interview with the flight engineers. The final design of the toolbox is shown below (picture 14).



Picture 14. Final Design of the Toolbox

The final design of the toolbox consists of 10 drawers and 2 storage rooms placed in the front and side of the toolbox. The upper part of the toolbox can be used as an adjustable workbench. The strength of this design is in the drawer position which is placed in the left and right side of the toolbox that helps flight engineers to reach the parts and pick the tools. The storage room is also placed in the side and front of the toolbox.

CONCLUSION

The toolbox redesign for flight engineers is aimed to facilitate engineers in storing and carrying mechanical tools and make it easier to mobilize the toolbox. This study was done by using mix method research where both quantitative and qualitative methods were applied. Case study was also used in this research to understand the activities and needs of the flight engineers. The toolbox redesign process based on the activities analysis, needs analysis, priority analysis, positioning analysis, system analysis, form analysis, material analysis, color analysis, icon analysis, ergonomy analysis, anthropometry analysis, layout analysis, and finishing analysis.

Mechanical tools are stored inside the drawer and arranged by the cleanliness level from the cleanest to the dirtiest. Toolbox design has a square shape as the basic geometry form of the toolbox so that it can contain a lot of flight engineer tools. The color aspect used in the toolbox starts with the brightest color, and it becomes darker on every level until the bottom part of the toolbox. The first drawer uses yellow color, second drawer is green, third drawer is blue, purple for the fourth drawer, and black color for the fifth drawer. The toolbox is designed using a strong material that is stainless steel sheet and 4x4 hollow steel. The design system applied on the toolbox is knockup-mobile-transformable so that it has a strong construction, mobile, and easy to use. The icon embedded in the toolbox was designed to help flight engineers locate where the tools are stored easily. The final design of the toolbox also pays attention to ergonomy and anthropometry aspects as the basis of the design. The layout analysis was done to decide

the needs, arrangements, and positioning of the tools inside the toolbox. On the other hand, finishing analysis was done to determine the suitable finishing type applied in the process of the finishing process of the toolbox. The result from data collection and analysis is the basis for redesigning the toolbox. The final design of the toolbox then will be produced to be the prototype product that will become the final product of the toolbox for flight engineers.

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