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Modelling the grain terminal cargo supply process using the road transportation

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Abstract: *The largest share of operations in a specialized port terminal consists in grain supply processes usually delivered by motor trucks, on traditional road transportation means. In this respect, any process improvement could add value with a high impact against the terminal productivity. The traditional grain port operation technologies can no longer be used because the maritime business in particular requires new operating rules embedded by the integrated logistics variables, that ensure a shorter delivering time and an enhanced safety framework for cargo operation. Under these circumstances, the processes' automation using modern technologies of supply, internal transportation, storage and forwarding of cargo flow, permanently monitored with an accurate control of operations, have determined the modern silo functional model. Moreover, the specific operations in the terminal are not only performed by automated processes, but there are many interventions and activities dependent on the human factor. This paper comes with an element of novelty, depicting the most relevant sub-processes carried out in the process of receiving grains in the terminal, in case of road shipment by truck. The authors have developed a model on this scenario, under a logical and generally valid flow sequences, that can be used by both those who want to update the terminal effectiveness and those who forth seek to benefit from a modern terminal functionality, valuing the processes and subprocesses improvement potential, in order to increase the quality of actions taken and the labour productivity, by eliminating port operation congestion and ultimately increasing the operational profit.*

Keywords**:** *process, cargo reception, cargo handling, grain operation, port terminal, process modelling.*

1. Introduction

The objective of the paper is to create a conceptual model for the process of cargo receipt flow, using the road transportation by truck, based on specific data collected from specialized port operators with the element of cargo flow.

The process approach of specific operations and activities in a specialized port terminal is the essential element underlying the development of a general conceptual model valid for large logistics processes carried out by port operators: cargo receipt, storage and shipping.

The ongoing specialization of maritime vessels has also required the ports adaptation, based on updated equipment and technology of operating terminals. This is also the case of the terminals specialized in the grains' operation, about which the most important operation element is represented by the silo, a modern and technological structure for the receipt, storage and shipping of grains.

As definition, a process is a collection of related and structured tasks that produce a particular service or product to address a particular goal for a particular actor or set of actors. Process modelling has been done using computing technology and organizational development since the 1970s (Harmon P., 2014). The interest in modelling techniques went through different phases and through different approaches, briefly listed as following: structured analysis in the 1970s (Gane C., Sarson T., 1979), BPR (Business process re-engineering) at the end of the 1980s / early1990s (Hammer M., Champy J., 1993) and workflow management in the 1990s. Lately, with the development and spread of Business Process Management (BPM) (WfMC, 2000), the process modelling usage has increased even more, although it focuses mainly on a selected number of modelling approaches, such as Business Process Management Notation (BPMN).

The state of the system actually includes the processes, the organization and the links between the processes. These states are often modelled, and the state of the organization is perceived differently by different people through these models, so several areas of use of these models may be useful (Krogstie J., 2012), such as those shown in figure no. 1.

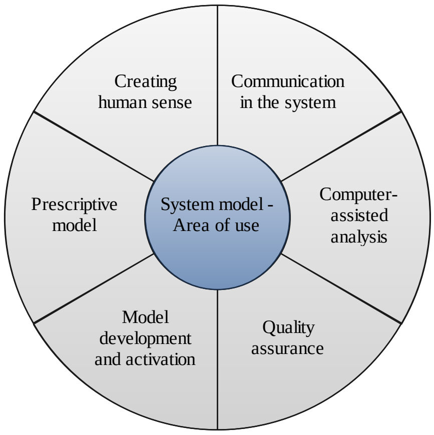

Figure no. 1 *System modelling areas of use (Krogstie J., 2012)*

The descriptive model of the current state of a system can be useful for specialists to understand and learn about the current perceived situation. The model can also play an important role in communication between people.

Computer-assisted analysis can be used to gain knowledge about the organization through simulation or deduction, often by comparing a model of the current state and a potentially better future model. Given that the model is based on a procedural approach in its construction, ISO certification compliance is ensured. The model can have a prescriptive role, which makes it useful in a traditional system development project, without being directly activated. (Aagesen G., Krogstie J., 2015)

2. Research methodology

Process management is not a new thinking approach in microeconomics or within corporate planning and control functions. Decades ago, the organization and management of business processes was studied and analysed by interested bodies in universities and business. Initiated by Michel Hammer and James Champy, BPM became a new concept of management in the 1990s. (Hammer M., Champy J., 1993)

Nowadays, the term BPM is indeed widely used, but often with different meanings, because there is no accepted common definition so far. On the one hand, process management is understood as a management perspective that deals with reengineering (radical redesign of business processes to dramatically improve indicators as: cost, quality, service, speed), optimization and standardization of system activities, case where appropriate methods focus on collecting, modelling, documenting and most importantly optimizing business processes independently by related IT support. On the other hand, process management includes tools and software products that are used in the organization for modelling, implementing and executing processes. From an IT point of view, the objective of process management has long been mainly the implementation of enterprise resource planning (ERP) systems, workflow automation and integration of IT landscapes through so-called “Enterprise Application Integration” tools - EAI. (Keller G, Teufel T, 1998)

Regarding BPM, IT experts produce business process models as a common language between managers and stakeholders (process analysts, engineers, users) (Dumas M. et al., 2013). Therefore, the business process should be structured in a flexible way to allow full use of enterprise IT systems (EIS) (Trkman P. et al., 2007). Consequently, numerous reference models and modelling methodologies have been developed in the field of EIS to support the requirement for business process modelling, development and implementation of information systems. However, they cannot support the coordination and interaction of process models in great detail. (Verdouw C. et al., 2011). No modelling construction fully covers all levels of system representation. Therefore, in order to clearly represent a process model from different aspects and to make them more intelligible for both the process analyst and the information system developers, it is necessary to choose a modelling language (Kim C.-H. et al., 2003). Therefore, the problem is to select the appropriate modelling language and to adapt it to both practical and theoretical aspects, that seems to be a deficiency in process modelling.

BPM is a specific language that includes concepts, methods, techniques and tools for the design, analysis, implementation and implementation of business processes (Weske M., 2012). Engineers also apply BPM in organizations as an optimization technique, and IT specialists, in order to execute and monitor the business process, consider that they offer a common language for communication with managers, process analysts and industry professionals (Dumas M. et al., 2013).

There are several stages in BPM for executing business processes and organizing the business process cycle, which is called the BPM life cycle, and process modelling is a foundation for the consecutive stages of the BPM life cycle (Mendling J., 2009). In addition, process modelling can be used to represent business logic in a more coherent way, to improve BPM, to support communication between business users and information system developers, to help the process analyst understand the field, in order to procurement of the organization's documentation and in order to prepare the requirements and the specifications for the information systems development, as well as a means of comparative evaluation of the system as a whole (Recker J., 2008). A flexible execution of business processes requires high quality modelling of syntactic and semantic formats, the sequence of activities, events and information flow (Verdouw C. et al., 2011). Therefore, an appropriate modelling language must be selected to represent a faithful and coherent conceptual model of business processes (Albani A., Dietz J.L., 2009).

Depending on the modelling perspective adopted in the organization's project and their purpose and scope, different techniques may be appropriate (Kunze M. et al., 2011), but the key criterion for selecting BPM should be understanding the models. Defining processes, documenting in the form of maps and models (understanding the processes) stabilizes the initial stage of BPM implementation and allows the organization to move to a higher level of maturity and achieve greater efficiency (Locamy A., McCormack K., 2004).

The process model, in a pragmatic approach, is well represented by the BPM technique when it supports an efficient cognitive process in reasoning with the model. The understanding of BPM, in this perspective, is the extent to which the technique can be understood by its users who have no specialized knowledge of the technique (Kock N. et al., 2009). A common measure of understanding BPM is the perceived ease of understanding a model (subjective measure) and correct answers on the content of the model (objective measure) (Gabryelczyk R., Jurczuk A., 2017). These measures describe the user's ability to read and interpret the process model prepared with a specific BPM technique.

Business Process Model and Notation (BPMN) is one of the most well-known standards for modelling and managing business processes, being extremely useful in the stages of defining and aligning software products. The goal of BPMN is to provide a unified set of elements and notations that are easy to understand and use by all participants in the delivery process.

Since 2004, the first version of BPMN has been presented as the standard notation of business process modelling. Since then, BPMN has been evaluated in various ways by the academic community and has become widely supported in the industry (Evequoz F., Sterren C. 2011).

BPMN provides easy-to-understand scoring for all business users, from business analysts who create the initial process design, to technical developers responsible for implementing the technology that will support the performance of those processes, and finally to business people who will manage and monitor those processes (White S.A., 2004).

The working tool for modelling the cargo receipt process is AuraPortal Helium Modeler, a process modelling program that has adopted the BPMN 2.0 standard for the process modelling class, with some additional custom developments. AuraPortal Helium Modeler has adopted the international standard Business Process Modelling Notation (v2.0) BPMN for the process modelling class, with some additional custom developments (e.g. collectors and checkpoints) covering certain BPMN deficiencies and significantly increases power. AuraPortal Helium Modeler is the new process modeler included in AuraPortal Helium, which allows users to design their own processes, being one of the most complete modelers available on the market based on the BPMN 2.0 standard.

3. Research results

3.1 Flow of operations

Numerous economic agents operate in large ports whose main object of activity is the cargo operation, among which, for dry bulk goods category, the grains provide an important share, being operated in specialized terminals located in the vicinity of river and sea basins for loading or unloading, both Panamax and river type vessels with direct transhipment on barges.

The operation and storage of grains is done by using specialized berths, with depths between 7 and 15 meters and the storage of grains is done in modern silos and warehouses that must ensure the necessary capacity for timely and safe delivery to beneficiaries.

The technological flow is the chaining of the following processes that ensure the safe transfer of grains from sender to recipient, as depicted in figure no. 2.

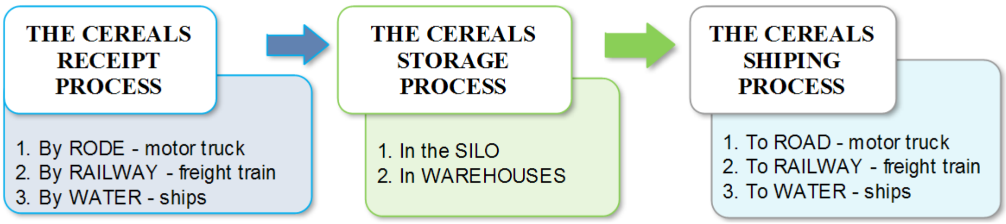

Figure no. 2 *The flow of grain transfer from consignor to beneficiary*

The receipt of grains represents the activity through which the grains arriving at the terminal are taken over by the specialized facilities of the silo, being further transferred to the storage spaces, assigned for the compartmentalization of those types of products.

Grain storage is the activity by which grains destined for the same compartmentation are transferred to specially designated spaces after they have been weighed. The process of storing grains overlaps with the process of preserving them, which is an extensive process that must be followed over time in order to have a clear picture of the evolution of the physical and chemical condition of the grains.

The delivery process must be well coordinated between the main operator, the operator on board the ship and the ship's management in order to comply with all normal procedures for loading a ship.

Given that the largest amount of grain arrives at the terminal by truck and consequently most operations are carried out on the reception flow of goods brought by trucks, it is necessary to develop a procedural model for simulation to seek for the optimum ways to improve the process of receiving by truck.

The other processes, storage and shipment, are independent of the receipt process and for storage a model will be built in order to find solutions to optimize the safety of grain storage. Consequently, for shipment the model for cargo flow on the ship will be built,being the most common used with the largest share in the operating volume of grains in silage, also for the same reasons in terms of finding solutions to improve processes.

The main processes that contribute to establishing the flow of grains arriving at the terminal by truck are outlined in figure no. 3.

The access of the motor trucks in the terminal can be assured only after they have passed two compulsory operational filters:
- The first to determine the mass of the grain loads,
- The second that determines the quality and conformity of the cargo loads.

After the truck weighing, they are directed to the sampling points. It would be preferable for sampling to take place before weighing because in case of non-compliance the weighing process would be automatically cancelled. If the goods comply and meet the required quality parameters, the truck is directed to the discharging ramp. Otherwise the truck is not received at the terminal, the dispatched load being rejected and the grain trader informed accordingly.

Figure no. 3 *Grain loads flow at arriving stages at the specialized terminal*

The truck unloading ledge must have several access lanes to which the unloading feed hopper must correspond in order to ensure the simultaneous discharging of several trucks. Also, each hopper must have a capacity of at least 30 m^3 to take over the load of a truck, regulated at 25 tons of cargo, ensuring a theoretical capacity to receipt the goods in accordance with the designed facility.

The goods in the hopper are taken over by chain conveyors fed by frequency converters to ensure the adjustment of the speed of the conveying line movement, according to the quantity of load available in the hoppers, measured by means of level sensors (maximum and minimum) mounted on each bunker.

Adjusting the travel speed of the conveyor chain allows for greater accuracy in adjusting grain uptake without leading to an overload for existing downstream equipment on the flow. The use of frequency converters also allows repeated starts / stops of the conveyors, a frequent operation in the case of truck reception because, especially in the off-season, there is a low cadence of reception of trucks at unloading.

Under environmental conditions, each hopper must be equipped with a dust collection system (circular bag filter, centrifugal fan, dust lock, dust collection and distribution piping system) resulting from the unloading of trucks. The dust collected by these cleaning systems is reintroduced into the goods circuit being injected into the system of chain conveyors. For the automatic cleaning of the bags, each filter must be connected to a system, preferably centralized with compressed air.

Grain unloaded from trucks and picked up by chain conveyors is transferred to elevators, which must have a capacity similar to that handled by chain conveyors. The control of the way in which the grains are taken over and directed on the elevators, in order to achieve a constant flow between the two transport systems - horizontal and vertical - can be achieved through a system of electric valves arranged at the mouth of the elevators. Also, on the elevating system, to limit the dust emissions, at the base and at the top, local dust filters (point filters with bags) must be provided, connected to the centralized compressed air system for cleaning the bags.

Once at the top of the elevator, the grain is unloaded by gravity through the piping system and guided by electric deflector flaps to the silage cells or to direct loading flows to the ship by means of chain conveyors that transport the grain load over the silage cells. As dust accumulates when goods move by gravity, even in closed circuits, to comply with environmental requirements, chain conveyors must be equipped with local dust filters that absorb dust and then reintroduce it into the grain circuit.

In order to distribute the goods in the cells, the chain conveyors located above the silage cells must be equipped with monitoring and control equipment to allow the operator to operate the route(s) established by the port operator's directives.

3.2 Establishing entities and defining them within the model of the reception process

From the description of the receipt flow of grains arriving at the terminal by motor trucks results a number of subprocesses, operations and activities that contribute to the development in good conditions, in a logical and efficient way of the cargo receipt process.

The whole process must be triggered by the notice of the port operator extended by the grain trader about the arrival of the motor truck in the terminal. Ideally, the operator should be notified in due time by a message containing all the data in the notice accompanying the cargo: data about the supplier, transporter and the final consignee, information regarding the cargo type, quality, quantity (gross, country, net) and number truck data. Further these data will be entered into the port operator's system for next identification and, more importantly, according to the type and quality of the goods, for planning for unloading.

Once the motor truck has arrived, the procedure for verifying the notice accompanying the cargo is started at the access gate by comparing the data obtained in advance from the shipping company and by presenting the weighing ticket (approved proof of quantity). If the data do not match, the operator notifies the beneficiary (grain trader) who in turn notifies the supplier. The compliance and claiming procedure are not subject to the activity of the port operator.

If the data match, the cargo sampling subprocess is initiated to determine the quality of the grains. The subprocess operations are performed by an independent operator contracted by the port agent and one contracted by the trader. Ideally, there may be only one operator approved by the two entities - the port operator and the grain trader. If the goods do not correspond qualitatively, the truck is directed to the exit of the terminal and the trader is notified about the non-compliance. If the cargo correspond qualitatively, but depending on the degree of load purity, the truck is assigned to a certain silage cell where it is allowed to discharge, the driver being notified about this operation.

The truck that has accepted permission to enter the terminal is directed to go through the weighing procedure. The truck is weighed at the entrance to the terminal (raw) and this value is recorded regardless of what is written on the scale ticket presented at registration. After unloading the goods, at the exit of the terminal the truck is weighed again to determine by subtracting from the gross the quantity of grain delivered in the silo (net).

After weighing, the truck is directed to the unloading point on a route established by the port operator and marked accordingly as the entry route. At the point of unloading, depending on the availability of the silage cell established after sampling, the truck is assigned a single ramp where it will unload the cargo taking into account the order of arrival.

After unloading the grain, the motor truck will be directed to the exit gate of the terminal on a route established by the port operator and appropriately marked as the exit route, at the end of which it will be weighed to determine the quantity of silage.

The flow of goods received by truck continues through the process of loading the silage cells (figure no. 4), a fully automated process with command and control possibilities performed by the silo operator.

The first sub-process is the management of grains in the truck unloading hopper through which the first filtration of the load takes place, the first action of collecting dust resulting from the unloading of trucks and through which, with the help of level sensors, the capacity to take over the goods is established further in flow.

Horizontal flow management ensures the transport of grain from the hopper through a system of chain conveyors whose speed is automatically adjusted to the flow controlled by the level sensors in the pick-up hopper and the reintroduction of dust into the circuit.

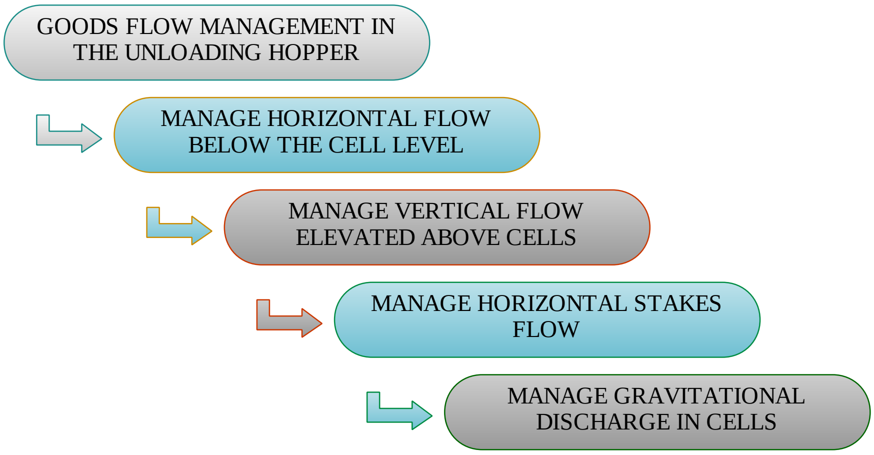

Figure no. 4 *The process of loading silage cells*

The vertical flow management subprocess ensures the transfer of the goods from the horizontal conveyor belts, the vertical transport of the grains through bucket elevators and the second dust collection action through the two local dust filters (at the base and at the top). The horizontal flow management sub-process on the trestle ensures the transfer of goods from elevators, the horizontal transport of grain by chain conveyors and the reintroduction of dust into the circuit.

In order to ensure the gravitational unloading of the goods through the piping system and guidance through electric deflection flaps to the silage cells, the routes predetermined by the silo operator according to the type of goods are monitored for each cell and the information received is taken into account from the level sensors in the operated cells.

3.3 Model of the receipt process of grains loads arriving at the terminal by motor truck (cargo flow at reception by truck)

Using the previous information through which were established and defined the subprocesses that contribute to the reception process of grains arriving at the terminal by truck, a modelling object will be assigned to each activity/operation/event to achieve the entire process flow chart, according to the data from table no. 1.

The integrated model of the process of receiving the grains arriving at the terminal by truck is represented in figure no. 5.

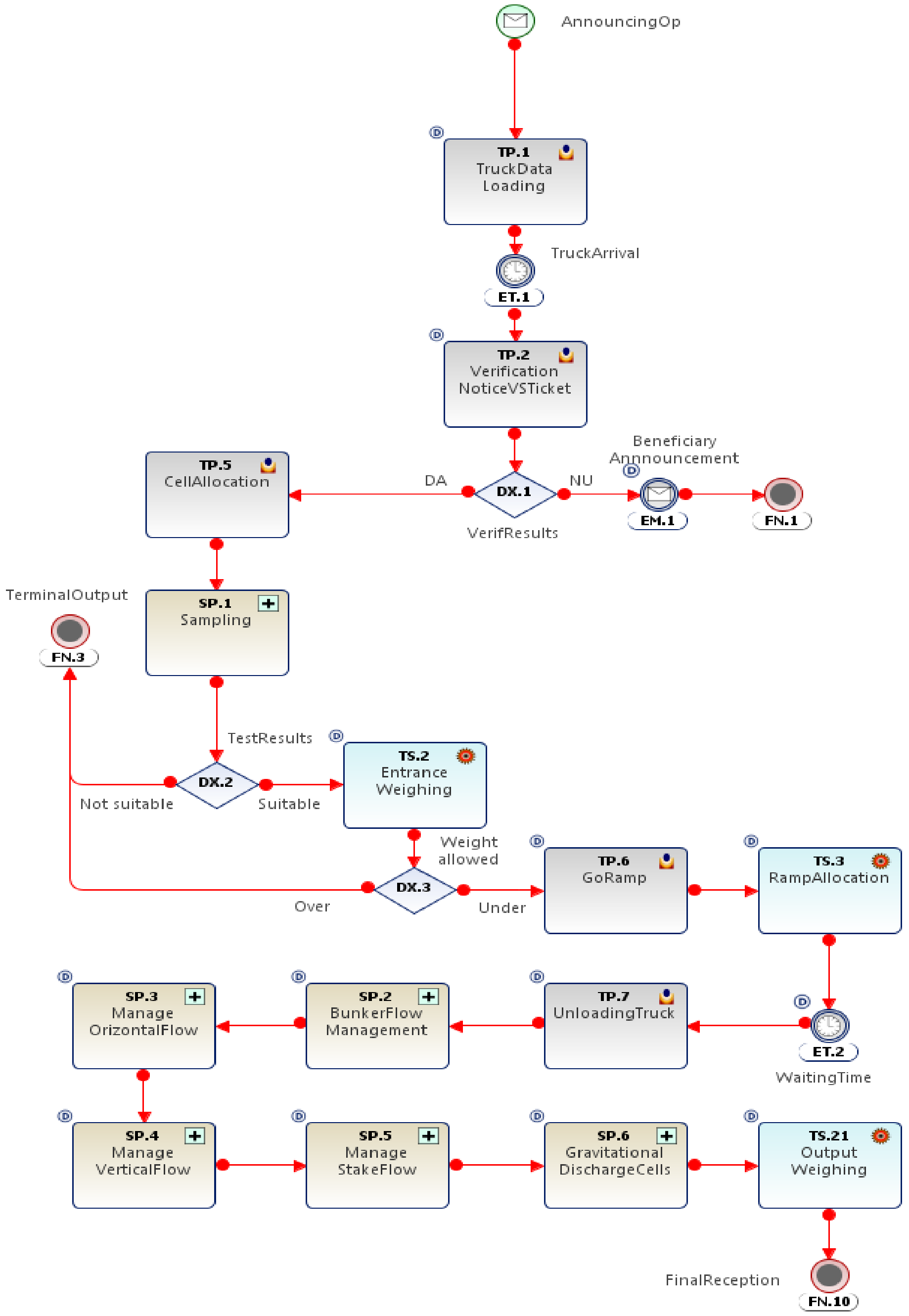

Figure no. 5 *Model of the process of grains loads receipt arriving at the port terminal by motor truck*

4. Conclusions

The activity in a specialized grains port terminal is a chain of logistics processes oriented towards a common goal of reducing the operating time of ships. Thanks to automation and modern command and control systems, the grain silo in the terminal is by far the best variable of port operation efficiency and effectiveness in terms of operational productivity.

But, within the grain loads receipt processes in the port terminal, not only automatic and automated operations are performed, but also activities that involve tasks and resources occur, that are not always optimized because they depend on both internal and external factors. The largest share of operations in a port terminal specializing in grains loads storage and handling, has the process of cargo receipt by motor truck and consequently, whatever the value obtained, this process would have the greatest impact on the productivity of the terminal. The present research has been focused on the grain cargo receipt process arriving at the terminal by motor truck, where, during the agricultural season and during the months following, there is a high inflow of trucks, which involves frequent operations of relatively small loads (25 tons/hopper truck) and fairly frequent changes in the types of cargo that transposed into stops and resumption of technological flow in the silo.

The development of a process model in a grain terminal - focused only on the use of the silo as a receipt, storage and dispatch entity due to its efficiency in terms of labour productivity - allows, through the procedural approach, to determine the flow of cargo from consignor to the consignee/ beneficiary and the definition of all activities that contribute to the fluidity of the flow, summing up the level of load. It is also possible to establish the elements of conditionality and alert levels - of resources and time - for certain activities or tasks in order to find solutions through simulation, for optimizing processes in order to reduce operating time and, implicitly, to enhance the operational profit.

The establishment of the processes with the operations, activities and tasks corresponding to each specific loading/ discharging flow has allowed the development of a model for the cargo loads receipt process which represents a unique result, which facilitate, without high costs necessary in case of actual application, the identification of congestion areas, analysis of the causes of their occurrence, guiding for solutions to prior improve the processes in a virtual environment, through the mathematical calculus, associated with various simulation methods.

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