Port Logistics: Improvement of Import Process Using RFID

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Abstract. This paper describes a new system developed to improve the import process of steel coils driven into a port terminal in the Port of Bilbao. A new RFID based system minimizes mistakes in identification of the coils during the inland movements of goods.

Keywords: RFID system · Tracking system · Port logistics · Steel coil

1 Introduction

Logistic has become a defining factor in industry 4.0. Around 90% of the worlds merchandize and commodity trade is transported by ship. During last years, ports have made an enormous effort on digitization, developing infrastructure to apply advanced techniques for collection and analysis of information [1, 2]. However, the investment cannot be profitable while port operators lack systems to automatically integrate information about their processes [3].

This paper describes a new system developed to improve the import process of steel coils driven into a port terminal in the Port of Bilbao. The large number of coils transported complicates all different tasks associated with its intermediate storage until they are sent to destination by road or rail. This translates into a significant error rate in shipments while coil improper handling can cause defects in the goods. The project developed uses radio frequency identification to validate the various stages in the import process and provides the technological infrastructure for real-time reporting of the execution of tasks [4].

2 Problem Description

Although historically the city of Bilbao has a great tradition in the manufacture of steel, now the crisis of the sector demands the importation of a great number of coils to supply the industry, mainly automotive, of the north and center of Spain. The Port of Bilbao is one of the main entrees of the country for steel coils, that are transported by road or rail to destination, accounting for 15% of total port traffic.

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Although the average stay in the harbor of a coil is less than two weeks, some coils can remain in the port warehouse for several months. During this period, intermediate movements often take place to facilitate access to adjacent coils. These actions, usually executed by the terminal staff without notification, lead to a progressive uncontrolled stock that can cause errors when identifying a specific coil. Main features of coils consist in material, thickness of turn, weight and width. The inland operations can cause damages in the 2D codes that turn the identification in a very hard task. It is quite common that during the final inspection, which is carried out when the coils are loaded on the trucks or wagons, errors are detected that entail an important loss of time until the real coils demanded are finally located and loaded. It is therefore necessary to develop a system to maintain the location of the coils updated and ensure the correct identification of each coil transported. In addition, one of the main requirements is to achieve this objective without significantly altering the operation of the terminal staff.

3 Functional Description

The project covers all the activity of the port terminal, guaranteeing the traceability of the coils since they are unloaded from the vessels until they leave the port. For this purpose, the project is divided into three fundamental stages: ship unloading, intermediate movements and terminal exit.

3.1 Ship Unloading

Unfortunately, each supplier uses a different identification system, always consisting of simple or two-dimensional bar codes. Currently the project is limited to the coils intended for the automobile industry that are purchased from supplier Tata Steel. Due to the quality and the high price of these coils, the terminal stores them in an intelligent warehouse that constitutes a key piece of the project.

The integration of the project with the port ERP deployed in the terminal is necessary. Technicians from the Basque company ADUR, developers of ERP TRANSKAL, have participated in the definition of the project to facilitate its integration and portability to other terminals.

This stage covers the unloading of the coils from the vessels and includes the attachment to the coils of the RFID tag to achieve the traceability during the rest of stages. For its execution, an application has been developed on the mobile computer used by the worker in charge of supervising the unload operation.

During this stage the worker must perform next tasks with the help of the mobile computer:

- Once the application is opened, the worker must authenticate and select the vessel to unload. ERP provides a REST service providing all the features of the expected coils.

- The operator must board the ship and proceed with a visual inspection of each coil. The application allows to associate each coil to the list through the bar code being able to add considerations and photographs on the status of the coil prior to discharge when any defect is detected.
- Once the preliminary inspection is finished, starts the unload. This task is carried out entirely by the port staff, hired by the terminal. Each time a coil lands on the dock, the operator must perform another visual inspection to detect any defects caused during the unload. Again, the application includes incident report with multimedia. Once the coil is marked as unloaded, the operator takes out a RFID tag from a bag and places it in a front of the coil, preferably over a freight. The mobile computer includes an UHF module allowing to map the RFID EPC with the bar code in the project data base.

Every time a coil is unloaded, the application reports in real time not only to the port terminal but also to the port authority, providing important info that can improve the planning about the vessel stay in the port.

3.2 Intermediate Movements

This stage includes all the displacements of the coils during their stay in the port. Transfers are always done by forklifts or by the automated warehouse crane. Therefore, the coil boom of the trucks and the crane hook have been equipped with an embedded RFID reader capable of detecting the loaded coil.

An embedded platform is powered on when the truck has started. The RFID reader includes two miniatured ceramic antennas placed in both sides to detect the tag on either side of the coil. The reader performs a continuous interrogating and when a tag is detected, the system saves the position and keeps interrogating until the tag is missed. Then the embedded platform posts to the cloud server initial and end positions, logging the travelling and updating the real position of the coil. As the GPS signal is lost when a truck enters the warehouse, in that case the system assumes it has been placed in to the internal storage area, waiting to be stored by the crane.

Although the terminal owns an intelligent warehouse, always a crane operator oversees the process. Every time the crane is started it gets from the ERP a list of tasks to be done. The list of coils that need to be moved is also sent to the embedded platform that manages the RFID reader placed over the hook crane. If the reader detects a coil not included in the list, a red light is turned on to alert the crane operator of a possible mistake. The functionality of the crane RFID system is like the one deployed over the forklifts. Every time a tag is missed, the system posts the coordinates of the crane to update the coils map of the warehouse.

The crane operator can always access to the information of the raised coil. Sometimes, as the coils are stored up to three levels, a movement of a specific coil implies an intermediary displacement of those are over it. In this case, Although, such a situation turns on the alert, the operator can obviate it and new location of the displaced coils are automatically updated.

Finally, the operation differs between the coils being transported by road or rail. The open trucks can enter the warehouse and the crane is responsible for loading the coils directly. However, the coils which are transported to destination by rail are arranged in the transit area of the warehouse to be loaded on the railroad wagons by forklifts.

3.3 Terminal Exit

Currently the shipping process is similar to the unloading process. Through an application, an operator of the port terminal oversees the coils loaded in each trailer or wagon to document through photographs any defects that are identified in them. Finally, the operator enters the license plate of the truck or wagon and scans the loaded coils. The application sends the information to the server receiving confirmation or notifying an error about the schedule. Once the load of a truck or railway is completed and verified, application notifies the port terminal and port authority the exit of the transport.

4 Implementation Details

The development of the global system has required to implement two main subsystems: the handheld application and the RFID embedded reader. In addition, the conditions of stored merchandise, steel coils, posed a technological challenge when using a technology based on radiofrequency. It was necessary to perform an analysis of the behavior of different RFID tags in the project scenario.

4.1 RFID Tag Analysis

Although designing RFID tags for metallic objects with satisfactory performance is still a challenge [5, 6], there are several alternatives in the market designed to operate under these characteristics. Far from designing a custom antenna, the analysis carried out within the project aims to validate the behavior of some UHF frequency RFID tags for commercially widespread metal surfaces. The study was carried out by analyzing the behavior of each label located on the outer surface of the coil, on one of its faces and in the inner hole. Table 1 shows the behavior of each tag type evaluated at different distances with the tag placed over the frontal side of the coil. For the tests, a VEGA reader from Thingmagic has been used as RFID reader with an omnidirectional 9dbi antenna (Fig. 1).

Table 1. RSSI signal received in the RFID reader at different distances by tested tags

Tag	1 m	2 m	3 m	4 m	5 m
Confidex Ironside	−26	−30	−39	-	-
Confidex Ironside Micro	−29	−36	-	-	-
Confidex Survivor	−26	−29	−33	−36	−39
M 116431 Gao	−28	−32	−37	−39	-
Confidex Carrier Tough	−29	−32	−36	−41	-

Fig. 1. Image captured during the analysis of the tags behavior.

As can be seen in Table 1, the results vary markedly among the labels used. As a result, the label chosen for the development of the pilot, due to its significantly cheaper price, was the “Confidex Carrier”. A label for conventional use that is glued to the coil using a methacrylate insulation with 1 cm thick.

One of the main problems was to locate the optimum position of the RFID tag on the coil. Unfortunately, any possible position includes potential risks. The location on the inside of the coil was ruled out by its poor electromagnetic behavior. In addition, the frictions caused with cylinder of the forklift can damage the device. In this sense, as it is usual to stack coils at various levels, and they are located supported by each other, it was decided to avoid their placement on the outside of the coil. Therefore, the best alternative is to place the label on one side of the coil. This involves placing two antennas at both ends of the forklift cylinder and on both sides of the crane hook.

4.2 Handheld Application

For the mobile application, the help of the developers of the ERP system deployed in the port terminal was required. Instead of developing an application from scratch, was carried out an update of the current application that was being used to validate the unload of the coils. In the ERP database, a new field was created in the table storing the coils to include the EPCGlobal identifier of the RFID tag associated with each coil. The “Zebra Workabout 4” (Fig. 2) mobile computer provides an RFID reader in UHF band, which avoids using an external reader complicating the task of the operator. The read range of the handheld can be set up to only access to the tag attached to nearest coil avoiding mistakes in the matching [7]. After the update, the operator must identify the coil using the bar code and associate the RFID tag with the integrated reader.

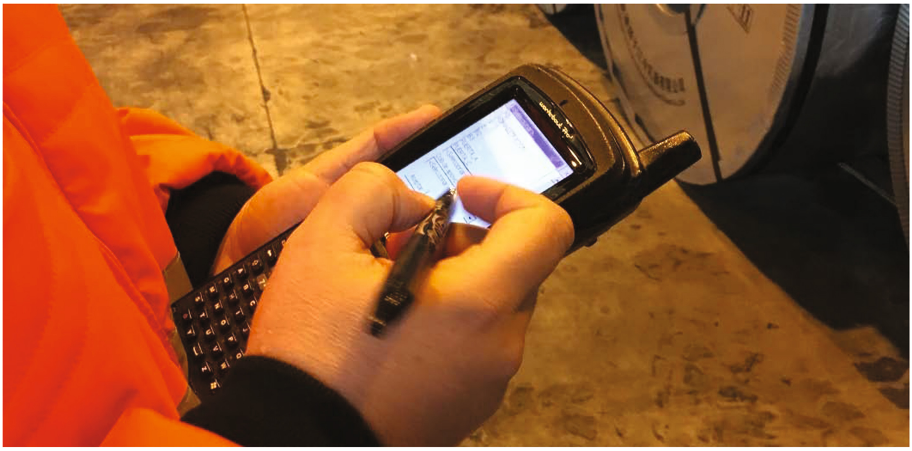

Fig. 2. Operator of the port terminal validating the unloading of a set of coils.

4.3 Embedded RFID Reader

A forklift and a crane have been equipped with an embedded RFID reader during the pilot (Fig. 3). System is composed of an M6e RFID reader from Thingmagic and a Raspberry Pi 3, responsible for providing the system functionality. This component of the system is fundamental to maintain an updated map of the warehouse [8].

Fig. 3. Image of the crane and forklift used in the pilot.

The M6e embedded reader is a small size high performance RFID reader that provides Support for two monostatic RF antennas and read and write levels, command adjustable from −5 dBm to +30 dBm. Connection with the Raspberry Pi is done by an UART port.

Algorithm in the embedded platform is divided in separated processes. A daemon process is continuously interrogating for RFID tags and provides, using the distributed object middleware for Python Pyro4 [9], current tags in the scope of the reader and the Received Signal Strength Indication (RSSI). Another Pyro4 enabled process, provides the current location of the forklift from a GPS module or the X-Y-Z coordinates of the crane provided by the SIEMENS PLC deployed in the crane through a Modbus connection. A third process, responsible of the business layer analyses the coils detected and location of the system to detect the coil movements performed. The ERP provides a web service to push every movement detected over an individual coil to guarantee the real-time tracking of all labelled coils in the warehouse.

5 Conclusion

To optimize the warehouse management, every single movement of any coil is conveniently reported to the adopted Port ERP, keeping the location always updated. This automatic generation of a map of coils drastically reduces the time spent by operators in locating the requested units and the number of intermediate movements in the warehouse. Also, failures due to misidentification of coils are removed. The port community system of the Port of Bilbao receives detailed information about the unload of ships process allowing anticipate disagreements with planning that may affect the transit of other ships. Finally, the port authority and customs authority receive updated input and output of trucks in the terminal.

Furthermore, RFID eradicates mistaken coil transport reducing significantly the error rate.

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