

# User-centered design for the marine industry

## Case: Recommendations for future casemates

Diseño centrado en el usuario para el sector naval  
Caso: Recomendaciones para futuras casamatas

DOI: <https://doi.org/10.25043/19098642.251>

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### Abstract

User-Centered Design (UCD) is an approach to the design of objects and spaces that focuses on satisfying the needs and expectations of users in all phases of design, considering both the physical and tangible characteristics as well as the intangible ones, referring to their behaviors, reactions, thoughts and interpretations. The objective is to create an efficient user experience for the people who are part of the designed service, and that will be translated into benefits derived from interaction, confidence in the use of the service, user satisfaction, reduced execution times, increased productivity, feedback and continuous improvement of the service. In this context, this case study presents the process of research, analysis and ergonomic and user experience recommendations, from the UCD for the design of casemates designed in Cotecmar for river vessels, in order to demonstrate the importance of design methodologies in systems and combat elements in ships. The objective is to allow that the scenarios where human beings interact with their workspaces have optimal conditions, enable the comfort of users, and offer the conditions to achieve maximum productivity and efficiency on board.

**Key words:** User-centered design - Casemate - Ergonomics.

### Resumen

Al considerar el diseño de objetos/espacios, debe contarse con una filosofía que considere las características, físicas y tangibles del usuario, así como aquellas, inherentes a su carácter intangible humano, como psicológicos, culturales y simbólicos. Por medio de un enfoque que tenga como eje central, la priorización del ser humano, en cada fase del diseño es posible acercarse ampliamente a suplir las necesidades y expectativas de las personas, y a través de la interacción, cumplir las expectativas de funcionamiento del servicio durante la actividad. A esta filosofía, se le denomina Diseño centrado en el Usuario, y su sentido primordial es el de incorporar una experiencia de uso eficiente para las personas, que, al integrarlo, perciban beneficios que permitan el incremento de la productividad, la confianza en el uso del servicio, la satisfacción al usuario, la reducción en tiempos de ejecución, y el soporte y mantenimiento del “servicio diseñado”. Este documento presenta el proceso de investigación, análisis y recomendaciones antropométricas y ergonómicas desde el diseño centrado en el usuario, para las futuras casamatas con el propósito de crear la inquietud respecto a las principales áreas que abarca el tema la ergonomía y el diseño centrado en el usuario, sin entrar al detalle en ellas, de modo que en los futuros sistemas o elementos de combate en los buques que se construyan, como también cuando sea necesario definir procedimientos, planes y grados de alistamientos, se tenga presente cómo esta disciplina puede contribuir a crear experiencias de usuario confortables y espacios con condiciones óptimas para obtener la máxima productividad de los tripulantes, logrando así la mayor eficiencia a bordo.

**Palabras claves:** Diseño centrado en el usuario – Casamata - Ergonomía.

Date Received: October 29th, 2022 - *Fecha de recepción: 29 de octubre 2022*

Date Accepted: February 9th, 2023 - *Fecha de aceptación: 9 de febrero de 2023*

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## Introduction

Science and Technology Corporation for the Development of the Naval, Maritime and River Industry - Cotecmar (as its acronym in Spanish), through continuous research, seeks to generate innovation and improvement in each of its products and services for the welfare of its customers and users, contributing from the design to make this possible. Among the corporation's products with opportunities for improvement is the casemate, an armored structure that protects the marines during combat, from where they can defend themselves and shoot when attacked; this is a very important element in the naval industry due to its function.

This project emerged as a manifestation of the need to improve the working conditions of marines and ship gunners, who must remain between six to eight (6-8) hours inside the casemates.

In addition, it was identified that, over time, the previously constructed casemates have been modified by some crews, adjusting them to the needs of vessels, and therefore there is no standardized product. Through the analysis of the user experience in the casemates, a series of recommendations are generated to incorporate in the future designs of the Corporation, providing welfare to the marines and satisfying both direct and indirect users, providing the basis for the design and construction of the casemate as a standardized product for the defense of the ships designed in Cotecmar.

## Background

The naval industry has been gradually consolidating through the efforts of many people, who have contributed to the possibility of Cotecmar standing out in the Latin American panorama, through the prioritization of knowledge, since it has the design and engineering capacity to generate solutions tailored to the needs of the sector (*Tascón, 2019*) in the country and the region, consolidated within the 20 most innovative organizations at the national level (*Cotecmar, 2022*). Throughout two decades, its infrastructure, both its Mamonal

and Bocagrande plants, together with its repair and maintenance processes and activities are internationally recognized for their operational capacity, the quality of the materials used and the work performed, for which the corporation is backed by certifications: ISO 45001:2018 (occupational health and safety), ISO 9001:2005 (quality management system), ISO/IEC 17025:2017 (metrology laboratory), Protection of Vessels and Port Facilities-PBIP issued by the Colombian Maritime Authority, Dian acknowledgment as an Authorized Economic Operator and ISO 14001 (environmental management system).

Like other national defense institutions in more developed countries, it is expected that in the projects developed by the Corporation and the Colombian Navy (Armada de la República de Colombia - ARC), studies that integrate the human being are considered and applied which, among others, establish ergonomic and anthropometric guidelines and recommendations in all fields of the projects, in the systems to be developed and in the subsequent interactions, such as the size and distribution of spaces, distances, reaches and anthropometric clearances, accesses and circulations, control consoles, types of indicators, lighting codes, interfaces, chromatic perception, alarms, quantity, hierarchy and types of information, psychology of form (or Gestalt), physical environment and its characteristics (noise, temperature, lighting and ventilation), etc. Thus, systems are expected to fulfill their promise of use, facilitate their proper operation and, in addition, should not be adapted to the needs of users, due to previous usability experiences with the equipment already finished, in order to reduce the costs and implementation times that these modifications entail.

The role of human factors is oriented to ensure that all user interaction with systems contributes to the performance of activities, so that errors are minimized, productivity is increased and comfort and safety are improved (*Wickens, Gordon, & Liu, 1997*). Thus, the framework for the performance of various activities during short or extended periods of operation is set out; including feeding, sleep cycle, on-call segments and enlistment ranks, job

rotation (if permitted by operational requirements), climate control, time study, etc.

The study and analysis of the particular human behavior (in this case, the crews) and of the actions that are developed and during the periods of operation of the ships allows us to focus our design methodology in order to find solutions closer to solving the needs from the design. Cotecmar has been working for years on developments with a high level of detail that allows us to carry out early verifications of the usability of spaces, equipment and elements of the ships built in the shipyard. As an example, we have the Extended Reality Laboratory, which uses immersive extended reality environments (virtual reality, augmented reality and mixed reality) to test the interaction and operation of designs proposed by the design and engineering management.

### User-centered design

Human-centered design is a problem-solving approach commonly used in product and service design and management frameworks, that develops solutions to problems by involving the human perspective in all steps of the problem-solving process.

User-centered design, hereinafter referred to as UCD, is a multidisciplinary approach to product development based on human needs, which seeks to better understand the target user and their activities, allowing for designing, assessing and improving design proposals, throughout the entire design process and with the purpose of creating more useful and usable products. (Norman, 1988) (Vredenburg, Isensee, & Righi, 2002).

In fact, UCD practices have been formalized by international standards (ISO, 2006), which define it as an approach to developing interactive systems, making systems usable and useful, focusing on users, their needs and requirements, by applying human factors, ergonomics, knowledge and usability techniques, improving effectiveness and efficiency, human well-being, safety and health, user satisfaction, accessibility, sustainability and counteracting possible adverse effects of their use

on human health, safety and performance. (ISO, 2006) Likewise, UCD methods enable the design of more desirable products, based on User Experience (UX); to bring to the market value-added products (Norman, 1988) that satisfy the needs, goals and feelings of the users from the design.

The needs are established based on the ship's missions, the number of passengers and crew members on the vessels and the design requirements are formulated once the research indicates the activities and processes that will be needed throughout the design and development process. Ergonomics as an unavoidable tool in the UCD process, allows us to make a thorough analysis of how people interact with the system and its elements to perform any type of activities, even if they involve some type of automation.

Ship design is a cyclical and iterative process that is managed holistically, where a people-centered approach positively contributes to the crew experience on board vessels. For this approach to be successfully integrated into ship design, it is necessary to understand the contexts of use, analyze the activities, visualize their roles, and then identify the needs to be solved through its implementation, followed by rigorous testing and assessment to determine whether the product is efficient from an onboard experience perspective (see Fig. 1).

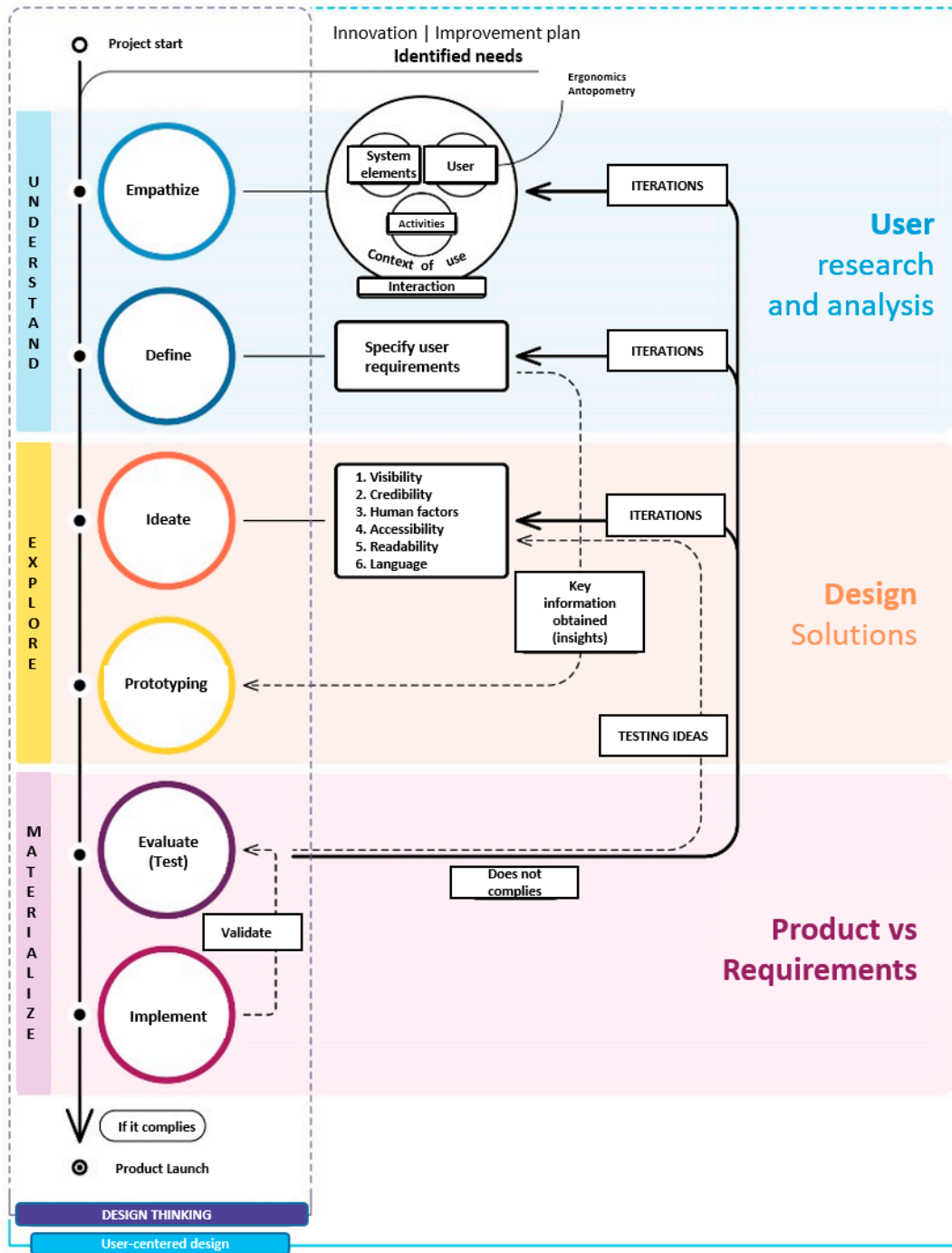
### Ergonomics

According to the definition of ergonomics or human factors (Human Factors and Ergonomics - HFE ) adopted by the IEA (International Ergonomics Association) (IEA, s.f.) in 2000, it is the scientific discipline concerned with understanding the interactions between humans and other elements of a system, and the profession that applies theory, principles, data and methods to design and optimize human well-being and overall system performance. (IEA, s.f.)

HFE domains were also defined in 2000 by the IEA to include (IEA, s.f.):

**Physical ergonomics.** It deals with human anatomical, anthropometric, physiological and

Fig. 1. General outline of User-Centered Design. Proprietary figure.



Proprietary figure.

biomechanical characteristics in relation to physical activity. (Analyzes work postures, material handling, repetitive movements, work-related musculoskeletal disorders, workplace design, physical safety and health).

**Cognitive ergonomics.** It deals with mental processes, such as perception, memory, reasoning and motor response, as they affect interactions between humans and other elements of a system. (Study mental workload, decision making, skilled

performance, human-computer interaction, human reliability, job stress and training, as these may be related to human system design).

**Organizational ergonomics** is concerned with the optimization of socio-technical systems (referring to systems where interaction takes place between people and machines, including those relationships between technology and users, as well as their psychological and cultural consequences on the individual and society), including their organizational structures, policies and processes. (Investigates topics such as communication, crew resource management, work design, work time design, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, virtual organizations, telework and quality management).

#### **The HFE principles**

HFE principles are rooted in socio-technical values. HFE participatory design principles and methodologies are applied in the design of tasks, jobs, products and environments. The principles of HFE are underpinned by the following core values (IEA, s.f.) (AIE; OIT, 2019):

- Visualize human beings as assets.
- Technology as a tool to help human beings.
- Promotion of quality of life.
- Respect for individual differences.
- Responsibility of all stakeholders.

#### Iteration

Iterations can be defined initially as activity repetition processes in the thought processes of the designer or design teams throughout the design and development stages, iterations are aimed at building concepts and processes for materializing or representing designs.

The materialization or construction of products, as part of one of the approaches of the iteration processes, can be given in graphic language through sketches, or through three-dimensional artifacts. In the case study concerning the recommendations for the design of the casemates, three-dimensional models were made in Rhinoceros based on the

survey of already built vessels, which allowed for the development of useful knowledge for the research during the user experience interview phase.

#### Anthropometry

Anthropometry is a fundamental discipline in the work environment, its relationship with ergonomics and safety, with the purpose of creating utensils, tools, equipment, considering its distribution and arrangement in space, through its geometric characteristics and its interaction with human dimensions, prioritizing the development of activities in a safe manner, and not involving the detriment of the physical conditions of people.

In this last section, it seeks to organize and design services by proposing the necessary spaces to develop specific activities in such a way that they can be carried out by the user, performing all the required movements, both close and extreme, without being exposed to possible risks derived from poor distribution, lack of space or excessive distance with respect to body dimensions. (Ministerio de trabajo e Inmigración Español)

The knowledge of static dimensions is basic for the design of products and makes it possible to establish the necessary distances between the body and its surroundings (dimensions of furniture, tools, etc.). The structural dimensions of the different body segments are taken on individuals in static, standardized postures, either standing or sitting.

The dynamic or functional dimensions are those taken from the working positions resulting from the movement associated with certain activities, i.e., it takes into account the study of the joints providing knowledge of the function and their possible movements, taking into account the biomechanics and making it possible to assess the capacity of joint dynamics. (Ministerio de trabajo e Inmigración Español)

#### Interaction

Action exercised reciprocally between two or more objects, agents, forces, functions, persons,

etc. This concept is applied in countless scientific and humanistic areas, giving it a different connotation according to the context; however, it always maintains its original definition: it involves different objects, which influence and modify each other, taking into account the situation and the surrounding circumstances. The Interaction Design, defines the structure and behavior of interactive systems (IxDA, s.f.) and the interaction designers are in charge of creating meaningful relationships between these actors in order to achieve a goal through actions.

### Casemates

The Casemate design has the first industrial design registration granted to Cotecmar, conferred with the power to protect its formal characteristics and internal configuration, effective from 11/04/2006 to 11/04/2016 (See Fig. 2).

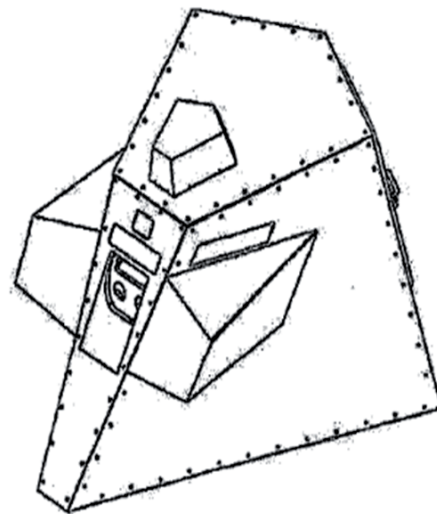
It was designed and built with the purpose of offering possibilities for the transit and patrolling of Colombian rivers in areas of conflict with illegal armed forces. This design has been incorporated into vessels built by Cotecmar and has been installed in the defense system of existing Navy units. Currently, Cotecmar has developed casemates articulated by a hoop system, which allows it to rotate by means of a manual back up system, and pedals to steer it. It houses two 0.50 machine guns, six to eight boxes of ammunition, a chair and an armored steel structure that protects the gunner and the armament. These casemates fulfill defense functions, thanks to which they can repel attacks and defend ships with great firepower. It has five (05) windows to view the exterior, one of them on the armament shield. The front windows have the purpose of visualizing the target area for firing, the central window operates as the "sight" field of the armament, while the side windows provide a wider view of the surroundings, enabling the visualization for the positioning and turning of the casemate and the location of possible aggressors.

The casemate has a pair of niches located on the sides that are integrated into its shape, which allow for internal spaces to store ammunition. It has an

air extractor on the upper surface and all its faces are angled (including niche faces), to repel and deflect impacts received. It has a welded and bolted steel structure, and two access areas: an exterior inclined door and a lower hatch that connects to the interior of the vessel.

Fig. 2. Representation of Casemate registered as an industrial design

**In Force Since: 11/04/2006**  
**To: 11/04/2016**



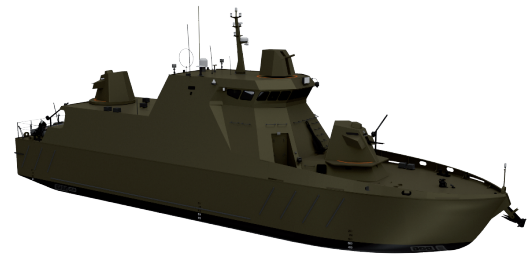
Beyond the design and construction plans during these years, as of the date hereof, there is no written document that supports the design of casemates, as well as studies or destructive tests that indicate their state of vulnerability. At Cotecmar, the design of the casemate has been modified since 2002 and since then 3 versions have been generated. The most recent was designed in 2008 and no significant formal changes have been made between them. The materials used in this design are: steel and armored glass.

The design of casemates developed by Cotecmar has been installed in the ARC units, referred to Patrulleras de Apoyo Fluvial (River Support Patrol Boats), in their two versions, Heavy (PAF-P) and Light (PAF-L) of 40.3 m and 30 m in length, respectively. It should be noted that the design of these vessels is also proprietary to the Corporation.

Fig. 3. Heavy river support patrol boat - PAFP (left) and light river support patrol boat - PAFL (right).



Proprietary figure.



## Objectives

Understand the current design of the casemates of some river vessels designed and built by the Corporation (taking into account that they have also been installed in existing ARC units) in order to analyze the user experience (crew and gunners) and identify the necessary aspects for their efficient operation.

- Check the physical conditions of the casemate.
- Map the interactions and activities where the casemate is a key element of the system.
- Identify opportunities for improvement in the design and construction of the casemates.
- Know the experience of casemate users.
- Propose a series of recommendations for the design of the next generation of casemates.

## Methodology

### Context

The user experience investigation originates from a Warranty Claim / Novelty Report received from the Naval Material Headquarters (JEMAN), requesting Cotecmar to make the necessary corrections and improvements to the casemate to allow for "easy removal and installation of the ammunition box". It is also mentioned that another vessel has a design that does allow this change of ammunition normally (referring to ARC Guillermo Londoño).

As a result of this request, the design team began a process to identify the possible fronts that would

allow the analysis to be addressed, based on some questions such as: Why do ammunition spaces need to be different or larger than the existing ones? What do we need to validate before making any design proposal? How do users interact inside the casemates? What are the conditions of comfort and well-being of users when using the casemates? The research was based on these questions.

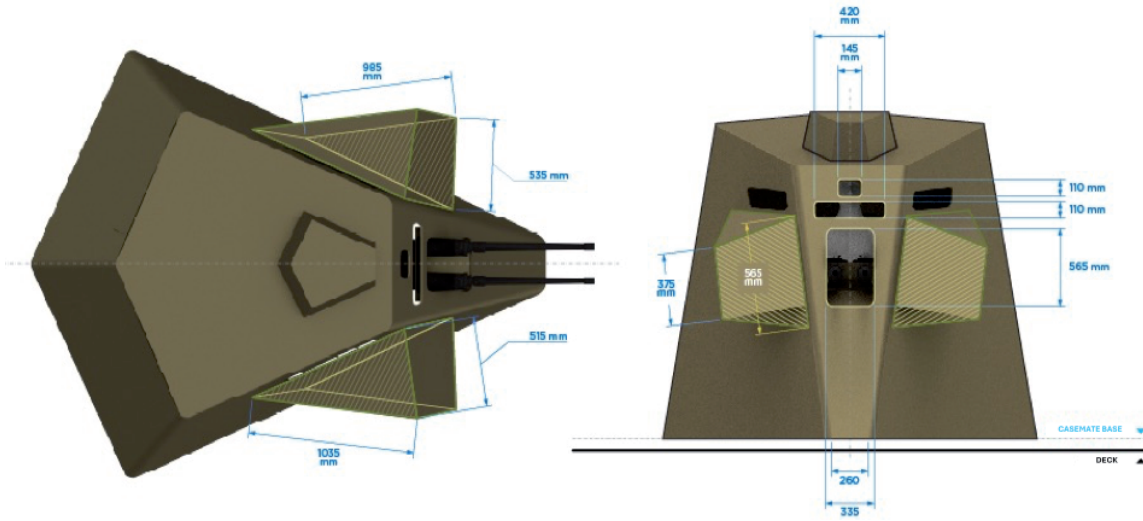
The purpose of establishing an analysis of these characteristics is to visualize the casemate as a product with spatial characteristics where a group of users (gunners) performs a series of activities interacting with the mechanisms of the casemate, where the efficiency in the fulfillment of its tasks as a defense and attack component of a ship is fundamental, and which must allow these tasks to be carried out without affecting the comfort of the user inside the casemate.

### Survey

To learn how the crew interacts with the product, a dimensional survey was made of two casemates manufactured by the Corporation, installed on two Heavy River Support Patrol Vessels (PAFP): unit ARC SSCIM SENEN ALBERTO ARAUJO (Generation I) and unit ARC JUAN RICARDO OYOLA VERA (Generation III). In the survey it was possible to observe a relevant condition for the research, since there are some differences between these, present due to modifications in the design, such as:

- Modifications made by the vessel's crew. Including some for the purpose of improving

Fig. 4. Casemate and its dimensions.



Proprietary figure.

- comfort in the operation of the casemates.
- Wear and tear of the casemate over time.
- Damage as a result of combat.

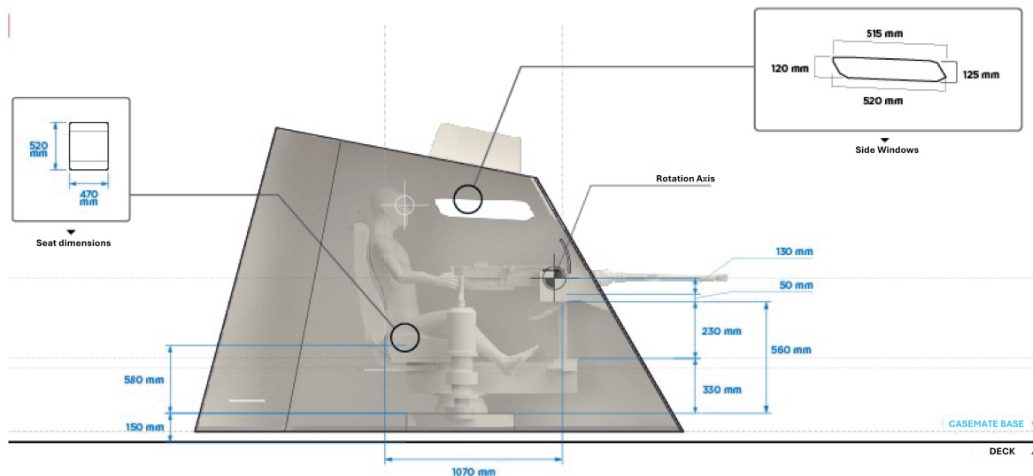
With the survey of the two casemates, a three-dimensional model was subsequently generated for validation and verification exercises. The following figures are the virtual representation of the casemate and the compilation of the dimensional log made.

The lengths of the main body and side niches (sizes, angles and shapes) were recorded in order to

gather and understand the intentions of the users in carrying out each design intervention, and to contrast these versions with the original design and identify their differences (see Fig. 5).

In addition to the survey of the main shapes and the outer body of the casemate, the dynamic dimensions and the operating ranges of the gunner to perform each activity were also recorded. In the three-dimensional model, the positions of each element (equipment, shafts or components of the casemate, etc. with their respective height and

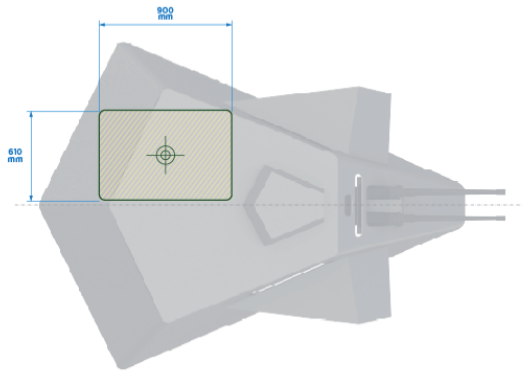
Fig. 5. Casemate and its interior dimensions.



Proprietary figure.



Fig. 6. Casemate and its inner hatch.



Proprietary figure.

size) were spatially located and anthropometric checks were carried out with the crews and the research team (see Fig. 6).

Each of the access roads were identified and surveyed. Entry and evacuation exercises were also simulated using the access elements of the casemate (door, ladders, steps, handrails, grips and hatch) to analyze the sequence of the action.

With the information gathered from this anthropometric and ergonomic analysis, we began to visualize the interactions that the gunner must perform. As a research team, we reproduced the movements and postures that users must adopt to operate the casemate. This led to the identification of those weak points in the design that would later become opportunities for improvement. This provided the basis for the construction of interviews, in order to know the experience of use of the casemate by gunners in detail, and thus, to build the user journey map (Nielsen Norman Group, s.f.)<sup>1</sup> with the activities during the interaction, highlighting the key points or pain

<sup>1</sup> User journey map: It is a visualization of the process a user goes through to achieve a goal. It consists of the user's actions arranged in a timeline, into which the thoughts and emotions experienced by the user throughout various phases of the process are incorporated to create a narrative of the process and is compiled into an overall visualization of the moments of the activity. These yield the information that allows for the identification of Opportunities (along with additional context, metrics found and identification of those responsible for making the changes) that will lead to optimizing the user experience.

points (Group, s.f.)<sup>2</sup> that determine the perception of a user experience.

The first visit was to the heavy river support patrol boat ARC SSCIM SENEN ALBERTO ARAUJO (see Fig. 7), where casemates were observed with side niches much larger than the original design, reduced spaces for ammunition storage and advanced deterioration in its parts: doors, gunner's station (chair), windows and extractors. Being a vessel with three casemates on the same deck and at the same level, the synchronization of the turning radii is essential to avoid accidents. This task is vital for the operation and, even so, it was observed that the pedals for the user to turn the casemate were in poor condition and the rotation of the casemate had to be done manually.

Fig. 7. Casemate of the A.R.C. unit. SENEN ARAUJO.



<sup>2</sup> Pain points: Defined as the problems that users may encounter in carrying out an activity. These are divided into three categories: At the interaction level (in particular with an interface or direct attention), journey level (in which the user wants to achieve a goal) and at the relationship level (in which the interaction affects the relationship with a company, organization or brand). Pain points are diverse (they can be broad or specific, direct or relatively insignificant, obvious or hidden) and identifying them is a first step in creating solutions that address real user needs.

The second visit was to the heavy river support patrol boat ARC JUAN RICARDO OYOLA VERA (see Fig. 8), which patrols the rivers of the Colombian Pacific coast. The casemates of this vessel have side niches corresponding to those of the original design. The casemate located on the centerline and on the bow has a special feature as it is elevated on a platform that places it at a higher height than the others that are located directly on the deck. This elevation requires the design to incorporate additional elements such as ladders, steps and grips to facilitate user access to the casemate.

Fig. 8. Forward casemate of A.R.C. unit. JUAN OYOLA.



### User interviews

This method consists of formulating open questions or topics (semi-structured), which allow for a guided conversation on a given topic. In the case study, to know in depth the perceptions, opinions, desires and emotions of the users of the casemates. The interviews were conducted through informal dialogue, so that the interviewee felt comfortable and could express him/herself without feeling judged, allowing his/her opinions to be as true as

possible to the experiences actually lived. (Trujillo, 2016; Schindlholzer, 2008) This tool allowed the research team to inquire qualitatively about the users' point of view. Likewise, it could be used in the information consolidation stage, after the usability evaluations, to deepen the users' perceptions of the interaction with the casemates. Additionally, it was complemented with the observation of contexts of use and the analysis of activities. The purpose of the interviews is to gather general information on the interactions and activities surrounding the use of the casemate and its systems, in order to learn about the users' experience and identify the strengths and weaknesses that may exist (see Fig. 9).

User Experience Design (UXD) is the process of analyzing user needs in order to incorporate the results into the design, either an interface, spatial layout, usability or the way a person relates to a product. Therefore, when the analysis interviews were conducted, two gunners with different years of experience were selected. Aptitude questions were asked to find out if the gunner has the knowledge, physical and mental conditions necessary to operate the casemate, behavioral questions to develop a behavioral profile, situational questions to understand their behavior in certain situations, and opinion questions to find out what suggestions they considered to include in the design, what they expected from, and from their interaction with, the casemates and their general evaluation of the casemates.

### Observation of contexts of use

The observation of contexts of use stems from the ethnographic research method, which focuses on describing a culture and its practices through understanding the social group from an immersive point of view; for such purpose, the research team used different tools, with observation and interview being the instruments that allowed for getting closer to users. Thus, observation in research allows us to identify and learn about the experiences of use of the crew (especially gunners), identifying the physical context of the immediate environment, giving relevance to the interaction relationships from the user's perspective. (Spradley, 1980; Bonilla & Castro, 2005).

Fig. 9. Form of interviews made with gunners - users of casemates (first sheet). Proprietary figure.

## Analysis User Experience

River Support Patrol Boat . Light (2021)

INTERVIEW DATA			
User Name	Erick Hernandez	Unit	ARC "Oyola"
Rank/Profession	Warrant Officer II	Place	BNL1 - ARC Bolivar
Age	24 years	Date	30/03/2022

### 1. CHARACTERIZATION USER

Who uses the space?	Stern Gunners -Warrant Officers Bow: Marines		
Age range	20 years	28 years	
Height range	1.7 m	1.85m	
Contexture	Wide - Skinny		
Special considerations	Any crew member of the unit / knowing how to operate pedals		

### SPACE

Purpose/Mission	Repel attacks whitout compromising the physical integrity of the crew member
Location	BOW x1 STERN x2
Components	Body, door, spoilers (niches) ammunition support (s4), armchair, base, engines, wiring box, pedals, red lights, plugs, extractor and telephone communication with Bridge
Armament (Quantity)	Browning .50x2 - Twins AMMO: 7.56 x 4 Boxes + 2 Boxes in spoilers (gun side)

## Analysis User Experience

River Support Patrol Boat . Light (2021)

INTERVIEW DATA			
User Name	Jorge Vásquez	Unit	ARC "Senen"
Rank/Profession	Professional Marine	Place	BNL1 - ARC Bolivar
Age	38 years	Date	30/03/2022

### 1. CHARACTERIZATION USER

Who uses the space?	Marines ALL THE CREW		
Age range	22 years	38 years	
Height range	1.7 m	1.85m	
Contexture	Wide - Skinny		
Special considerations	Must have prior instruction on the use and operation of the casemate		

### SPACE

Purpose/Mission	Repel attacks won the unit Have early warning before being attacked It is the Harpoon remote combat system (newer than Scorpion)
Location	Top deck x3 units BOW: Harpoon Remote Combat System (Newer than Scorpion)
Components	Body, door, spoilers (niches) ammunition support (s4), armchair, base, engines, wiring box, pedals, red lights, plugs, extractor and telephone communication with Bridge They share the characteristics of the ARC Oyola casemates
Armament (Quantity)	STARBOARD - PORT: Brawning 0.50 x 2 - Twins AMMO: 12.7 mm x 4 boxes - 2 boxes in spoilers (guns side). Supports on shaft for ammunition

Observation of contexts of use is an effective method for inquiring into natural situations of use about what gunners do. It allows us to reveal characteristics of the interaction with the products during the development of activities; evidencing the flows, errors, inefficiencies and challenges to complete the tasks.

However, this method does not make it possible to interpret what the users think and perceive; therefore, we combined the results with the

interviews to forge a comprehensive view of the casemate use situation. (*Goodwin*).

We conducted observation of contexts of use with two gunners to visualize how different anthropometric percentiles interact with the casemate, and assess the ability of the casemate to adapt to users with different characteristics, how anthropometry affects the efficiency in the operation of the casemate, and what is the scope that each gunner has in interaction with the casemate,

Fig. 10. Vertical visibility range - 170 cm user height. Own figure.

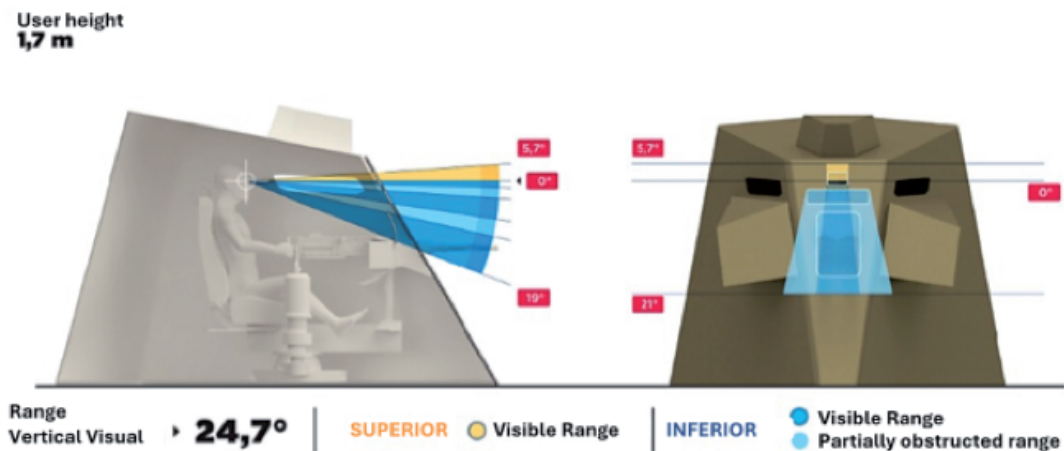


Fig. 11. Vertical visibility range - 180 cm user height. Own figure.

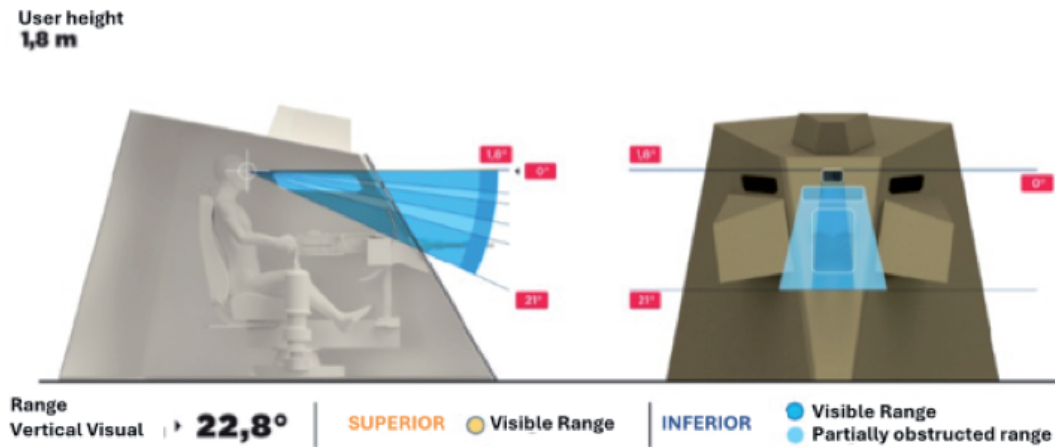
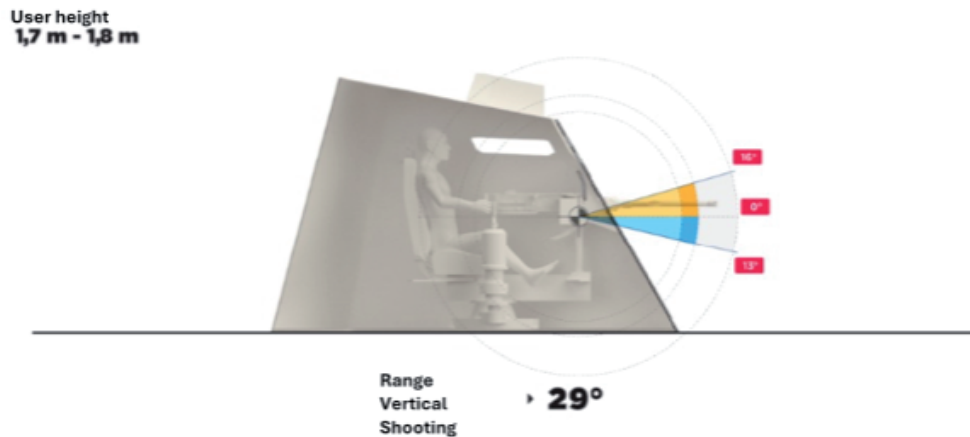


Fig. 12. Vertical firing range. Proprietary figure



we understood the origin of the differences and how these can affect the gunner in the prolonged use of the casemate (see Figs 10, 11, 12 and 13).

### User profile

By means of the user profile, it was possible to select and describe the characteristics of two users (gunners), identifying the profile of the people for whom the design is intended, so that, in the future, checks can be made and the needs of use of those who interact with them can be met.

Likewise, the profiles identified reflect particular attributes that correspond to the personal experiences of each of the users, including context, rank, skills, knowledge, activities, demographic information, experience of use and general experience in interacting with the casemate and their perception of its design. (Rubin & Chisnell, 2008).

### Usage evaluations

It is a method that collects user information during the development of tasks with one or more

Fig. 13. Swivel range and horizontal firing. Own figure

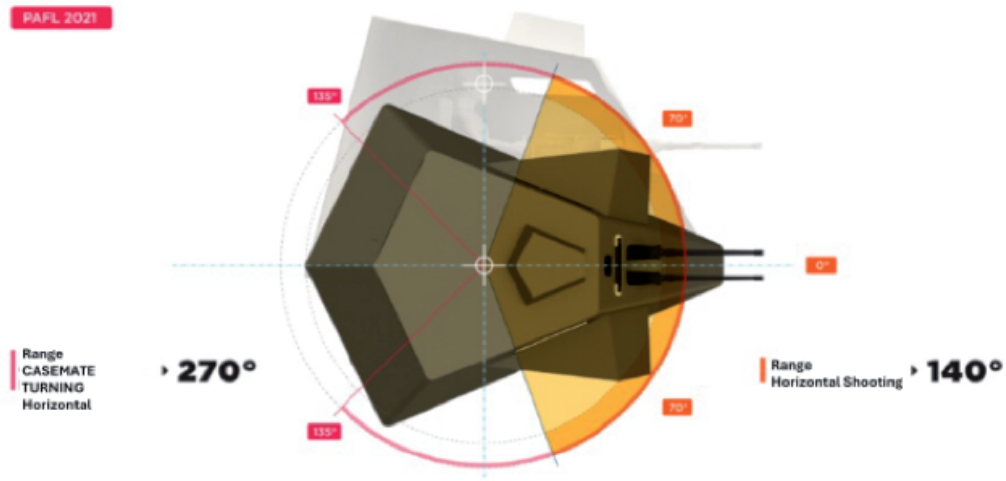
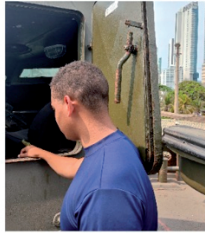


Fig. 14. Profile 1, Warrant Officer II. Proprietary figure.



**ERICK HERNÁNDEZ**  
Petty Officer Seaman II

**About Erick**

As a Petty Officer Seaman of the ARC OYOLA, I have been in watchkeeping activities and combat simulation exercises in the position of aft casemate gunner.

**Key Phrase**

"I always prefer to leave the door open, because as the door is angled, it becomes very difficult and heavy to close it from the inside and in the evenings standing guard, it contains the heat."

Age: 24 years old

Height range: 170 cm - 185 cm

Build: Hectomorph

Residence: Caribbean Zone - Colombia

**Experience in the use of casemates**

The user has 2 years of experience in the use and operation of casemates.

**Tasks performed**

- Cleaning and oiling
- Maintenance
- Dry check
- Gun calibration and graduation
- Weapons assembly and disassembly


**Motivations**

- Feeling safe inside the casemate
- Would like to have the opportunity to be in a combat situation operating the casemate.

**Frustrations**

- The high temperature inside suffocates him
- Cannot have a good posture because the chair in his casemate has no backrest
- Difficult to receive orders from the wheelhouse because of the noise

Fig. 15. Profile 2, Professional Marine. Proprietary figure.



**JORGE VASQUEZ**  
Professional Marine

**About Jorge**

As a Marine of the ARC SENEN ARAUJO, he has been in combat activities, guard and simulation exercises in the position of casemate gunner.

**Key phrase**

Most of the time you can't see anything through the window, because it becomes a "zafarrancho" full of smoke and shells and through those windows I can't see, I have to get up and get closer to be able to see.

Age: 38 years old

Height range: 170 cm - 185 cm

Build: Mesomorph

Residence: Caribbean Zone - Colombia

**Experience in the use of casemates**

The user has 10 years of experience in the use and operation of casemates.

**Tasks performed**

- Cleaning and oiling
- Maintenance
- Dry check
- Gun calibration and graduation
- Weapons assembly and disassembly

**Motivations**

- Feeling safe inside the casemate
- Believes that in combat situations, the casemate is efficient
- He is confident in his experience in handling the weaponry.
- Believes that everyone can do a good job with effort

**Frustrations**

- In combat situations, he has difficulty listening
- Must make a greater effort to hold the weapon due to his height
- Ingress from the inside is difficult because the hatch is too heavy

prototypes. During this research, information was collected from the observations of context of use and from interviews made, making it possible to observe deficiencies or opportunities for improvement in the performance and provision of a service. (Rubin & Chisnell, 2008).

This type of evaluation was carried out using a protocol with clear objectives, the results of which were used to assess and compare different options for carrying out any of the activities with the casemate. It made it possible to highlight the deficiencies that the casemate may still have in terms of use and functionality, making it possible to identify points to improve interaction and, by extension, to increase the comfort and efficiency of the casemate's capabilities. (Goodwin).

Through the analysis of the information gathered in the interviews, a visualization of activities was

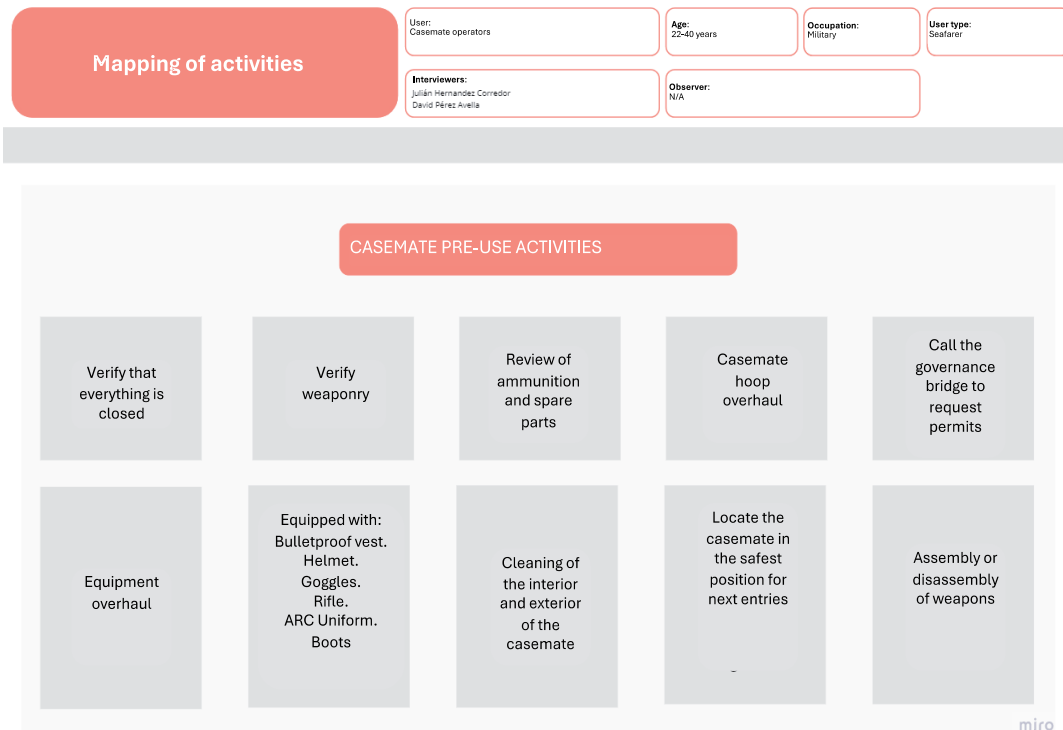
generated, which was divided into three general phases corresponding to the user journey map:

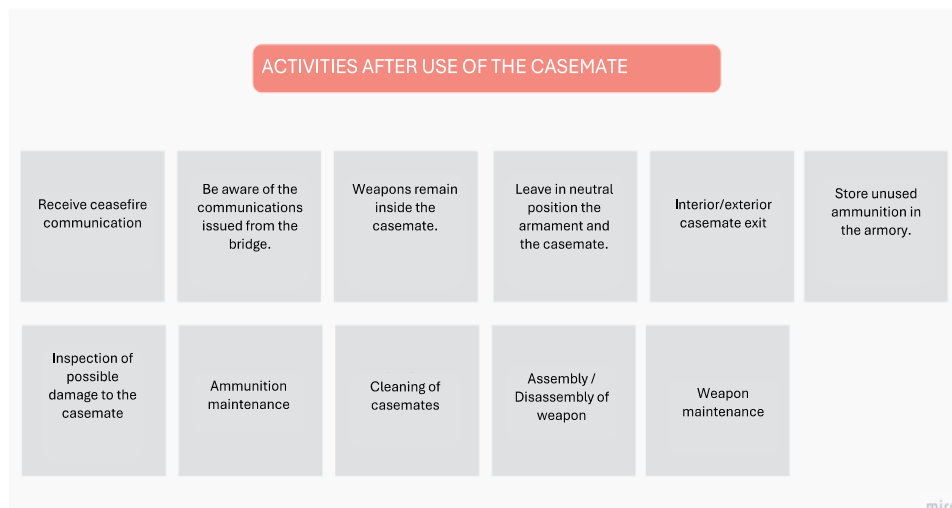
1. Activities prior to the use of the casemate.
2. Activities during the use of the casemate - This included an annexed phase aimed at analyzing the activities during the use of the casemate's armament.
3. Activities after the use of the casemate.

With this breakdown of activities, it was possible to identify the user's route along the basic activities (with their corresponding tasks) for the use of the casemate, differentiating them into necessary, useful or optional.

Comments, recommendations and responses to user interviews identified activities in need of design action for improvement (see Fig. 16).

Fig. 16. Mapping of activities carried out during the interaction with the casemate. Proprietary figure.





## User journey map

User journey maps make visible the steps users follow to achieve a goal through their actions. To expose an overall view of the experience, user journey maps should be based on actual testimonials and evidence supported by information gathered through research, rather than being an idealized or assumption-based representation of how users are expected to interact with a designed product. (Nielsen Norman Group, s.f.)

The user journey map is a tool that can be used to holistically understand the user experience, a process that records the phases (or moments) of activity development that coincide with those mentioned in point 4.6 (Usage evaluations). These phases were crossed with the variables of the analysis that corresponded to different topics that allow for understanding how the activity is carried out through the moments of each of the phases (See Fig. 17), categorized as follows:

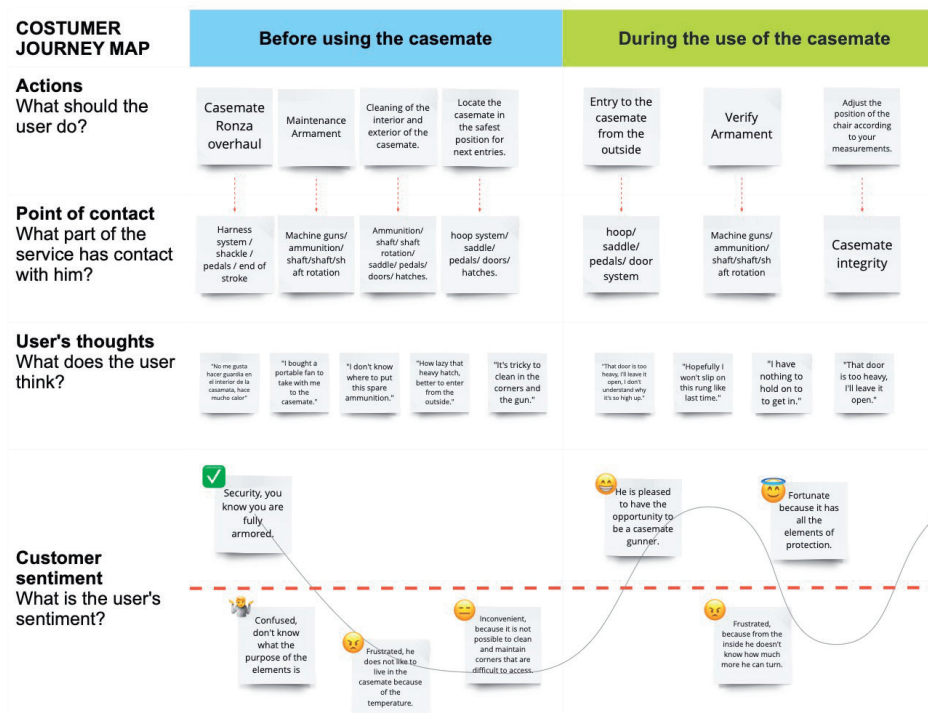
- Actions: activities that users must perform to meet their objective.

- Contact points: points where the user interacts with the physical elements during the action.
- User's thoughts: phrases or comments made by the user while performing the activities or based on previous experience.
- User's feelings: Those emotions that are caused by the performance of actions, such as pleasure, joy, pain or frustration depending on what the interaction generates when carrying it out.

The map itself is a tool that helps visualize and share the research findings in a graphically organized manner and compiles the information gathered and the research findings. From this, a visual narrative is prepared to communicate "the user's journey" (as its name suggests) and all relevant moments, critical successes, pain points and any key (insight) that allows us to develop a design proposal that largely or fully satisfies the promise of use offered by a product.

With the information gathered in the User Journey Map, we analyze the points that are seen as critical, the pain points related to the interaction and determine how the users feel during each of the

Fig. 17. User journey map. Proprietary figure.





phases of the activity. Based on this information, design opportunities are proposed (see Fig. 18) that could help improve the complete user experience, making changes to alleviate pain points, improve functionality, accessibility and perception of the design so that, as a whole, they can increase the value of a relevant product in the historical record of design at Cotecmar.

Thus, a section is included that compiles the design opportunities, visualizing them in Fig. 18.

### Design opportunities

Each identified problem becomes a design opportunity. Through the research, it is possible to identify the problems that may arise in the interaction and operation of the product, the weak points of the product, the user's needs, and the "gaps" in the current design of the casemates. From the comments received in the interviews, the investigation revealed some findings such as the following, corresponding to the dialogue with the crew of the patrol boat ARC "SENEN ARAUJO":

Fragments of interview made with user of ARC "SENEN ARAUJO"		
Question	User comments	Finding
1. How is the operation inside the casemate?	"The motors [to perform casemate turning] don't always work."	- Users must operate the motors manually to perform rotation.
5. How do you perceive the casemate seat?	"The [seat] location and posture CANNOT be adjusted"	- Change the seat for one that allows adjustment of the gunner's position and posture.
10. Physical conditions inside the casemate: How does it feel to operate the casemate?	"High temperatures indoors"	- Fans used to mitigate this condition.
12. What could be improved? What do you think can be incorporated into the design? How would these changes help?	<ul style="list-style-type: none"> <li>- Location of armament at chest level.</li> <li>- Pedals with lower base to rest the foot and heel.</li> <li>- Ventilation.</li> <li>- Change of ammunition (cartridge belt and ammunition boxes only).</li> <li>- Ammunition feed differs between left and right.</li> </ul>	<ul style="list-style-type: none"> <li>- Modify the height of the gun location.</li> <li>- Modify the seat for the user.</li> <li>- Incorporate better ventilation system.</li> <li>- Optimize the ammunition change activity.</li> <li>- Unify the casemate's armament and ammunition.</li> <li>- Consider the possibility of including a firing guide to complement the sight and tracer projectiles.</li> </ul>

Fig. 17. User journey map. Proprietary figure.

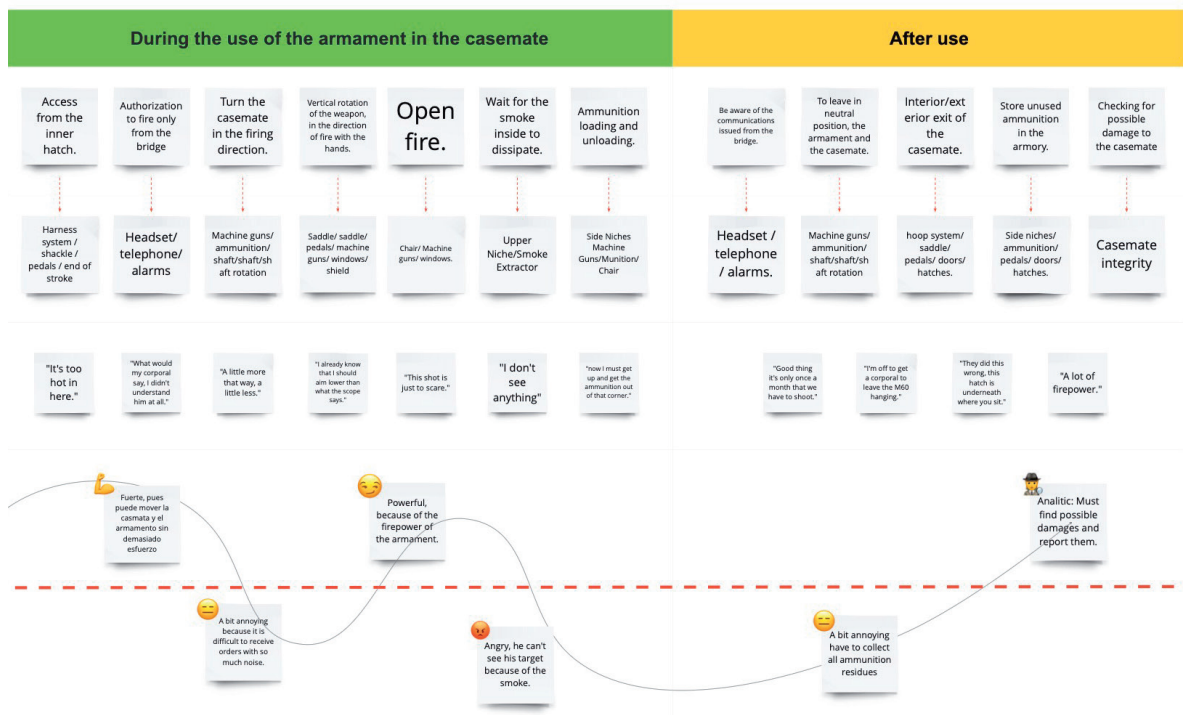
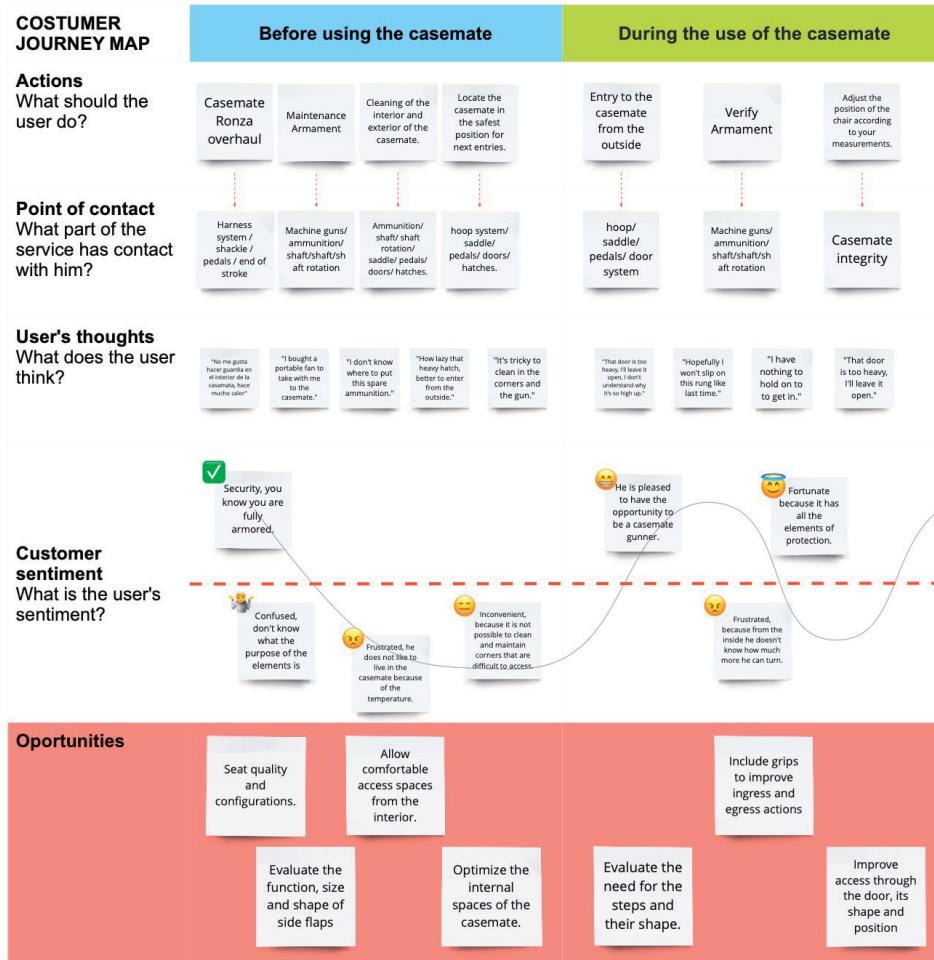


Fig. 18. User journey map including design opportunities. Proprietary figure.



Based on the findings of the information gathered, a list of the areas where design opportunities can be carried out was prepared. These design opportunities were separated into the following categories, according to the types of activities:

1. Visibility.
2. Access.
3. Operation.
4. Comfort.

In each of the categories, the design opportunities were segmented with the following labels that identify the pain points to analyze in order to establish the type of design intervention to optimize the design for the future:

- Problems: Those challenges faced by users in carrying out their activity.
- Needs: Those required by users to perform

their activity and which are not being supplied at the time of analysis.

- Gaps: Those aspects absent in the interaction that, if present, could improve the development of the activity.

### Visibility

1. Group the front windows into a single window of larger area to increase visibility on the shooting target.
2. Reduce side niche sizes to allow for enlargement of side windows.
3. Adjust the height of the side and front windows to provide comfortable visibility for shorter users within the 5th percentile of the Colombian population.

Fig. 18. User journey map including design opportunities. Proprietary figure.

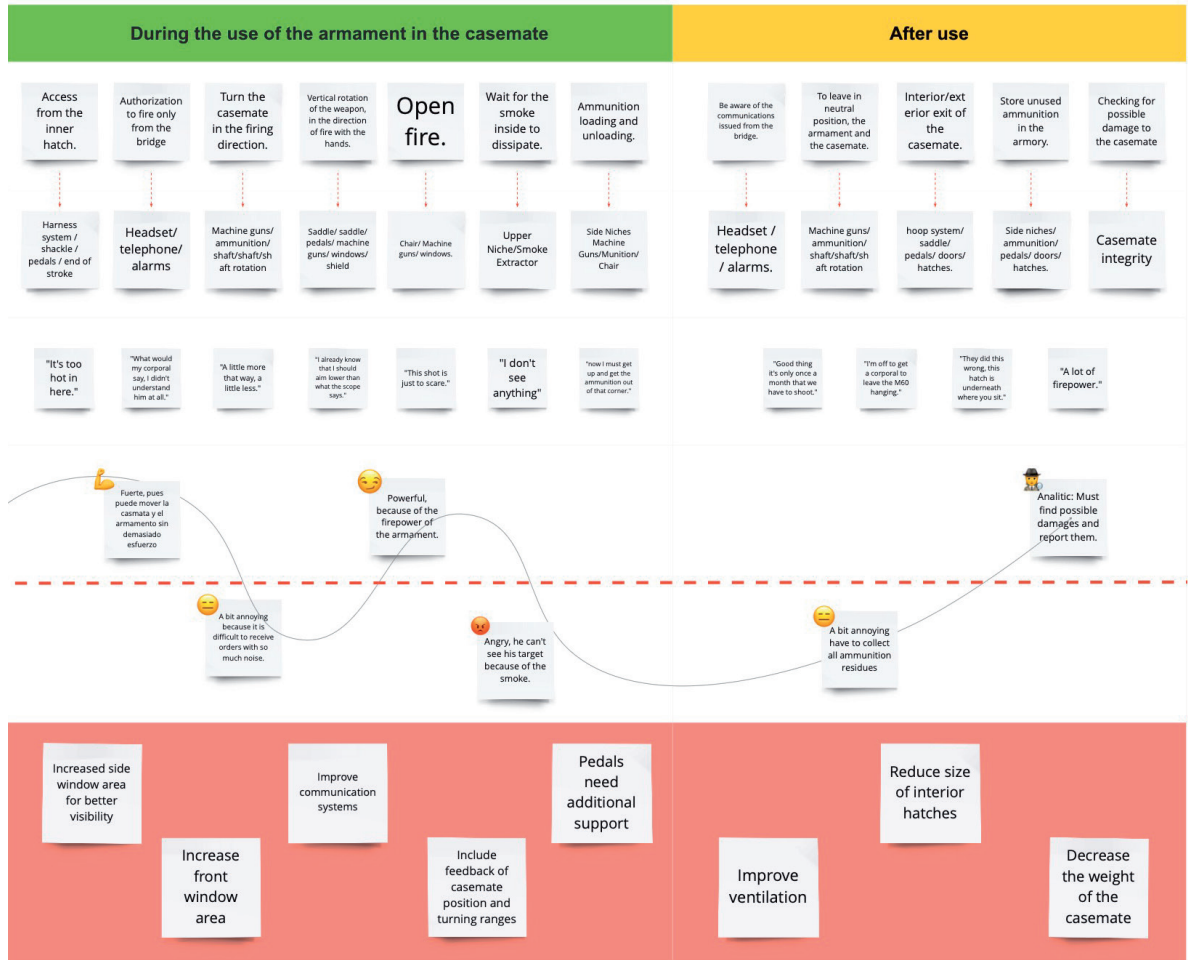
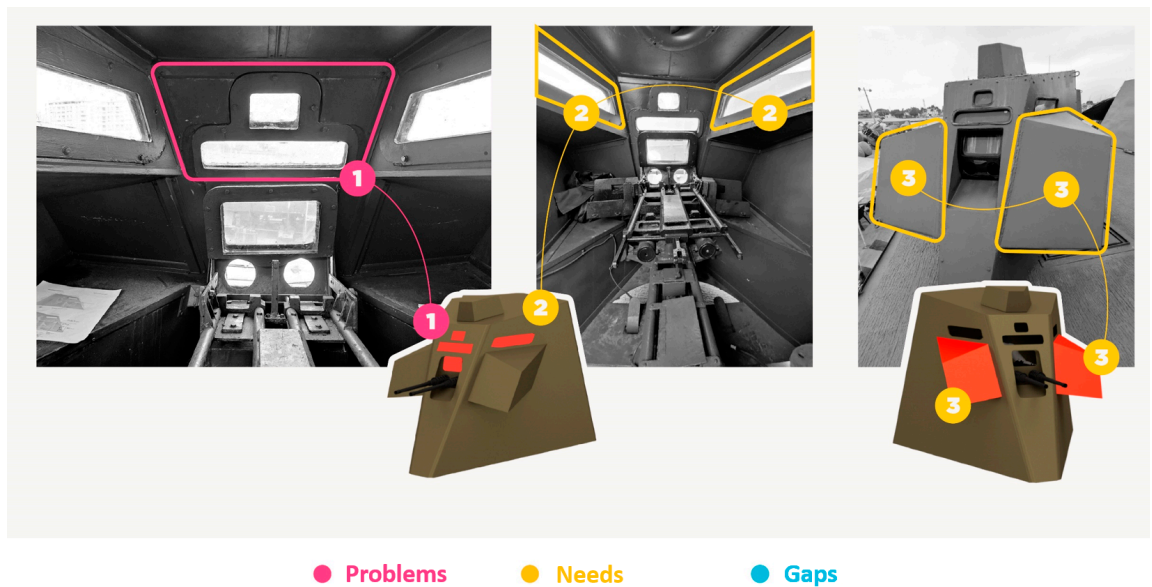


Fig. 19. Design opportunities: Visibility. Proprietary figure.



## Access

1. Reduce the height from the deck to the door in order to allow shorter vertical access to the casemate.
  2. Redesign the door to have a basic orthogonal (rectangular) geometry.
  3. Include grips to facilitate access to the casemate, both from outside and inside the vessel.
  4. Replace the square bar steps with treaded steps.
  5. Review the position, orientation, shape and design of hatches (including their mechanisms) for access from the interior in order to optimize entry to the casemate.
  6. Allow the reservation of a free area to facilitate access from inside the vessel to the casemate.
  7. Restrict the opening swing of the door to the outside to ninety degrees (90°) in order to allow a quick and more comfortable closing.
3. It must include a feedback system that provides visualization of the range of rotation and, in turn, indicates the radial "end of stroke" of the casemate.
  4. Side niches:
    - Redesign the shape of the side niches in accordance with the general geometrical characteristics of the casemate. Increase the angles of inclined surfaces to increase the capacity to redirect the impacts received.
    - Volumetrically modify the niches to accommodate ammunition boxes mounted on the armament and allow quick and convenient access to them.
  5. Include a hands-free communication system with acoustic protection.
  6. Relocate the ammunition boxes located behind the user's seat to a position where they are directly accessible when operating the casemate.

## Operation

1. Place the armament in a neutral position at the user's chest (pectoral) level.
  2. The position of the gunner's seat must be adjustable longitudinally (Y-axis) and vertically (Z-axis) inside the casemate.
- \*Weight:** As an additional consideration, it is proposed that the redesign of the casemate should allow for a reduction in its overall weight in order to allow for greater efficiency in the turning radius to achieve the objectives more effectively.

Fig. 20. Design opportunities: Access. Proprietary figure.

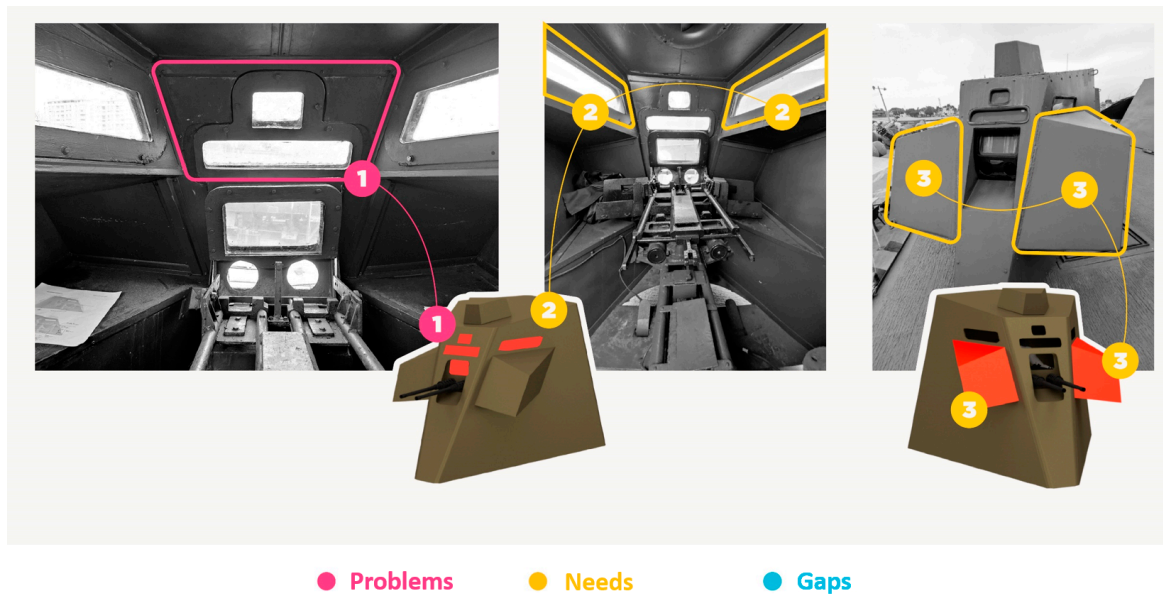
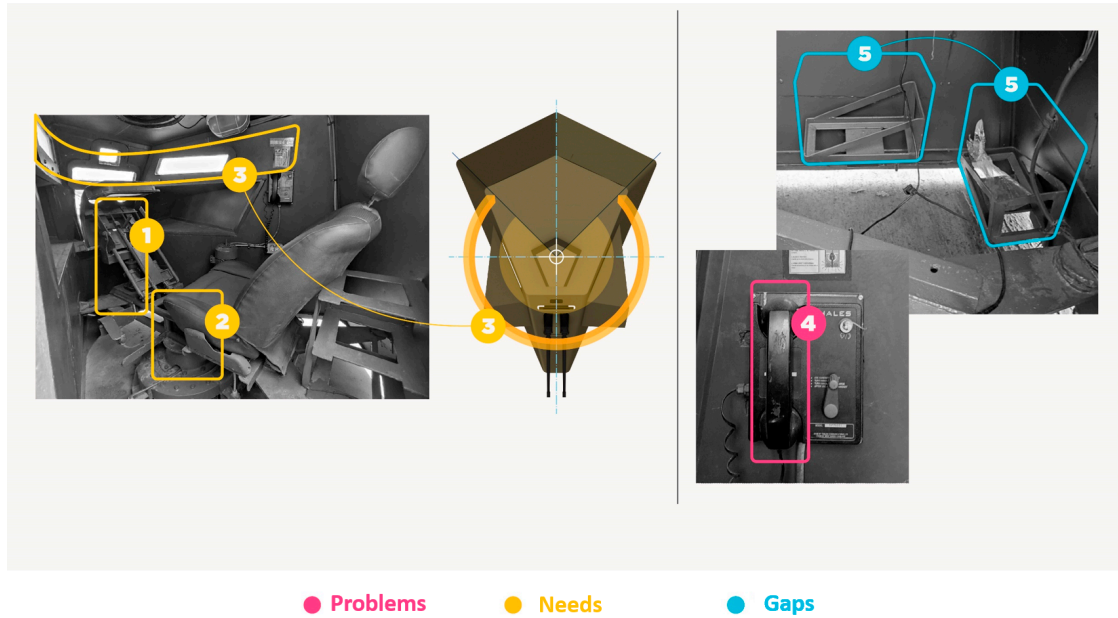


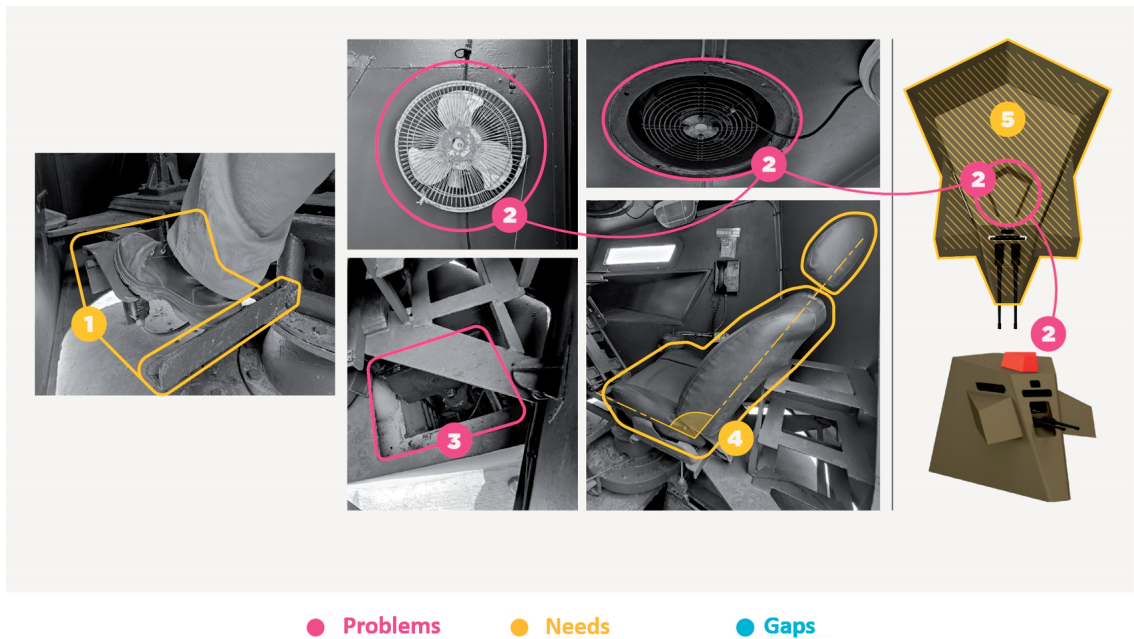
Fig. 21. Design opportunities: Operation. Proprietary figure.



Comfort

1. Redesign the base of the drive pedals to allow full foot and heel support.
2. Improve ventilation (and its operation system) inside the casemate: Increase and relocate ventilation equipment and grilles in areas of the casemate that increase and allow a continuous air flow and that do not compromise user integrity.
3. The user seat should be reclining and adjustable to different angles.

Fig. 21. Design opportunities: Comfort. Proprietary figure.



4. Redesign formally and dimensionally, the internal hatch, including its fastening and drive systems.
5. Expand the interior space of the casemates while maintaining their geometric characteristics of defense, in order to allow comfortable movements for users within the 95th percentile of the Colombian population.

## Conclusions

From the research it was possible to identify the points of intervention where improvements could be incorporated in the casemates in the future, in order to project a permanent, iterative and continuous spiral of design to increase the value of the product.

Having identified these points, the design process increases its ability to meet user needs, to approach the promise of a product in terms of its use and to achieve highly assertive design solutions that facilitate and make it possible to reach a product that is not restricted only to usability, but that meets the facets of user experience that Peter Morville proposes: valuable, usable, useful, desirable, accessible, credible, findable; these facets show that the experience revolves around people with different spheres and that interaction is not limited to efficiency and functionality, but that other fields of the human being have an impact: individual, social, cultural, contextual and specific to the product.

Through the incorporation of UCD processes and methodologies, which have been widely disseminated in other contexts and industries (*digital development, for example*), the vision of building solutions from design has expanded, through a framework of joint creation with the user, which converge in a finished product, but not in an unalterable proposal; this means that it can continue to be tested, updated, adapted and improved over time according to changes in the technological scope, in the environment, and in people (*and therefore, in societies and culture*). Therefore, it represents a multidisciplinary research

area with an interdisciplinary work orientation (Hassan Montero & Martín Fernández, s.f.), a guideline fully implemented within the Corporation's Design Management.

Although the design of interfaces, furniture and spaces are the most widely developed areas of human-related design in the naval, maritime and river spheres (addressed by anthropometry and ergonomics), UCD and research on the user experience make it possible to increase those fundamental aspects of functionality and also to learn about approaches that emphasize interaction factors, traditionally neglected, such as the user's emotions and thoughts, as important attributes within this behavior.

Thus, investigating the user experience turns out to be the main input to deploy a "general map" that offers a broader and more inclusive perspective, which allows access to a deployment of resources necessary to know all the variables around an interaction: valuable information to materialize highly satisfactory solutions from efficiency to the welfare of the people involved, strongly impacting the perception and interaction between system, objects and human being, and therefore, being more in line with reality.

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