Integration of Information Technology and Automation: Facilitators and Barriers

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Abstract: - Information Technology (IT) should effectively assist business strategies of companies, being a crucial factor for success. The difficulty of integration has brought software providers to develop integrated solutions to provide a common user interface and data management system. These Systems are referred as Manufacturing Execution System (MES).

Automation Technology (AT) includes all hardware and software of an automated industrial plant, which includes Programmable Logic Controllers, Industrial Networks, Supervisory Systems, and all software licenses necessary to run the system.

The integration of IT with AT provides data from the ground-floor to the management level of enterprises. Owing to the advance of technology, hardware and software architecture, automation systems enable the acquisition of a huge quantity of information that can assist in decision-making of companies. Integration models are presented, along with the main facilitators and barriers of the integration between IT and AT and suggestions for future work in this area.

Key-Words: - Information technology, automation technology, MES, automation and enterprise integration.

1 Introduction

Due to an increasingly competitive world, companies are looking for continuous improvement in its processes. The literature suggests that the alignment between business and information technology is necessary for the competitiveness of any company [1].

Numerous articles on the subject of strategic alignment of information technology and information systems have been published in the last few years. Some authors make the distinction between Information Technology and Information Systems. While some authors consider that the first is confined to technical aspects, and the second considers the flow of work, people and information. Others consider the concept of Information Technology (IT) in a broader sense, as it will be adopted in this paper.

IT has evolved from an administrative support tool to a more strategic role within the organization. IT strategic competitive weapon is used to support existing business operations, but also makes possible new business strategies [2].

The use of IT as a competitive advantage is discussed by Kearns & Lederer (2004) [3].

In the other hand, automation of productive industrial plants also allows a more sophisticated and efficient administration. Thus, the integration of automated systems with database and therefore the dynamic between shop floor and IT becomes an important tool for industry. This integration is an important prerequisite for improving [4]: flexibility, agility, efficiency, quality, cost, productivity, energy rationalization and rework reduction.

A frequent considerable problem is that a lot of information does not create any knowledge.

Nowadays some companies are investing a lot of money and effort to integrate IT and AT. However some companies have not been achieving the success they expected.

This paper presents a study about the existing integration models and facilitators and barriers of integration. Furthermore, suggestions are presented for future works in the area.

2 Integration models

The main integration models are presented: CIM, MESA International and S-95.

2.1 Computer Integrated Manufacturing (CIM)

The use of computer in manufacturing started approximately fifty years ago and it continued to be updated in the last decades [5].
The objective of CIM (Computer Integrated Manufacturing) was the integration of various islands of automation [6].
To simplify model understanding, a hierarchical model representation was created and represented by a hierarchical pyramid.
There are several versions of this pyramid. Figure 1 shows the representation proposed by Webb [7], where the pyramid is composed by five levels of automation.
Table 1 shows devices and systems of each automation level.

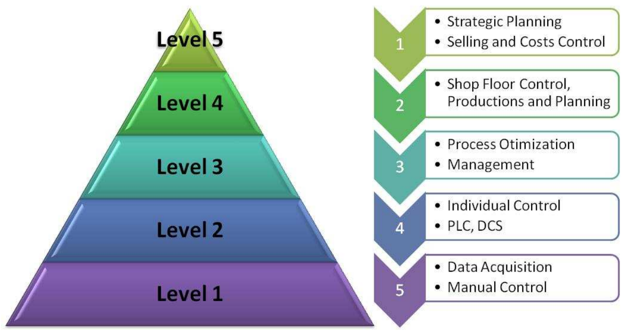

Figure 1 – Levels of Automation Hierarchy

Level	Devices/Systems
5	ERP (Enterprise Resources Planning)
4	MES (Manufacturing Enterprise Systems), MRP (Material Requirement Planning)
3	Supervisory Systems
2	Programmable Logic Controllers (PLCs), DCSs
1	Sensors, buttons, drivers, etc.

Table 1 – Devices according to automation levels

2.2 Manufacturing Executions Systems Association (MESA)

ERP (Enterprise Resource Planning) is derived from MRP II (Materials Requirement Planning) and it is commonly seen as a successor of CIM (5).
Figure 2 shows the plant information model according to MESA (8).
The definition of MES by MESA International is [8]:
"Manufacturing Execution Systems (MES) deliver information that enables the optimization of production activities from order launch to finished goods.
Using current and accurate data, MES guides, initiates, responds to, and reports on plant activities as they occur. The resulting rapid response to changing conditions, coupled with a focus on reducing non value-added activities, drives effective plant operations and processes. MES improves the return on operational assets as well as on-time delivery, inventory turns, gross margin, and cash flow performance. MES provides mission-critical information about production activities across the enterprise and supply chain via bi-directional communications."

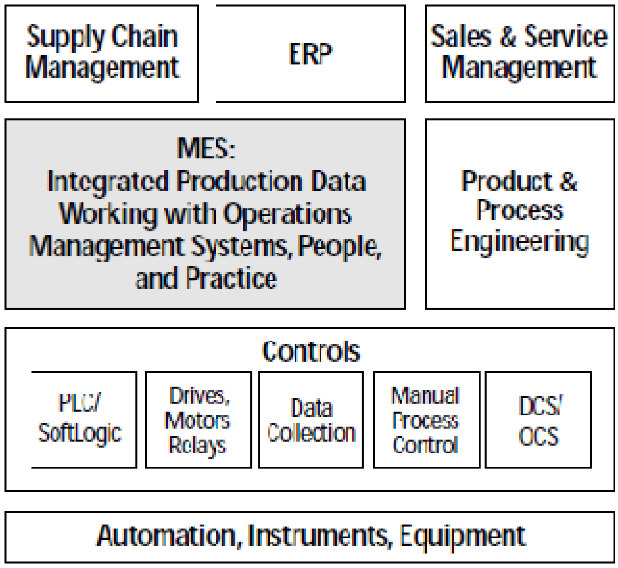

Figure 2 – Plant information Model according to MESA (8)

2.3 International Society of Automation (ISA 95)

ISA-S95 is a multi part standard for Enterprise/Control System Integration. It applies to Batch, Continuous and Discrete processes.
ISA-95 models and terminology can be used to determine which information has to be exchanged between systems for sales, finance and logistics and systems for production, maintenance and quality (9).
ISA-95 standard can be used for several purposes, for example as a guide for the definition of user requirements, for the selection of MES suppliers and as a basis for the development of MES systems and databases [9].
ISA-95 did not start from the first beginning, as long as it considers others standards in its development. Three works influenced ISA-95: ISA-88 (Batch Control), Purdue Reference Model for CIM and the MESA International for MES context model.
Figure 3 shows S-95 model that is composed by four levels.

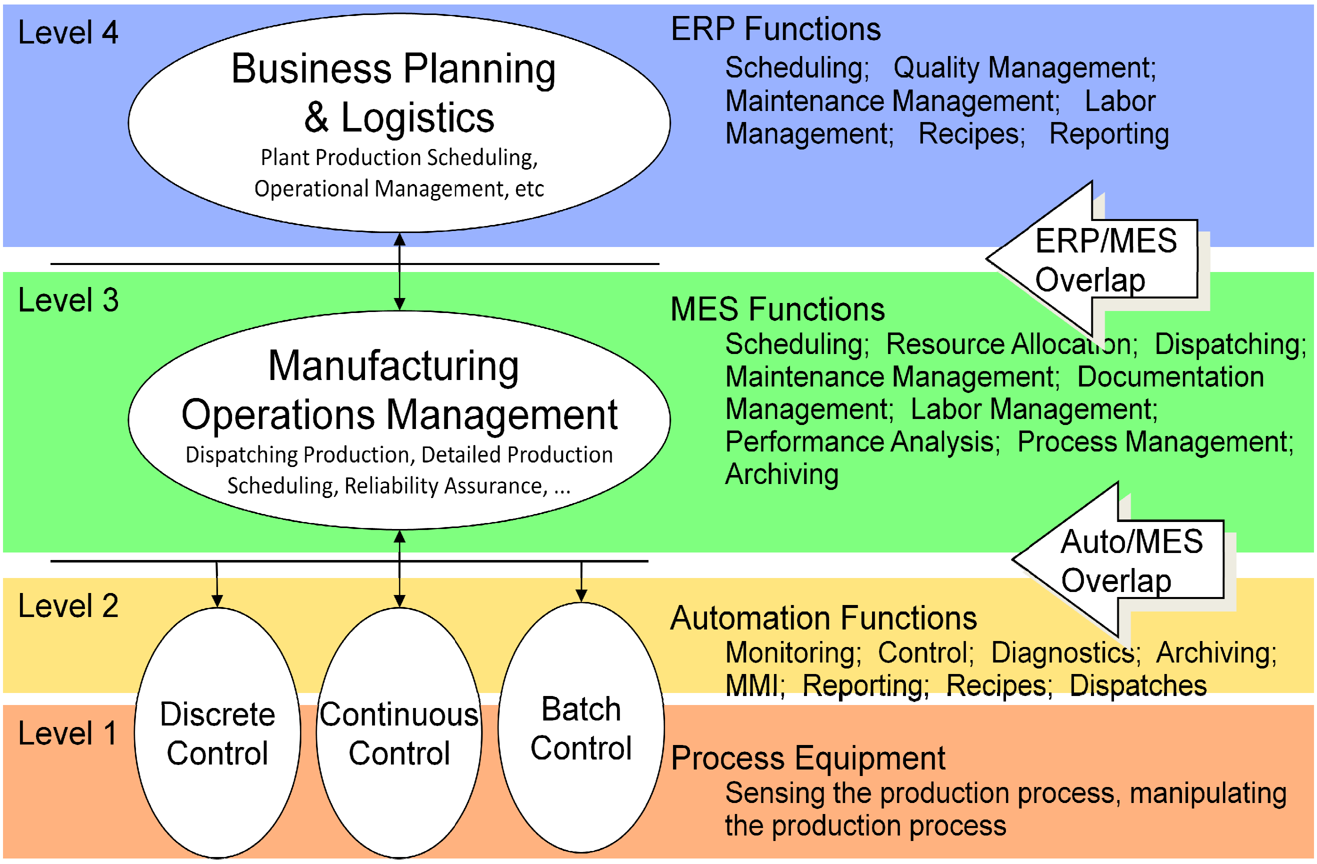

Figure 3 - S-95 Model (9)

Figure 4 presents MES identified 11 main functions [10]. The functions are: Scheduling, Resource Allocation and Status, Performance Analysis, Product Tracking and Genealogy, Maintenance Management, Dispatching Production Unities, Quality Management, Labour Management, Data Collection/Acquisition, Document Control and Process Management.
The identification of critical interactions between different parts of MES is the major contribution of S95 Model [8].

3 Integration Aspects

Integration is important to organize humans and machines as a whole system [11]. By integration, it means communication and interoperability from shop floor to management systems.
The benefit of integration can be different for each company, but some factors will apply to most of them [10]:

- Visibility of processes;
- Ability to make them more responsive;
- Provision of track;
- Trace capabilities.

Information and communication technologies will be the core in new developments. Fundamental requirements to the applications and systems are [12]:

- Enterprise integration and interoperability;
- Distributed organization;
- Model-based monitor and control;
- Heterogeneous environments;
- Open and dynamic structure;
- Cooperation;
- Human integration with software and hardware;
- Agility, scalability and fault tolerance.

MES function is to meet the requirements of fully computerized and automated integration; in contrast to this major problems remain due to the interface between the enterprise corporate level and shop floor [11].
Standard IEEE C37.1, whose last revision was in 2007, provides the basis for the definition, specification, performance analysis and application of SCADA and automation systems for electrical substations [13]. The first SCADA systems were basically telemetric [14] and allowed to inform periodically the current status of industrial processes, only monitoring signals of representative measurements and states of devices across a panel of lights and indicators, and had no application interface with the operator.
Briefly, SCADA systems are composed of: RTUs (Remote Telemetry Units) or controllers,

communication, master station and HMI (Human Machine Interface). Typically, a SCADA system is composed of at least one master station and one or more controllers or RTUs.
Nowadays, SCADA master stations have modern hardware and software in distributed architecture. Power processing is distributed among several computers and servers that communicate via local area network (LAN).
The use of Ethernet facilitated the communication of shop floor to management level of enterprises. Nevertheless, there are companies which do not allow corporate network connection with the network industry.
MES companies are developing some enhancements, such as integration, scalability and graphical configuration [8].
Advances in networking computing (network protocols, internet, intranet and extranet) and software technologies (object, components, client/server architecture, CORBA, ActiveX, XML, XSLT, SOAP) enable the development of MES [10].
Security and system integrity are the main reasons for the fact that there are companies that do not allow this communication yet.
In the other hand, some enterprises that adopted connection of networks are experiencing an unexpected problem: after the implementation of communication and deployment of last generation automation systems, a lot of data stored, however transformation of data into information for use to generate benefits to the company is not implemented.
The installation and administration of large heterogeneous IT infrastructures are becoming more complex and time consuming [15].

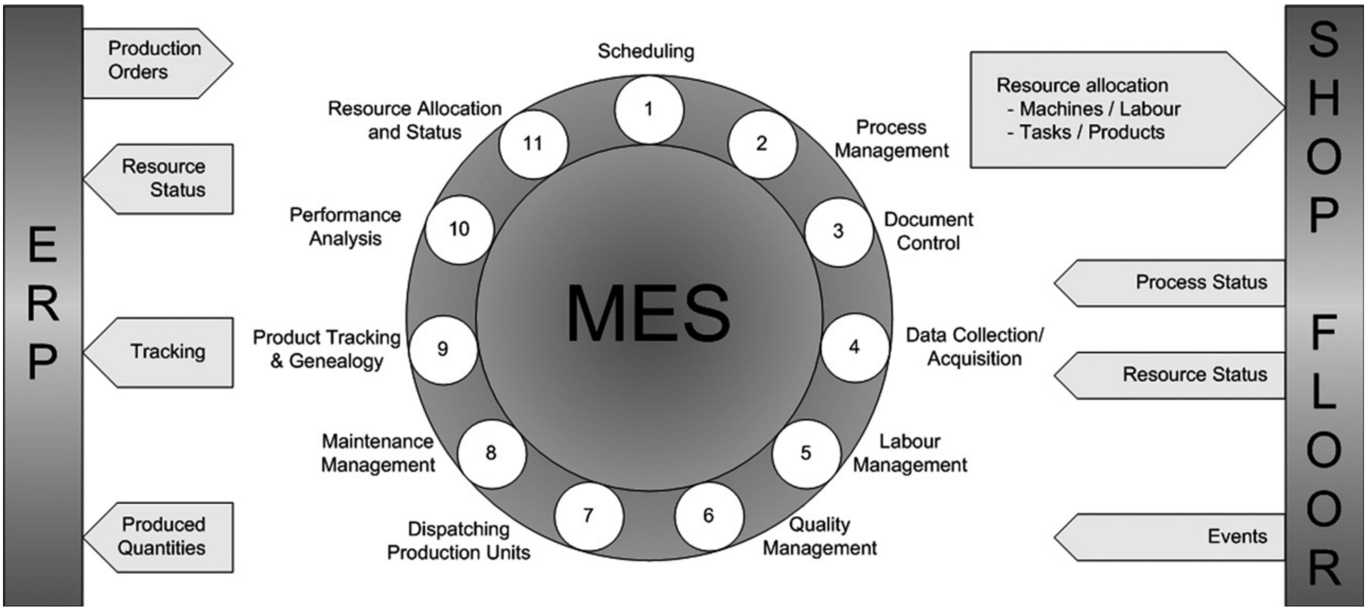

Figure 4 - Manufacturing Execution Systems funcionalities

4 Facilitators and Barriers of Integration of IT and AT

In order to study the integration of IT and AT, the conditions that facilitate this integration are classified as Facilitators. In the other hand, if a condition makes it more difficult, it is classified as a Barrier.
Normally automation projects managers can find professionals with good skills in IT and AT. It is difficult to find professionals with knowledge in both areas. So, the lack of knowledge in these areas is one of the barriers for the integration of IT and AT.
Other barrier is absence of a good horizontal strategic integration between all the departments, mainly IT and AT departments. Thus, in order to transform this Human Resources barrier in Facilitator, specific training in this area is a good strategy.
In addition, it is strongly recommended that the training courses are combined with alignment meetings.
The difference between IT and AT hardware lifecycles normally creates natural barriers for the integration between them because there is no compatibility between new software and old hardware. IT hardware normally is always updated while industrial automated plants use the same computers for more than a decade.
While interoperable systems can function independently, an integrated system loses significant

functionality if the flow of services is interrupted [11].

Most automation applications are certified to be used only with pre-determined operational systems. In some cases, upgrading applications is not an easy task.

Due to different software applications running in the corporate level and shop floor, there can be difficulties in the communication between them.

Enterprise architecture needs addressing more on how to align business strategy to technology for implementations, and not just focused on business or IT with separated research and development [11];

Integration of IT and AT departments can be a barrier or Facilitator, depending on how the enterprise handles these departments. Similarly, strategic alignment of business and technology can be a barrier or a Facilitator, depending on the way enterprises face it.

A Facilitator of integration is development of high technology equipment that provides more reliability. Storage, memory and processing capacity of IT and AT equipments have grown increasingly in the last years.

World Wide Web and new IT technologies enable further integration of software and hardware systems across company boundaries [15].

The efforts for standardization and development of integration models, for example ISA-95 are the strongest Facilitators of enterprise integration.

In order to organize Facilitators and Barriers of IT and AT integration, they were clustered in Human Resources, Hardware, Software and Business, as it is presented in

Figure 5 and Figure 6.

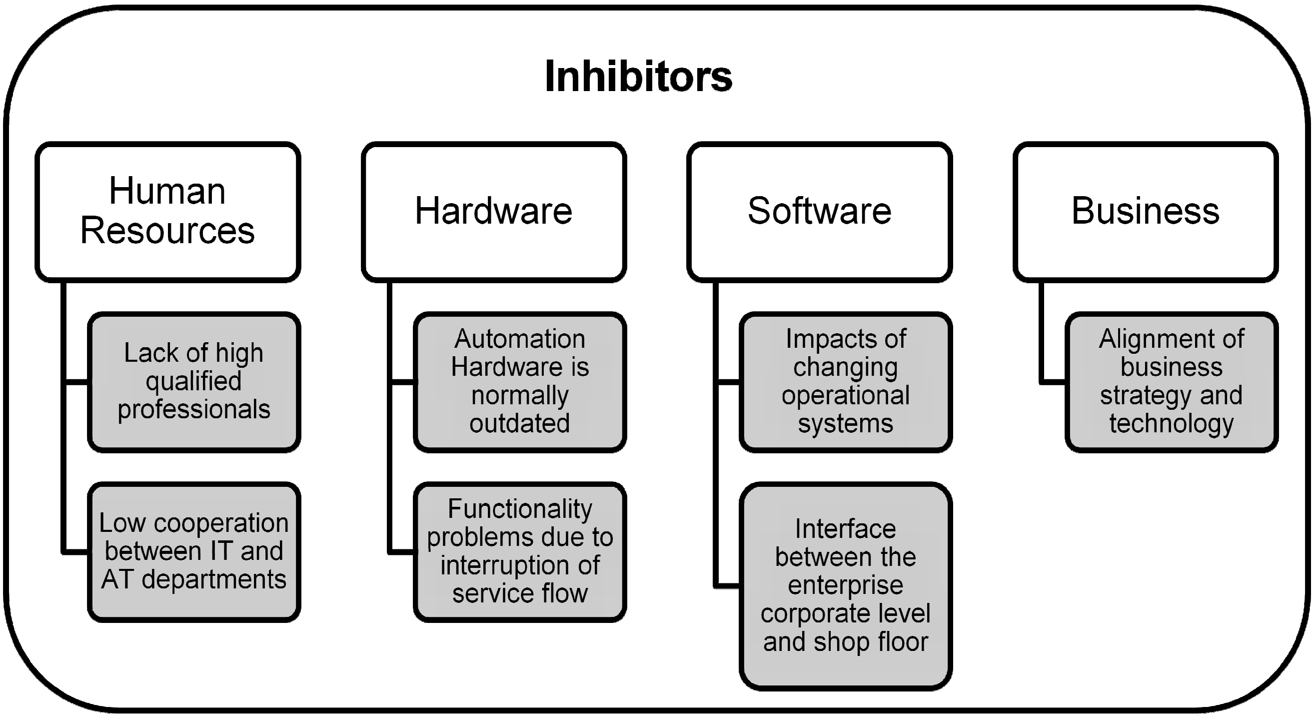

Figure 5 – Barriers of integration of IT and AT

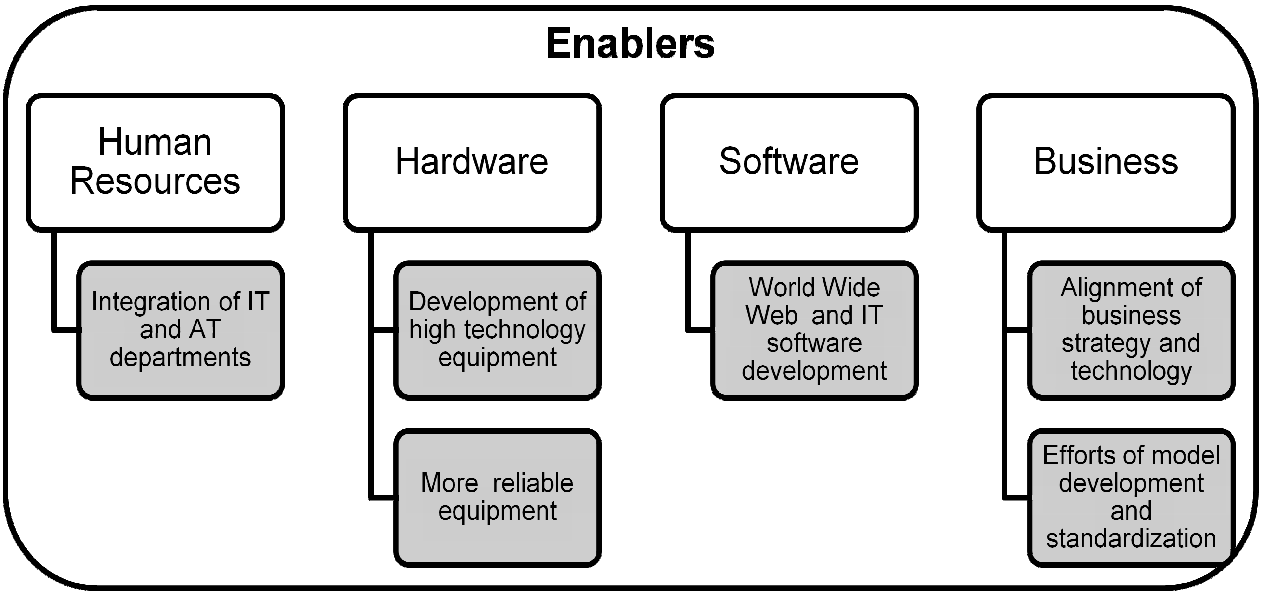

Figure 6 - Facilitators of integration of IT and AT

5 Case Study

As a case study, this paper presents Hardware and Software architecture of the automation and integration of a port terminal storage and dispatch of bulk solids.

The industrial plant is composed by three warehouses, a storage yard and four road bins.

Figure 7 illustrates the physical layout of warehouses and Figure 8 illustrates the flow of goods within the terminal. The port system has the capacity to discharge of 3 million tons of fertilizer and sulfur, and the yard has storage capacity of 85 tons and operates 24 hours a day.

In order to plan department activities of the terminal jointly, there must be communication between departments so that decision-making and all transactions are made to achieve the objectives of the company as a whole. Therefore, the industrial automation system of shop floor should be fully integrated into the management system.

The purpose of port terminal automation is to enable product receipt and dispatch. The orders are inserted by ERP and are sent to PLC automatically. The port terminal uses SAP ® ERP.

Thus, necessary equipments to execution of the inserted order are turned on sequentially without human intervention.

Figure 7 – Physical position of storage

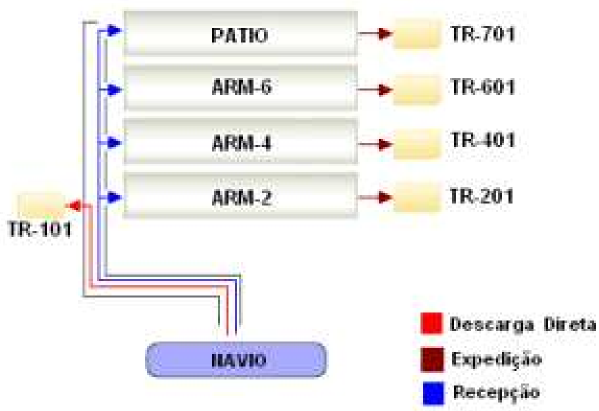

Figure 8 – Functional position of storages

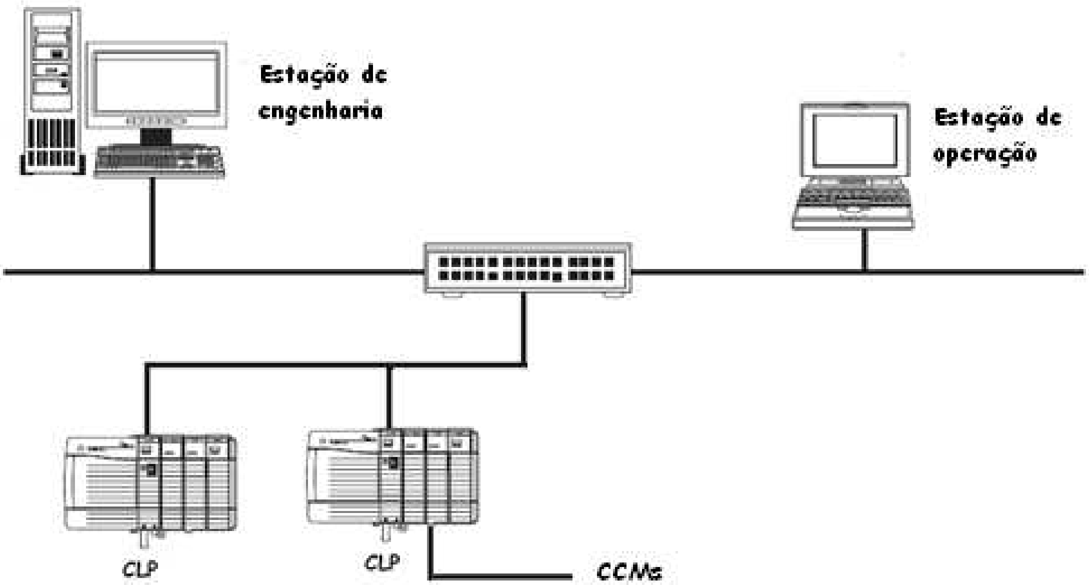

Figure 9 – Automation hardware architecture

5.1 Hardware Architecture

As presented in Figure 9 , hardware architecture is composed by two PLCs, two operation stations and networking.

The use of Ethernet network to communicate PLCs and Supervisory Systems facilitated the integration of automation system with ERP.

Supervisory Systems provide an interface where the operator can monitor variables, send remote commands, configure parameters and visualize the industrial plant.

5.2 Software Architecture

Software Architecture of port terminal is composed by: ERP, XI interface, Oracle database, RSSQL, RSLinx driver, CLP database.

Figure 11 presents bidirectional communication between SAP and PLCs.

RSLinx is the communication driver that enables communication between PLC and RSSQL software that is responsible for reading and writing information of PLC database in port database (Oracle).

SAP Web Interface XI is used to communicate Oracle database with SAP.

Industrial plant operators visualize orders inserted by the ERP in Supervisory System screen.

Truck data for receipt or dispatch products are sent to ERP by means of RFID technology that enables load traceability.

An RFID tag can hold much more information if compared to a bar code [16]. Furthermore, RFID tags can be passive or active tags (read-only or read-write tags, respectively) [16].

The operational sequence of expedition is as described below:

- In the ordinance, the truck receives a device called ”tag” where all the information about that loading are stored. Then, the dimensional characteristics of the truck and the amount to be loaded, are stored in the ERP system;
- Inside the hopper, the "tag" is read by an RFID antenna. When you are done reading, the information is sent to the ERP system and the automation system (PLC and Supervisory System).
- When you press the button on the system Supervisory System, the loading begins through the activation of their mats and translation movement of the carrier vehicle, according to the model of truck. The cutting load is done automatically by the system, leaving the system ready for a new shipment.
- There is a screen where the operator can either abort the loading or modify the constant cutting; this constant takes into account the residual amount of product on the mats.

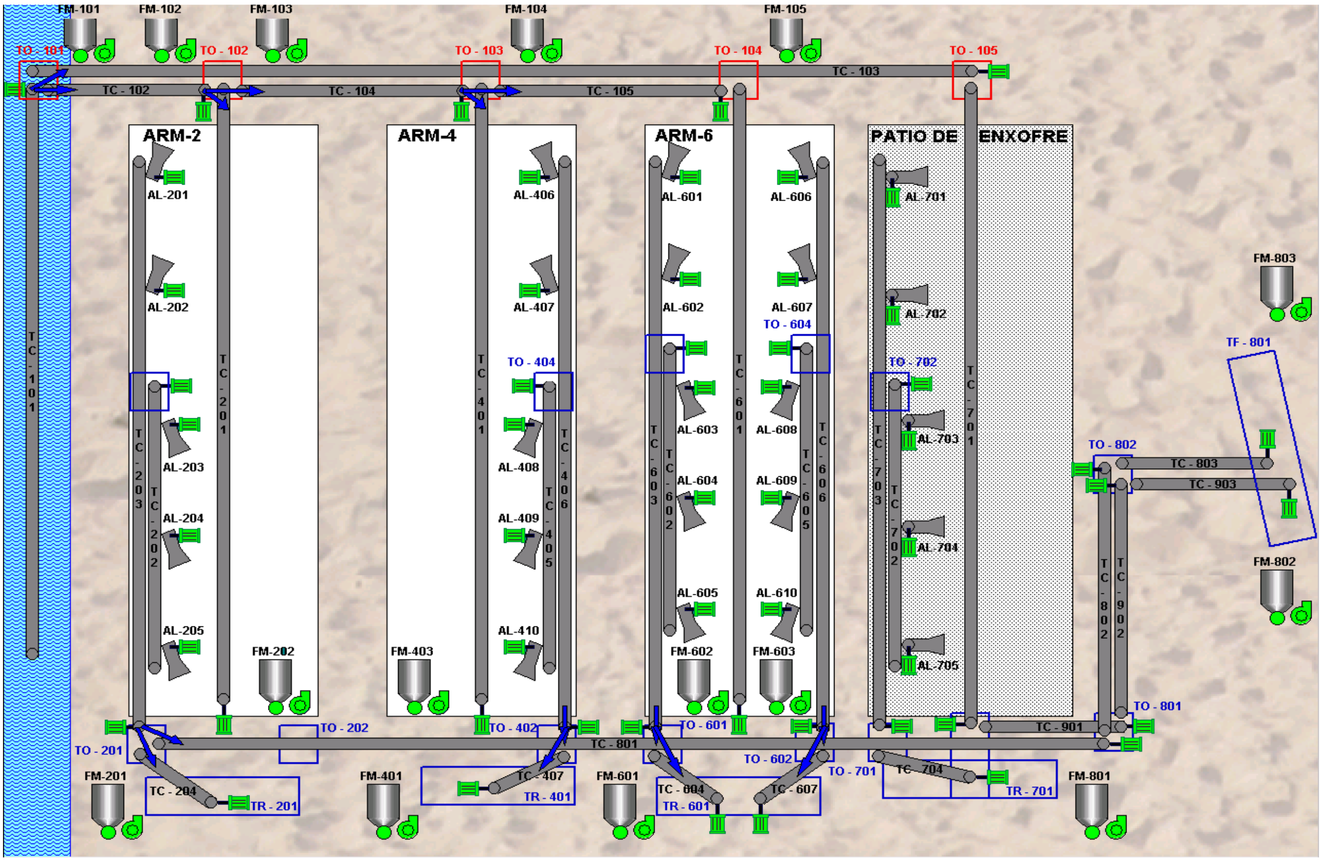

Figure 10 - Port Automated Process

The sequence of the receiving step is described below:

- The receiving order is received in ERP system;
- This order into the queue is automatically collected and displayed on the Supervisory System by the operator;
- The operator selects the receipt and initiates the route;
- The equipment of their route are triggered automatically, sequentially.
- If any equipment necessary to run the cash is the problem, the operator sees on the screen quickly through Supervisory System animation flashing yellow.
- If necessary, the operator can stop the route momentarily or abort it.

Figure 10 presents an overview screen where the operator can monitor all equipments status of the receiving or dispatching process.

5.3 Facilitators and Barriers

In this case study, it was possible to observe the following Facilitators:

- Development of high technology equipment;
- Efforts of model development and standardization.

In the other hand, the following barriers could be found in this case study;

- Lack of qualified professionals;
- Low cooperation between IT and departments.

5.4 Case study results

Improvements have been achieved over the system in general, especially in relation to the traceability of information. Moreover, the maintenance was facilitated by the availability of the entire history of the equipment, especially data on the number of defects and hours of operation.

For security reasons, it was developed a procedure for operating the terminal in manual mode, without any system aligned. This last action was set to meet unusual conditions such as communication failure, loss of SAP, etc.. In these cases, at least the unloading of ships should remain under threat of daily fines by time when the vessel on the quay.

The solution of hardware and software employed was effective in large automation systems and can be replicated for systems with similar characteristics even though completely different processes.

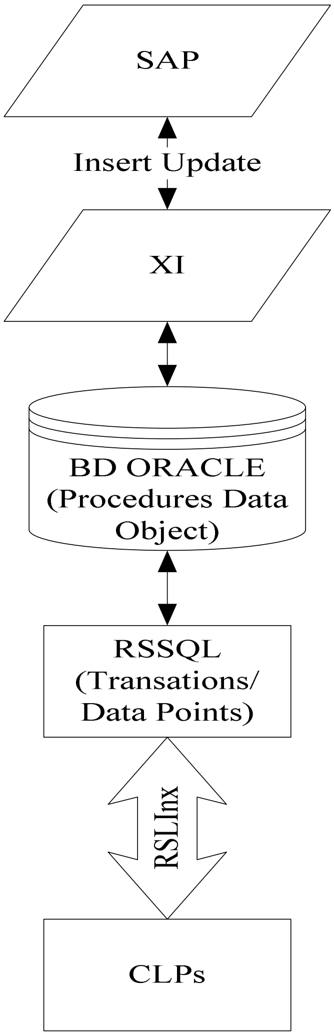

Figure 11 – Software Architecture

6 Conclusions

Action is needed in several areas of the company to achieve a high level of integration of IT and AT. The integration of these areas demands communication between various sectors, which does not happen easily.

Even though enterprise integration is an important study subject, it is necessary to identify how this hardware and software architecture can help to achieve strategic objectives.

According to Saenz de Ugarte et al, improvements and the future business characteristic trends can be summarized as follows:

- Integration;
- Heterogeneous knowledge synthesis;
- Standardized connectivity;
- Real-time performance;
- Web-based architecture;
- Scalability and reconfigurability.

To conclude, another important area that needs to be developed is about metrics: how to measure integration level, performance and maturity alignment. Metrics must take into account the type of business and should be adapted according to the needs.

These metric analyses are important to help defining which processes need to be implemented first, and what data should be collected in order to generate important information.

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