

## Design and Development of Ambulance Service Provider

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**Abstract:** This research made it possible to launch a cooperation program between the University, the Industry and the National Institute of Medical Emergency of Portugal (INEM), to design a new medical emergency ambulance. The study has built a conceptual reference framework of an Ambulance Type B, focused on the sanitary cell, i.e. the area of a vehicle in which the assistance to the patient, stabilization and transport take place, as well as the interaction between the main medical equipment, medical personnel and patients occurs. This type of ambulance is used by the INEM to attend more than 91% of emergency calls. This project has developed a holistic participative design approach to the user's needs, qualifying space with the conditions to improve the medical staff and patient experience. The research results have emphasized design as one of the main factors for the development of Prehospital emergency and patient transport vehicles.

Prehospital care “deals with acute events which, by their nature, are unpredictable regarding to

place, time and type of event. There is an almost endless variety of acute incidents, most of which have a low frequency of occurrence” (Anantharaman Venkataraman, et al, 2014, p.9). According to Büscher “most studies of emergency work focus on control centres, where emergency calls are received and response teams are dispatched,” (Büscher, 2005, p.3). The previous studies also focus on the response time of services and clinical and medical practices, forgetting the ambulance as one of the most important elements within the emergency response system. The process of transformation of ambulances failed to follow sufficiently the advances in other areas According to National Institute of Medical Emergency of Portugal - INEM Annual Report 2015, the “ambulances accounted for 91,49% of the total calls, and more than 81% of these ambulances are Medical Emergency Ambulance- MEA”,

Introduction

with 891.223 annual calls representing on average 1.7 ambulances activated per minute.

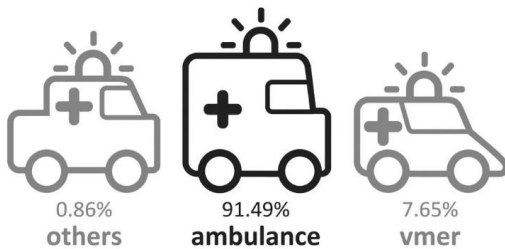


Figure 2: National Emergency Medical Institute Ambulance.

## 2. Design Research Framework (DRF)

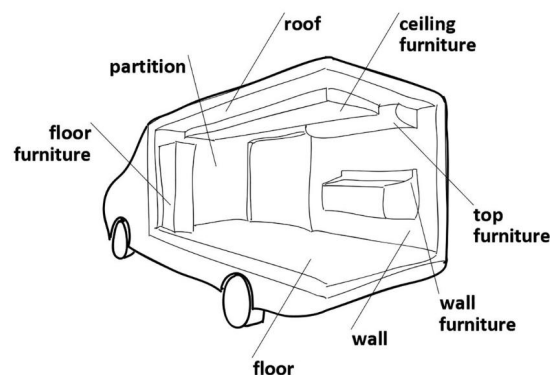
The design and development of a new sanitary cell (Figure 2), is a complex project, it has to fulfill different types of requirements: technical, legislative, medical, clinic and constructive. To construct a comprehensive and accurate concept of the ambulance Type B, in particular, the INEM Type B EMS Ambulance (Figure 3), it was essential to draw a Design Research Framework (DRF), based on those requirements as they have implications in ambulance space, emergency practices as well as safety of crew members and patients. The DRF evolved from three kind of activities: analytical, interpretative and project.

### 2.1 Analytical activities

The approach to this problem was based on an ethnographic research with participant observation, working with users, groups of specialists and also surveys. The work carried out had the following tasks: identification and characterization of the service provided by INEM, equipment identification and characterization that supports the Prehospital medical emergency service, bibliographic review, selection of methods to be used, fieldwork, analysis of precedents and the participatory design observation .A study was carried out to understand the structure and procedure approved by the National Emergency Medical Institute, which analyzed sequences of actions, type of service provided and also means involved and the intrinsic characteristics that define Prehospital

emergency in Portugal. At the same time, research was carried out on the equipment to be studied, the national manufacturers, the reference companies in Europe and North America and the methods and construction techniques currently used. In Europe's and North America's study, a questionnaire was made addressed the types of technologies used in vehicle transformation, materials used and their functions, as well as methods of selecting them for functions they had to perform - aesthetic functions, censorial, mechanical resistance, structural, etc. According to the methodology adopted and the methods employed, of direct / participated observation, the questionnaire to INEM collaborators at national level, focused its work with a group of ambulance technicians, instruments that supported the research / action cycles necessary to consolidate a feasible solution. This participation component and group involvement allowed not only a better understanding of the problem but also the incorporation of the contributions of specialists (doctors, nurses and ambulance technicians), that goes beyond the questionnaire assumptions and unstructured

interviews, made over the contact time.



participant observation The follow-up of health professionals lasted 150 hours and was divided between the Ambulance Type B, where its crew is formed by Emergency Ambulance Technicians(EATs), Figure 5, and the Medical Emergency and Resuscitation Vehicle, intended for fast transport to the patient's site - the team involves a doctor and a nurse. This experience allowed identifying and understand on the ground the equipment in use; interactions and complementarities between the two kinds of ambulance and between the EATs; and record data that help to better understand this reality,



Figure 4: Participant observation with the doctor and nurse in Medical Emergency Ambulance.



Figure 5 Data recording - drawing of a patient in Medical Emergency Ambulance.

focus group, National Emergency Medical Institute Specialists In order to obtain qualitative data on the current configurations of the INEM ambulances and to collect information on future ambulances, a working group was set up with the participation of emergency ambulance technicians. The first exercise proposed to

this group consisted in sanitary cell arrangement without changing vehicle size and consequently the cell, changing only its position, furniture location and ambulance components. Based on a scale model: 1:10, solutions were developed to configure the ambulance interior that best fit the needs of its users.



Figure 6 Scale model: 1:10 of Medical Emergency Ambulance.

The second proposed exercise consisted in stimulating the group's creativity to identify and characterize requirements, needs, ambitions and desires, from a prospective perspective - an ambulance of the future. Participants used a variety of printed graphics - images and drawings - and constructed collage and overlay

techniques that expressed their own ambitions. New forms were designed using A3 sheets with an ambulance print that served as a reference element in terms of volumetry and scale of form, allowing exploratory and speculative interaction on futuristic concepts of the equipment.

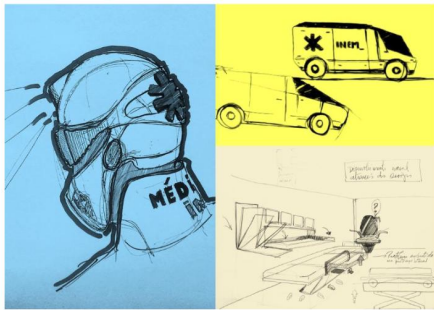
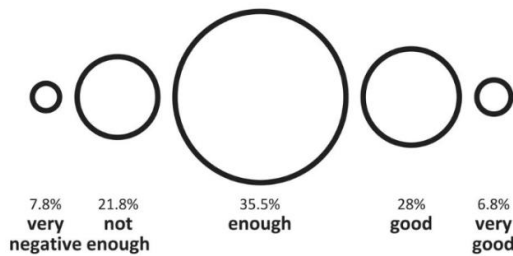


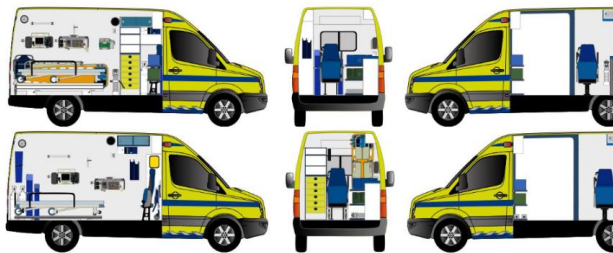
Figure 7 Example of futuristic concepts of the equipment made in second exercise with specialists.

National Emergency Medical Institute, national survey The information obtained helped to elaborate a questionnaire on the last model of the National Emergency Medical Institute's Ambulance in circulation, in order to test the degree of satisfaction that emergency ambulance technicians, doctors and nurses had on the overall performance. This activity counted on the dissemination and execution, with the support of INEM, which provided the means to send the document to its collaborators, resulting in a response rate of around 10% (130 Answers)

of the whole universe to be surveyed. The questionnaire was constructed using a scale of 5 values, with questions grouped around the following themes:• sanitary cell (dimension, geometry, volumetric);• mobile equipment (medical and emergency equipment used inside and outside the ambulance);• usability and ergonomics of the equipment (fixed structures and mobile);• exterior of the vehicle (location and quantity of doors, access ladders);• electrical and communication infrastructure (quantity and location of light points and electrical outlets, intercom);• materials used in the construction of the ambulance (robustness, texture, color, cleaning).The questionnaire allowed to obtain quantitative data as well as a general picture of the current ambulance, and it is now necessary to interpret and extrapolate this data. It is intended to extract information that can contribute to the work's main objective - the design of a new solution, viable and recognized as advantageous, for the various beneficiaries in the construction, maintenance and use of this type of equipment. The data was compiled into a graph, which represents synthetically, the evaluation of the existing equipment.



sanitary cell architecture and proposals for design concepts Functional schemes were generated allowing the generation of architectural proposals for the different sanitary cell typologies. The generation of architectural proposals for the sanitary cell was carried out with a Mercedes Sprinter Van and allowed to identify and select solutions, which served as design guidelines in the development of the new concepts and models,



The prototype evaluation was performed in small groups of two to three people, but in most cases, individually. The evaluation was accompanied by the design researcher, who provided an initial framework for the prototype, and its brief analytical description so that the conditions for the assessment could be created without interference. At the

same time, complementary information was given on materials, finishes, colors, functions, possibility of modularity, among others.

In this way, it was possible to help the evaluator to be given the opportunity to complete their own mental image of the product. The users' impression of the prototype's utility was reinforced by the information given on materials, finishes, colors, functions and modularity. It was also possible to help give the evaluator the opportunity to complete their own mental image of the product, during the evaluation. The questionnaire evaluated the Pragmatic Quality associated to product usability, the Hedonic Quality / Stimulus, associated with the product's ability to stimulate the user in terms of novelty, interest and interaction, the Hedonic Quality / Identity associated with product capability allows the user to identify the attractiveness, which describes the overall value of the product experience based on the quality perceived, by the respondents - emergency staff. The two types of evaluation reported above provide qualitatively and quantitatively different pictures of prototype evaluation. These differences may be explained by two major factors related to the design and the

evaluation approaches chosen in the case study. The two types of evaluation were done with real users, which knew the business. This fact could explain the richness of data because the users were motivated to contribute to the design of a new emergency ambulance, and they applied their knowledge used in daily work in order to provide suggestions and some small/particular prototype improvement.

### 3. Remarks

As a first observation, we highlight that Prehospital Medical Emergency requires the involvement and the work of several specialists, as well as integration of multidisciplinary competences, which jointly define the strategy, and design the way to operate it's a second observation, we highlight the difficulty of implementation of complex products and systems, associated with the design of this typology of products (political, economic, technical, productive, technological, organizational, logistical, etc.).As a third observation, we highlight the lengthy continuity of the design process, with repeated revisions. The design process never ends. As a fourth observation, we highlight the relevance of the design, especially in the project's strategic

definition and in the construction of the objectives and goals to be achieved.

**Conclusions** The consulted bibliography and investigations that served as the starting point for this work, allowed to conclude that knowledge in the area of Design of Ambulance of Pre-Hospital Medical Emergency is still reduced. Research on this typology of systems is found mainly in the areas of service, patient care and guidance, also medical practices and procedures. The assignments for academic design that have been already finished in this area, and from what has been known so far, have had a lot of difficulty in overcoming the concept definition or prototyping phase. In order to overcome these difficulties, this research had as objective adding the contribution and the involvement of all main stakeholders - groups that define and provide service (eg: INEM) and ambulance manufacturers (eg: Auto RibeiroLda) .This approach was essential to obtain a multifocal and simultaneously integrated vision of reality, which allowed the Design to configure a new paradigm of action in this field, provoking the generated transfer of knowledge and its consequent application in the product / equipment destined to the medical emergency market users, and

therefore to patients / persons. The Conceptual Framework, created the appropriate environment by identifying and integrating the different expectations of the partners into a coordinating methodological tool, in which partners were able to jointly map key issues and challenges, set priorities and also were able to clearly indicate the goals and expected benefits of the project. The participatory approach to this research, in which design functioned as a pivot of action and dialogue between these various actors, required that this environment was previously observed and mapped, so that it generated the conditions for hosting a project / research of this nature. The achieved results - an ambulance in commercialization and one in the process of industrialization- were the effort result of this network, created by research in design. It reflects the expressions of an action-research culture that has been extended to organizational, business and academic levels. It is essential for Design to re-imagine and construct new and meaningful work models, transversal to all its fields, in order to change the impact paradigm of its action. This change requires the construction of cooperative networks with the government, academia, industry and all those interested

in the process, so that design can take on its own nature, generating a more informed, multidisciplinary and systematic type of thinking and in order to ensure positive results and the long-term sustainability of action. This type of research in design, based on a cooperative source and configured through an action /research network, has multiple benefits:- as a mechanism to generate a strong commitment, involvement and stakeholders' contribution, which leads to the progressive integration of knowledge and allows to take design to the implementation phase;- is a consistent process able to adapt to changing circumstances throughout the project;- is a highly creative approach to problem solving that leads to suitable and applicable solutions in many contexts, therefore, it is a highly transferable process.

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