Brazilian Journal of Operations & Production Management 13 (2016), pp 124-136

BJ O&PM
ABEPRO
ISSN 2237-8960
Brazilian Journal of Operations & Production Management

PROJECT AUTOMATION APPLICATION WITH LEAN PHILOSOPHY AT THE CONSTRUCTION OF OIL REFINING UNIT

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Abstract

The growth of investment demand in the oil and gas industry motivated improvements in Brazilian construction and assembly processes. To this end, the support of automation tools and principles of Lean Construction projects used in the construction and Assembly of a cracked naphtha hydrotreating unit in southern Brazil between 2009 and 2012. This study aims to demonstrate the role of these tools by the Lean philosophy and proposes, from the critical analysis of an empirical study, barriers and benefits identified in the application in the Planning and Control of Industrial Construction. This methodology is of qualitative nature from exploratory and descriptive, by means of bibliographical study with Bibliometric analysis and experimental study, in order to show barriers and benefits of using automation tools to projects linked to the principles of Lean Construction. In this article it was demonstrated the importance of visual management of the enterprise to meet the priorities of work, uninterrupted production and commissioning. With the use of the tools of automation projects, the identification performed, subsidizing the planning teams for programming services, advocating the optimization of costs and deadlines. However, initially, in the practical case demonstrated, only items with high weight on analytical structure of project assembled.

Keywords: Project Automation, 3D Model, Constructability, Milk Run, Lean Construction

1. INTRODUCTION

According to Eastman *et al.,* (2010) in the early 1970 worldwide the first three-dimensional objects formed from surfaces connected. Further computational functions were developed to create these shapes with variable dimensions, appearing the first parameterized 3D objects. The first systems CAD (Computer Aided Design) were introduced in Brazil in the early 1980, being the framework for the appearance of project automation in the country. Thus, in the course of this decade there has been a considerable increase in productivity in the generation of technical documents in isolation. However, after the submission of the documents in the CAD system, they were printed on paper and distributed to the target audience independently to CAD system, generating out of date documents for the execution of projects according to Papadoupolos *et al.,* (2014). The 3D CAD applications began to be used for the production of 3D models at the end of this decade, however, did not present any kind of structuring the information, i.e., the same way that a technical drawing, a 3D viewing without any kind of parameterization (Cardoso *et* Almeida, 2013).

This way in parallel in the early 1980, 2D CAD programs began to be developed commercially in order to increase productivity and eliminate some problems associated with 2D designs handmade Khatib *et al.,* (2007). The technologies CAE (Computer Aided Engineering) began arriving in the mid-1980. In this way, the software 2D and 3D also won greater space or acceptance in engineering projects.These tools started to gain importance, not only for ease in represent geometric shapes, but also for using databases with information and technical specifications for pipes, instruments, equipment and metal structures and concrete, concerning their symbologies. According to the same author, the spread of local networks of computers in engineering offices also facilitated the creation of new structures where the projects could be developed collaboratively and simultaneously by more than one

ABEPRO
DOI: 10.14488/BJOPM.2016.v13.n1.a15

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Volume 13, Número 1, 2016, pp. 124-136
DOI: 10.14488/BJOPM.2016.v13.n1.a15

professional. In this way, the traffic engineering documents on paper was avoided, significantly increasing the integration between the technical disciplines, enabling virtual studies of logical and physical interference, physical arrangements and greater data consistency (Yogui *et* Junior, 2012).

According to Slack *et al.,* (1999) these CAD systems (Computer Aided Design), or computer-aided design, allow the use of products in computer simulations, where their performance can be tested with a high degree of accuracy, without physical testing. The development of CAD and CAE systems resulted in the development of Building Information Modelling (BIM) technology. One of the main problems associated with the current methodology, based on 2D documents is the difficulty and the amount of time it takes to access information of such a project, for example, cost estimates, energy efficiency analysis, structural details and others. A technology program that uses the methodology BIM allows the user to combine objects modeled in 3D generating 2D drawings to compose the project technical documentation according to Eastman *et al.,* (2010).

Davies *et al.,* (2009) report that their research on megaprojects were identified six processes required for managing a megaproject:

1. Integration system to coordinate the design, engineering, integration and the deliverables of a complete functional operating system;
2. Project and program management to support an integrated supply chain;
3. Project automation technologies to support engineering, construction, integration and maintenance, off-site fabrication, pre-assembly and modular production to improve productivity;
4. Predictability and health and safety aspects;
5. Logistics with just-in-time concept to coordinate the supply of material in an agile and efficient;
6. And integrated operation to apply in testing systems, testing and preparation for release.

The methodology of project automation with integrated information in an enterprise through databases and 3D CAD tools emerged in the oil and gas industry by the need to centralize all the information relevant to each stage of refineries and platforms in a single environment and serve as decision support in all phases of a project. With the application of this concept, the automation of internal and external processes, information management, and quality audits become more effective. There is a possibility to do simulations for: planning, programming logic, production control and for industrial safety studies and construction phases.

2. RESEARCH METHODOLOGY

It was initially done a wide bibliographical research in periodicals database SCOPUS. To guide this research, a tree of keywords, as shown in Figure 1 below, was created and such words were inserted in these search engines by following the shape of the Boolean “and” and “or”. For the cataloging of these files was used the software EndNotes X 7 ™, where was stored the raw research. After reading titles and summaries (abstracts), a few articles were selected, thesis and books to serve as theoretical basis for the elaboration of the article related to the topic of lean construction, 3D models with a focus on sustainable logistics and milk run. In accordance with that, Bibliometrics was done through quantitative analysis of principal authors, publishing peaks, networking between the authors and authors versus theme.

With the development of this research was made an experimental study of Analysis Division of constructability areas with unique supply routes, using the 3D model as integrated environment project information and adherence to the principles of Lean Construction for the supply of materials and equipment at the rate of consumption required by the construction and Assembly of the project. There was a focus on streaming, following priority ?construction sequence of each physical area. The study was carried out using the project automation tools to achieve necessary information, generated and consumed in every moment of the life cycle of the building. The analysis of this methodology was realized in an oil and gas company for the project of construction and Assembly of a unit of oil refining.

In addition, it was approached the role of project automation tools in this scenario at the stage of design, procurement, construction, Assembly and commissioning in order to reduce costs and deadlines, by optimizing the processes of transportation and storage of materials and equipment for application in building and Assembly. Figure 2 shows the development cycle of the survey, in which there is a triangulation involving the experimental study, bibliographical, documentary and incorporating theoretical knowledge and applied that add value to the study and generate conclusions and future research.

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DOI: 10.14488/BJOPM.2016.v13.n1.a15

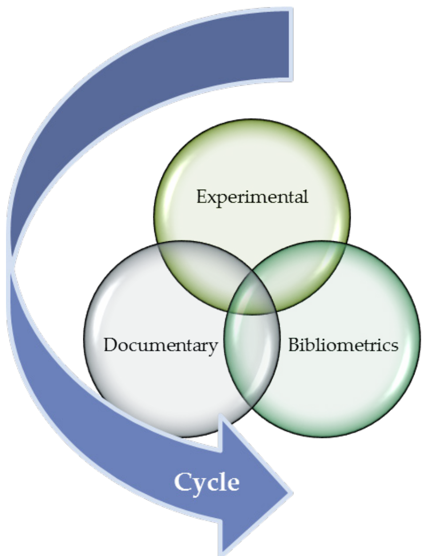

Figure 2. Triangulation of the research cycle

Source: The authors, 2015

Therewith, as shown above, initially a Bibliometric analysis was left in order to generate the literature review. Then, using the documentary analysis through the location, identification, organization and assessment of information contained in reports, seeking the reconstruction of past data in order to obtain clues for future projections. And finally, an experimental analysis of a practical application in the construction and Assembly of a unit of oil refining.

3. BIBLIOMETRIC ANALYSIS

According to the research carried out at the base of SCOPUS, 171 articles were found on the topic of sustainability logistics or milk run theme. Use the software to catalogue these items X 7 EndNotes found and NVivo software and Vantage Point for Bibliometric studies below.

We observed that the greatest authors regarding Sustainable Logistics are Digiesi, S and Dent, G with 3 (three) articles published each according to the table 1 below.

Table 1. Authors who have published more about Sustainable Logistics

Ranking	# Article Published	Name
1	3	Digiesi, S
2	3	Mossa, G
3	2	Absi, N
4	2	Balandin, S
5	2	Bioly, S
6	2	Byrne, P.J
7	2	Dal Borgo, E
8	2	Feillet, D
9	2	Fidlerová, H
10	2	Klumpp, M
11	2	Knaak, N
12	2	Kruse, S
13	2	Macharis, C
14	2	Marino, G.P
15	2	Meneghetti, A
16	2	Monti, L
17	2	Mummolo, G
18	2	Nolz, P.C
19	2	Page, B
20	2	Paloheimo, H
21	2	Prause, G
22	2	Ryan, P
23	2	Sakál, P
24	2	Schmidt, S
25	2	Smirnov, A
26	2	van Lier, T
27	2	van Nunen, J.A.E.E
28	2	Waris, H
29	2	Woxenius, J

Source: the authors 2015 using the software Vantage Point

Note that is a a still unheralded topic , but growing in the periodical of SCOPUS (Figure 3) and there are researchers who isolated groups that talk about the subject. The exception is the author Van Lier and Waris, who have a larger network of researchers involved and are cited in other works, as shown in Figure 4.

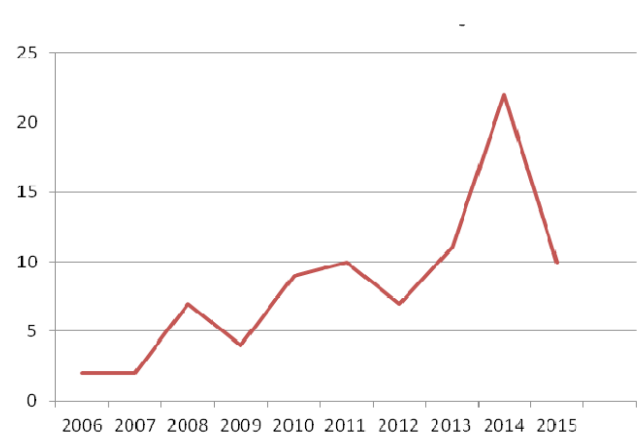

Figure 3. Number of articles published per year on logistics base in SCOPUS

Source: the authors 2015

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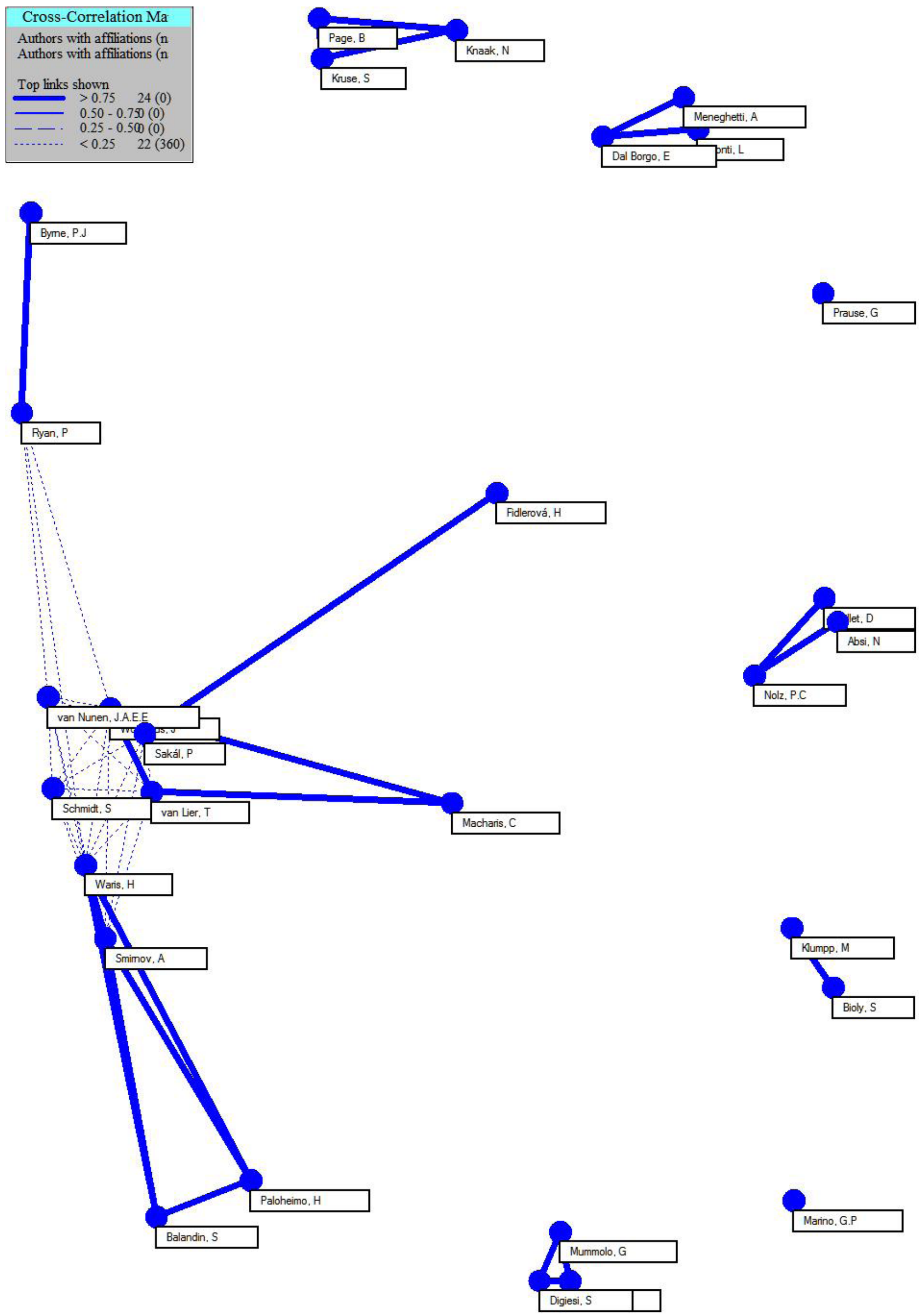

Figure 4. Networking among the authors who talk about Sustainable Logistics

Source: the authors 2015 using the software Vantage Point

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In addition to this analysis, the study of which fear each author more works, developing the table below:

Table 2. Authors x Themes

Reset		Authors with affiliations (name)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
		# Records	20	11	7	4	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1
Author Keywords	# Records	Show Values >= 1 and <= 2 Cooccurrence # of Records	sustainable logistics	Sustainability	Logistics	Green logistics	Freight transport	simulation	Supply chain	sustainable development	constraint programming	Eco-efficiency	energy efficiency	Green transport corridors	Local potentialities	Medical waste collection	Multi-objective programming	Optimization	Ridesharing	Smart spaces	Smart-M3	Stochastic inventory routing	sustainable	Sustainable logistic	Systemic design	Transportation	Value chain	adaptive large neighborhood search	Agent-based simulation	automated storage and retrieval systems	Automated warehouses	Automotive	Carbon footprint	Closed-loop supply chains
1	3	Digiesi, S	1						1																							1		
2	3	Mossa, G	1						1																							1		
3	2	Absi, N	2													2						2						1						
4	2	Balandin, S				1													2	2	2													
5	2	Bioly, S	1	1		1																												
6	2	Byrne, P.J	1		1		1	1	2														1											
7	2	Dal Borgo, E	1								2		1																	1	1		1	
8	2	Feillet, D	2													2						2						1						
9	2	Fidlerová, H	2							1																	1							
10	2	Klumpp, M	1	1		1																												
11	2	Knaak, N		1	1																								1					
12	2	Kruse, S		1	1																								1					
13	2	Macharis, C	1				1																											
14	2	Marino, G.P													2									2	2									
15	2	Meneghetti, A	1								2		1																	1	1		1	
16	2	Monti, L	1								2		1																	1	1		1	
17	2	Mummolo, G	1						1																							1		
18	2	Nolz, P.C	2													2						2						1						
19	2	Page, B		1	1																								1					
20	2	Paloheimo, H				1													2	2	2													
21	2	Prause, G		1										2																				
22	2	Ryan, P	1		1		1	1	2														1											
23	2	Sakál, P	2							1																	1							
24	2	Schmidt, S																								1								
25	2	Smirnov, A				1													2	2	2													
26	2	van Lier, T	1				1																											
27	2	van Nunen, J.A.E.E										2					2	1																1
28	2	Waris, H				1													2	2	2													

Source: The authors, 2015. Using the software Vantage Point.

Concerning to the topic of Milk Run was carried out the analysis of counting which words appear in articles found to show whether the research was carried out correctly, in addition to demonstrate quickly researchers about what the theme addresses, as shown in Figure 5. We also realized a relationship tree of the words contained in the abstracts and titles of articles, using the treecloud software (http: treecloud.univ-mlv.fr), Figure 6, where we see quickly that the milk run is used as logistical transport by the factories, having relationships with the system Just in Time (JIT), Lean concepts, supply chain, integrating buyers and sellers and having the cost as key factor to be worked. We can also notice that can be carried out programming algorithms to minimize the logistical routes problems encountered by vehicles.

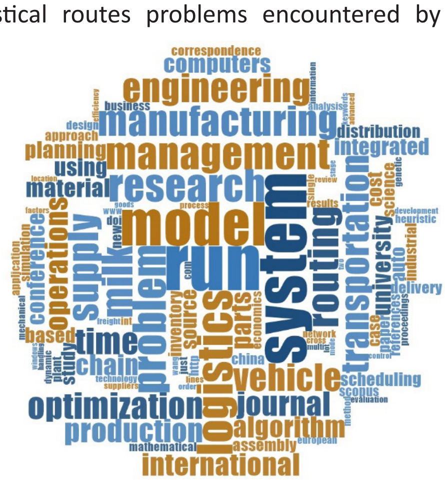

Figure 5. Most frequent words in articles surveyed about Milk Run

Source: The authors, 2015. Using the NVivo software 10

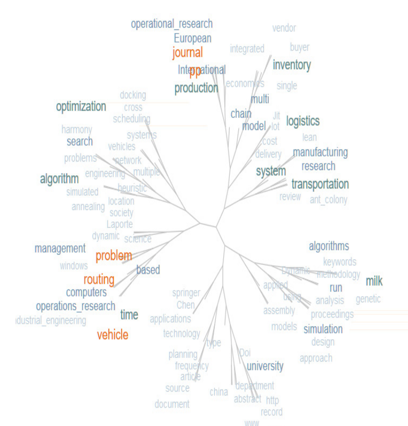

Figure 6. Tree Cloud of words found in articles surveyed about Milk Run

Source: The authors,2015. Using the software Tree Cloud

4. THEORETICAL DEVELOPMENT

4.1. Toyota Production System

Toyota Production System (TPS) was created by members of the Toyoda family and was based on Henry Ford and Frederick Taylor techniques. According to Maximiano (2005) the two most important Toyota System principles are: eliminate waste and manufacturing with quality. The principle of eliminate waste was applied to the factory, also known as lean production and is to produce more saving resources. The principle of manufacturing with quality is to produce flawless, which is also a way to eliminate waste.

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In addition to the two principles mentioned above, Toyota Production System also has another principle which is essential for the operation of eliminate waste and manufacturing with quality, which is the commitment and engagement of employees. According to Maximiano (2005) two of the Toyota Production System creators (Toyoda and Ohno) concluded that the main product of the Ford model was the waste of resources - human effort, materials, space and time. Large scale plants, piles of materials in stock, large empty areas. Ford System wasted especially human resources.

The resources should be on standby to fulfill the work program safely and deal with emergencies. This was the philosophy of just in case (or just to make sure). Until the 80's western companies followed this philosophy. But for the Japanese ones it was waste, especially after the Second World War, when the country was facing shortage of resources. Thus it was born the basic building block of the Toyota Production System: eliminate waste.

- According to Toyota manuals, waste can be classified into seven types:
- Overproduction
- Motin (of operator or machine);
- Waiting (of operator or machine);
- Conveyance;
- Processing itself;
- Inventory (raw material);
- Correction (rework or scrap).

The elimination of costs is the main TPS purpose eliminating losses, ie., cut out all conditions that could generate costs and not add value to the product. The TPS also proposes a production model based on other principles that can increase the business performance (SÁNCHEZ *et* PÉREZ, 2001): continuous improvement; zero defect; production and delivery Just-In-Time (JIT); pull production; multifunctional teams and decentralization of responsibilities.

For internal resources of a production process, the layout or the physical arrangement keep a fundamental role in flexibility of production. The way resources are grouped in the manufacturing area, ensuring that the flow of operations is defined correctly, sets how the layout carries out its task, reducing the movement of products in the process and streamlining passage times of lots of components between work stations (SLACK *et al.,* 2002).

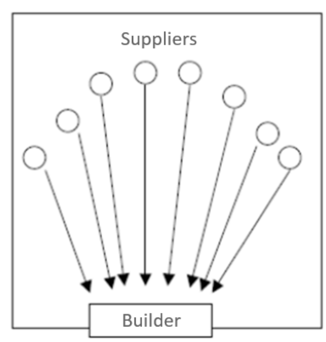
4.2. Milk Run Method

The Milk Run methodology aims to reduce the transport flow, facing a growing need in all sectors of the economy and can be adapted as required. In essence, consists of collecting the products of one supplier and to deliver for several retailers or collect in multiple vendors and deliver to only one retailer (CHOPRA *et* MEINDL, 2008). This method can be easily applied to the internal process of a company, like this study, on construction and assembly of an oil refining unit.

The designation Milk Run arose from the practice of a milk carrier that spent in several farms, collecting milk and made deliveries to the dairy companies, without repeating the way on the route (ALVARENGA, 2010). According to Chopra *et* Meindl (2008, p. 274), the specification of a transmission system affects the performance of supply chain, establishing an infrastructure where the transport operational decisions about schedules and routes are taken.

In the conventional system, suppliers deliver products directly to the builder, as shown below in Figure 7. The cost of transportation is included in the product price (MOURA *et* BOTTER, 2002).

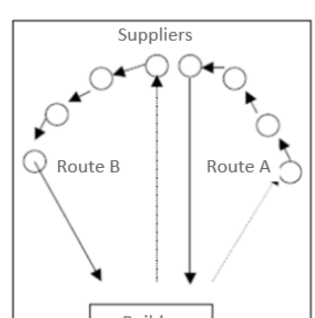
Figure 7 - Routing scheme in traditional production system



Source: Adapted from Moura *et* Botter (2002)

Figure 8 shows the Milk Run System, where the builder is responsible for collecting parts or components directly from suppliers. Thus, the builder will absorb the shipping costs. In this system, the collection is scheduled, the loading capacity in vehicles used for transport must be high and the route should be studied in order to optimize, minimizing transportation costs (MOURA *et* BOTTER, 2002).

Figure 8 - Routing Scheme in lean production system



Source: Adapted from Moura *et* Botter (2002)

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In conclusion, the Milk Run has as main objectives: scheduled collection, control of materials in transit, optimizing the route and the vehicles used for transport maximizing their capabilities, reduce inventory costs, reduce logistics costs and flexibility in loading and discharge (NUÑEZ, 2010).

4.3. Sustainable Logistics

Sustainable logistics generates that companies establish sustainability practices and rationalization of its spending and processes. Some authors, such as [DIGIESI *et al.,* 2015] discuss sustainable logistics with the following themes: transport of goods, internalizing external costs, environmental costs, social costs, inventory management, logistics, and cost function stochastic variability of demand for products, stochastic variability of lead-time of supply, among others. This shows how important and broad the concept and if the company carry out its sustainable logistics plan will have much economic gains.

The Sustainable Logistics management plans are planning tools with goals and responsibilities defined, actions, goals, deadlines for implementation and monitoring and evaluation mechanisms. In Brazil, the federal Government created the normative SLTI/MP nº 10, of 12 November 2012 laying down rules for the preparation of this plan in State sphere.

4.4 Project Automation Tools and BIM

As manual data collection normally gives low-quality data and is error prone, the automated project performance control is a novel approach that still is in the beginning, but can provide more accurate and frequent information (Navon, 2005). So, the best way to measure the actual performance in real-time economically is by automating it.

As the National BIM Standard (NBIMS) Project Committee of the BuidingSMARTalliance, Building Information Model (BIM) is a digital representation of physical and functional characteristics of a facility and it serves as a shared digital representation founded on open standards for interoperability.

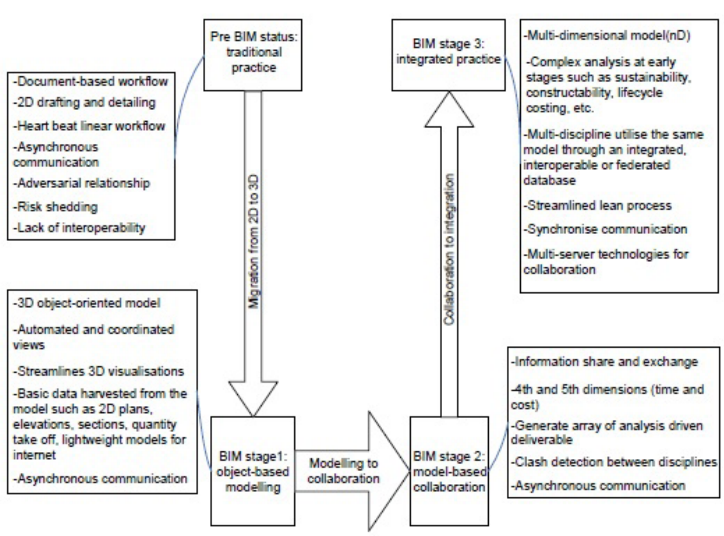
According to Bryde *et al.,* (2013), Building information modelling (BIM) is an appropriate tool for project managers and should be considered by the project management profession as a way to help manage construction projects, generating benefits as cost reduction and control through the project life cycle and significant time savings.

Allison (2010) affirms that some of the potential benefits of using BIM for project management are:

- Organize the project schedule and budget;
- Work well with the Design Team;
- Hiring and controlling the Subcontractors;
- Requests For Information (RFIs) and Change Orders;
- Optimize the Owner's experience and satisfaction;
- Project margin;
- Progressive Owners are mandating BIM on their projects;
- PM Firm Growth.

As Khosrowshahi *et* Arayici (2012), BIM implementation is a major change management task, involving diversity of risk areas. Succar (2009) identified the BIM maturity stages to systematically analyse and understand BIM by subdividing it into its components. As shown in Figure 9 there are three stages in the BIM implementation: (1) Stage 1 (object-based modeling); (2) Stage 2 (model-based collaboration) and (3) Stage 3 (network-based integration).

Figure 9. BIM maturity stages in BIM implementation



Source: Khosrowshahi *et* Arayici (2012)

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Therefore the BIM maturity stages provide a systematic framework for the classification of the BIM implementation and their stages can be used as a benchmarking tool for the comparison of data (Khosrowshahi *et* Arayici 2012).

On the other hand, there are barriers and challenges to increase productivity, efficiency, quality and to achieve sustainability through BIM implementation such as (Arayici *et al.,* 2011):

- Overcoming the resistance to change, and getting people to understand the potential and the value of BIM over 2D drafting;
- Adapting existing workflows to lean oriented processes;
- Training people in BIM, or finding employees who understand BIM;
- The understanding of the required high-end hardware resources and networking facilities to run BIM applications and tools efficiently;
- The required collaboration, integration and interoperability between the structural and the MEP designers/engineers;
- Clear understanding of the responsibilities of different stakeholders in the new process by construction lawyers and insurers.

4.5 Lean construction

Since the end of the70's , various business sectors have changed their way of organizing their productive activities, generating new paradigms. These new paradigms have emerged, initially, in the Japanese auto industry, notably the Toyota Production System. There is still no consensus that the lean production includes fully the new paradigm in the management of production. However several studies and works in different areas come encouraging implementation of the new paradigm (FORMOSO, 2000).

According to Koskela (1992), the principles of lean philosophy are:

1. Reduce the share of non value-adding activities.

2. Increase output value through systematic consideration of customer requirements.

3. Reduce variability.

4. Reduce the cycle time.

5. Simplify by minimizing the number of steps, parts and linkages.

6. Increase output flexibility.

7. Increase process transparency.

8. Focus control on the complete process.

9. Build continuous improvement into the process.

10. Balance flow improvement with conversion improvement.

11. Benchmark.

Galeazzo *et al.,* (2014) define lean practices as a set of techniques that aim to eliminate each form of waste along the value chain. As the authors, the lean practices also apply to the supply chain through strict collaboration with stakeholders, with the ultimate goal of streamlining the whole production process.

The lean supply chain is a strategy based on cost reduction and flexibility, focused on processes improvements, through the reduction or elimination of the all "wastes" (non-value adding operations). So, leanness in a supply chain maximizes profits through cost reduction, while agility maximizes profits through providing exactly what the customer requires (Carvalho *et al.,*2011).

Therefore, one of the goals of lean operations is to use fewer resources to generate the same outcome and what is clearly, inherently environmentally friendly. Fewer materials are used in production, and quality improvements reduce rework, scrap, power/water consumption and pollution costs. So, the benefits of lean are extensive, including strategic direction with expected outcomes, and strategic operational improvements that cover a broader range of sustainability issues (Piercy *et* Rich, 2015).

4.6 Synergism between lean construction, automation projects and sustainable logistics

The synergy between the Lean Construction, Sustainable projects and Logistics Automation occurs due to several inherent characteristics and similar in both methodologies and/or technologies. How to reduce variability issues, reduce cycle times, reduce batch sizes, increase flexibility, select an appropriate production control, standardize approach, use visual management, design the production system for flow and value, cost of logistics, stochastic variability of demand for products, stochastic variability of delivery lead time, hiring and controlling the subcontractors, progressive owners are mandating BIM on their projects, work well with the design team are some of the aspects in common. This possibility of simultaneous and coordinated action association between these three purposes of production management is called synergism, whose goal is the sum of the parts is greater than the isolated actions of each of these. Clark (2007) States that the synergy with two or more agents working together to produce a result obtained by any

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of the agents independently (separately).

This article presents an empirical study in the construction industry with the aim of identifying how is treated the synergism between Lean Construction, BIM and sustainable logistics in companies of this sector with same features. However, its operation, without synergy, makes use of the potential of these management principles is not total. The integration of this operation, so it is essential for the real enjoyment of these systems (CRUZ, 1998).

5. EMPIRICAL STUDY ON CONSTRUCTION AND ASSEMBLY OF A OIL REFINING UNIT

5.1. Study scenario

According to Tolmasquim (2012), logistics and energy are key factors that lead to progressiveness and effectiveness of a country's production. Currently in Brazil both aspects are in constant development, total energy demand is continuously growing, with a prediction of increased around 5 a year until 2020. The transport and industry sectors are the main responsible for this consumption.

The experiment was accomplished in this socio-technical context in an oil refinery, located in Rio Grande do Sul, in southern Brazil. Where the objective was the construction and Assembly of the following units: "on-site" Diethanolamine and waste water unit and the expansions and connections called "off-site" with the local control center (CIC), substations and distribution systems, utilities and other process units in refinery "off-site". The process of using French technology unit to produce a fuel with low sulphur content-less pollutant and that existing national agency specifications answered petroleum (ANP). The units began the project at the end of 2007 and were completed in early 2012. At the apex of workforce of the enterprise, there were approximately 3000 employees. With the departure of the units at the beginning of 2012 oil refinery came to be able to meet internal and external markets with quality and respect for the environment.

Project automation tools were not very widespread within this context, especially in earlier works. The fundamental requirement for implementation, the 3D model in all the developments carried out in the same refinery previously, updates, from a certain moment, were no longer performed during the design phase. The only exception is the pipeline project, which had already begun in past works, the issue of isometrics in 2D from 3D model, although not contractually required. However, the conciliation project activity on 3D CAD tool with the documentation issued ended up getting to a final stage of the project, near the end of construction and assembly and start of match between the project with what was built, called the step BUILT-IN. There was a high number of rework by adopting this task sequence, creating a lack of reliability in the 3D model for analysis, simulations and miscellaneous information extraction, getting outdated and not consistent with respect to the issue of documents in 2D. Especially discredited by stakeholders of project.

This history of failure cited above served as a motivation for team for this project. The team focused on treating the negative points of this historic contractually. In this way, monitoring the pipeline area began to demand items contained in the contract for extracting isometric drawings from the 3D model, because they were exposed to the increased productivity of these automation tools. The effort was concentrated in this discipline through the automated pipe spools break, doing an automation between the Executive project and subsequent phases (construction, electromechanical Assembly and commissioning). Therefore, the benefits of these methodologies and technologies can be verified when used to integrate people, upgrade to constructability, simulate computationally scenarios for most suitable choice of items scheduled and logical sequence of mounting the short-term planning and monitoring of visual form, running with skills and people needed to establish plans of action when necessary and increasing assertiveness of the redesign. In this way these aspects aim to decrease rework, reduce costs and deadlines, because in this way the empirical study carried out contributed to improvement in performance of the construction and Assembly of new developments in the area of refining and supply

5.2. Empirical study on the Planning and Control of Industrial Construction

For the execution of the project of the refining unit, where the requirement for compliance with challenging deadlines was huge, the search for solutions that minimize cycle times, rework and production stops was constant, but could not lead to an increase in the cost estimate for the project. Thus for accuracy of fulfillment of strategic objectives (deadline, cost and quality) to direct, manage and prioritize the manufacture of materials, equipment, metal structures and pipelines, Division strategy was used for areas of constructability, schedule monitoring services (work package) through the use of the 3D model and integrated validation services schedule (work package) with several monthly meetings. These meetings were involved stakeholders responsible for different phases of the project (design, supply, construction, Assembly, commissioning and operation). The 3D model was chosen as Integrator for environment monitoring and controlling by reason of encompass all disciplines of design, including all physical items and commissionable at a unique environment. The greatest difficulty was the lack of standardization, making more difficult the integration between design and supply systems with planning and advancement of the

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work. These integrations have developed, integrating the software, PDMS (Plant Design Management System), SPPID, SPI and SPEL (CAE Tool for design disciplines), schedule in Microsoft Project, and the Controltub (management of tool manufacture and Assembly of industrial pipes) with all 3D viewer. This viewer allowed customization already in their specific language and, thus, made the information in an integrated manner, adhering to the principles of BIM (Building Information Modelling). After that the systems had their iterations established successfully, an ideal scenario was created to carry out planning, simulations and production flaws prior to construction. These ideal settings achieved around 30 physical advancement of the project and start the application effectively at the intersection of the release of the Executive project of pipelines, freeing them to manufacture.

Fundamentally, the 3D model used in this study in order to identify activities predecessors to fieldwork and monitoring of construction and Assembly, making the planning of activities, focusing on detailed project information, with exceptions of some disciplines for cultural aspects. So,it was analyzed: cost and deadline information, updates or changes in design, technical specifications, physical interference and analysis for large equipment prioritization of work.

The production was used to pull items that should be with the project consolidated Executive until a specific date for a future programming services, namely, pull the production Executive project according to priorities in planning and constructability to release items to construction on the date of need for construction. In this way the majority of the items fit to be manufactured or assembled were the areas of priority constructability by following the guidelines of the Toyota Production System to the productivity gain. Doing a merge and aimed at providing inputs for production, the goal was to suit its ability and not allow stopping production for lack of material. With attention to the overproduction, another challenge was to avoid wasting with raw materials and finished products, accumulated without application in the Assembly not to generate high stocks and need for preservation. The decentralization of responsibility, through the Division of subareas of constructability and delegation of supervisors responsible for each sub-area or cell, favored the increase in productivity in the Assembly. Another factor that also had a positive impact on productivity has been the development of a layout that favored the description of materials and crane access, avoiding intermediate stocks. Using the Milk Run methodology in civil construction and electromechanical Assembly of the unit was positive and leaner, where unique teams designated for the monitoring of equipment, materials and pipes for storage containers next to the sub-areas of the field. Each team was dedicated to collect materials from various suppliers for the same stock “in loco” of their respective sub-area (C1, C2, C3 and C4), as shown in Figure 9. Thus, all the materials needed to meet the schedule of services areas are prioritized. It should be remembered that for each sub-area there is a planning and priority of completion. Supervisors of these priority sub-areas were the more actively monitored how the “route of the milk”, aimed at the supply of material.

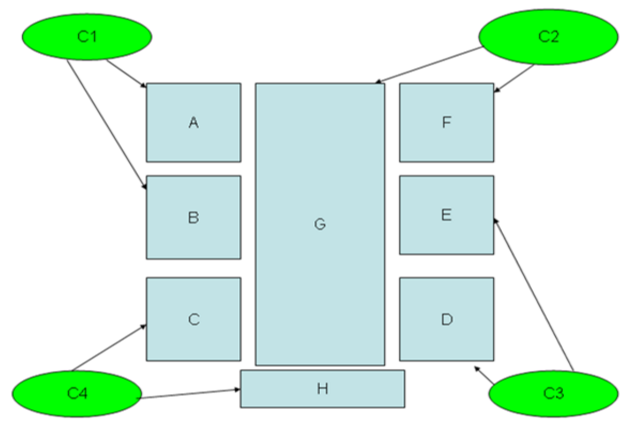

Figure 9. Supply planning methodology of materials by Zoning

Necessarily, there was a professional monitoring the factory equipment and expediting one or more trucks as a resource allocated and dedicated to search on any suppliers for each sub-area. In case of lack of some material, contingency plans were prepared with the search for materials in other stock “in loco” (C1, C2, C3 and C4), as shown in Figure 9, to fill this lack is always recorded and controlled. All changes were recorded in a database, which signaled the obligation to buy or search for materials provided to return to the team that released the supply given to spare.

Then, you will be quoted a practical example how to apply this method of Division by using the 3D model for identification and priority tasks planning contributed to the venture. In Figure 10, shown below, extracted from the 3D model visualization software used, one of the most important tests and equipment, the test of the hydrogen compressor was analyzed by an interdisciplinary team of planning and industrial Assembly. After identification of the analysis of the requirements for completion of the tasks to the hydrogen compressor test, one of the systems required for test execution had many lines of Red pipe that had not been made and only the main branch in purple that was completed. These pipe lines were operating system of high and low pressure steam which needed to be prioritized, by the need to be assembled for release of commissioning tests, washing, degreasing, passivation and blowing out with steam pipe lines completed. In this way, all the requirements for the implementation of the main compressor unit test are met. At the time the image was taken from the 3D viewer in June 2011, all the Red pipe lines had not been manufactured,

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just the main line with purple had already been completed.

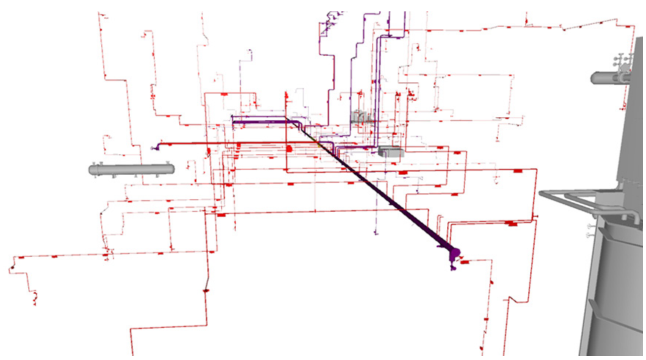

Figure 10. Use of the 3D model for the identification of priority areas

Thus, the manufacture of piping lines snippets "spools" in red were prioritized, being carried out at night. In addition, during the day, there was a dedicated team of each sub-area responsible for assembling the material. On 23 November 2011, after five months of work, the entire line of pipe was mounted and with the washing of the system completed, as shown in yellow in the figure 11, being possible to release the remaining commissioning tests and finally achieve the goal of testing the hydrogen compressor.

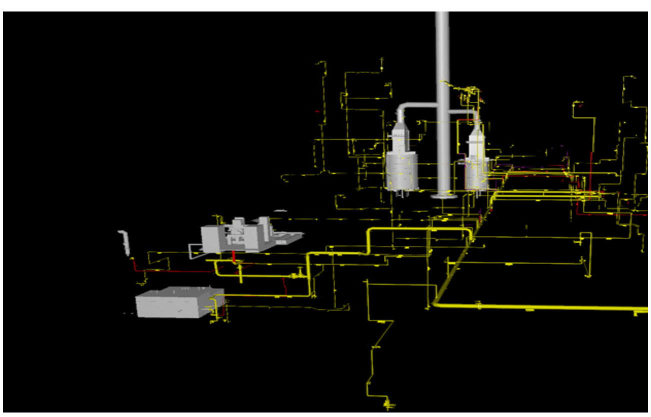

Figura 11. Priority area with the identification of completed activities

CONCLUSIONS

The concepts that set in Toyota production system and the Milk Run method with the projects automation tools have adapted within a methodology applied in the construction and Assembly of a unit of industrial process.

In this article it was demonstrated the importance of visual management of the enterprise to meet the priorities of work, uninterrupted production and commissioning. With the use of the tools of automation projects, the identification can be performed, subsidizing the planning teams for programming services, advocating the optimization of costs and deadlines. However, initially, in the practical case demonstrated, only items with high weight on analytical structure of project were assembled. To achieve the agreed deadlines for the departure of the unit is to create reactive solution of prioritization. With planning and controlling methodologies, using areas and divisions mainly with the support of the 3D model, to integrate the project Executive with other enterprise systems, making simulations of production, it was possible to visually identify the planned item colors, breakthroughs and bottlenecks that should be treated.

However, the plan of action of night and Assembly manufacturing during the day as shown in Figure 8, was only effective on account of a needs assessment to make, as has been demonstrated throughout the article. At the same time, it was also the actual process of transport and storage, because there were dedicated stocks "on the spot" near or next to the area of production, without waste of time, when the Division by areas was propagated not only to production, but also for engineering systems. Each sub-area had a supervisor, responsible for the preservation and application in the Assembly. The Systematics of the cellular layout became motivational for cross-functional teams and dedicated to the success of the cell or sub-area, with awards by results, in accordance with the priorities defined by the planning of the project.

We also noticed a significant decrease in inventory of pipes, coils, providing less purchase do material by virtue of a better management of their activities. In this way with this job, it was possible to demonstrate that, as Lean tools and methodologies and project automation should be used since a phase III of gall and not only reactively to kill specific objectives. Irreproachable in this project the benefits were numerous, ?? , in the case of a poster does integrated 3D visualizer to be able to fulfill the Adjustment of project completion cracked naphtha hydrotreating in March 2012 The goal was achieved with a game of unity in first attempt, unprecedented in this refinery.

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