Planning and Scheduling Methods and their Applications in ERP Systems on the Czech Market

Hana Klčová, hana.klcova@cvis.cz
Dagmar Šulová, dagmar.sulova@cvis.cz
Petr Sodomka, petr.sodomka@cvis.cz
Faculty of Management and Economics
Center for inVestigations into Information Systems
Tomas Bata University in Zlín
Mostní 5139, 760 01 Zlín
Czech Republic

Abstract

Production and logistical processes are some of the most critical processes in every industrial enterprise. Mastering these processes has a direct influence not only upon the entrepreneurial activities of individual firms, but also on the whole of the supplier-customer chain and on industrial branches as a whole. For this very reason, these processes have always been, are and will continue to be the centre of interest in the exploitation and use of modern information systems and technologies.
ERP systems represent a key software infrastructure for production and logistics management. Their effective application in everyday working practice should however not take place without the use of the corresponding methods for the planning and management of production and logistics processes. This paper summarises the main observations of the Center for inVestigations into Information Systems (CVIS) in these fields. It provides an overview of the main results and outcomes of research study investigations into the Czech ERP market with an orientation on the planning and management methods integrated into the applications logic of ERP systems.

Key words: Enterprise Resource Planning (ERP), Manufacturing Resource Planning (MRP II), Just in Time (JIT), Advanced Planning and Scheduling (APS), Supply Chain Management (SCM), Theory of Constraints (TOC)

1. Introduction: Presuppositions for production process automatisation

Documentation provides the basic framework for the management of the material flows in production and logistics processes. At the same time, the circulation of such documentation generates information flows that enable flexible and adroit interventions for the attainment of the aims established and set out in the operational plans. In order to be able to fulfil the plan, it is necessary to unify and to integrate information relating to production and logistics processes, and especially there where an enterprise produces a variety of product types – or even, makes use of a variety of differing types of production or management methods. Furthermore, the mastery and automatisation of material flows in production presupposes a complex approach to inventory records, production process organisation, the economic aspects and the requirements on ensuring information security.

The complex recording of inventory can be assured through the permanent tracking of the current state-of-affairs regarding material flows of raw materials, other materials, sub-assemblies and finished products in the production and logistics process. Without such records, it is impossible to have any sort of control over the fulfilment of an enterprise's production plans – this then becomes a process with a high degree of uncertainty built into it, which in turn leads to uncontrollable increases in stock and inventory levels, increasing demand for new storage facilities, as well as demands on the transport and manipulation of these materials or finished products. The complex recording of inventory levels is an essential presupposition for the realisation of one's operational plans and the creation of a normative base that would enable the automatisation of the production management process in the information system.

A further key requirement is the delimitation of the relationships between the functions and competencies within an organisation. In a functionally-oriented enterprise, maintaining the hierarchical organisational structures of the enterprise form the basis for the creation of the organisational schema of the production manufacturing process. Individual functions then receive a summary of information necessary for the realisation of defined activities. The strict maintaining of precisely delimited competencies remains an important condition, while not only the results of the process` measurement and controllable but also the course of the whole process itself. A process-managed industrial enterprise however organises its key production process according to the principle that decisions are influenced by the needs and requirements of the process and customers, and not the needs of the activities and functions [1].

In the course of production automatisation, it is essential to ensure its relationship with the logistical processes. One cannot however forget to take into consideration the interlinkage and dependency with the technologic level of the production process itself. So-called Manufacturing Execution Systems (further only MES) are usually used to acquire real-time operational data as a rule. These form a layer located between the technological level of the production process and ERP systems in the overall hierarchy of an enterprise's information system. Thus, these MES concern themselves with the detailed collection of data and its processing for evaluating the production process from a multitude of various points-of-view and for operational management purposes [2].

An indivisible component of the production process is its interlinkage with the management and calculation of costs and prices. These then primarily serve to correct the process and enable the assurance of the requisite effectiveness of the production process. The system uses calculus equations that are then directly derived from the applicable production management methods. Equally, an important task is also the definition of information inputs and outputs with a view to the needs of planning and managing the delivery of materials, work-in-progress, the distribution of finished items, etc. At the same time, it is essential to differentiate the phases which will be automated and integrated into the information system and those which will remain purely in a formalised form [1].

2. Research Methodology

The Center for inVestigations into Information Systems (further only CVIS) has conducted research studies of the Czech ERP market on an annual basis since 2000. CVIS' research methodologies are based upon years of personal experience [1] and observations and knowledge defined in professional literature by authors like Gill, Johnson [3] and Pavlica [4].

General bases for the ERP systems investigation, classification and efficient utilization are formed in pivotal monographic studies of Professors Jiri Voříšek [14] and Zdeněk Molnár [15] from the end of nineties, and in significant foreign studies of the renowned research companies such as Accenture [16] and Deloitte [17]. The last two cited works form, together with expert publications of T. H. Davenport [18], T. Stevens [19] and D. L. Olson [20,21], the base of the own ERP systems classification.

The research itself is performed in the following ways and forms:

1. A questionnaire-based research investigation of vendors, in the form of quantitative questions supplemented by qualitative control of the data and information provided by them (e.g. through telephone conversations with customers to verify selected references and the correctness of information about the functionality and other aspects of their ERP solutions).
2. A qualitative control question process of both user and vendors in the form of market research and targeted discussions, which then tend to be elaborated into case studies (more than 50 studies).

The research aims are:

1. To prepare an overview of the Czech ERP market for prestigious Czech publishing houses like Computer Press, Extra Publishing and CCB.
2. To verify the general theories relating to the ERP market and to generate situational and contextual interlinked theories.

Table 1: Czech ERP market investigation in form of a written questioning (CVIS 2000-2008)

Year	Main topic	Additional topic	Number of respondents
2000	ERP systems	-	51
2001	ERP systems	ASP	45
2002	ERP systems	IS efficiency, information asymmetry	49
2003	ERP systems	ASP, ERP projects	53
2004	ERP systems	System integration, strategic alliance	72
2004	IS for SME	Trade models	49
2005	ERP systems	Trade models	80
2005	IS pro SME	Economical systems	63
2006	ERP systems	Information asymmetry, services, BI	75
2006	IS for production	Detailed analysis of APS/SCM functionality	68
2006	IS for SME	Economical systems, problems with projects	61
2007	ERP systems	Servicing and trends in ERP market	77
2007	IS for SME	Economical systems, problems with projects	60
2008	ERP systems	Servicing and trends in ERP market, management of production and logistics processes	80

The authors of this paper use their own previous experience with research studies into the Czech ERP market as the basis for realising individual research study investigations. The selection of the sample group is performed deliberately, and on the basis of the following requirements and principles:

1. To acquire data and information from the maximum possible number of suppliers of all of the information systems on the Czech market equipped with an ERP function - through the use of repeated questioning.
2. To exploit the team's personal contacts with concrete individuals in positions of responsibility in the managements of the supplier enterprises – in order to inculcate motivation and to evoke interest in taking part in the research endeavour.
3. In the course of creating the sample for the questionnaire-based investigations, emphasis is placed on ensuring that the given sample corresponds with the base-set, and thus includes all who meet the set criteria – i.e. domestic producers of software in support of ERP systems as well as representatives of world-class software corporations providing their ERP systems in the Czech market.

   The aim is therefore to ensure the maximalisation of the number of respondents, while at the same time bearing in mind the potential risk of oversimplifying the techniques and a certain level of superficiality in the responses.
4. Previous experience has shown that, in research studies into the ERP market, there is no direct correlation between the size of sample and the simplification of the techniques and thereby also reducing the ability of the questionnaire to provide meaningful responses. Respondents are sufficiently motivated to supply an exhaustive reply by the opportunity to present their products in professional publications, and which is taken and understood to be, in its own way, a certain form of promotion.

The high-quality response ability, validity and reliability of the research study are buttressed by the following principles:

1. Should new questions be integrated into the questionnaire, then a small pilot study is performed on a small sample of respondents in order to verify whether the questions are sufficiently well-formulated and comprehensible to all and thus make the requisite sense.
2. The research sample of respondents is deliberately selected; in 2008 it represented approximately 90 % of the basic sample-base – from the perspective of the number of implementations of the ERP systems under study.
3. The information acquired through the questionnaire investigation is verified telephonically, and in selected cases, confronted through discussions with customers and the use of qualitative questioning (e.g. enquiries, and directed discussions).
4. The reliability of the research study is based upon the annual repetition of tried and tested methods and approaches, while at the same time, any eventual deviations in the results over time are tracked and rigorously controlled.

In view of the above-mentioned facts, it is therefore possible to generalise upon the outcomes and conclusions deriving from the written questionnaires and other research methodology.

3. "Push" and "Pull" methods in the planning and management of production

Developments in the automatization of production processes reach back to the period pertaining at the cusp of the nineteen-sixties and seventies, when the first MRP systems began to be used. The precursor of the MRP I application algorithm was the **Minimum Inventory Level Production Management** method, which was the first ever method to be used in information systems. The method is based upon breaking down the overall production process into several phases. The state of th1e inventory is checked and controlled between each of the individual phases. If inventory reserves drop below planned-for limits, there are replenished and the production flow continues to run relatively smoothly. This static way of managing things is however hard to adapt to changes and also pointlessly tied up costs and resources in maintaining these set inventory reserves [1].

As compared with **Minimum Inventory Level Production Management**, the **MRP (Materials Requirements Planning) I** method is distinguished by its close connection with the logistics chain (e.g. supply, storage, transport). MRP creates a balance between customer requirements and their fulfilment. MRP only maintains essential resource reserves in storage to fulfil unplanned demands on the basis of time-related priorities.

The period that saw the birth of ERP systems also saw the beginnings of manufacturers' demands for the automatisation of the planning of material requirement consumption flows (MRP I). The first such automatised system came into existence through the collaborative efforts of the Case Corporation and IBM. The Case Corporation has an almost one hundred year tradition and is ranked among the most distinguished world-class manufacturers of agricultural and construction machinery. In 1960, a team from IBM under the leadership of J. Orlicky, implemented the first ever MRP system for this company. The applications in this MRP system at the time included methods for the planning and scheduling of material flows for the production of the Case Corporation's complex product portfolio. From this time onwards, we have seen the implementation of ever more extensive MRP systems whose operation and administration have required the establishment of service teams and the assurance of sufficiently advanced and efficient hardware. The 1970s, for this very reason, saw the massive development and evolution in industry of computing centres equipped with hall-sized computers [1,5].

More or less at the same time (in the 1960s) and independent of MRP systems, the first numerically controlled (NC – Numeric Control) machinery began to make their appearance.

Over time, these NC machines penetrated into the fields of large-lot and mass production, which only served to increase demands for their complete management by computers (i.e. CNC – Computer Numeric Control). Moving on from the resolution of purely technological problems (e.g. for the digital calibration of the input parameters of lathes and turning machines), automatisation of the production process has evolves into the form of the massive implementation of fully-automatic manufacturing plant and machinery and production lines. New demands on the organisation of the production and ancillary processes including the processing and administration of the supporting documentation has gone hand in hand with this phenomenon. Among the key items of information contained in these production process documents is data and information about the progress, size, content and determining of production batches and the final completion and assembly of finished products. This information is also linked to data and information of a financial nature (e.g. direct costs and overheads), and to data and information resulting from the management methods used (e.g. delimiting capacity) and data and information ensuing from the overall organisation of the production process (e.g. determining the optimal location and placement of production means and tools and ancillary equipment).

Planning with the assistance of the MRP I algorithm led to unreal production plans, since they were oriented only on the planning of material consumption needs, even if this was closely correlated with the logistics chain. The MRP I method automatically counts on unlimited capacity, which however is in practice a rarely useable presumption. For this very reason, the MRP I concept was expanded and upgraded into the **MRP II (Manufacturing Resource Planning)** system, and in such a way as to include precise control of the planning of purchasing in relation to production and sales. The consumption of materials is determined on the basis of the requirements flowing from the individual production orders. The materials consumption needs were set according to the consumption patterns for the resources essential for the production and completion of these orders.

The MRP II method represents the "Push" principle of management, according to which the product is manufactured on the basis of plans and subsequently "pushed" through the enterprise's processes until it reaches the final customer. The production plan is created on the basis of predictions of eventual demand. MRP II however, reacts with difficulty to requirements for changes, in relation to construction changes for instance. It is also impossible to constantly change the plans as a result of each and every change to the input requirements. It is essential to prevent and avoid repetition and further changes are resolved on an operational basis or through the use of other visualisation methods (e.g. planning tables). Modern information systems now even know how to offer online visual simulation tools for instance. If simulation is not available, it is possible to use Gantt chart, which depict the individual operations in a clear manner and enable intuitive changes to a plan while respecting the constraints imposed by limited capacity.

The MRP II method is currently used by the great majority of ERP systems available on the Czech market. Some of these products are exclusively oriented on the diligent application of MRP II algorithms, e.g. **Infor ERP MAX+**, while other such "push" systems are enhanced by advanced TOC (Theory of Constraints) elements, e.g. **Dialog 3000S**.

Production and logistics planning and management processes on the basis of "push" principles are complemented by systems exploiting "pull" principles. These are, taken together, designated as **JIT (Just in Time)** methods. JIT represents the "pull" management principle, according to which the production of a product is initiated by the customer. In such cases, all of the requisite components are "pulled" by the enterprise's processes "just in time" (i.e. just at the right time) right up to the final completion and finishing of the product and its handover to the customer [13].

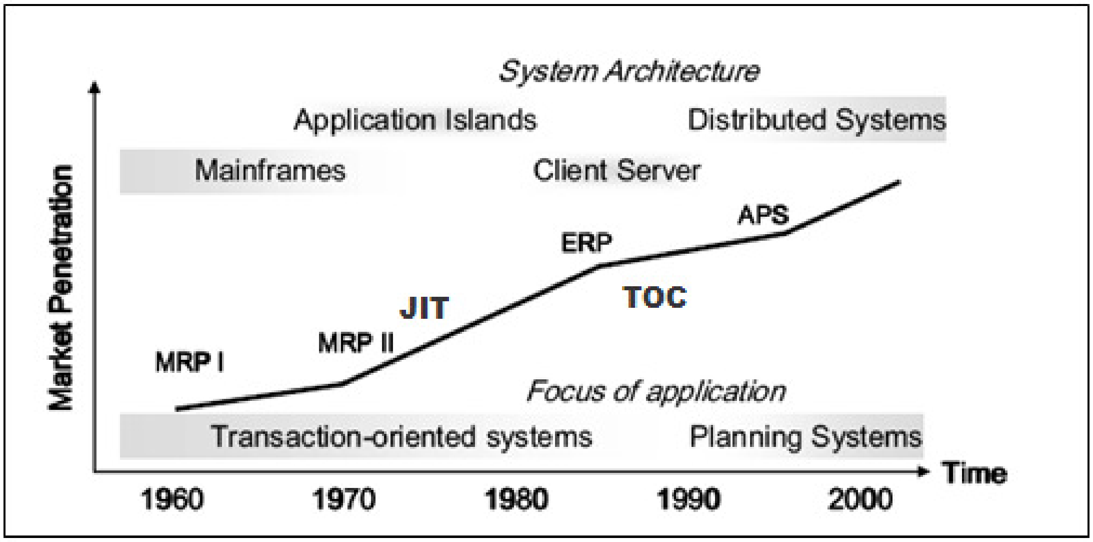

Fig 1. Planning and management methods in information systems and their development over time (CVIS, adapted according to 11)

In essence, one can look at management according to JIT principles in two ways. The traditional and narrower sense talks about the exploitation of JIT in the course of managing the individual levels of the production process or between the individual work stations or workshops. “Just In Time” production requires the delivery of materials, products or services at the times when they are needed for the active production sub-processes which directly react to the requirements set by the customer. Its main consequence is predominantly in cost reductions for inventory storage and time-loss savings. [1,6,7,13].

The JIT method is used by a whole range of ERP systems on the Czech market, even if the overall number is substantially less than those using MRP II methods. JIT is available for instance in the **Microsoft Dynamics NAV** system or the vertical solution of the **SAP Business All-in-One** system designed for the automobile industry for instance. The **AROP** production system, which is a specialised modular component of the **WAM S/3** complex ERP solution, makes very good use of the JIT method and it can be integrated into other ERP systems as well.

Kanban (from the Japanese, can be loosely translated as **“the initiation of production by a signal”**) is another subsidiary method based on the “pull” principle. Kanban is a suitable tool especially for workshop production management and production planning. It was originally developed in the nineteen-fifties by the Toyota Motor Company for the more effective management of materials flows in their automobile assembly lines.

The whole system functions such that individual workplaces, assembly lines, etc. evoke the activity of their precursor production stage through the use of so-called “kanban” cards – i.e. order forms that also function as delivery notes. Self-regulating – **Kanban system** is formed as a result of this system.

The Kanban system presupposes the decentralisation of order management. In the course of determining the priority of "what to produce first" we base our decisions on the number of individual orders, their relationships to the requisite products and other rules. This method makes a kanban workplace less dependent upon its surroundings without weakening its ability to fulfil the aims and goals of the enterprise as a whole. The Kanban system principle can of course equally be validated in supply chains.

The Kanban system is best applied in situations where there are repetitive production runs of the same or closely related components and with a great degree of equality in the demand for them (i.e. in mass or serial production runs) as well as for the harmonisation of capacity (i.e. in limiting bottlenecks in production runs). It makes relatively great demands on the smooth functioning of material flows and on employees, who should not only be sufficiently well–qualified but especially, well-motivated. The education and motivation of people itself makes up one of the most significant cost elements in the implementation process of a Kanban system into everyday working practice. [8]

The so-called **Electronic Kanban system** functions in conjunction with the information system. It serves for writing off materials used by a worker at a machine and for basic two-way communications between employees in the production and logistics processes and those who are responsible for writing off materials and completed sub-assemblies. Based on the combination of such an intelligently managed transfer of production, planning and tracking material flows, it is possible to make recommendations to individual workplace and in line with a given production plan and the instantaneous and actual fulfilment of sub-deliveries of components and sub-assemblies regarding the amounts of material or semi-finished products are needed as well as to determine suitable transport or transfer times.

Electronic Kanban systems use bar-code technologies and wired or wireless connections of the end-terminals. These are either programmable terminals, or simply "non-intelligent" client equipment.

The **SAP Business Suite, IFS Applications** and **Infor ERP LN** systems are all typical ERP systems that are widely available on the Czech market that support Electronic Kanban systems.

4. Combined production planning and management methods

The first method which combines the "push" and "pull" principles is the **TOC – Theory of Constraints** and its **DBR (Drum, Buffer, Rope)** method for the management of production and logistics processes. Even if TOC is often only associated with the problems and issues relating to production and logistics, it is also easy to use for the optimalisation of other enterprise activities. The Theory of Constraints can also help managers in such fields like for the visualisation and improvement of an enterprise's processes, for resolving communication problems or it can be of assistance in the course of looking for new approaches, for cost management for instance.

TOC represents a relatively new, non-traditional way of resolving problems and ways of thinking. It mainly has to do with a complex managerial approach to the management of an enterprise oriented on its growth and increasing the achievement of the values set for the enterprise's goals, rather than being a concrete method at the MRP II or JIT level.

In the field of managing production, TOC works with the requisite data similar to what is needed for the MRP II or JIT concepts. Since TOC is oriented on bottlenecks, there is a lesser demand to a certain degree for the absolute precision of the data relating to other elements of the system.

As has already been mentioned, TOC principles are also embodied in the **DBR** methodology. The **Drum** schedules the activities of limited resources – it sets the rhythm. The **Buffer** represents the protection of through flows from unpredictable events – e.g. materials for bottlenecks. And last but not least, the **Rope** synchronises operations according to the tempo set by the drum – releasing materials in harmony with its flowing through bottlenecks [5,9].

TOC can be applied not only in production conditions, but also in commercial enterprises. A complex ERP system can be used for this – similar to specialised applications for the advanced planning and scheduling (**APS**). The **Infor ERP Visual**, **Infor ERP SyteLine, QAD Enterprise Applications** or **IFS Applications** are all typical information systems which can master working with TOC principles on the basis of advanced planning and scheduling and integrated within the framework of an ERP core. Equally, TOC is an element of several partner solutions created on the basis of the **SAP Business All-in-One** and **Microsoft Dynamics NAV** systems.

Another method which combines the "push" and "pull" principle is the less well-known **Seiban** system (from the Japanese, it can loosely be translated as "targeted production according to unambiguous numerical identification"). The Seiban method serves for the maintenance of the differentiated identification of a customer or their order items from among a general set of parts and orders. The simple Seiban principle brings significant advantages both for suppliers as well as for customers. The moment the order is received and accepted, it is allocated its own number. All further orders, deriving from this main one (e.g. production orders, purchase orders, material requirements, resource inventory reservations, etc.) are formed including this identification number. There is no need to concern oneself with complicated steps establishing their ranking or ordering number, as is usually the case elsewhere. These orders "inherit" the same seiban number as their "parent" or the precursor order.

The Seiban method functions on the basis of the allocation of a specific seiban identification number for all of the parts, components, sub-assemblies, materials and orders dependent upon an order for a specific customer, a concrete project or whatever else it may be. This enables one to easily track everything that relates to a certain product, project or customer. This has to do for instance with the separated registration and recording of inventory according to exceptional priorities and to specific projects. In addition, it enables one to find all of the above-mentioned related detailed information about historically created orders, which can be absolutely specific and realised only once [10].

This way of managing production also enables one (thanks to the help of the inputting of this number into an ERP system) to see the whole structure of the product from top to bottom with all of the above-mentioned related types of orders, inventory, or activities.

If it is necessary to move a purchase order forwards or backwards or to alter the ordering of production runs, the Seiban system enables one to rapidly and precisely see the effects and impacts of these changes on the higher and lower levels of the product structure. In comparison with the "pull" Kanban system, where the final customer is not defined and where a production run – even if internally identifiable, is not targeted; the Seiban concept represents targeted production with unambiguous numerical identification.

An application where Seiban methods are characteristic especially for its ERP system is the **IFS Applications** system. In the IFS Applications system Seiban represents a general principle for the management of production in the form of the elaboration of so-called dynamic orders (i.e. **DOP – Dynamic Order Processing**). Equally, the Czech **Byznys WIN** ERP system is widely available on the Czech market.

5. Advanced planning and scheduling in ERP systems

Advanced planning and scheduling is a component of specialised applications that are usually integrated within the context of SCM or supplied independently for the purpose of planning the production process [12]. These systems decidedly do not replace traditional ERP systems; they are either add-ons or directly integral components which create the support mechanism for planning and decision-making at all levels. We can mention the following as being three of the main characteristics of an APS system:

- Unified planning of the entire supply chain – from supplier to a single company customer, or to whole networks of companies.
- True optimalization based on the mathematical models and exact or heuristic algorithms.
- Hierarchical planning systems. These optimalisation of the planning of whole supply chains as a single system is not possible, since it is broken down into individual parts, which however cannot be resolved independently (since one would lose the optimal aspects). This thus leads to compromises between its ease of implementation and weighing-up the degree of independence of individual planning tasks.

The following table compares the functions of ERP and APS systems in individual fields.

Table 2: Comparison of traditional ERP systems (ERP I) with APS systems [11]

Field:	Traditional ERP systems:	APS systems:
Planning philosophy	Planning for unlimited capacity	Real plans which take the restricted capacity and nature of key resources into consideration
	Aim: feasible plans	Aim: optimal plans
	"Push" and "pull" systems	Combined systems
Management field	Production management	Demand satisfaction
Production type	Primarily discrete production	All industries
Main orientation	Transaction systems: e.g. finance, controlling, HR, production	Planning demand, production, logistics, supplier chains
Information flows	One-way	Two-way
Able to be simulated	Low	High
Ability to optimise costs, profits, prices	Minimal	High
Production duration	Fixed	Flexible
Progressive Planning	Limited	Available
Rapid (pre-)Planning	Low	High
Data memory capacity for calculations	Database	Memory-resistant

The **Infor ERP SyteLine**, **Infor ERP Visual**, or **IFS Applications** are typical ERP systems that are widely available on the Czech market that make use of integrated APS functionality. Equally, an example of a Czech APS system integrated into the core ERP application is the Czech **Karat** ERP system, even if the functionality of this solution is restricted to some of the most frequently used algorithms (viz more detailed description in the following section).

6. Main outcomes of the research study and analysis of the Czech ERP market in the production planning and management methods field

The basis for the management of production and logistics processes is the “push” principle. ERP systems exclusively supported by the MRP II method predominate on the Czech market. This is for two main reasons:

1. The diverse product offer available on the Czech market include so-called “small production” ERP systems among others, which are intended for the management of single part or small series production in a single workplace (one machine). This can make do with the use of only the “push” principle (e.g. the **EPASS** ERP system).
2. Other ERP systems are also available on the market that support only certain specialised product types, for instance – for the planning, recording and tracking of production in mills and bakeries (e.g. the **ComSTAR2000** ERP system), which in principle is based upon predicting and setting of plans.

It is also clear from our results that the presence of electronic kanban and TOC systems have strengthened their place in ERP systems ever since 2003. This corresponds to the growing need of enterprises to make use of a wider variety of methods (even in principle completely differing ones), this is especially true at the workshop management level.

When selecting concrete methods, then apart from the type and dispositional arrangement of the production process what is decisive is the way and stability the production is moved on to its final user, the structure of production itself – and above all, its ability to support the attainment of the main goals of production and logistics process management, These are:

- Meeting requirements for the delivery of materials and sub-assemblies for completing the production process.
- The optimal planning and exploitation of production and storage capacities.
- Meeting delivery deadline.

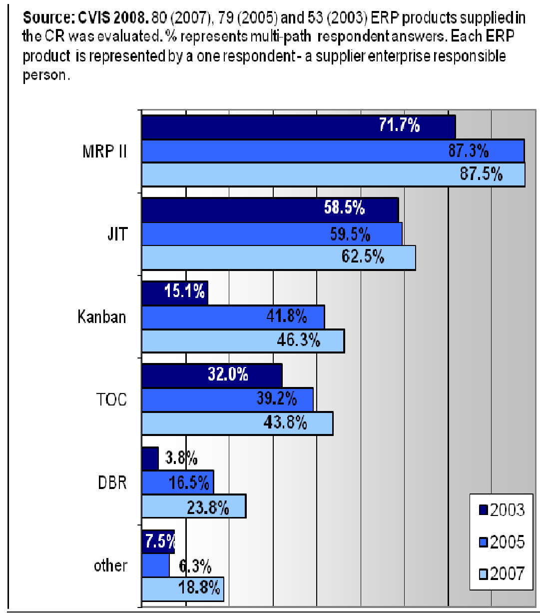

Fig 2. Production planning and management methods in ERP systems on the Czech market

The field of advanced planning and scheduling algorithms has seen a marked shift in their integration directly into the core of ERP systems. This shift is exclusively linked to algorithms for forward planning and backward planning, which enable enterprises to promise delivery deadlines on the basis of CTP and ATP. On the basis of the results of our research study and survey of the Czech ERP market, the following classification and commentary relating to the position of ERP solutions with the support of APS functionality is possible.

6.1 Lower class ERP solutions supported by APS

For domestic producers of ERP systems, it is by no means a matter of certainty that advanced planning algorithms are an element of such systems. Despite this fact, it is possible to find a number of positive examples. For instance, the **Karat Software** Company outsourced the development of this functional feature to its partner organisation (NWT Computer, a division of the Adder Company). They subsequently bought the rights to it and this partnership solution was integrated as a full-value component of their ERP system. The APS solution within the overall framework of the Karat information system supports make-to-order, i.e. non-repetitive single-item production runs and producing inventory stock – these are usually small series, large series or mass production runs. Equally, its functionality also covers continual assembly-line production runs with a single finished product. It is not oriented on the area of process production runs and on assembly-line production runs with multiple finished products. In view of this conception, its main validation is predominantly in mechanical engineering, metal-working, foundry, plastics-processing, furniture and cabinet-making and other closely related industries.

From the process cycle point-of-view, APS covers everything from purchasing to sales and deliveries. Its basis is founded on the main production plan (i.e. MPS – Master Plan Schedule), and collaterally with the main plan it is possible to create "user" plans. These allow one to carry out simulations that can later be projected onto and integrated into the main plan.

The APS integrated into the Karat ERP system support both of the key algorithms:

1. **CTP (Capable to Promise)** – This is based upon planning operations. In the course of planning, the effort is to optimalised the through-put times and customer delivery deadlines. The calculation is performed on the limited capacity of production resources, i.e. on operations, materials, human resources, ancillary tools and equipment, plant and equipment, and workplaces depending upon how busy they actually are.

2. **ATP (Available to Promise)** – This enables enterprises to promise delivery deadlines based on the actual state of inventory, work-in-progress, sales orders (received and accepted orders) and purchase orders at all inventory levels ranging from sales to purchasing.

The advanced planning and scheduling (APS) application in the Karat ERP system lacks an interactive Gantt chart function, which is replaced by a simpler variant that does not enable more complicated and detailed working with individual orders. Equally, support for SCM functionality is also missing in this ERP solution.

We can classify the Karat ERP system as far as its support of APS is concerned as a representative of lower class solutions. In view of its excellent price/quality ratio however, it has found its place above all in smaller manufacturing enterprises. Other domestic producers of ERP solutions have adopted a similar approach to integrating APS into core ERP systems; for example, **ABRA Software, K2 atmitec** and others, despite the fact that each of them is at a differing level of development and ability to make using this functionality a reality at the customer level.

6.2 Intermediate class ERP solutions supported by APS

The majority of world-class ERP solutions provided on the Czech market not only include the basic planning algorithms, but also other advanced APS functions. Typical examples are **Microsoft Dynamics AX, Infor ERP Visual** or **Infor ERP SyteLine**.

For example, the Infor ERP SyteLine system plans for individual orders (requirements) according to priorities, and always begins by backward planning. As long as it does not encounter any bottlenecks or restrictions in that day's data, it performs its planning function. In cases where it encounters that day's date, it performs forward planning – and then backward plans once again – in order to optimalised the process. It is also possible to set so-called "virtual todays" in the system and to plan to that particular date. This all takes place hidden from the eyes of the users – in the background. Users of the system do not even receive warnings or other announcements about how far advanced planning is.

Infor ERP SyteLine also respects lean production principles. It takes into consideration not only the availability of capacity, but also of materials and inventory levels at the same time. It is possible to set the planning of certain resources as being a finite state and the rest of the resources as infinite. The system makes use of more advanced controlling concepts than DBR, since it takes bottlenecks into consideration, and in each case it calculates things at all possible levels. Users can also make use of an interactive Gantt chart; the use of which assists in intuitively planning order-processing and production.

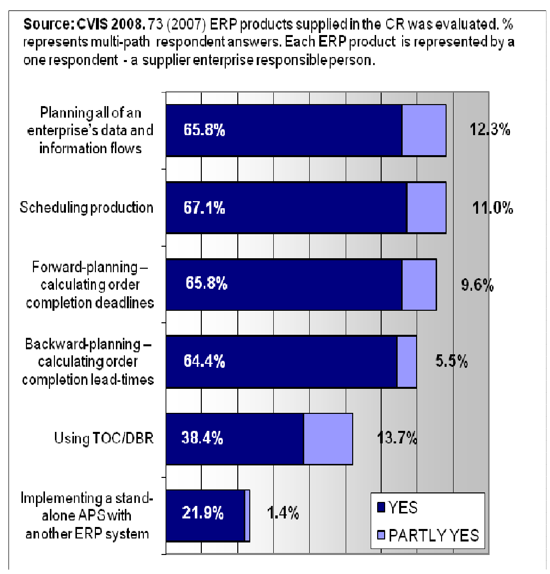

Fig 3. Support for advanced planning and scheduling in ERP systems on the Czech market

Equally, the system supports collaborative planning in chains, in the so-called "Multi-Site" regime. Examples of the successful implementation of this solution linking a number of companies or entrepreneurial units within the framework of an

SCM exist on the Czech market. A typical example of such a project is the implementation of the SyteLine system in the Grund Company.

Infor ERP SyteLine, thanks to its abilities ranks among the intermediate class systems which support advanced planning and scheduling. In view of the very high-quality of projects implemented by SyteLine's partner institution for the Czech Republic – the ITeuro Company, this production control and management solution is a competitor to the SAP solution, linked to the financial and other ancillary support SAP modules, that apart from the production management module some clients have had implemented. Examples of such projects can be found in companies like Česká zbrojovka a. s., Uherský Brod and Strojírny Třinec.

6.3 Top class ERP solutions supported by APS

The top class of ERP solutions which also support APS functionality includes complex software applications like the **SAP Business Suite** with its integrated **SAP APO** modules, or **SAP SCM** and **Oracle E-Business Suite** with integrated **Oracle Advanced Supply Chain Planning** functionality. Their possibilities are extremely extensive and apart from this advanced production and supply chain management functionality also include **SCM** project planning.

SAP APO and **Oracle ASCP** also know how to resolve the key problems that tend to occur within the context of the strategic planning of supply chain projects: location-allocation problems and the strategic planning of networks. Location-allocation problems determine the mutual roles of all of the components of a network – that is to say from suppliers to distribution centres, distribution centres to production plants, products to production plants and from stores or suppliers to production plants. In both systems, these relationships are resolved with a view to their geographical nearness, while also taking into consideration capacity restrictions or restrictions to individual elements of the chain, and last but not least in evaluating overall costs, which should be as low as possible. Linear programming models are used for the strategic planning of networks. Strategic planning may be used for changes in supplier chains or in the course of expansions into new areas or fields that lack the requisite infrastructures.

Both solutions find a place for themselves almost exclusively in large-sized organisations and supranational corporations. Smaller enterprises could encounter serious problems with effectively using such solutions and especially with their ability to master the implementation of projects of such demanding and detailed functional applications. The realisation of more extensive projects linked to APS support and the necessity of resolving collaborative planning solutions in chains, it would seem that it would be better to make use of ERP systems like **QAD Enterprise Applications** and **IFS Applications**, which we classify as **upper intermediate class systems**. These systems find a use for themselves and validation in many Czech enterprises – above all in the automobile, mechanical engineering and food-processing industries.

7. Conclusions

The management and controlling of production processes is an extremely demanding task since it covers a whole range of mutually intermingled as well as mutually independent and differing activities. While for instance, the financial agendas of many organisations tend to be very similar, production is characterised by a whole range of specific features, which are to a significant extent unique to each of these enterprises. For these reasons, the implementation of an information system into an industrial enterprise should primarily be based upon the technological and organisational conditions in the production and logistics processes. Managements should know how to decide about the choice and implementation of solutions which not only provide the requisite functionality, but also manage to integrate the interlinked or follow-on processes.

This is also the reason that the Center for inVestigations into Information Systems has undertaken long-term investigations into the Czech ERP market and why it puts together tables providing a clear overview of complex ERP solutions with an orientation on the needs and requirements of production and manufacturing enterprises. The actual individual specialised applications designed for advanced planning and scheduling (APS) – which are sometimes understood and taken to be a “cure-all” for planning production processes, are – in practice useless and unusable, as long as the enterprise in question does not have the corresponding integrated processes within the framework of an ERP system, a unified and consolidated data-base, and an appropriate set of established and standard methods for the management and control of its production and manufacturing processes.

8. References

[1] Sodomka, P. *Informační systémy v podnikové praxi*. Brno: Computer Press, 2006. ISBN: 80-251-1200-4.

[2] Michael, M. W. *S88 Today – For MES Tomorrow* [online]. wbf.org [cit. 2008-08-08]. From: <http://www.advancedautomation.com>.

[3] Gill, J.; Johnson, P. *Research Methods for Managers.* London : Paul Chapman Publishing, 1991. ISBN 1-85396-119-1.

[4] Pavlica, K., et al. *Sociální výzkum, podnik a management.* Praha : Ekopress, 2000. ISBN 80-86119-25-4

[5] Basl, J. a kol. *Teorie omezení v podnikové praxi: zvyšování výkonnosti podniku nástroji TOC.* Praha: Grada, 2003. ISBN 80-247-0613-x.

[6] Günther, H.; Mattfeld, D.; Suhl, L. *Supply Chain Management und Logistik*. Physica-Verlag, 2005. ISBN: 978-3-7908-1576-4.

[7] Stadtler, H.; Kilger, Ch. *Supply Chain Management and Advanced Planning: Concepts, Models, SoftWare, and Case Studies.* Berlin: Springer, 2008. ISBN: 978-3-540-74512-9.

[8] Gross, J. M.; McInnis, K. R. *Kanban Made Simple – Demystifying and applying Toyota's Legendary Manufacturing Process.* New York: Amacon, 2003. ISBN 0-8144-0763-3.

[9] Goldratt, E. M.; Cox, J. *Cíl (2. přepracované vydání).* Praha : Interquality, 2001. ISBN 80-902770-2-0.

[10] Klčová, H.; Špelina, J. Seiban – metoda řízení výroby a její uplatnění v ERP systému. In *Systems Integration 2006 : Proceedings, Prague June 11 – 13, 2006.* Ed. Jan Pour and Jiří Voříšek. PUE, 2006, pp. 453-460. ISBN 80-245-1050-2.

[11] Lütke Entrup, M. *Advanced Planning in Fresh Food Industries*. Physica-Verlag, 2005. ISBN: 978-3-7908-1592-4.

[12] Günther, H.; Van Beek, P. *Advanced Planning and Scheduling Solutions in Process Industry.* Berlin: Springer-Verlag Berlin Heidelberg New York 2003. ISBN: 3-540-00222-7.

[13] Henderson, B. A.; Larco, J. L. Lean Transformation. Richmond: The Oaklea Press 2003. ISBN 0-9646601-2-1

[14] Voříšek, J. *Strategické řízení informačního systému a systémová integrace.* Prague : Management Press, 1997. ISBN 80-85943-40-9.

[15] Molnár, Z. *Efektivnost informačních systémů.* Prague: Grada Publishing, 2000. ISBN 80-7169-410-X.

[16] Accenture. *Hodnota podnikových informačních systémů v České republice.* Prague : January 2001. Internal study of the company Accenture.

[17] Deloitte Consulting. *ERP's Second Wave – A Global Research Report. 2000.* ISBN 1-892383-42-X.

[18] Davenport, T. H. Putting the Enterprise into the Enterprise System. *Harvard Business Review*, 1998, vol. 76, pp. 121-131. ISSN 0017-8012.

[19] Stevens, T. All Fair in Integration. *Industry Week*, 2001, vol. 250, no. 6, pp. 24-29. ISSN 0039-0895.

[20] Olson, D. L. *Managerial issues of ERP systems*. New York : McGraw-Hill/Irwin, 2003. ISBN 0-07-286112-6.

[21] Olson, D. L.; Chae, B; Sheu, C. Issues in multinational ERP implementation. *Int. J. of Services and Operations Management*, 2005, vol. 1, no. 1, pp. 7-21. ISSN 1744-2370.