IMPROVING THE PRODUCTION PLANNING AND CONTROL SYSTEM IN A BUILDING COMPANY: CONTRIBUTIONS AFTER STABILIZATION

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ABSTRACT

Several papers have discussed the importance of the Last Planner Method as a means of stabilizing the production process in building sites. After process stabilization, however, a continuous effort is necessary in order to maintain and perfect the positive results obtained from the implementation of production planning and control systems.

This article presents the preliminary results from an ongoing research project undertaken in a construction company from the South of Brazil. The main objective of this investigation is to propose guidelines to maintain and improve production planning and control systems after process stabilization. A series of fifteen projects were studied, aiming to identify the main barriers and also factors that contribute to the success of planning and control systems in the long term. The main sources of evidence used were the PPC (Percentage of Plans Completed) indicator, causes of the non-completion of work packages and interviews with company directors, clients and site engineers.

One of the major factors that contributed to the success of planning and control system was the realization of weekly meetings focussed on learning rather than problem solving. This meeting involves company directors, a planning and control coordinator, and all site engineers. The results achieved in different sites are periodically disseminated throughout the company, pointing out the main barriers for implementation. Also, a strong emphasis is given in those meetings to the discussion of the Last Planner Method underlying ideas.

KEY WORDS

Production Planning and Control, Planning system, Last Planner Method, Learning, Implementation.

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INTRODUCTION

One way of introducing lean production ideas in construction projects is through the stabilization of the work environment, by shielding production from the upstream variability and uncertainty that management is not able to prevent (Ballard and Howell 1997a). In this context, removing constraints and undertaking actions aiming to minimize the occurrence of problems that interfere with the execution of work packages are essential steps in the search for this stabilization (Ballard e Howell 1997b; Tommelein 1998; Choo et al. 1999).

In the medium-term planning level it is important to identify and remove any constraints which may interfere with the continuous workflow (Tommelein 1998). In the short-term level, Ballard and Howell (1997b) claim that planning should be developed through actions that must aim at protecting production against the effects of uncertainty.

According to Ballard and Howell (1997b), production can also be protected through the implementation of plausible plans (previously submitted to an analysis of achievement of their requisites) and through an analysis of the reasons why planning tasks have not been accomplished. (Ballard e Howell 1997b). Once shielding production is implemented, it becomes possible to move upstream, i.e. to the front of the shield, to reduce inflow variation, and to move downstream, i.e. behind the shield, to improve performance (Ballard and Howell 1997a).

Previous studies concerned with the implementation of the Last Planner Method have given strong emphasis to initial stages of implementation (the stabilization phase), usually through the development of a few case studies in construction companies. Very little research has been conducted about construction companies that have successfully implemented this method, and that are trying to reduce inflow variation and improving downstream performance.

In Brazil, there is a relatively large number of companies involved in the development of planning and control systems, based on the Last Planner Method. Most of them are in the initial stages of implementation, and have faced the usual problems related to that, such as the lack of understanding of its underlying principles, inability to evaluate the impact of planning effectiveness in terms of cost, and no change of attitude from site managers.

However, some companies have been very successful in the implementation of Last Planner and achieved a fairly good level of stabilization. For these companies, a continuous effort is necessary to maintain and improve their production planning and control systems in all their sites. For that reason, the decision was made to develop a research study which aims to propose guidelines to maintain and improve planning and control systems at this stage of development.

The investigation was developed in a construction company from Porto Alegre, Brazil, that have successfully developed a production planning and control system, based to some extent on the Last Planner Method. The development of this system started in 1998, and it has been implemented in fifteen projects so far, mostly in industrial projects and hospitals.

GENERAL DESCRIPTION OF THE COMPANY AND ITS PLANNING AND CONTROL SYSTEM

The building company selected for this research is a medium size company that is mostly involved in fast, complex and uncertain industrial and commercial building projects. It has been an ISO-9002 certified company since February 2001. The scope of certification covers the production planning and control system. The company has also been a partner in several research projects, conducted by The Building Innovation Research Unit (NORIE) from the Federal University of Rio Grande do Sul, in the last few years.

The construction projects of the company present the following characteristics:

- <u>Short cycle time</u>: most industrial and commercial building projects that are carried out by this company have a fairly short duration, since the client usually needs the facility to perform its core business.
- <u>Interference from the client's production process</u>: often the scope of work is related to the refurbishment or extension of an existing building. For that reason, construction work is largely affected by the client's work environment. Sometimes, an industrial production line is in full operation. This fact demands much interaction between the construction company's site activities and the client's production system.
- <u>High product flexibility</u>: the construction company is often hired to manage both the product development and the production processes, and there is usually an overlapping between them. Production usually stage starts before design is completed, and several design changes are demanded by the client throughout the project.

These characteristics and also the complexity of their projects make it essential for this company to have a very effective production planning and control system.

Table 1 presents a description of the construction projects investigated in this research study as well as the main stages of development of the production planning and control system, which are depicted below:

- Stage 1 - Initial development: the first empirical study was developed in the construction and refurbishment of a hospital intensive care unit (Project A). This was led by a doctorate student from NORIE;
- Stage 2 - Development and implementation: considering the success on the planning and control system in the first project, the company made an effort to implement it in all construction sites. At this stage, the planning and control system was also included in the ISO-9002 Quality System;
- Stage 3 – Maintenance and improvement: after the implementation in all construction sites, a number of extended features were introduced in the system, such as health and safety management, and product development planning and control.

Table 1 - Description of construction projects and planning and control system stages of development.

Name	Description of construction projects	System stage of development	
		Number	Description
A	Construction and refurbishment of a hospital intensive care unit	1	Initial development of the Production Planning and Control System
B	Construction of a hospital physiotherapy unit	2	Development of the Production Planning and Control System and implementation in all construction sites
C	Construction of an industrial pavilion for publishing company		
D	Construction of a industrial pavilion for a tire manufacturer		
E	Structural Repair in a petrochemical industry		
F	Refurbishment of the dining-hall and laboratory for a chemical industry		
G	Refurbishment of a hospital surgery rooms and apartments		
H	Construction of a restaurant		
I	Refurbishment of an industrial building for steel mill		
J	Construction of a commercial building for a data communication company	3	Maintenance and improvement of the Production Planning and Control System
K	Construction of a laboratory for a petrochemical industry		
L	Construction and refurbishment of a laboratory for a petrochemical industry		
M	Construction of a silo for a cement industry		
N	Construction of a building for a steel industry		
O	Construction of a pavilion for a tire manufacturer		

STAGE 1: INITIAL DEVELOPMENT

The production planing and control system was initially implemented in an empirical study that was part of Bernardes (2001)'s thesis. The first author of this paper was the site manager at that time. The main causes for the non-completion of work packages are listed below:

- Lower productivity than expected: this problem was mainly due to the fact that the site manager found difficult to establish the actual capacity of the gangs;
- Client’s interference: this occurred mostly due to the characteristics of a hospital environment. In many occasions, the work on site had to be interrupted due to the noise produced by the ongoing activities;
- Shortage of material that should have been provided by the contractor: this was caused by the lack of reliability of some subcontractors material supply systems. This is a serious problem for this construction company because all labour used in its projects is subcontracted.

After the conclusion of this project, the production planning and control system was evaluated. Despite the initial effort for implementation, the research team found that some core ideas of the Last Planner Method were not completely assimilated by the construction company. This is due to the fact that only a few elements of the Last Planner Method were emphasized in the first stage of development, such as short-term planning and control, and resource scheduling. Look-ahead planning and constraint analysis were fully implemented only in the Stage 2 of this research. The aim was to introduce a step by step learning process in the company in order to avoid an overload of new ideas which could create some counteraction either from subcontractors or from the site manager himself.

Despite the problems mentioned above, the company decided to implement the proposed planning and control system to two new projects (projects B and H). According to the company directors, this decision was made due to the benefits provided by the system specially in terms of reducing interference from client’s activities, and increasing degree of commitment from subcontractors. One director also highlighted the fact that the system made it possible to expedite decision making in the construction site, and, due to its simplicity, allowed the company to coordinate the management of different construction projects.

STAGE 2: DEVELOPMENT OF THE PLANNING AND CONTROL SYSTEM AND IMPLEMENTATION IN ALL CONSTRUCTION SITES

During Stage 2, the company decided to join a ISO 9002 certification program, because this was increasingly becoming a mandatory requirement from construction clients in Brazil. The company saw that as an opportunity to standardize its planning and control system and disseminate it throughout the company. The strategy for the development and implementation of the system is presented bellow:

- <u>Establishment of a general coordination for the implementation of ISO 9002 quality system</u>: the site manager of Project A was appointed as the coordinator of the development and implementation of the ISO 9002 quality system. Besides, he also coordinated the implementation of the production planning and control system in all construction sites.

- <u>Inclusion of the production planning and control system into the ISO 9002 quality system</u>: the planning and control system, developed in Project A, became the core process of the quality management system. The aim was to make the quality system more useful, by fully incorporating a process that had a key importance for the company, and also to use the ISO 9002 auditing routines as an additional mechanism to enforce the implementation of the planning and control system.

- <u>Weekly learning meeting</u>: before the company started implementing the planning and control system, a weekly meeting was held at the company's office, involving company directors and site engineers. That meeting was mostly focussed on solving production management problems, especially the most urgent ones. The scope of this meeting was changed during Stage 2. It became a learning meeting, in which the necessary training for the company staff, related to both the quality system and production planning and control, was provided. It became also an opportunity to report and discuss the implementation of the planning and control system on different sites. The number of participants was increased: besides company directors and the site engineers, also technicians, safety specialists and trainees took part in this meeting.

By the completion of the ISO 9002 quality system, the production planning and control system was implemented in all existing construction projects. According to one of the company directors, the incorporation of the planning and control system into the quality system had a key importance for its success: *"ISO plays a major role. It creates respect and some kind of fear. It provides credibility to things. If the program* (referring to the planning and control system) *had not been incorporated into ISO9002, perhaps it would have been weaken"*.

From the point of view of another company director, the incorporation of production planning and control into the quality system contributed to standardize the proposed system: "*without the ISO system we would probably have in each project some pseudo-planning, something similar to a procedure, but still with many peculiarities established by the site manager"*. The company's site managers also agreed that the ISO9002 quality system contributed towards organizing and standardizing planning and control procedures.

STAGE 3: MAINTENANCE AND IMPROVEMENT OF THE SYSTEM

At Stage 3, the company developed a number of improvements in the production planning and control system. The main factors that contributed to the continuous development of the production planning and control system were:

- Planning and control co-ordinator: after obtaining the ISO 9002 certification, the company decided to maintain the co-ordinator of production planning and control in charge. According to the perception of some company directors and site managers, his leadership has been very important for the dissemination and improvement of the system;
- Weekly learning meeting: these meetings became a routine at the company. After the company obtained the ISO-9002 certification the production planning and control process are the main focus of discussion. Planning indicators (e.g. PPC and causes of non-completion of plans) from all sites are presented and discussed. This provided an opportunity for all site managers to learn from each other, making it easier to disseminate the improvements in the planning and control system to all sites.
- Learning of production management core concepts and principles: the planning and control co-ordinator started doing an M.Sc. course in construction management and engineering at UFRGS. He was then able to understand better some of the underlying ideas of the Last Planner method, and to detect some weak points in the existing planning and control system. Mainly due to his leadership, discussions on core concepts and principles related to Lean Construction and to the Last Planner method have been introduced in the weekly learning meetings.
- Partnership with NORIE-UFRGS to develop new research projects: a new link agreement between NORIE and the construction company was established. The main strategy has been to extend the scope of the planning and control system to other processes, such as health and safety management, product development, and physical flow management. Also, a stronger emphasis has been given to medium-term planning and constraint analysis.

The main changes that have been introduced in the production planning and control system are presented bellow:

- Long-term planning: the integration between planning and const estimating was improved by producing the initial version of the long-term plan before the bill of quantities. This has contributed to increase the accuracy in cost estimation and to make cost control more effective. It became possible to establish a clear link between the time frame of different projects and the company overhead costs. The directors of the company stated that this integration between planning and cost estimating has given more reliability to the proposals presented to clients. One of them said: *"nowadays we are much more open to risk a reduction of completion time than before"*. Sharing the same opinion, another director said: *"I have a system that will make this construction project run according to what has been estimated"*;

- Medium-term plan: constraint analysis at the medium-term term level was fully implemented as part of the system. The aim was to avoid unexpected urgent demands of resources by the production system, allowing the fulfillment of the quality criteria in the short-term plan, as suggested by Ballard and Howell (1997b);

- Resource programming: based on the analysis of constraints, a resource schedule at the medium-term planning level was introduced. This also contributed to increase the effectiveness of short-term planning;

- Planning coordinator: the planning and control coordinator played a key role in the implementation process from the point of view of both the company directors and the site engineers. His support to the dissemination of ideas and in the learning process was considered to be fundamental for the continuous improvement of the system.

ANALYSIS OF THE RESULTS

The evolution of the production planning and control system in the three stages of development is presented in Figure 1, using two performance indicators: (a) the PPC (percentage of plans completed), and (b) the implementation efficacy.

The implementation efficacy indicator was calculated through a subjective evaluation on whether a set of fourteen practices have been fully or partially implemented. These practices attempt to make some of the underlying ideas of the production planning system more explicit. They are fully described by Bernardes and Formoso (2002). The evaluation was carried out through semi-structured interviews and also by direct observation at the construction sites. Each practice receives a weight that corresponds to the degree in which it is used. The weights are assigned according to the following criteria:

- Weight 1.0: a practice is being largely used in the company;

- Weight 0.5: a practice is being partially used in the company;

- Weight 0.0: a practice was not implemented.

For instance, Table 2 presents the score obtained in Project A for all fourteen practices. The project score is given by the sum of weights divided by fourteen. The combined analysis of this indicator and the PPC provides some evidence on whether the production planning and control system have been effectively implemented.

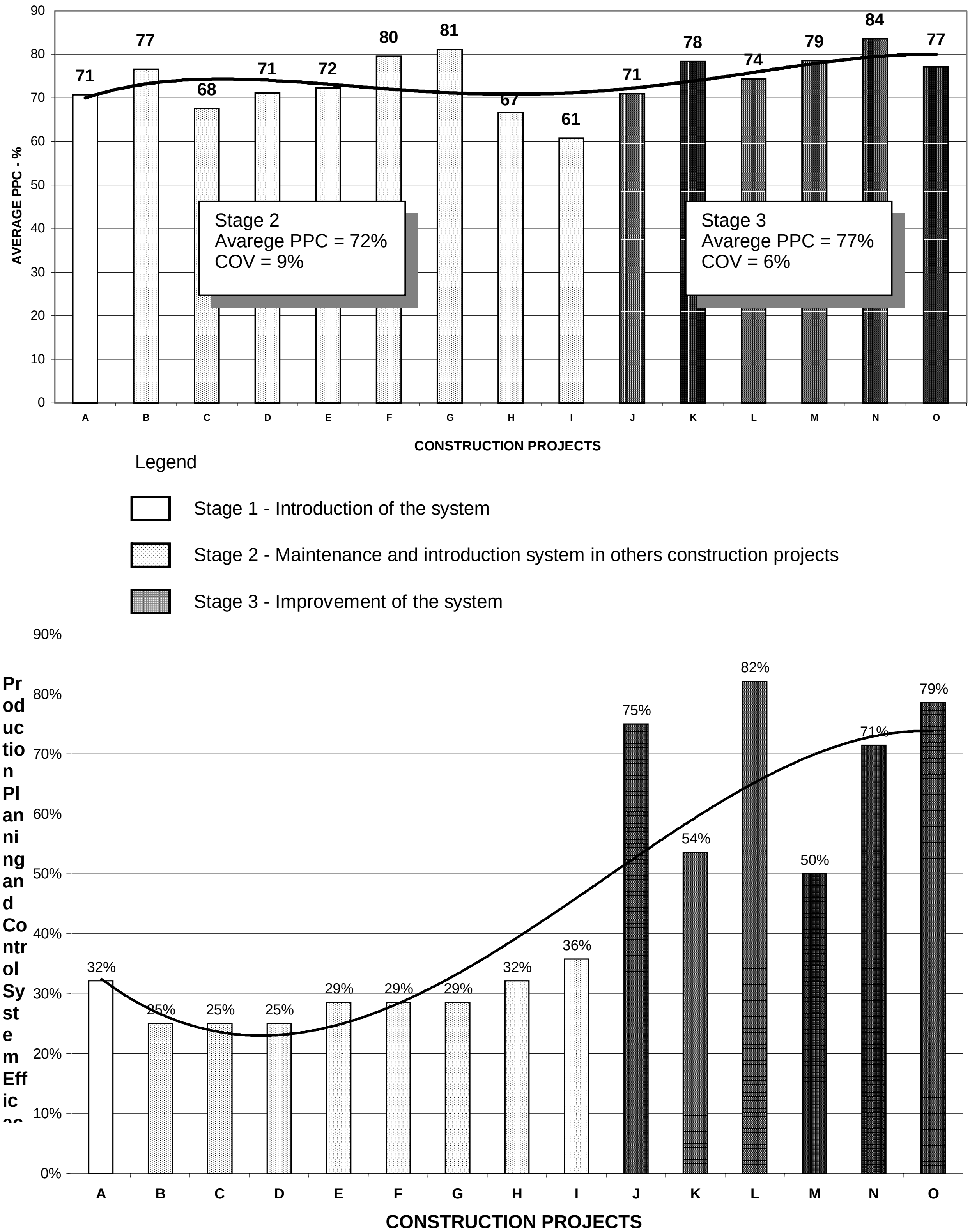

Figure 1 – Average PPC and Implementation efficacy for different projects

Table 2 - Implementation Efficacy of Project A based on fourteen practices

Practice	Weight
1. Production planning and control standardization	0.5
2. Planning and control hierarchization	0.5
3. Analysis and qualitative evaluation of processes	0.0
4. Analysis of physical flows	0.5
5. Constraint analysis	0.0
6. Use of visual devices	0.5
7. Formalization of short term planning	1.0
8. Detailed specification of tasks	0.5
9. Programming of workable backlog	0.0
10. Shared decision making	0.5
11. Use of PPC and identification of the causes of problems	0.5
12. Use of performances indicators	0.0
13. Corrective actions based on the causes of problems	0.0
14. Meetings for information diffusion	0.0
TOTAL	**4.5**
Implementation Efficacy of the production planning and control system	**32%**

Based on Figure 1, it is possible to conclude that there is a clear trend of improving both the PPC and the implementation efficacy. Stage 3 presentes both a higher PPC and a lower coefficient of variation (COV), compared to Stage 2.

In Stage 2, projects B, F and G has an outstanding performance in terms of PPC. The results obtained in projects B and F can be explained by the fact that these project were relatively less complex compared to other projects. Both of them had relatively little interference form the clients' processes because they consisted of new buildings. Regarding project G, this was an extension of project A, in which the production planning and control system was initially developed. In that case, the implementation of production planning and control was facilitated because the client and some of the subcontractors were used to it and also due to the fact that the company knew the site fairly well.

The site manager of projects G and L pointed out that "*in the hospital, we knew more about what we were doing. The schedule we had created together was well established. The design was fairly repetitive*". Regarding project G, the client representative said:

> *I don't know in which way they saw myself, but I think when everybody is playing the same tune, when everybody is going towards the same direction, there are only two attitudes to take: either take part or to abandon the process. Some people get involved more quickly; others more slowly. I think my presence was welcomed and was positive because I was the link between the client and the major supplier –the building company.*

The causes for the non-completion of work packages and the content of short term plans have also been analysed in this study. There were indications that the quality of work package definition has improved from Sate 2 to Stage 3. This may have an influence on the results, since the PPC indicator is made higher than it should be. For instance, work packages such as "dismantling metallic structure" or "general cleaning" did not fulfill the quality criteria proposed by Ballard and Howell (1997b), since it was not possible to precise the amount of work to be carried out. This may have contributed to reduce the PPC level during Stage 3.

Another factor that affected the results of Stage 3 in terms of PPC was the fact that the company started to co-ordinate both the product development and the production processes in some of the projects. This obviously tends to increase the degree of uncertainty involved production planning and control, which may affect the reliability of the planning system.

Regarding the implementation of core planning and control practices, there was a dramatic increase in Stage 3, starting in Project J. In fact, the best performing projects (J, L and O) were the ones in which the planning and control coordinator was directly involved or a case study in partnership with UFRGS was being carried out. This indicates that the understanding of core production management concepts and principles played an important role in the performance of the production planning and control system.

An attempt was made to correlate the average PPC and the system implementation efficacy. However, no strong correlation was found (r^2 = 0.0788) between these two variables. This indicates that besides the implementation of such practices, other factors tend to affect the PPC level, such as project complexity, degree of uncertainty, and previous learning in the same site. Moreover, some of the practices have a positive influence in the production planning and control process as a whole, but might not have a direct and immediate impact in the PPC indicator - this is the case, for instance, of the practice "analysis and qualitative evaluation of processes".

CONCLUSIONS

This paper presented a case study carried out in a construction company in which a production planning and control system based on the Last Planner method have been successfully developed and applied in 15 different projects. The main factors that have positively affected the continuous improvement of the system are summarized bellow:

- The ISO 9002 certification had a positive effect, since production planning and control was a core process in the quality management system. This contributed to widely disseminate the planning and control system in all company projects. The auditing routines became an additional mechanism to enforce the implementation of the planning and control system.

- There were several indications that learning the underlying core production management concepts and principles involved in the planning and control systems played a key role in the continuous improvement of the system. This was achieved by the having a planning coordinator that had the opportunity to do a postgraduate course, and also by the realization of a weekly meeting focussed on learning rather than problem solving.

- The identification of a set of fourteen core practices involved in the production planning and control system also had a positive effect in the development process. These can be used to guide implementation and evaluate its effectiveness. Also they can support learning since they make some of the underlying ideas of the planning and control system more explicit. Although the content of the set of practices adopted in this study can be questioned, this kind of procedure seems to be effective as a tool to support planning and control systems implementation.

- The partnership that was established with the research institution provided an outstanding opportunity to introduce new production management ideas in the construction company. This made it possible to develop in three years a planning and control system that has given a good reputation to that company in the local industry. From the point of view of the research institution this partnership provided a very rich testing ground for new ideas related to planning and control systems.

In the future, the authors intend to further investigate the learning process that the production managers go though when implementing a planning system, and also to identify the main abilities that are necessary for successfully running the system.

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