Information Requirements for IT Services of Custom Production Procurement Process

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***Abstract*—** Modern manufacturing enterprise produces a wide nomenclature of outputs that requires a wide range of supplied materials and component parts. Procurement of such a company involves choosing suppliers for each item needed, defining of period and size of each delivery, purchasing and supply, warehousing of goods. In order to be efficient all this activities need a proper coordination which under nowadays conditions can be provided only by IT system. The quality of IT support is a foundation of the quality of the whole process. To develop a proper IT solution or to customize an existing one the real business process should be analyzed carefully in order to identify the requirements to IT services of the future IT system. The paper describes an approach for identification of requirements of IT services for procurement process of custom production.

***Keywords*—** Manufacturing enterprise, procurement process, IT service, business process, information requirements.

I. Introduction

Manufacturing enterprise is a complex organizational and technical system that provides full cycle of production of outputs. The manufacturing system is defined as being the ensemble of machining systems which are used for realization of a certain product. Each of these machining systems is made up of machine-tool/tools, apparatus, parts, an operator and it executes one of the manufacturing operations [1]. The objective of the manufacturing enterprise is to convert the input production factors by means of processing them into the outputs (products, results). Between the inputs and outputs various specific tasks are set and solved and only the unity of these tasks describes and provides industrial transformation process. Among the most important tasks there are: supply, storage, product manufacturing, sales, financing, personnel training, new technology implementation, as well as management [2].

The complexity of managing a modern manufacturing enterprise is caused by a variety of assets involved and processes implemented that need proper coordination between themselves. In particular, the manufacturing enterprise puts forward special demands on the procurement system, which is caused by the wide range of produced outputs, the wide range of consumed material resources and necessity to comply with the terms of order execution. Effective procurement is one of the key factors of enterprise's competitiveness. Procurement must be organized in such a way as to ensure timely receipt of the necessary production resources and at the same time to avoid the inefficient use of funds for stocking.

Inventory management includes procurement and storage processes. The objective of procurement management for manufacturing enterprises includes the purchase or leasing of the means of production, purchase of raw materials, semi-finished products, hiring of employees. The objective of storage includes all operations related to warehousing and storage of the means of production, raw materials, semi-finished products, which arise before the actual production process, in the intervals between private production sub-processes and after them [2]. In this paper the range of procurement management tasks is narrowed down to purchase, supply and storage of raw materials and semi-finished products to provide the core production.

Effective procurement in modern manufacturing enterprises is provided by well-coordinated resource management which includes an appropriate IT support. The more complex the production is, the more important role plays an appropriate IT support of procurement process: it is necessary to take into account a wide nomenclature of resources supplied, a wide list of suppliers, different dates of delivery, capacity of storage facilities and other factors. The quality of the IT support is defined on the stage of formulation of IT services requirements which takes place at the very beginning of configuring of an appropriate information system module. The paper analyzes the procurement process of custom production (using the example of the Case Company) and proposes an algorithm to determine the requirements for IT services of procurement module of the information system.

II. Procurement Process of Enterprise

According to the Value Chain Model [3] all activities of the organization are split into 'primary activities' and 'support activities' – the first are facilitated by the latter ones. One of the support activities is "Procurement" – it is a function of purchasing of resources used in the value-creating activities. Value chains provide a high-level organization of the functions that an enterprise performs. To provide a more detailed view, these top-level business functions are broken down to functions of smaller granularity and, ultimately, to activities of operational business processes [4].

Today however, the expectations of Procurement are shifting. According to [5], many executives are increasingly looking to Procurement to engage the business in strategic conversations about how the supply chain can be optimized to deliver the greatest returns.

All firms (including Just-In-Time operations) keep the supply of inventory for the following reasons [6]:

1. To maintain independence of operations;
2. To meet variation in product demand;
3. To allow flexibility in production scheduling;
4. To provide a safeguard for variation in raw material delivery time;
5. To take advantage of economic purchase order size;
6. Other domain specific reasons.

Procurement process of manufacturing enterprises is a very information demand process that requires precise, well-timed and reasonable data to be performed appropriately. In line with most of the manufacturing enterprise functions procurement management functions are supported by enterprise information system, in this case Enterprise Resource Planning (ERP) System, which is a part of enterprise IT architecture. The connection between business needs of an enterprise and its IT architecture is realized through information services. Information systems should be able to support and react promptly and precisely to the requests of business environment.

Procurement process deals with data concerning nomenclature of materials and component parts, suppliers, material consumption rate, scope and time of delivery, warehouse capacity etc. In order to provide IT services that meet the information requirements of users more completely and precisely, mathematical models of inventory management can be used. The approach to information requirements identification of procurement process should include the algorithm to be followed. Such an approach would help to provide a certain level of IT-support of the procurement process. The paper aims to develop such an algorithm and to implement it while defining IT service requirements in a Case Company.

III. IT Support of Custom Production Procurement Process

A. Planning the Inventory Amount

Inventory is the stock of any item or resource used in an organization. An inventory system is the set of policies and controls that monitor levels of inventory and determine what levels should be maintained, when stock should be replenished, and how large orders should be [6].

The amount of different kinds of the resources stored in the stock must be monitored on regular basis (Fig.1). The current stock – is the main part of stocks that continuously provides production process before the next delivery. The amount of the current stock depends on the frequency and quantity of delivery and the resource demand from the production. Also for each resource item an insurance stock must be estimated. Insurance stock – is an amount of resource, which supply production in case of unexpected circumstances. It means that if, for example, the next delivery is late, and the resource requirements are covered by the insurance stock. The optimal size of this stock can reduce the costs of its storage and at the same time it has to meet the level of resource demand. Otherwise the supply shortage appeared. The latter can result in the suspension of production, which generally causes great losses, because time constraints are exceeded. Moreover necessity of urgent search of the supplier causes the increase of total cost of resource.

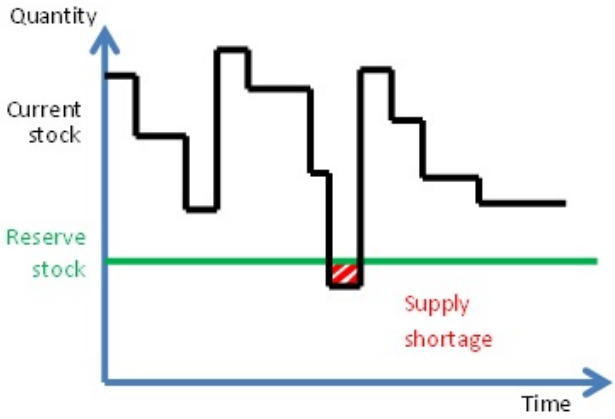

Fig. 1. Example of current stock dynamics

As one of the functions of supply management is reducing expenses on purchasing, transportation and storage of resources it is important to understand the structure of resources cost. It consists of:

1. Purchase cost – usually it is the largest part of the total cost. This price is stated in the document "Order to supplier".
2. Delivery costs – the costs for preparation and transportation of resources. The delivery can be held by the supplier, by Logistics Company or the company can deliver resources on its own. In the last case, the cost will be lower, but not every company have transportation department with necessary equipment. Moreover the cost of insurance is also must be taken in the account especially when we deliver resources by sea or on a long destination.
3. Storage costs – costs, connected with warehousing and providing needed storage conditions. It consists of:
   - Electricity, water and heating supply of the warehouse.
   - The salary of warehouse personnel.
   - Taxes and other expenses.

Almost all mathematical models of supply management use these 3 items mentioned above for estimating the optimal order size and period.

B. Features of the Custom Production

The amount of inventory needed is closely related to the production program which in turn has to correlate with the sales plan. The production program states which products and how much of them to produce [2]. As the material consumption rates are defined for each element of the goods nomenclature, the material requirements for the production cycle can be easily calculated. Material requirements are set by their types, classes, grades and profiles. Method of material requirements calculation is determined by the technology of production for which the materials are intended. After having defined the material requirements and having known the current stock available the order size and period can be calculated using traditional mathematical models described in [7 - 9].

As a production program is a starting point of resource requirement calculation, it needs to understand the source of it. The production program is based on the production capacity of the company from one hand and on the other hand – on the demand forecasted. The estimation of the future demand is a very complicated process (depending on the industry branch) that causes a certain level of uncertainty in the figures of the production program and, as a consequence, in the estimation of the amount of inventory needed.

The feature of the custom production from the planning point of view is that the demand is known – it is clearly determined by customer orders for the next period. Such an assumption helps to keep the inventory amount at the optimal level, necessary and sufficient.

As companies, oriented on custom production, are highly dependent on each customer order, proper procurement is vitally important for them. The exact amount of resources needed to complete a particular customer order should always be at disposal of a production department. To guarantee the stable execution of the procurement process the correct identification of its information requirements is crucially important.

C. IT Services within Enterprise Architecture

Enterprise Architecture nowadays is a central concept to align business requirements with the IT potential. Traditionally, the components of the enterprise architecture can be represented as a set of layers comprising a set of structural components. The number and names of layers varies in different sources (for example, [10 - 12]), but the concept is more or less the same.

Authors of this paper rely on the TOGAF (The Open Group Architecture Framework), which declares following layers of the enterprise architecture [11]:

- Business
- Information or Data
- Application
- Technology

Showing the enterprise architecture model within layers allows specifying the relationships between enterprise core components. The idea is that each layer contains components that execute processes and offer services to the layer above. This concept is shown in Fig. 2.

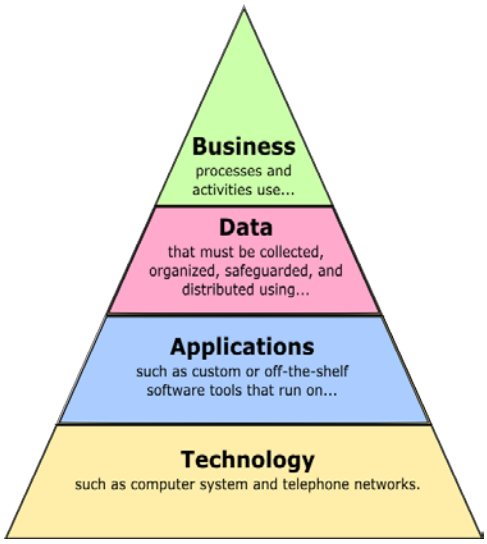

Fig. 2. Layers of Enterprise Architecture [13]

The alignment between Business and Information Technology is a key issue in every organization and showing, how they can fit together is one of the key objectives of enterprise architecture [14, 15]. This is also true for the manufacturing enterprise and for its procurement process. The execution of procurement business process (Business layer of enterprise architecture) requires various information (Data layer), that can be received with the help of information system of the enterprise (Application layer) using computers, mobile devices or other technical resources (Technology layer).

On the level of Business it is important for an enterprise to have the business process management in place. To find and analyze all information requirements of the procurement process, this process itself should be managed in a proper manner. Business process management includes several stages [16], the first and one of the most important is “Design, document and implement process”. If the procurement process of the manufacturing enterprise is modeled with the use of appropriate notation, there will be shown functions and events of the process that require specific information. The model of the process will also image the resources of information needed and the possible forms of its presentation.

In the enterprise modeling the service concept plays a central role. A service is a unit of functionality that some entity (e.g. a system, organization, department) makes available to its environment, and which has some value for certain entities in the environment (‘service users’). Service orientation supports current trends ranging from the service-based network economy to ICT integration with Web services [10]. Services can be provided by organizations to their customers, by applications to business processes, or by technological facilities (e.g., communication networks) to applications.

If talking about the IT, it is reasonable to say that the value of IT for business is not in the IT per se, but in providing right IT services in the right way [17]. It is within the scope of the Information Technology Service Management (ITSM) to provide value through the services In the case of manufacturing enterprise and its procurement process, ITSM is

focused on providing the process executers with the right information fast enough, in a convenient form of presentation and giving possibility to process this information (for example, if there are mathematical models of inventory management, the relevant calculating tool should be included in the procurement module of the information system). To manage IT services and IT operations in the best way, authors recommend using IT Infrastructure Library (ITIL), which is widely adopted as a framework for ITSM.

D. Approach to Identify Information Requirements of Procurement Process

The following steps should be fulfilled in order to identify all the information requirements of the inventory management process for future development of IT services:

1. Analyze and model the procurement process (preferable business process modelling notation – EPC or BPMN);
2. Define all the needed information inputs and their sources and outputs of the process;
3. Define the type of all information inputs and outputs: primary (raw) data or processed data;
4. For all processes data define the tools and techniques of its processing (including mathematical models);
5. Define the document flow supporting the information flow of the process.

This process needs not only storing and retrieving the data, but requires complicated mathematical calculations as well. The efficient IT support of procurement process is impossible without modern mathematical tools and techniques.

E. IT Services of "1C" Solution for Procurement Management

One of the wide-spread information systems in Russia is "1C". The solutions of this IT producer according to different sources occupy more than a third share of Russian IT system market. Often Russian companies prefer this solution to the foreign analogues because of its adaptiveness to Russian business specific character.

As it was emphasized above (see point 3.2) one of the requirements of efficient procurement management is its coordination with production and sales plans. 1C provides such a coordination. Planning subsystem of this IT solution combines several directions:

- sales planning;
- production planning;
- procurement planning [18].

Despite the fact that all three directions mentioned have different planning technique, different requirements and restrictions, the planning concept of, the approaches and mechanisms for them are the same. One of the planning principles of the planning subsystem is the possibility of planning the inventory amount sufficient not only for the production program, but also for maintaining the required level of warehouse inventory.

1C coordinates not only planning activities in sales, production and procurement, but their execution as well. It is realized by means of providing the group of IT services "order issuing". The system supports the coherence of four types of orders:

- customer orders;
- orders to supplier;
- internal orders;
- manufacturing orders [18].

Customer order is an order of the external contractor for the purchase of any product. To fulfill a customer order it is necessary to ensure the availability of materials and components in accordance with the material consumption rates in the amount necessary for the production of the ordered quantity of products. Order to supplier is an order to an external company for the supply of materials for the manufacture of products. Issuing of the order to supplier based on the customer order ensures the precise procurement execution for each particular case: materials and components for a particular order will be supplied, reserved and used only while this order processing and will not be consumed for other needs.

Each order among common attributes (such as name of materials and components, its characteristics, quantity, unit of measure) contains specific information that allows to accurately identify, monitor and control each item of inventory intended for a particular order: dates of planned and factual material placing on the stock and issuing from the stock, warehouses where the item is stored and where it is intended to be transported, responsible person, accounting records and all the historical documents connected with the item.

1C procurement solution provides also a number of additional IT services that make procurement management more efficient:

- possibility of reservation (and reservation cancellation) the inventory amount on current and future stock;
- comparing of different suppliers prices and choosing the best one;
- coordination of the suppliers' information concerning the inventory item (for example, when different suppliers have different names for the same item);
- group and ungroup the information about a set of products treated as a single unit;
- lot-size inventory management for the purposes of correct inventory assessment;
- inventory quality management.

IV. Approbation of the Approach in the Case Company

The company Lenpolygraphmash (hereinafter referred as a Case Company) is a manufacturing company that was founded in St. Petersburg in 1890. The core business of the company is developing and manufacturing printing machinery with special functionality for the Ministry of Defense of the Russian Federation, products of led and woodworking industry [19]. Like all companies with complicated production process the Case Company needs a certain level of IT-support for effective business performance. Among other IT-system implementation issues, one of the challenges within procurement module of IT-system was providing a consistent supply management support. The company decided to implement and adapt the

procurement module of "1C" system instead of existing self-made solution. As the Case Company runs a custom production, which means the uniqueness and importance of each single custom order, it requires a smoothly running procurement process supported by the appropriate IT functionality. In order to provide it the clear requirements definition is needed. Based on these requirements the IT Services can be designed, transited into "1C" platform and operated [17].

The analysis of the Case Company allows modeling the process landscape (Fig. 3), which helps to identify the environment of the procurement process and as a consequence – the sources and the recipients of information from this process. After that the process itself can be analyzed and modelled in more details (the model of the process can be presented in any process modelling notation according the complexity of the process and the preferences of the developer).

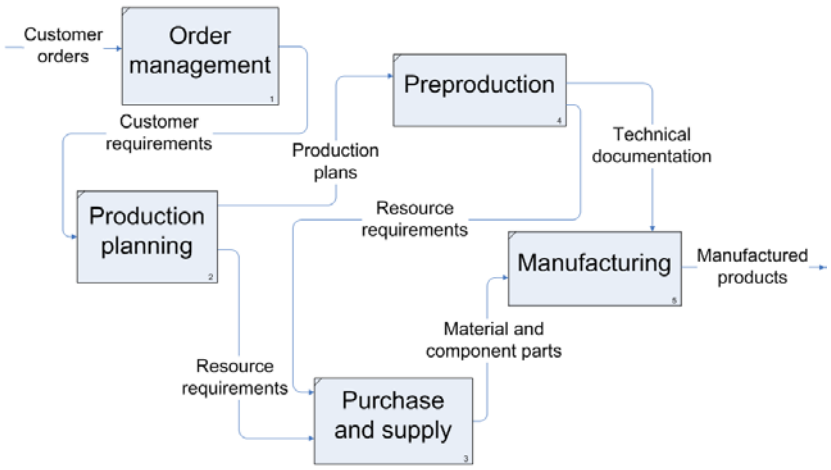

Fig. 3. Context diagram of procurement process

On the basis of resource requirements from production planning and preproduction processes the overall resource requirements are calculated. After that, a document "Purchase Plan" is created which includes:

1. Nomenclature of resources, its serials and characteristics.
2. The amount of every position of required nomenclature.
3. The time constraints when every position is needed.

For estimating the optimal order size and period basing on the "Purchase Plan" a document "Optimal purchase strategy" is created. The input information for it is the information about the prices of resources, average lead time, minimum and maximum batch size and the data of the "Purchase Plan". Using appropriate mathematical models of inventory management with deterministic demand (see [7 - 9]) optimal period and optimal order size are calculated.

After having created the "Purchase Plan" the suppliers of the resources must be chosen. Different factors are used as the criterion of selecting supplier being: price, approach of just in time delivery, known in industry, size of organization, geographical location, and quality, evaluation of environment, capacity, services, and delay in delivering good, packing, transportation and storing [20]. Traditionally, suppliers are selected among those whom have ability to represent concerned quality, time of delivery and suggestive price. Supplier selection techniques are analyzed in [21]. The supplier selection procedure of the Case company is described in internal documents.

Before the date of purchase comes, order for resource replenishment must have been made. This fact is registered by the document "Order to the supplier". This document must contain the following obligatory positions:

1. A list of ordered materials and component parts, with detail characteristics;
2. Delivery dates;
3. Quality requirements and methods of quality measuring;
4. Order price;
5. Responsibilities of the parties.

After having paid supplier's invoice the Supply Department controls the resource delivery and correctness of filling the forwarding documentation.

Resource arrival is registered by the document "Goods and services arrival". After having verified the quality of arrived resources (incoming inspection) and filling the "Report of inspection", where they register the results of inspection, the checked resources are put to the stock, using the document "Materials receipt ticket".

The outputs of the purchase and supply process are materials and component parts issued to the departments. Resource issuing begins with the processing of the received request for resources from departments. If the previously established limit of resource consumption for the particular department is not exceeded, the requested resource is issued using the document "Material requisition". If the limit is exceeded, the request is corrected and processed again. At the end of the year the total resource consumption are analyzed and the limits can be changed if needed.

After having analyzed the purchase and supply process of

the Case Company the requirements for supply module of the information system can be set. This module should allow managers of Supply Department to:

1. Maintain all the necessary supply management functions and create appropriate documents – such as:
   - form orders to suppliers;
   - register payment for supplies;
   - register the resources arrival, movement and issue;
   - fix the inventory making, etc.
2. Monitor the execution of supply process by providing analytical information, presented in convenient format of automatically-made reports.
3. Facilitate a process of making summary resource requirements on the basis of "Production Plan" and specifications by automatic calculation using mathematical models.

The following information requirements for the particular functions of the purchase and supply process were found out:

1. Plan resource requirements:
   a. Annual production plans;
   b. Last year consumption;
2. Estimate the optimal order size and periodicity:
   a. Constrains:
      – Carrying costs, Shortage costs, Delivery costs;
      – Storage conditions;
      – Minimum order size;
      – Maximum order size;
      – Discounts for amount;
      – Possibility for joint replenishment (items with the same supplier / source city);
   b. Supplier reliability (timely delivery, price rising);
   c. Convenient values for periods and order size;
3. Check the necessity for making a new order, make an order:
   a. Current inventory level for every item;
   b. Optimal order size, reorder point and periodicity;
4. Register the resources arrival:
   a. Delivery time and costs;
   b. Quality and quantity of resources arrived;
5. Issue resources to the department:
   a. Requested amounts.

The description of the IT services provided all the requirements mentioned above is presented in Appendix 1.

The effectiveness of process execution is evaluated by performance indicators. Performance indicators of "Purchasing and supply" process after implementing of supply module that includes mathematical models of inventory management can be the following (the list can be modified or expanded):

1. The level of provision departments with resources;
2. Optimization of order, delivery and storage costs;
3. Control of stock reserves limits;
4. Reduction of losses during transportation and storage.

V. Conclusion

Procurement process is very important for providing uninterrupted manufacturing of goods. In modern manufacturing enterprises it seems impossible to effectively run purchasing and supply activities without an appropriate IT support. To customize properly the procurement management IT solution for needs of a particular company the detailed analysis of real business process and its information requirements should be carried out. Clearly defined information requirements form the foundation for further development of appropriate IT services. The paper describes the procurement process of a manufacturing enterprise, highlights the special aspects of custom production, develop an algorithm of IT service requirements identification and demonstrates the approbation of this algorithm in a supply department of a real company.

The paper does not cover the problem of the decision-support tools for arranging the procurement IT support because this issue lays beyond the scope of the current research. However it can be a subject of further investigation. The results concerning this problem can be found in [22, 23]. Another subject for further research concerning IT support of procurement process can be IT services of B2B data sharing in relationships "company-supplier" and "company-customer" (see, for example, [24]).

Appendix

Description of the Information Services of Procurement Process and their Content from "1C" Procurement Module of Case Company

The following IT-services are involved in the supply and procurement process:

1. Data Book *"Nomenclature"* – stores the information about all used by the company items of materials and component parts:
   a. Name
   b. Unit of measure
   c. Nomenclature group
   d. Nomenclature type (material / component part / semi-finished product)
   e. Storage conditions required
2. Data Book *"Contractors"* – stores information about suppliers
   a. Full organization name
   b. Contact information (phone number, e-mail, fax)
   c. Discounts for quantities
3. Document *"Production plan"* – sets the amounts for items that are planned to be produced in the certain period (year, month)
   a. Period
   b. The list of items with the amounts
4. Document *"Purchasing plan"* – sets the amounts for items that are planned to be purchased in the certain period (year, month)

a. Period
b. The list of items with the amounts

5. Document *"Setting inventory models constraints"* – for every item in the list sets the following constraints for inventory models:
a. Carrying costs
b. Maximum / minimum batch size from every supplier
c. An average delivery time from every supplier

6. Document *"Optimal purchasing strategy estimation"* – calculates the optimal output parameters for inventory models:
a. Optimal order periods for periodic models
b. Optimal order quantity, Reorder point (ROP) for continuous models

7. Document *"Order to the supplier"* – fixes the preliminary agreement with the supplier to provide the company with resources till the certain date:
a. Date
b. Supplier
c. Amount
d. Price

8. Document *"Goods and services arrival"* – registers resources arrived from suppliers:
a. Date
b. Resource item
c. Supplier
d. Amount
e. Price
f. Order (link to the document)

9. Document *"Material requisition"* – registers the amount of resources that was delivered to the departments:
a. Date
b. Resource item
c. Amount
d. Department

10. Report *"EOQ comparison"* – a table that compares EOQ value with average order size:
Input parameters:
a. User: Date interval
b. User: Resource item or nomenclature group
c. Arrived amount
d. EOQ
Output parameters:
a. Resource item or nomenclature group
b. Avr. order size
c. EOQ
d. Delta (in units & %)

11. Report *"Inventory level diagram"* – a diagram that can be drawn for every resource. It shows the inventory level changing in dynamic:
Input & output parameters:
a. User: Date interval
b. User: Resource item
c. Arrived amount
d. Delivered amount
e. ROP level
f. Optimal periodicity

12. Report *"Reorder point reaching"* – a table that indicates reaching to the ROP level (for continuous models)
Input parameters:
a. User: Date
b. User: Resource item
c. Current level (up to the Date)
d. ROP
Output parameters:
a. Resource item
b. Current level
c. ROP
d. Delta (in units & %)
e. Explanation (order, not to order, prepare to order)

13. Report *"Days till new order"* – a table that indicates reaching the day of placing new order:
Input parameters:
a. User: Date
b. User: Resource item
c. Last order moment
d. Optimal periodicity
Output parameters:
a. Resource item
b. Optimal periodicity
c. Days from last order moment
d. Delta (in days & %)

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