

# Production layout improvement in emergency services: a participatory approach<sup>1</sup>

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**Abstract.** Volunteer fire department is a service that responds emergency situations in places where there are no military emergency services. These services need to respond quickly, because time is often responsible for the operation success besides work environment and setup time interfere with the prompt response to these calls and care efficiency. The layout design is one factor that interferes with the quick setup. In this case, the spaces arrangement can result in excessive or unnecessary movements; also the equipment provision may hinder the selection and collection of these or even create movement barriers for the workers. This work created a new layout for the emergency assistance service, considering the human factors related to work through the task analysis and workers participation on the alternatives of improvement. The results showed an alternate layout with corridors and minimization of unusable sites, allowing greater flexibility and new possibilities of requirements.

Keywords: human factors, volunteers, firefighters, setup time reduction, layout design

## 1. Introduction

Voluntary service is an unpaid activity, provided by an individual to any kind public entity, or a private non-profit organization that has civic goals, cultural, educational, scientific, recreational or social assistance, including mutual aid [1]. The Volunteer Fire Department is a service present in most cities in southern Brazil where there are no military services to perform actions in order to minimize suffering and reduce its consequences to people, to reduce the number of deaths caused by accidents of various kinds and minimize damage to assets.

The action taken by firefighters in attendance events covers four major groups: Fire Fighting, Rescue, Prevention, Help and Pre-Hospital Support [2]. This type of service intended for fast production, where speed performance is the main feature in services provision [3].

In many cases, the designated to the brigades are not suitable to their needs, i.e., they were not designed with features and specific structural organizational to the firefighters work involved. This is the

case study in a small city in Southern Brazil. After thirty years of services for the community using rented buildings, the corporation has demonstrated the need to build its own headquarters, and one possibility was the acquisition of the current rented building. The reformulation of a current layout is needed during the deployment of a new service unit or when it is necessary to promote the redesign plans or other business operations already in operation [4]. In this context the ergonomic principles consideration can be important to internal space planning [5]. Some projects comprehend the magnitude and complexity of material flow, distance between activities, connections between the elements, frequency of movements, and communications between people or areas, as well as the importance of the relationship between these areas [6-14-15]. The layout optimization method combining the systematic planning and human factors at work, which aimed to reduce fatigue [7] is particularly relevant for the design and suitability. Other approaches including workers participation [8-5], show significant results, and provide

<sup>1</sup> Developed with collaboration of Volunteer Fire Department partnership.

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important stakeholder participation, allowing a great chance of success with the new plan.

This work aims to contribute to a new layout design for emergency services installations, with the employees participation on alternatives decisions, giving priority to improve rapid response and interactions with the environment, allowing operators to perform their individual or collective activities without changing their health, increasing their capabilities values [9] and appreciating the basic principles for the definition of physical space: security, economy of motion, flexibility and long-term use of space [4].

## 2. Methods

First, data were collected on the work carried out by emergency services analyzed, seeking to understand the local situation and problems sources. Some local visits and a brief description of the research objectives allowed an initial interaction with the workers. The comprehension of current situation and work organization was accomplished through spontaneous interviews with workers, commander, instructor and manager. This step has created indicators to drive the demand to real needs. The responsibilities of each service sector and tasks requirements were analyzed, since the workplace arrival until the departure time, including the work plans inside building and outside services and all types of provided care.

The second evaluation stage was conducted through direct observation of the workers. In this case, two drivers and a firefighter were observed in order to identify the procedures performed during the work shift. This observation may cause influence on the performance of these workers, even trying to be as unobtrusive as possible, but the presence of an observer will lead people to engage in additional behavior to normal activity [16]. For these workers demonstrate the actual process, not the process that must be done, preliminary observations were made, to train the employees with the presence of ergonomics to make the following observations were considered. The observations were conducted with three workers during a week to capture the differences between the internal workload and attendance at events, taking the average of seven days. The activities workflows during work shifts were identified, e.g. the flow and the difficulties during setups, and the commitment in the so-called quick service care.

A questionnaire was applied to workers in order to obtain their commitment with layout changes. Macro ergonomic organizational questionnaire survey can be a useful tool at many stages, e.g. monitoring worker opinions during a change implementation [16]. The questionnaire allowed the participation of five workers, an instructor, a member of the command and a manager. The aim was to understand differences of opinion among management members and command member in relation to firefighters. The data obtained in the participatory and expert assessment was compared to verify the workers comprehension on relative importance of the displacements between workplaces.

The new layout was designed considering the most important score between the two ratings in order to minimize the displacements required to perform setups and to approximate similar equipment and space needed for key tasks achievement. Besides, it was also considered the needs expressed by workers in the questionnaires.

## 3. Results

### 3.1. Local service background

The region covered by the service includes a main city about 30,000 habitants, and support four neighboring towns. The calls include in most cases: fires in buildings and vegetation, traffic accidents involving personal injury, trauma attendances and medical care for disabled or low-income families (Figure 1).

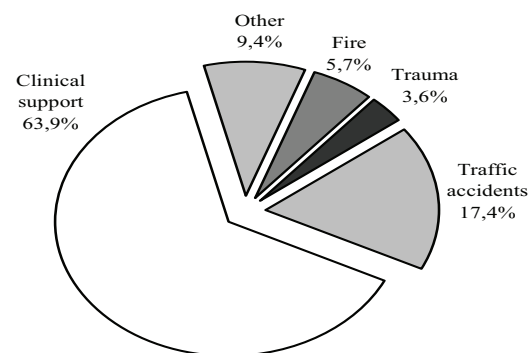


Figure 1 – Attendances by type in 2010.

Other services provided in minor extent including: natural events such as track obstruction, either by falling trees or landslides, floods, support for security events, lectures, animals capture promoting risk of

accidents, risk areas isolation as well as other prevention activities. The management department is responsible for administrative and financial compromises, and is composed only by volunteers who have worked before as firefighters. The command is responsible for operational commitments, and composed by two active volunteer firefighters. The corporation accounts with a free training service for volunteer firefighters by a non-paid instructor. Individuals trained in this course stay in the brigade for six months to obtain experience accompanied by professional firefighters. After, they are able to serve as volunteers to help other service teams.

The building is rented and located in downtown, accessed by two main streets, but uses only one for an emergency exit. On the other hand, it was not built to be used for such service and the layout and distribution of vehicles and devices were being changed progressively as the equipment acquisition or replacement. So, the inefficiencies of the current layout are derived from these physical restrictions and by the lack of planning. The service vehicles are ready in front of the building, near the emergency exit with the most frequently equipment used, while the specific equipments are arranged inside the building and loaded when needed.

### 3.2. Task analysis

The tasks and places were observed and recorded according to table 1. The time lengths sum demonstrates the spent time to perform the tasks (Figure 2) and the concerning use of space (Figure 3).

The work shifts follow a schedule where firefighters work uninterrupted for 24 hours and rest for 72 hours. For this, 13 are engaged professionals, where 12 workers perform the shifts and 1 replace worker during holidays. The distribution of internal tasks follows a weekly schedule, where in each day the workers must carry out tasks while they are not performing emergency care. These tasks include cleaning, vehicle and equipment maintenance, environmental organization, filling occurrence documents, receiving community people, preparing meals, etc. During the free time the workers perform leisure activities like watching TV, listening to music, gymnastics, weightlifting, reading and training. These activities are accomplished in a gym and in a small library. Despite of having time to sleep during the shift, that is constantly interrupted by emergency calls night and day. These interruptions occur every 2.5 hours on average, causing sleep discontinuity.

Table 1

Sample of data collection about time and space use by the workers.

Time	Employee	Place	Task
20:00	Driver 1	Bedroom	Changing clothes to take the shift work
20:00	Driver 2	Bedroom	Changing clothes to take the shift work
20:00	Firefighter	Bedroom	Changing clothes to take the shift work
20:02	Driver 2	Kitchen	Waiting
20:03	Firefighter	Kitchen	Waiting
20:06	Driver 1	Garage	Checking vehicles and equipment
20:45	Driver 2	Communication room	Emergency call
20:46	Driver 2	Garage	Starting vehicle
20:46	Firefighter	Garage	In Vehicle
20:47	Driver 2	External	Emergency care
20:47	Firefighter	External	Emergency care
21:01	Driver 2	External	Communicating victim conditions and transport to hospital
21:01	Driver 1	Communication room	Communicating victim conditions to responsible nurse in hospital
21:07	Driver 2	External	Communicating return to base
21:07	Driver 1	Communication room	Returning message received
21:09	Firefighter	Garage	Cleaning Vehicle

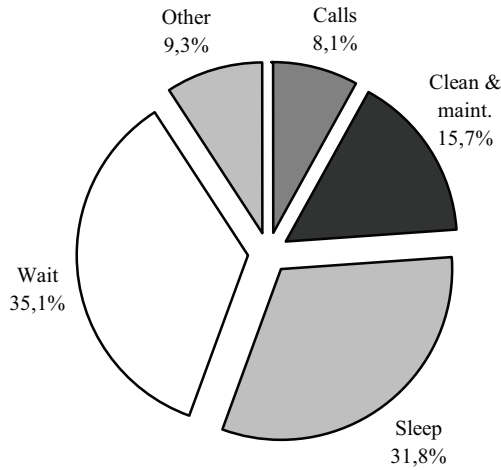


Figure 2 – Time usage to perform the tasks.

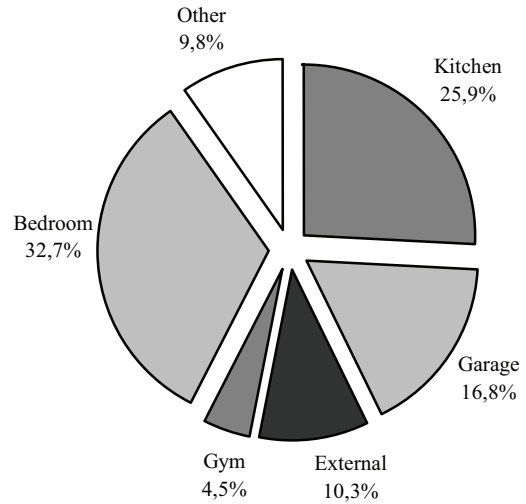


Figure 3 – Space usage to perform the tasks.

The setup begins when the phone rings. The workers move from their original positions, where they are executing internal tasks. If the call indicates an external service, these 3 workers choose two among the attendants, which separate the necessary equipment and go to vehicles. One of them remains in the building waiting for a possible new call or to perform the communication with the vehicle and the hospital. So, the communication room is a key point to make the setup between internal and external services. Considering the use of spaces in the tasks, it becomes evident the importance of the relationship between communication room and most of space used performing the tasks. This relationship facilitates the movement of workers executing the setup. It was also clear that the passage through the garage area is complicated by the presence of private vehicles.

The importance of proximity to the communication room with the most commonly used workplace becomes fundamental for the rapid implementation of the setup, because workers have more chance of displacements during the work shifts.

3.3. Workers participation

The workers were asked about the importance level of relations between the different work spaces and the communication room during the tasks execution required during setup at the emergency exit, according to their understanding of the situation. They used the following comparison scale: 1) Fundamental; 2) Very importantly; 3) Importantly; 4) Indifferent; 5) Not important; 6) Unwanted. The results are showed in table 2.

Table 2

Link importance between Communication room and other places in emergency building - Result of employees applied questionnaire.

Employee	E1	E2	E3	E4	E5	Director	Commandment	Instructor	Median	Consider Importance
Garage	5	3	1	2	1	1	1	1	1	1
Bedroom	2	1	1	2	1	2	1	2	1,5	1
Bathroom	5	6	4	3	4	3	4	3	4	4
Laundry	6	5	4	4	5	6	4	6	5	5
Deposit	6	6	5	6	5	5	6	5	5,5	5
Courtyard	5	6	4	4	4	5	4	5	4,5	4
Gym	5	5	4	4	4	5	4	5	4,5	4
Office	5	2	4	5	5	4	5	4	4,5	4
Workshop	5	5	4	5	4	4	4	4	4	4
Kitchen	2	1	1	2	2	1	1	2	1,5	1

In addition, workers were able to demonstrate his questioning by workplaces that are not available and can be aggregated in the new layout, as a classroom for use in safety courses and conferences and parking for private vehicles. We also proposed improvements to laundry and garage design to meet the city's growth and new acquisitions based on that growth.

The difference in perception of importance between the specialist and the workers is shown in Figure 4.

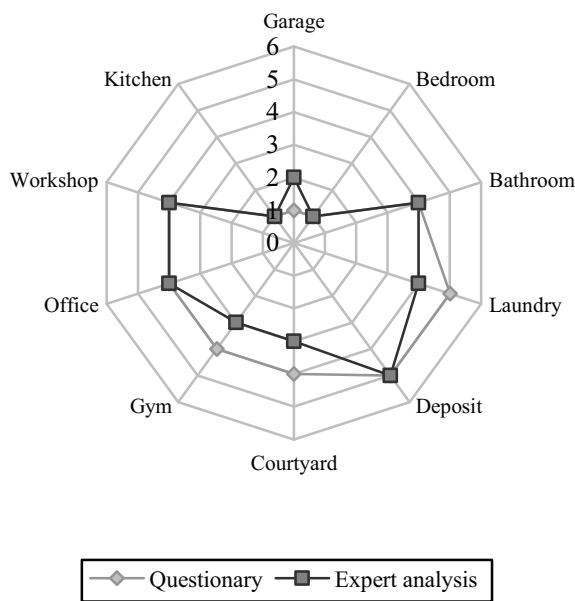


Figure 4 - Relative importance differences between expert analysis and participatory approach.

### 3.4. Planning new layout

The current layouts (Figure 5) and the new alternative (Figure 6) were compared considering the distance traveled by workers in over shifts in relation setups found in the importance ratings (Table 2). The data obtained from analysis of the two layouts are shown in Table 3. The proposed alternative was compared with the current layout of the building and the distance traveled in the movements required during working hours, and the relative importance for the realization of the set of events to attend.

## 4. Conclusion

The decision to change the layout is often overlooked because it involves much time and efforts generating in turn high costs, but its correct evaluation can affect work conditions, reducing unnecessary movements and processing costs.

Layout studies usually ignore the principles of human-centered design, and therefore it seems that the relationship between work and human beings are not shown in the manufacturing process. Instead, worker participation in decision-making, which is presented in a different way in this assessment, anticipates many questions by those not directly related to the production process.

The generation of alternative layout with minimization of corridors allowed a better distribution of workplaces by eliminating unusable places. Also it allows greater flexibility and adaptability to new requirements such as: an auditorium for presentations and certifications, increase the communication room, bedrooms and laundry facilities.

The comparative results between the participatory evaluation and the expert assessment were very similar in this study, possibly because the workers involved have a high education level, and high degree of knowledge about their tasks.

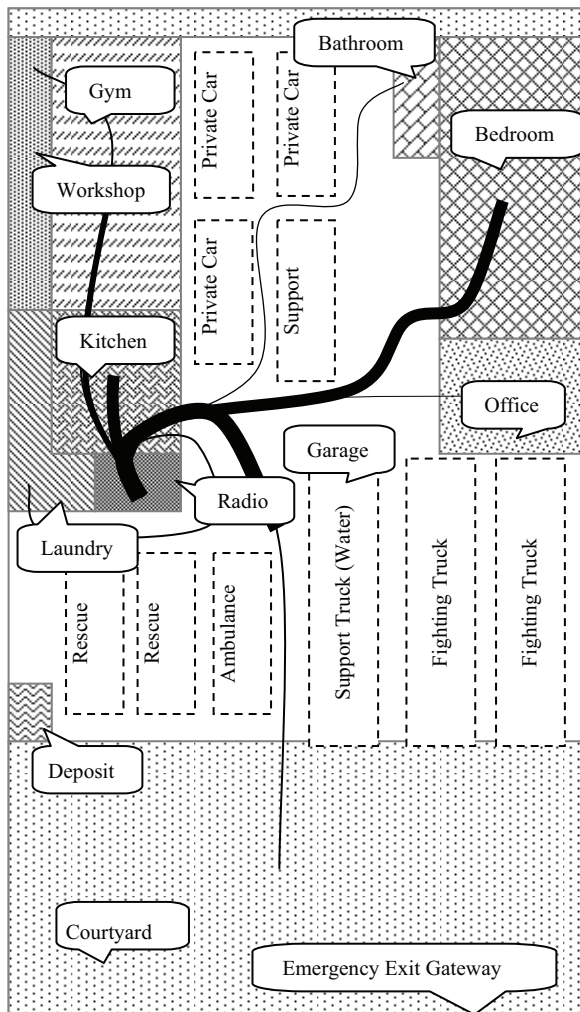


Figure 5. Previous layout with vehicles positioned and setup moves demonstrated with importance defined by the thickness of the representing line.

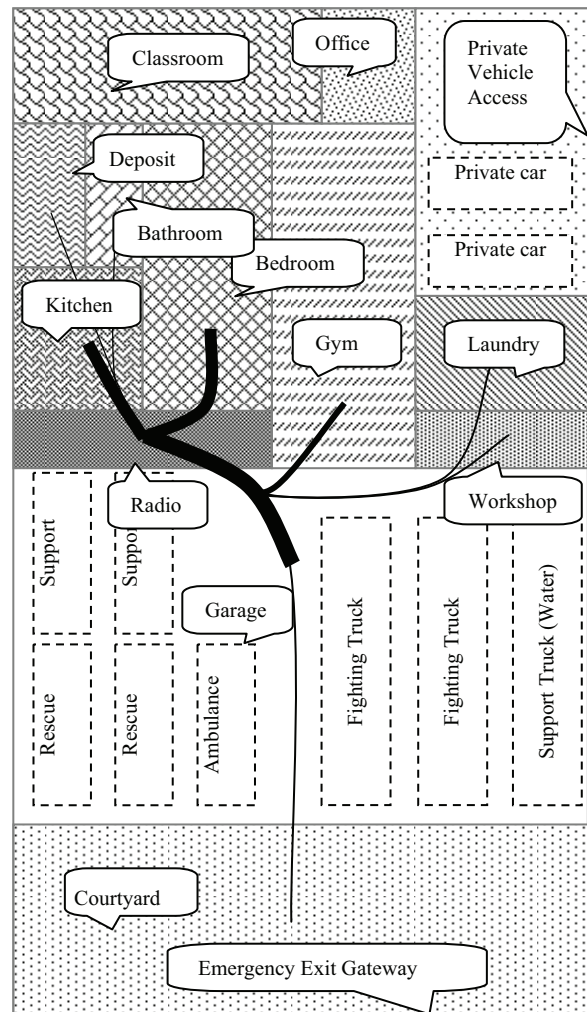


Figure 6. Proposed layout with vehicles positioned and setup moves demonstrated with importance defined by the thickness of the representing line.

Table 3

Comparison between current and new layout considering the relative distances to perform setup tasks.

Place	Relative importance (1-6)	Current layout (m)	Proposal layout (m)
Garage	1	9,66	6,67
Dormitory	1	18,65	4,66
Kitchen	2	4,66	3,66
Laundry	5	14,98	13,32
Gym	4	10,32	8,32
Bathroom	4	18,98	7,32
Office	4	15,31	0,00
Workshop	5	17,98	15,31
Courtyard	4	21,64	20,31
Deposit	5	14,98	8,32

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