

## PRODUCT DESIGN OF MARINE SOLDIER BACKPACK WITH QUALITY FUNCTION DEPLOYMENT METHOD

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### ABSTRACT

The success of Marines in carrying out the task should be supported by the ability, technique and also sufficient instrument. One of the equipment is the backpack of combat. Which is improved along with the improvement of the age. The availability of soldier combat backpack was considered not comfortable. The intention of this research is to redesign the available combat backpack. It utilizes QFD (Quality Function Deployment) method and also principles of ergonomic which that intended to meet the requirement in solving the available problems. We can get information about any desirable and prioritized attributes by user and also any prioritized technical characteristics in designing this combat backpack by applying QFD. In order to apply the principles of ergonomic, the design of this combat backpack need anthropometric data from the Yon Marine soldier's body. The undertaken statistical tests are hopefully able to represent the whole population (Yon Taifib soldier). The result of this research is a prototype of the combat backpack.

**Keywords:** Combat Backpack, Quality Function Deployment (QFD), ergonomic.

### 1. INTRODUCTION

The Indonesian Navy is a force in securing the seas of the Republic of Indonesia, in accordance with the Law of the Republic of Indonesia Number 34 of 2004 Article 9 concerning the TNI, it is stated that one of the tasks of the Indonesian Navy (TNI AL) which has strategic value is carrying out the tasks of the TNI in the marine sector in the defense sector. , and enforce the law in order to maintain the security of the maritime area and international law (UU TNI, 2004). This is a very difficult task for the Indonesian Navy because it has to maintain the security of the marine area which is 2/3 of the territory of the Republic of Indonesia.

SSAT (Integrated Fleet Weapon System) as the core strength of the Indonesian Navy in the context of implementing defense and security at sea, is required to be able to deal with various threats and disturbances by enemies at sea, both from the surface and below the surface, as well as threats that require power projection to land by sea. As stated by Djoko Purnomo (1996; 3), the Integrated Fleet Weapon System (SSAT) has four components, namely warships, aircraft, landing/occupying troops (Marine Corps), and bases.

Marine Soldiers have the main task of fostering and providing strength as well as fostering amphibious and reconnaissance elemental capabilities land as well as special operations tasks in the context of carrying out amphibious landing operations, or other operational tasks. When carrying out combat operations. Marine soldiers are equipped with individual special equipment including weapons, combat helmets, combat backpacks, and others. Personal equipment is basically equipment that is basic in nature to support soldiers in carrying out their duties, both during training and in actual combat duties, combat backpacks are used to accommodate equipment and logistics to be carried.



Figure 1. Marine Corp

Combat backpacks owned by Marine soldiers are currently a division of the TNI Headquarters (Headquarters). The combat backpack used by the Marines can be seen in figure 2.



**Figure 2.** US GI Alice LC2 Medium Backpack (Korean Backpack)

Korean backpack technical data (observations):

- a. Main pocket: 20 x 14 x 6.5 inches. Front pocket each has size: 10 x 5 x 3 inches.
- b. Used to carry supplies for  $\pm$  3 days.
- c. There are three small pockets and one main pocket.
- d. The color of the bag is green or brown that works as camouflage.

From observations and direct interviews with several Marines, it is stated that the combat backpack needed at this time is a multifunctional combat backpack that can carry a variety of equipment and logistics according to the tasks to be carried out, such as for Heli Cross Movement, Rubber Lifeboats, as well as special landings. Where the old backpack needs to be replaced with a new one to replace the TNI backpack that has been used so far because of the shape there are still many shortcomings that need to be changed so that it can be used better by soldiers in carrying out training and assignments. One of the methods used to make backpacks is to use the Quality Function Deployment (QFD) method in designing a new backpack product where the backpack that will be made later must also have strength according to TNI combat standards and be impact resistant, comfortable when carrying supplies and be able to reduce the feeling of discomfort, fatigue carrying the burden carried during training and combat. In addition, the respondents also felt some complaints about the Korean combat backpacks that have been used for now.

Among other things, the inconvenience in using the existing combat backpack, especially in its use, namely the size of the bag that is too wide, the bag strap is too small, and does not suit the body shape, it is too short so the load focuses on the shoulder, besides that it is also difficult to remove the backpack when in an emergency situation.

Therefore the role of the backpack itself is very important for Marines where it is used to carry logistics and combat equipment when carrying out training and combat operations. Therefore, it is necessary to design a new combat backpack that is more ergonomic and better in terms of shape and material to be made. So that it can increase success in carrying out all forms of training and on the battlefield using the Quality Function Definition (QFD) method.

As for the previous research, Permana applied the QFD method in designing ergonomic sail shoes for the Indonesian Navy, where to find out the desires/needs of consumers (KRI Soldiers) in designing ergonomic sail shoes and getting a sail shoe design for KRI soldiers. Researchers use the QFD method in their research. To find out whether the sail shoes are ergonomic or not, a comparison is made between the old sail shoes and the new sail shoes as a result of the design by doing a Nordic Body Map as a comparison of the complaints felt by consumers before and after the redesign. Furthermore, Hunsam (2008) conducted research on the redesign of assault vests based on the needs of Kopaska. This study aims to redesign the existing assault vest. The research uses the QFD method and the principles of ergonomics which are expected to solve existing problems. With the application of QFD, information can be obtained about what attributes are expected and important by the user as well as what technical characteristics are prioritized in the manufacture of assault vests.

Another study, namely Effendi (2013) carried out research and design of reconnaissance equipment using a quadcopter to support special operations for the elite Kopaska unit, with a reconnaissance tool capable of meeting the needs of troops, of course, Kopaska was able to complete its main tasks more effectively and efficiently and was able to minimize loss of material and personnel. This study uses the QFD method. This QFD method is used to translate consumer needs and desires into product design characteristics. From the results of the identification of consumer needs, the existing contradictions are resolved by drafting and selecting concepts to obtain optimal results.

Another study, namely Muhammad Arif (2015), carried out research and redesigned the TNI backpack which was more specifically for the Amphibious Reconnaissance Battalion (Yon Taifib) starting from the quality of the combat backpacks that had been used by Yon Marines soldiers were still not satisfactory. By using the QFD method, where the combat backpack product made can meet the needs of Yon Taifib soldiers, so that it can increase the morale of soldiers when carrying out combat training and during actual combat operations. The satisfaction level of the new combat backpack is higher than that of the old combat backpack.

## 2. MATERIAL AND METHODS

### 2.1 Ergonomics

Ergonomics comes from the Greek word "Ergos" which means work and "Nomos" means law. Thus, ergonomics can be defined as the study of human aspects in the work environment which are reviewed in terms of anatomy, physiology, psychology, engineering, management and design. In this case, ergonomics is intended as a science that studies humans in relation to work. According to Nurmiyanto (2004) Ergonomics is also concerned with optimization, efficiency, health, safety and human comfort at work, at home, and recreational areas. Meanwhile, according to Wignjosoebroto, (2003; 80) Ergonomics is a rule or norm in a work system.



**Figure 3.** Anthropometric data required for Product/Work Facility Design.

Ergonomics is also a rule or norm in a work system. Every activity or work carried out should always refer to the principles of ergonomics. If not, then the activity or work can cause inconvenience to humans, high costs, also an increase in accidents and occupational diseases, as well as a decrease in performance which results in a decrease in work productivity.

This is understandable because ergonomics is also concerned with optimization, efficiency, health, safety, and human comfort in the workplace.

### 2.2 Product Concept

According to Philip Kotler (2002), defines a product as anything that can be offered to the market for attention, ownership, use or consumption so as to satisfy a need/want. From the above definition it is clear that the product is not only tangible (tangible) but also intangible (intangible).

The product consists of three main components, namely:

- a. Core Components, namely the physical product itself which is influenced by elements of form, dimension, size and others as well as functions that can be displayed such as performance, technical specifications.
- b. Packaging Components, which consist of the following factors:
  - 1) Selling price (price)
  - 2) Quality in terms of design, process, product.
  - 3) Place / container / packaging (package)
  - 4) Variety of models, styles
  - 5) Design features (grade)
  - 6) Trademark (brand name)
  - 7) Special characteristics that distinguish it from others (trade marks)
- c. Supporting service components, which include the following:
  - 1) *Delivery time*
  - 2) Guarantee period (reliability, warranty)
  - 3) Parts
  - 4) Installation, repair, maintenance
  - 5) Instruction manual
  - 6) After-sales service

Product characteristics are the character, identity, advantages and others possessed by a product. Product characteristics can be in the form of "product quality" or things that are special, distinctive, special from a product that gives characteristics and makes it easier to identify

## 3. RESULT AND DISCUSSIONS

### 3.1 Data collection

At this stage, data collection is carried out which includes data on combat backpacks, as well as technical data from existing combat backpacks and are used now. Technical data from combat backpacks include size, existing facilities and capacity of equipment, which were obtained through interviews,

questionnaires, as well as by direct observation and ergonomics data. Ergonomic data collected is anthropometric data on the body of Marine soldiers which includes height, body width, and so on.

### **3.2 Making House of Quality**

Making *house of quality* starting with getting data on the voice of customers from Marines to identify all the needs and desires of Marines regarding the new designed combat backpack, then identifying technical responses to meet the needs of Marines. The next step is to determine the relationship between the technical response and the needs of the Marines and determine the relationship between the technical response. The final step is to find the order of importance of the technical response.

### **3.3 Drafting Alternative Concepts**

At this stage, the drafting of the concept of a combat backpack that suits the needs of Marine soldiers is carried out. The exploration of alternative concepts was carried out internally, namely from the author's knowledge and externally, namely from interviews with Marines, consultations with experts and literature searches.

### **3.4 Concept Selection**

The activity carried out at this stage is to analyze all the alternative concepts of a combat backpack that will be made and eliminate some of them based on the best ranking to get the best or most promising combat backpack concept. The method used is a structured method, namely by giving weight to each alternative concept.

### **3.5 Prototype Testing**

*Prototype* of the combat backpack is made in a real form so that it is expected to be able to represent the actual combat backpack being researched. It is hoped that in the future the combat backpacks that have been made can be used by all TNI soldiers, especially Marines, to carry out in training and combat areas.

Test *prototype* combat backpack includes performance testing and the working mechanism of the backpack. This test will be carried out by Marines to see if the design results are not as expected, and through distributing questionnaires and interviews to Marines to compare whether satisfaction with the new backpack is better or not than the old backpack and see if the combat backpack is in accordance with the needs and desires of the Marines.

### **3.6 Drafting Alternative Concepts**

After the preparation of the House of Quality, the design of a new combat backpack is expected to be able to meet the needs of soldiers during training and on the battlefield. And the design of the new combat backpack also considers the results of the calculation of the attributes and which technical response is the priority. In product design, it is necessary to prepare alternative concepts. This alternative concept is an arrangement of concepts that might be developed in this product. These alternatives are arranged in a table called a morphology chart.

*Morphology chart* itself is necessary for the design of a new combat backpack based on possible alternatives. In the morphology chart, all technical responses that become priorities are arranged for alternative concepts so that there will be many alternatives from which one or several concepts will be selected from hundreds or even thousands of alternative concept arrangements which are a combination of each alternative.

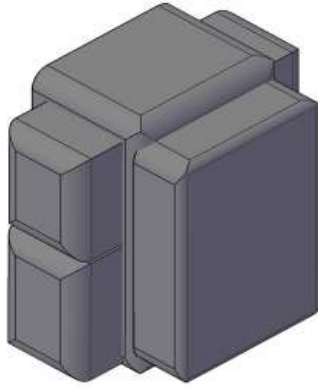
### **3.7 Concept Selection**

After the preparation of alternative concepts, the next stage is the selection of concepts. The concepts presented in the preparation of alternative concepts will be selected through a concept screening which will later select a concept that will be realized as a prototype of a new combat backpack. Starting from the design, the material to be chosen for the backpack, the load capacity of the bag, the strength of the bag material, the color to be used and other additions so that the concept of the backpack specified will be much better. In determining the concept of making bags, of course, you can't work alone, therefore of course it will involve developers and bag designers, namely people who are competent in the field of making backpacks that are in accordance with the prototype to be made.

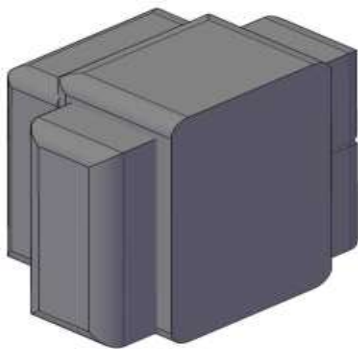
### **3.8 Prototype Making**

After getting design recommendations from the chosen alternatives, and anthropometric measurements of the body, the next stage is making a prototype using AutoCAD software, starting with designing the shape of the backpack and its additional features.





**Figure 4.** Backpack Design Front View



**Figure 5.** Backpack Design Back View

For size backpacks use the 90th percentile, to accommodate 90% of the population. The combat backpack is made of 100% polyester (filament) and double coated. From the results of the design above, the next process is to make a physically real prototype. Making a real prototype is intended so that the combat backpack can be tested directly to find out the advantages and disadvantages of the combat backpack. Pictures of each part of the physical prototype as well as pictures of the use of the prototype.

**a.** The front. The backpack is wrapped in 100% double-coated polyester fabric, using ropes and parasitic fabrics to be able to enter other equipment items, the bag is designed to use 1 slot for the top cover, so it can close and tighten the bag. At the top it is also made high so that the head functions to protect the head, and the shape of the bag is slightly elongated so that the capacity of the bag becomes larger. While the hardcase is made of strong material so that the backpack is strong against impact. On the front is also equipped with a large pocket so that it will be easier for soldiers to take the equipment that is in it, as well as 2 pockets on the right and left to put additional equipment. The black bag material will provide a neutral color so that when used during training or

combat operations, it will be disguised. The model size of the bag is made slim according to body posture so as to facilitate the movement of soldiers during use for training and combat.



**Figure 6.** Front View Prototype

**b.** Back. The right and left bag straps are given thick foam so that when used during basic military training activities, you will not experience shoulder pain due to hard materials and in the middle of the bag straps there is a hook between the straps so that the bag position can be maintained in the desired position. As well as a strap at the bottom of the bag that has a function to hold the position of the backpack carrying heavy loads other than the shoulders and back. The part of the bag that is in contact with the back is given thick foam to withstand the impact of the bag with the back due to the soldiers' daily activities.



**Figure7.** Prototype Back view

**c.** Side part. There are 2 right and left pockets to put additional equipment (electronic

devices) that can be used for combat operations and training activities.



**Figure 8.** Prototype Left Side View

d. Vest Part. The vest that will be used can later be used during training and combat, can also function as self-protection from opponent threats because the vest has chest and back protectors, and serves as a place for ammunition magazines that are carried during training and fighting. The vest itself can be paired or removed with a backpack where behind the back of the vest is a camel pack for drinking water, so soldiers are easy to use during operations or training.



**Figure 9.** Prototype Vest Part

### 3.9 Analysis of Data Processing Results and Discussion

The analysis stage of the data processing results and discussion is the stage

that must be passed after the data collection and processing stage. Each step of data collection and processing in the previous chapter will be analyzed and discussed in this sub-chapter.

The analysis carried out involves analyzing the anthropometric aspects of the data taken, the conceptualization analysis of the design of the combat backpack that will be made, including several alternative concepts that will be developed. Each concept will be described in its own initial specifications. The design details will also include the preparation of product technical specifications, considering anthropometric aspects and the voice of the customer. This includes the activity of analyzing the results of the interview. This will produce a combat backpack solution that will solve the problems in this final project.

From the evaluation of the existing combat backpacks, we can see the advantages and disadvantages that exist. With the shortage we can plan the target value of the new backpack that we will make. The target value that we have planned is expected to be able to correct existing deficiencies. The table shows that there are several target values that the existing backpacks have. For example, the ease-of-use attribute in the second backpack has the same target value as we expected, so that in manufacturing we can imitate the ease-of-use attribute in the second assault backpack. For the capacity and strength attributes of the planned backpack, the target value is greater than the existing one, so we need to make a new backpack with more capacity and strength than the two backpacks we already have.

From the technical matrix image, it can be seen that the ranking of attributes is based on customer importance, the technical response of each attribute and the target value we want to achieve. The first rank is not to make the shoulder hurt, the next in a row, the bag material is strong 3.03, it doesn't make the back hurt 2.9, the main function (carrying logistics) is 2.87, the shoulder strap is not easy to lose 2.8, additional function (carrying electronic equipment) 2.77, impact resistance 2.77, enough pockets 2.7, colour is not flashy 2.67, ergonomic shape 2.6. This means that in the design of attributes, the main priority is the strong bag material. Determination of which technical response needs to be considered first in the design can be seen based on the priority percentage obtained from each technical response.

### 3.10 Result Analysis (Output)

From the results of testing tools, it is known that there is an increase in the capacity

to accommodate equipment in the new backpack. The new backpack has additional equipment places, namely: a protective vest where a lot of equipment can be used as a magazine for small 7.62 mm caliber ammunition as many as 4 bags. And the placement of camel back for drinking water with a capacity of 2.5 liters of water. The electronic case is in the backpack or vest, the hardcase placement on the vest also produces an additional function, which can serve as a protection against shots. Where the hardcase can withstand / reduce the penetrating power of bullets that hit us. This reduces the risk of serious injury. The black color selection on the new combat backpack works for camouflage in the jungle.

In terms of satisfaction of Marine soldiers with the new backpack compared to the old backpack, this is better as shown in table 5.4. Where it appears that the average satisfaction of the attributes of the new backpack has increased compared to the old backpack. The attribute does not make the shoulder hurt from 3.1 to 3.73 because the new backpack has added foam and the shoulder strap is made rather large. The attribute of the bag material is strong from 3.03 to 3.73, the bag material is waterproof and has better stitching and good material so that it is strong to accommodate existing equipment. The attribute does not make back pain from 2.9 to 3.53 because there is additional foam on the back of the bag. The main function attribute (carrying logistics) due to the addition of the capacity for the electronic equipment and ammunition that was originally one is now separated, in addition, the top of the backpack can also be extended so that the capacity is greater.

The hook attribute of the strap is not easily separated from 2.83 to 3.6 because it uses a larger quick release so it is not easily separated or broken. The attribute is easy to put on and take off from 2.8 to 3.6 because the new backpack has a large shoulder strap and the vest that is attached to the backpack is easier to put on and take off. Additional function attributes (carrying electronic devices) from 2.77 to 3.67 due to the addition of a new hardcase in the backpack. Impact resistance attribute from 2.77 to 3.67 due to the hard case inside the new backpack. The attribute of sufficient pockets from 2.7 to 3.53 because the new backpack has 3 large pockets on the front and left of the backpack. The color attribute is unobtrusive of 2.67 to 3.53 is because there is a change in color from green to black, choosing black on the new combat backpack because it can adapt to the existing nature. Ergonomic shape from 2.6 to 3.53 due to the newly made

backpack according to the anthropometric data of Marine soldiers.

### **3.11 Ergonomic Analysis**

For electronic equipment that was originally in the old backpack was placed in the backpack thereby reducing the capacity for supplies and logistics, now in the new backpack it is in a bag cover that can be opened easily so that it can make it easier for soldiers to take electronic devices and equipment.

For the camel back place to be placed outside the combat backpack, which is inside the assault vest, making it easier when filling water, the placement of the drinking hose is easier when compared to the use of veples on the waist. In addition, when drinking, it will not interfere with the hands when in a standby position with weapons.

The capacity of the backpack can be adjusted according to the needs of soldiers because the top of the backpack can still be extended, from the old 30 liter capacity to 40 liters in the new backpack, so soldiers no longer need to share supplies and equipment with other soldiers.

The back of the backpack is also equipped with foam which can prevent injury or abrasions to the waist. In addition, the size of the shoulder strap is made slightly larger and the strap on the abdomen can also be adjusted to the shape of the body, making it easier for soldiers to move on the training and combat field.

And also the additional function of an assault vest can be used together with a combat backpack where the assault vest itself has several additional functions, namely as a personal protective function, carrying additional magazines and drinking water. So that soldiers who carry out training and battles can move more optimally and don't feel pain.

## **4. CONCLUSION AND SUGGESTION**

### **4.1 Conclusions**

Based on the house of quality (HoQ) and the analysis and interpretation described in Chapter IV and Chapter V, the results obtained in this study in accordance with the research objectives are as follows:

a. The quality of the combat backpacks used by Marines is satisfactory. This can be seen in the value of the gap in satisfaction with all positive attributes.

b. Combat backpack products that are made can meet the needs of Marine soldiers later, so that they can increase morale during training and during actual combat operations. The satisfaction level of the new combat

backpack is higher than the old combat backpack, this is based on the results of the last questionnaire given where there is an increase in satisfaction from the old backpack. The gap value obtained from the level of satisfaction starts from the main function (carrying logistics) 0.40, additional functions (carrying electronic devices) 0.73, impact resistance 0.90, the strap is not easy to break 0.70, the strap hook is not easy to lose 0.77, does not make the back hurt 0.63, no shoulder pain 0.63, easy to put on and take off 0.80, easy to open and close 0.77, enough pockets 1.00, ergonomic shape 0.93,

#### **4.2 Suggestion**

Some suggestions that can be used for further research to produce a more perfect combat backpack include:

- a. The design of a combat backpack can include testing materials, seams and reliability when worn for actual operation, resulting in a combat backpack that has truly been tested.
- b. Making a better combat backpack design, and paying attention to user feedback.
- c. The new backpack model can be applied or used by the Indonesian Navy in particular and the TNI in general.

There are changes in the bag following current developments and adjusting the needs according to the battlefield and training.

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