Chapter 10
Conceptual Framework for the Integration of Tactical and Operational Decisional Levels

D. Pérez-Perales, F. Alarcón, P. Gómez-Gasquet, and M. M. E. Alemany

Abstract The need to adapt to increasingly competitive markets, adapting to new organizational forms and pursuing greater flexibility, forces companies to make decisions more agile. To face current dynamism, it is necessary to provide information systems for planning with sufficient flexibility to achieve the proposals established in the traditional operations planning and control system (OPCS) scheme. This is possible due to the introduction of new Industry 4.0-based production technologies that give decision-making more flexibility and efficiency. In this paper, a conceptual framework for the integration of the tactical and operational planning is proposed, doing more emphasis in the expert system that integrates and coordinates the specific decisions of both levels.

Keywords Conceptual framework · Tactical planning · Operational planning · Integrated planning

10.1 Introduction

It is a fact in many companies the need to properly coordinate decisions at different time levels, and more particularly between tactical an operational ones.

To achieve this, two clearly differentiated visions are used in practice: the hierarchical planning of the levels or their simultaneous planning.

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There are several authors [6, 17] who point out different reasons to address the previous question according to the hierarchical approach.

Other authors such as [20] or [22] advocate for the simultaneous planning of the two decision levels.

The analyses of both approaches have allowed to address some shortcomings and identify a set of elements that could be enhanced. Moreover, the new paradigm of Industry 4.0 and its related technologies have changed the way this tactical-operational planning process is carried out [4, 15, 11].

This paper proposes a conceptual framework to support the integration and coordination of the tactical-operational planning process. One of the key aspects is the consideration of the new advances due to Industry 4.0-based technologies which allow to obtain more flexible and efficient integrated solutions.

The paper is structured as follows: In Chap. 2, a brief review about different visions for the tactical-operational planning process is conducted, basically those ones based on hierarchical and simultaneous planning of the decision levels. From the previous analysis, a conceptual framework is proposed in Chap. 3. Finally, in Chap. 4, some conclusions are drawn.

10.2 Review of Visions for Tactical-Operational Planning

As aforementioned in the introduction, two clearly differentiated visions for tactical-operational planning are used: the hierarchical planning of the levels and their simultaneous planning.

The **hierarchical vision** of tactical and operational planning splits the problem into two subproblems, which require "mechanisms capable of coordinating the different decisions of each level together with the information exchanged" [13].

Many authors have addressed the advantages and obstacles of using this vision. One of the main advantages concerns to the compatibility with the organizational structure of the company and consistency among various planning activities in the different levels of organization's hierarchy [18]. Infeasibility and suboptimality among the decisions made at the different hierarchical levels of the firm are among the main obstacles [16].

Due to space restrictions, just other consulted works from literature are quoted, such as those from [1, 5, 8, 9, 12, 19, 23] or [21].

On the other hand, the **simultaneous planning** of the tactical and operational decisional levels. As in the case of the previous one, some advantages and obstacles exist. Bitran and Tirupati [3] expose that although developing integrated decision models capable of dealing with all decisions at once may seem desirable at first, the integrated models have several drawbacks. First, these models are so complex that their optimality is just guaranteed in a few practical cases and with excessively high computational times. Second, even if computational power does not restrict obtaining their solution, these models do not respond to the hierarchical structure of many companies, since their monolithic approach does not allow the interactions between those responsible for each level of the hierarchy.

Other consulted works are those from [7, 10] or Almada and James [2].

10.3 Proposal of a Conceptual Framework for Tactical-Operational Planning

In this third section, a conceptual framework for tactical-operational planning is proposed. As stated in the acknowledgements, this proposal is developed as part of the funding project NIOTOME [14], where some deficiencies of tactical-operational production planning systems were first identified in order to contribute with some improvements and therefore with an innovative proposal.

The deficiencies identified are:

- The decomposition of the decision process into subproblems facilitates having models approvable by the decision-maker; however, these models have a partial vision of the problem.
- There are no check procedures to determine consistency between levels.
- The traditional operations planning and control system (OPCS) scheme is a common and widely used proposal. New proposals must face the inertia established in this traditional vision.
- Information systems for OPCS are complex and rigid, following the theoretical approach and leaving out practical reality. In many cases, the hierarchical planning system faces alterations in the production process, urgent orders or breakdowns that would force altering the plans.
- The cycles of decision-making are shortened, which force decision-makers to alter the proposals of the information systems in order to greater adapt to that reality and improve the proposals.
- It is key to identify obsolete models. The decision models made by the model designer may not correspond to reality (change in the processes over time, misinformation of the model designer, …).
- The OPCS information system is not ready to absorb and treat the huge amount of available data in the company thanks to Industry 4.0-based technologies.

This paper proposes a conceptual framework for the adaptation of the instruments available in the tactical-operational scope of the OPCS so that they are able to take advantage of the information of its environment to provide more adjusted solutions to the reality of each moment, improving efficiency throughout the production system.

This must be specified in two main objectives, which are aligned with part of the aforementioned project [14].

1. The tactical and operational levels must have decisional independence, as well as a high degree of coordination by extending the decision process that closes

the tactical-operational loop (flow from the operational to the tactical) and improving the efficiency of the joint tactical-operational planning process.

2. Information and its obsolescence must be considered. The data must be processed and converted into relevant information that must reach all decision levels for effective decision-making. The simple updating of the values of the models with the data already available, the elaboration of values based on machine learning systems or the transformation of the constraints or objectives of the models under the tutelage of a manager that establishes the most appropriate time to do so.

Therefore, a change in the traditional OPCS framework has been proposed, which has been presented towards a system with greater integration and better use of information by defining an intermediate layer between the tactical and operational level called tactical-operational objectives integration system (TODIS), as it can be seen above in Fig. 10.1. TODIS nomenclature is defined in Table 10.1.

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First, an initial plan is generated (optimally or heuristically). Then, an initial schedule is also generated (optimally or heuristically). This schedule is constrained by the IN sent from the initial plan. If this initial schedule is infeasible, the IN must be changed to result in a feasible programme. If feasible, the efficiency of the joint initial plan-schedule is computed.

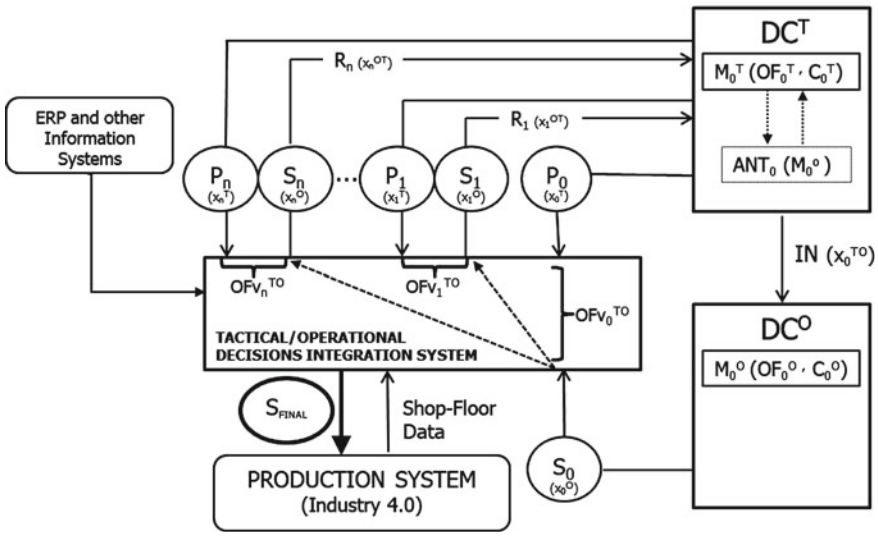

Fig. 10.1 Framework for the integration of tactical and

Table 10.1 Nomenclature

DC^T	It corresponds to the tactical decision centre (human or computer resource), which is responsible of the tactical decisions (plan)
DC^O	It corresponds to the operational decision centre (human or computer resource), which is responsible of the operational decisions (schedule)
$M_0{}^T$ $(OF_0{}^T, C_0{}^T)$	DC^T makes initial decisions (initial plan) by means of a tactical decisional model $M_0{}^T$. This model is made up of an objective function $OF_0{}^T$ and some constraints $C_0{}^T$
$M_0{}^O$ $(OF_0{}^O, C_0{}^O)$	DC^O makes initial decisions (initial schedule) by means of an initial operational decisional model $M_0{}^O$. This model is made up of an objective function $OF_0{}^O$ and some constraints $C_0{}^O$
ANT_0 $(M_0{}^o)$	$M_0{}^T$ can anticipate to a lesser or greater extent $M_0{}^O$. This anticipation may affect its objective function $OF_0{}^T$, its constraints $C_0{}^T$ or both
P_0 $(x_0{}^T)$	It corresponds to the initial plan P_0 generated by DC^T. This plan is the result of solving $M_0{}^T$ and obtaining the value of the tactical decision variables $x_0{}^T$ throughout its planning horizon (made up of a set of planning periods)
IN $(x_0{}^{TO})$	Once $M_0{}^T$ is solved and obtained the value of the tactical decision variables P_0 $(x_0{}^T)$, some of them $(x_0{}^{TO})$ are sent to DC^O within an instruction IN that constrains $M_0{}^O$ and therefore the value of the operational decision variables (initial schedule) obtained when $M_0{}^O$ is solved
S_0 $(x_0{}^O)$	It corresponds to the initial schedule S_0 generated by DC^O. This schedule is the result of solving $M_0{}^O$ and obtaining the value of the operational decision variables $x_0{}^O$ throughout its planning horizon (made up of a set of tactical planning periods)
$OFv_0{}^{TO}$	Once $M_0{}^T$ and $M_0{}^O$ are solved, the TODIS evaluates which is the efficiency of the joint tactical-operational planning process. This efficiency is the sum of the objective functions values of both models $(OFv_0{}^{TO})$, computed only for the schedule horizon. Both values $(OFv_0{}^T$ and $OFv_0{}^O)$ must be expressed in monetary units; otherwise, they must be converted
S_n $(x_n{}^O)$	The TODIS feeds on the initial plan P_0 $(x_0{}^T)$ and schedule S_0 $(x_0{}^O)$, as well as the real data of the production system and proposes a set of alternative schedules S_1 $(x_1{}^O)$, S_2 $(x_2{}^O)$, …, S_n $(x_n{}^O)$ based on possible improvements with respect S_0 $(x_0{}^O)$
R_n $(x_n{}^{OT})$	Each alternative S_n $(x_n{}^O)$ generated by the TODIS results in a reaction R_n $(x_n{}^{OT})$ sent to DC^T which constraints $M_0{}^T$ and therefore the new values of the tactical decision variables P_n $(x_n{}^T)$ obtained when $M_0{}^O$ is solved
P_n $(x_n{}^T)$	The TODIS generates a set of plans P_1 $(x_1{}^T)$, P_2 $(x_2{}^T)$, …, P_n $(x_n{}^T)$ which are the result of solving again $M_0{}^T$, but in this case, considering the reactions R_1 $(x_1{}^{OT})$, R_2 $(x_2{}^{OT})$, R_n $(x_n{}^{OT})$
$OFv_n{}^{TO}$	The TODIS calculates the efficiency of the joint tactical-operational planning process for each couple of S_n $(x_n{}^O)$ / P_n $(x_n{}^T)$, by obtaining the sum of their objective functions values $(OFv_n{}^{TO})$
S_{FINAL}	The best alternative S_n $(x_n{}^O)$ / P_n $(x_n{}^T)$ is selected based on the "efficiency" of the joint tactical-operational planning process, that is that with the best $OFv_n{}^{TO}$

So far, everything is run as it is carried out in the company. Actually, this proposal does not require an integration of complex information systems and is based on a basic data exchange, since the logic of the process is completely located in the new system (TODIS), so its implementation in companies is inexpensive.

At this point, TODIS, an expert system that draws on all the information from the tactical and operational levels, collects this initial schedule and generates different alternatives, relaxing the constraints from the IN. This will mean an improvement to a greater or lesser extent in the efficiency (OFv_n^O) of these schedules. Then, TODIS evaluates the plans that best fit to these new alternative schedules. Basically, each plan is recalculated taking into account the different types of reactions from these new alternative schedules. These plans will have a penalty in a greater or lesser extent in its efficiency (OFv_n^T),

Finally, TODIS will assess which plan-schedule generates the highest joint efficiency (OFv_n^{TO}), that is the highest integration between tactical and operational decisions.

Figure 10.2 shows this closed-loop scheme for the integration and coordination of tactical and operational decisions. Blue-coloured data refers to those specific decisions that link tactical and operational levels.

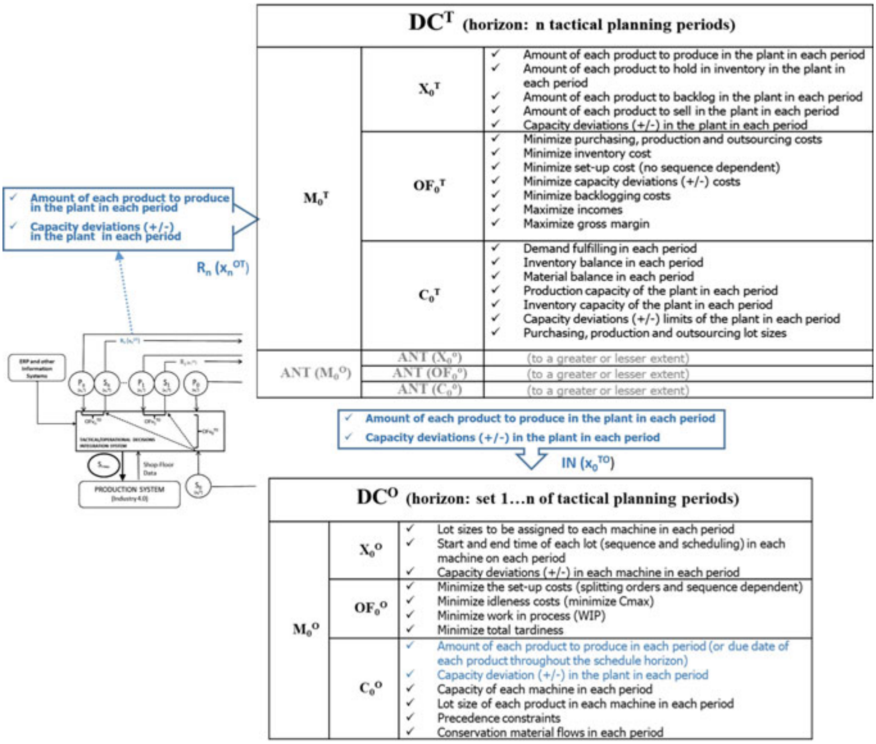

Fig. 10.2 Closed-loop scheme for the integration of tactical and operational decisions

10.4 Conclusions

This paper has proposed a conceptual framework to support the integration and coordination of the tactical-operational planning process. It enhances the traditional hierarchical planning approach by considering the new advances due to Industry 4.0-based technologies which allow to obtain more flexible and efficient integrated solutions.

The framework encompasses an expert system, called TODIS, that integrates and coordinates the specific decisions of both levels, in a closed-loop. It is a layer that feeds on the results (plans and schedules) elaborated in the upper and lower level, respectively, as well as data from ERP and other corporative information systems and real data of the plant (where it is remarkable the use of Industry 4.0-based technologies).

TODIS facilitates integration between plans and schedules, aids in its improvement and proposes alternatives, which if accepted, are managed at the corresponding decision levels, such as consolidated plans or schedules.

It must be remarked that TODIS can be integrated into the current decision-making system, so it is assumed that, on the one hand, the planner generates its definitive plans (tactical level), and these are available for the schedulers who, on the other hand, generate its definitive schedules (operational level). The schedules specify the timed sequence of production orders for a subset of plan periods (schedule horizon).

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