

# Ergonomic intervention at loads storage and transfer on vessels of Amazon State

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**Abstract:** The Amazon State waterway transportation has weaknesses, especially regarding the conditions of vessels which, in general, are unsuitable for transporting people and cargo. In many cases, they navigate with the number of passengers and loads over their capacities and transport both of them on the same deck. According to the Ministry of Defense (BRASIL, 2006) norms, passengers should not share the same deck with loads. This situation occurs, among other reasons, because the boats do not have a suitable place to store products. Furthermore, due to lack of ergonomic equipment for loads transport, improvisations are performed by the stevedores to reduce product loss. In many cases, they carry too much weight on their heads and backs. According to Dul and Weerdmeester (2004), the manual lifting of cargo is one of the biggest causes of back pain. On this premise, an ergonomic analysis in the region boats was performed with the aim of proposing improvements to the existing conditions. The ergonomic methodology proposed by Moraes and Mont'alvão (2003) was used. Some alternatives for loads storage on decks, product transportation equipment and access to vessels were proposed. These solutions optimize the load storage and transfer in the Amazon vessels.

**Keywords:** vessels, loads storage and transfer, ergonomics, product development.

## 1. Introduction

In the boats of Manaus city, capital of Amazon State, is possible to observe that, in many cases, the forms of storage and transporting of products are precarious. Many improvisations are found and can compromise the safety and health of users.

The holds of ships where the loads are stored, generally, are not suited to the specificities of each product and do not have dimensions to accommodate the amount of material transported. This situation makes certain goods to be arranged on main deck floor, hindering the movement of people.

Regarding the displacement of these loads, there is no suitable equipment to transport them. Because of this condition, the stevedores usually carry excess of weight on the spine, which can cause serious damage to muscular and skeletal systems. According to Dul and Weerdmeester (2004), many functions involving loads lifting do not meet the ergonomic requirements. This type of activity is a major cause of back pain. Dul and Weerdmeester (2004) also say that the recommended weight limit for this kind of movement should be 23 kg.

To manual lifting and transport of goods, these authors recommend equipments that relieve human labour, such as trolleys, levers, pulleys, winches, roller conveyors and mobile platforms.

Based on the found needs, it becomes clear that an ergonomic intervention in the storage and transfer of goods on vessels of Amazon State is required to make possible the generating of alternatives that improve the working conditions of users.

## 2. Waterway transportation

The most used mean of transportation to carry people and cargoes in the Amazon State is the waterway transportation. Novaes (2004) defines waterway transportation as one that concerns all types of carriage performed on the water. The river transport (in rivers) and lacustrine (lakes) are included.

According to Davidsson et al. (2005), the water transport via sailing vessels offers one of the most used and less costly means of transporting bulk goods. Ballou (2004) also argues that the waterway mode of transportation is suitable for large amount of cargoes and long distances, what provide lower costs per transported unit. Mello (2001) claims that its low cost of shipping is rewarding element of its slow service, which attracts low-value goods and non perishable.

Despite the advantages of this type of transport, Galvão (1996) states that the waterways, just like the railways, require to be economically viable, a large volume of cargoes

in both directions (in the outward and return), which is, today, a reality not reached. Maia (2004) also declares the inefficiency, insecurity and high costs of Brazilian ports when compared to other ports in the world.

According to Frota (2006), the waterway mode of transportation is responsible for the survival of the Amazon basin complex, because almost the entire basic supply is made through their waterways. Another fundamental role played by that modal is in the social scope, making the transport of inland communities, their energy supply, promoting also the accessibility to education and health.

### 3. Characterization of port infrastructure

The Amazon State, for being intersected by rivers, has the waterway mode of transport as a major means of transportation in the region, both between neighbouring counties, as for the long routes until the major centres. Frota (2006) also states that the waterway network comprised, mainly, for the Amazon basin, is the most viable transportation option for the State. However, existing ports do not have adequate infrastructure. There are not specialized waterway terminals for loading and unloading of passengers or specialized vessels to transport them. The embarkation and disembarkation of passengers is conducted, today, in the same waterway terminals used to handling cargo. The expansion and development of the integrated system river transport of Amazon State encounter a bottleneck at the base for loading and unloading of passengers and goods at the development poles.

Frota (2006) also states that there are illegal ports, where boarding and landings are conducted along the ravines, in an extremely precarious and insecure way.

According to field research on ports of Manaus and Tabatinga cities, was also observed difficulties relating to: access to these sites, which often is done with wooden planks; and the lack of structure for unloading cargoes, mainly, of food products.

### 4. Characterization of river craft

The vessels of Amazon State are, mostly, built of wood. According to Frota (2006), although this is the main transport system in the region, the vessels which sail carrying cargo and passengers today are the same ones that were built decades ago. It can be noted that there was no evolution in the project and, mainly, in the way of construction and raw material used. The hulls are built with wood planks laid lengthwise along a structure also made of wood, and caulked with resin and fibrous material, which provides a greater vulnerability to the vessels. Due to problems linked to the use of wooden hulls and the absence of division of the hull into compartments by bulkheads, most of the accidents leads to the wreck

in a very few minutes. Figure 1 shows one of the models adopted regionally.

Frota (2006) also states that due to the need for faster transportation of passengers and cargoes, most of the state boats have motors with more power than those used for decades. As a result, the cruising speeds are greater, the tensions in the hooves structure are larger, just as is higher the risk of collisions with stumps, sandbars and other vessels. When an impact with a trunk occurs, the caulking does not resist and along the entire hull, inundations may occur. Sometimes the hoof does not stick, but the wooden boards run and caulk loose, flooding the holds very quickly, which does lead to the wreck a large vessel, to local standards, into 3 (three) or 4 (four) minutes, according to Frota (2006).

Frota (2006) also emphasizes that although the naval steel is the ideal material for construction of boats hulls that travel in the Amazon River, and although there are financial resources of the Federal Government to implement safer projects, the following factors hinder the effective implementation:

- Culture of Amazonian population that has vessels. They are accustomed with the abundant raw material, fruit of the harvest of their own region;
- The engineering of design is in the minds of most people in the region, and, also, the workforce is very cheap; and
- Difficulties related to the bureaucracy for access to the credit of the Merchant Marine Fund / National Bank of Economic and Social Development - BNDES.

### 5. Ergonomic assessment

According to Moraes and Mont'álvão (2003), ergonomic assessment is an exploratory phase that includes the mapping of the ergonomic problems encountered during the development of activities for storage and transport of cargo on Amazon vessels. This part consists in organizing the man-task-machine system, when the Characterization and Serial Position of the System is defined. It is, also, when the delimitation of ergonomic problems is made, according to taxonomic classification. These difficulties, after being registered and classified, become an important source for the development of requirements and parameters.

#### 5.1. Characterization and serial position of the system

For better understanding of the functioning of system: "Vessels of Amazon State" and its characteristics, it was elaborated the model of Characterization and Serial Position of the System, proposed by Moraes and Mont'álvão (2003), which is presented below, in Figure 2. In this model, the target system, its characteristics and the serial position are



**Figure 1.** Hull construction. Source: Harbours Captancy - AM.

presented, considering since the process that feeds (power supply) until the one that receives (ulterior).

## 5.2. Delimitation of ergonomic problems

According to Moraes and Mont'Alvão (2003), for better understanding of the troubles at the first visit to the workplace, during the ergonomic assessment, it must be taken as a guideline categories of problems that include needs and shortages, and specific faults. With the categories of troubles in mind, it becomes easier and more efficient to conduct unsystematic observations.

Inside the Categorization and Taxonomy of Ergonomic Problems of the System, these problems are highlighted: of movements, that refer to excess weight carried, distance of load travel, frequency of the objects movement to lift or carry, disrespect the recommended limits of manual materials movement, with risks to muscular and skeletal systems; of displacement, that refer to excesses of paths and digressions, long distances to be travelled to perform the task activities; and problems of accidents which are

those that compromise the security requirements involving safety environmental and non-compliance with routines and rules.

### 5.2.1. Categorization and taxonomy of ergonomic problems

#### *Access to vessels:*

At Figure 3, it can be seen two improvised ramps, without fixation and handrails, used to access a vessel. The instability of the boat can cause accidents.

At Figure 4, it perceives that two people need help from others to get off the boat because the access ramp is narrow and has no handrail.

#### *Main Deck:*

At Figure 5, it can be noted a vessel where goods occupy almost the entire space of the deck, obstructing the free movement of persons. The absence of fixation on the loads is also observed and may cause accidents.

#### *Holds of Vessels:*

It is observed, at Figure 6, that the stair to the hold has no handrail. The user needs to improvise to get there in safe.

It can be noted, at Figure 7, that the access to the hold of the vessel is hampered by the fact that the ladder is made of metal tubing (material and shape that make hard to grip) and has no handrail. The small distance between the baseline and the hatchway turns the access harder. That situation causes discomfort to users and can generate accidents.

In Figure 8, it can be observed that the goods stored in the bilge have no protection. This condition may cause accidents with loss of product.

In Figure 9, it is perceived that the surface of the hold follows the format of the ship's hull. The absence of coating on the floor creates an irregular and insecure workplace, not offering equilibration to the loads.

#### *Stevedores:*

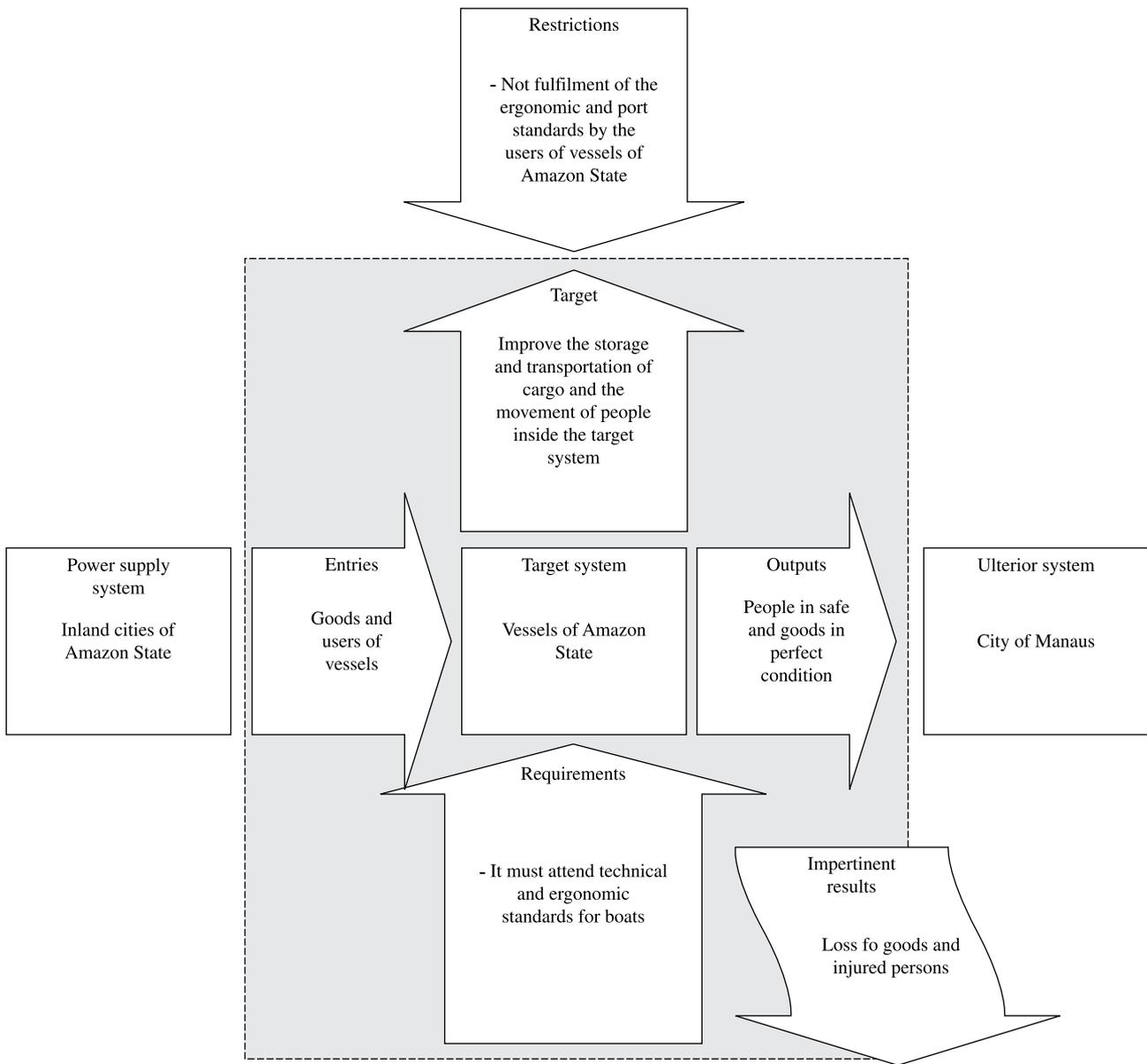
At Figures 10 and 11, it is noted that, because of the absence of ergonomic equipments for cargoes transportation, the stevedores realize the loading manually, usually, carrying excess of weight on the head and spine, what can cause serious damage to muscular and skeletal systems.

## 6. Ergonomic diagnosis

According to Moraes and Mont'Alvão (2003), the ergonomic diagnosis comprises the task analysis through the characterization and the behavioural analysis of the task, what includes the study of the activities performed during real situations of work - getting of information, manual operations, oral communication and gestural, adopted postures and positions of body segments.

### 6.1. Behavioural task analysis

Drury (1987 apud MORAES and MONT'ALVÃO, 2003) defines the Task Analysis as a process of identifying and



**Figure 2.** Characterization and Serial Position of the System.

describing units of work and assess the required resources for the successful performance of the job.

To know the postures assumed by the stevedores in the accomplishment of tasks, the behavioural registration was performed.

### 6.1.1. Behavioural registration

This registration may refer to the postures assumed by the system user, visual exploration, getting of information, manual operations, communications and displacements during the accomplishment of tasks. They are drawings made from the photographs that were taken at the stage of Ergonomic Assessment.

In Figure 12, it is observed that the stevedore performs frontal flexion of the trunk, associated with the action of carrying goods on his back. It is perceived that his left hand is over his head to cushion the contact with the load and for the subsystem that holds the product does not slip.

In Figure 13, it is observed that the stevedore performs lateral neck tilt, abduction of left shoulder, lateral flexion of the left elbow, abduction of right shoulder and frontal flexion of the right elbow.

## 7. Port standards

To obtain an efficient and safe design of equipments to store and transport loads at vessels of Amazon State, first,



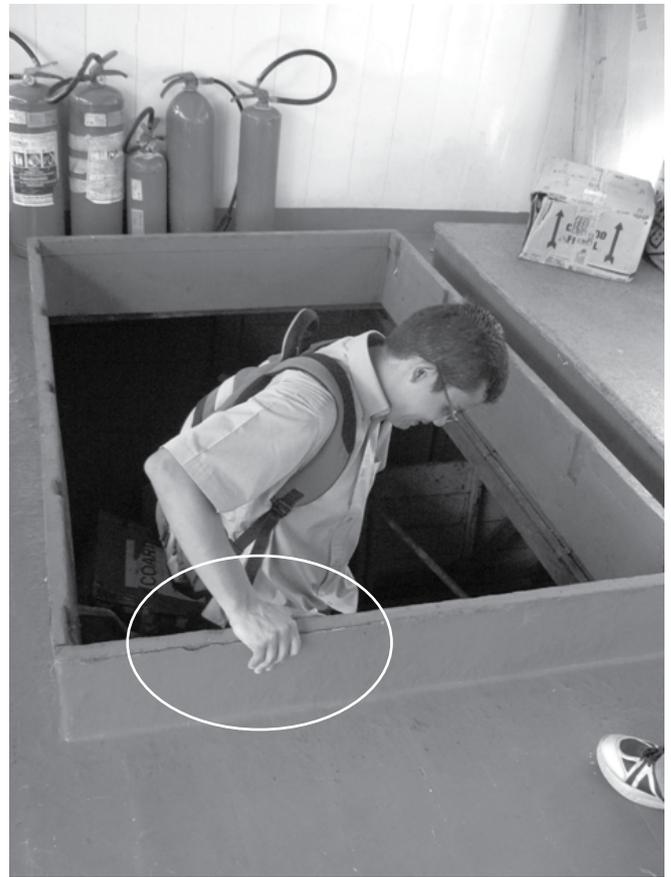
**Figure 3.** Accidents problems. Source: Plogamazon (2010).



**Figure 5.** Problems of accidents and displacement. Source: Techna (2008).



**Figure 4.** Accidents problems. Source: Plogamazon (2010).



**Figure 6.** Accidents problems. Source: Plogamazon (2010).

it is necessary to know the norms for access to boats, for circulation on decks, access and storage at holds, of safety workplace for activities with bags transportation, beyond the study of standards for personal protective equipment. Therefore, some of these regulations will be presented below:

### 7.1. NR 29 - Regulatory standard of safety and health at port work

The provisions contained in this NR apply to port workers in operations both aboard and ashore, as well as the other workers engaged in activities at organized ports and



**Figure 7.** Problems of accidents. Source: Plogamazon (2010).



**Figure 9.** Problems of space / interiors architecture. Source: Plogamazon (2010).



**Figure 8.** Problems of accidents. Source: Plogamazon (2010).



**Figure 10.** Problems of moving. Source: Plogamazon (2010).

at port installations of private use located inside or outside the organized port area.

*Access to vessels:*

- The stairs, ramps and other kind of access to the vessels must be maintained in good repair and cleaning, being preserved the characteristics of non-slip surfaces.
- Ladders used for access to vessels must have sufficient width to allow safe transit and should be garnished with a safety net, in perfect condition of conservation.

*Decks:*

- Decks should be kept clean and clear, with a circulation area that allows the safe movement of workers.

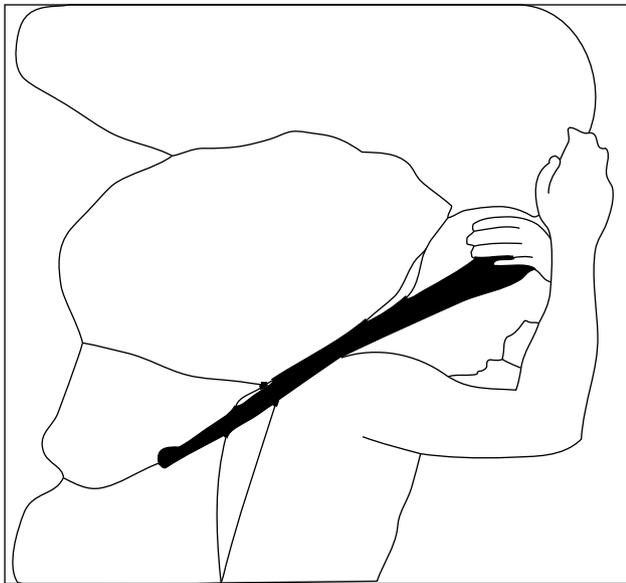
- The loads or objects that, necessarily, have to be stored on deck must be anchored and tied immediately after stowage.

*Holds of vessels:*

- The stairs of access to the holds must be in perfect condition of conservation and cleanliness. When the hold of a vessel have vertical ladder until the floor, the stair must be equipped of parapet or with steel cable parallel to the ladder to be able to apply devices of type lock falls, coupled to the seat belt used in the operation of ascent and descent the ladder.
- The used lining must provide balance to the load and create a regular and insurance floor.



**Figure 11.** Problems of moving. Source: Plogamazon (2010).



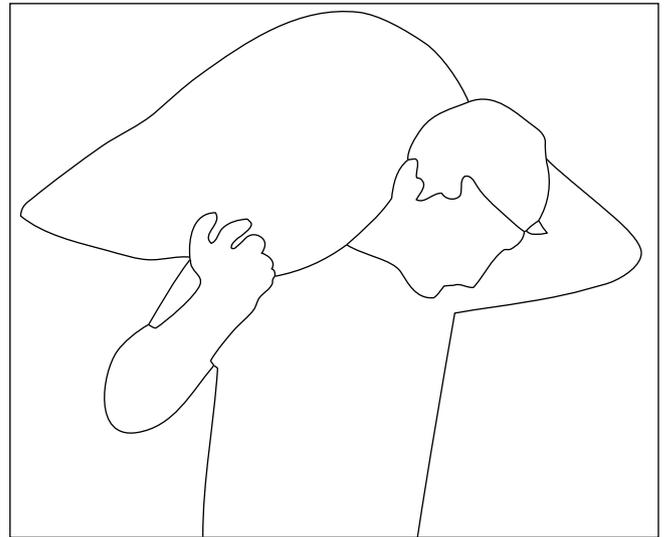
**Figure 12.** Stevedore carrying goods.

## 7.2. NR 11 - Regulatory standard of transport, movement, storage and handling of materials

This NR establishes the security requirements to be observed in the workplace, with regard to transportation, movement, storage and handling of materials, be it mechanically or manually, aiming the prevention of labor misfortune.

### 7.2.1. Standards of safety workplace at activities of bags transportation

- The cargoes transportation should be realized through impulse of wagonette, carts, wagons, appropriate wheelbarrows, or any type of mechanical traction.
- The floor of the warehouse should be composed of antiskid material, without roughness, using,



**Figure 13.** Stevedore carrying goods.

preferably, the asphalt mastic, and maintained in perfect condition of conservation.

## 7.3. NR 6 - Regulatory standard of personal protective equipment - PPE

The company is required to provide to employees PPE appropriate to the risks, under the following circumstances:

- Wherever the measures of general order do not offer complete protection against the risks of labour accidents, of occupational diseases and of work;
- While the measures of collective security are being implemented; and
- To meet emergency situations.

### 7.3.1. Personal protective equipment

For the tasks of storage and transfer of loads at vessels of Amazon State is required these Personal Protective Equipments:

- Safety glove to protect hands against cutting and piercing agents;
- Safety glove for hand protection against thermal agents;
- Hamper-drop security device for user protection against falls in operations with vertical or horizontal handling, when used with safety belt for protection against falls; and
- Safety belt to protect the user from the risks of falling in working at heights.

## 8. Ergonomic standards

For the Amazon vessels offer greater safety, comfort and efficiency to its users, especially, in the task of

carrying loads, it is necessary, besides the application of the regulatory standards, the system adequacy to ergonomic norms. Therefore, next, will be broached some rules for lifting and manual transport of loads.

### 8.1. Ergonomic standards for manual lifting of loads

According to Iida (2005), the recommendations for manual lifting of loads are:

- Keep the load as close as possible to the body, to reduce the moment of inertia (in the sense of Physics) caused by the load;
- Try to keep symmetrical loads, dividing them and using both hands;
- The load should be 40 cm above the floor; and
- Before you lift a weight, remove all the obstacles around, which may hinder the movements.

### 8.2. Ergonomic standards for manual transport of loads

According to Iida (2005), the recommendations for manual transport of loads are:

- Keep the load close to body;
- Provide adequate handholds;
- Work as a team;
- Get over the uneven floor;
- Use carts; and
- Use conveyors.

## 9. Analysis of parallels

According to the norms for the task of manual transport of loads, discussed before, it is recommended the use of wheelbarrows, carts or mechanic conveyors. Therefore, in this item, will be realized an analysis of some equipments aiming the knowledge of systems and subsystems that can be used as solutions to the product that is being proposed.

Carts for loads transporting:

At Figure 14, there is a car for cargoes transportation, made of steel, with internal dimensions of 390 × 510 × 690 mm and external of 410 × 560 × 780 mm (height × width × depth), and capacity for 130 l.

Positive points: it transports large capacity of loads and is made of resistant material.

Negative points: it is small.

## 10. Requirements and parameters

According to Bonsiepe (1984 apud PUERTO, 2005), the requirements of use are formulated as necessary features. Considering the priority degree, these requirements are subdivided into three classes:

- Requirements to be satisfied categorically;
- Desirable requirements; and
- Optional requirements.

Once formulated the requirements of use, follows the stage in which must be determined the parameters. The Table 1 shows the list of requirements and suggested parameters.

## 11. Generation of alternatives

Based on data survey, it reached to some solutions that may turn possible the development of tasks of loads transport and storage, with safety, and the improvement in the people mobility areas at boats.

### 11.1. Alternatives

At the first alternative (Figure 15), it is observed that two areas to store cargos were delimited in the main deck of a



Figure 14. Cart for boxes. Source: Plastitalia (2009).

Table 1. Recommendations of requirements and parameters.

Requirements of use	Parameters
Main deck must have easy and safe access.	Use ramp or ladder; non-skid surface, minimum width of 0.80 m; use guard net.
Main deck must have a safe place to store cargos.	Keep main deck clean and unobstructed; loads must be tied immediately after stowed.
The holds must have easy and safe access.	Stairs must be endowed with parapet or be equipped with steel cable parallel to the ladder.
The holds should have a safe place to store the cargos.	Keep the hold of the vessel in perfect condition of conservation and cleanliness; the lining of its surface must be regular and should offer balance to the load.
Equipment for manual transport of loads should be easy to handle.	Use casters; apply low level of complexity.
Equipment for manual transport of loads should be suitable for extreme users.	Apply dynamic anthropometry: percentile 05 and percentile 95.

vessel. These delimitations are made through wooden planks arranged horizontally, attached to columns, made of the same material, which reach the ceiling of the main deck.

At the second alternative (Figure 16), it is visualized a model of equipment for loads manual transport, made of steel tube and wooden planks. It has casters and anthropomorphic handles, what means that conforms to the anatomy of the stevedores' hands. Its base with dimensions of 300 × 450 × 650 mm (height × width × depth) can carry boxes with goods, avoiding workers to carry loads on their heads and columns.

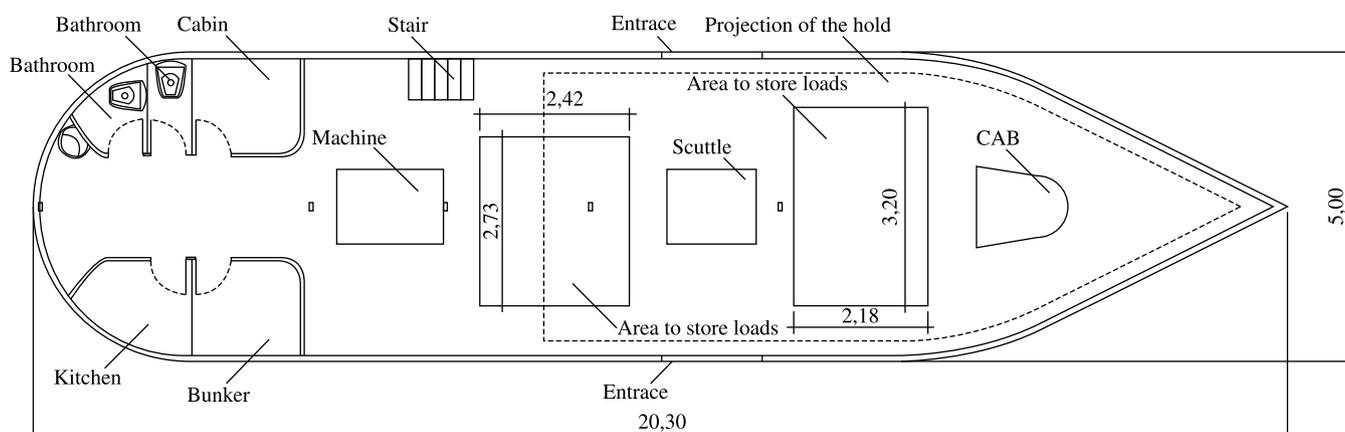
At Figure 17, it is perceived another model of equipment for manual transport of loads, made of steel tube and wooden planks. That cart can carry until three boxes of goods. It has four casters and flexible handles.

## 12. Final considerations

The presented article meets the main goal of promoting improvements in work conditions of mixed boats' users of Amazon State.

Through simple solutions, it is observed that changes are possible in the present situation of Amazon State waterway transportation, requiring, only, more government incentives and awareness by the users of this transport mode.

It is recommended the use of equipments, during the act of loading, when the weight exceeds 23 kg. Cargoes that weigh more than this are common to be seen during the loading task. However, this job must be observed, because some factors should be discussed and analyzed to make the work be the ideal. People should have similar heights and forces. Beyond that, the movements should be previously



**Figure 15.** Alternative for main deck.



**Figure 16.** Alternative of equipment for manual transport of cargos.



**Figure 17.** Alternative of equipment for manual transport of loads.

combined so that there is no risk during manipulation of these cargoes.

“The people involved in the handling of loads must be trained. Often, is difficult to change ingrained habits of movement.” (DUL; WEERDMEESTER, 2004, p. 31)

It is badly needed the use of equipment for lifting loads and for the development of transportation on regional ships. Equipments such as carts, levers, pulleys, cranes, among others, would be of great assistance to relieve stress and overcome any obstacles.

It is needed to create mechanisms that restrict the lifting of loads, because this activity does not meet ergonomic requirements and is the major cause of back pain among the workers. They depend of this activity, because there are few alternatives for economic support. Therefore, they should continue supporting the transport of cargoes, but using instruments, tools or methods of less aggression to health.

The activities of loading and unloading in ports of Amazon state do not have adequate systems, and this is evident in the made records. In these registers, stevedores handle the goods without any type of safety equipment or even signs to guide them during the development of their tasks.

Regarding the alternatives proposed in this article, it is verified that they are feasible to be adopted. However, their inclusion in the present environment transcends the technical analysis of engineering and ergonomics. Two factors stand out, among several:

- The shipbuilding at Amazonia, in the discussed segment, is strongly driven by empirical techniques. The builders do not have technical training; and
- The intervention in the stevedores' activities arouses concerns about reduction of services supply, with the introduction of systems to carriage support.

The two mentioned factors demand changes in educational and professional levels of the involved, because these elements represent a profound transformation in the “method” or *modus vivendi* of these workers.

### 13. Acknowledgments

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