# Approach to Information Requirements Identification of Procurement Process of Custom Production

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*Abstract:* Procurement process has become one of the key business processes of the enterprise in the last few years. This is especially true in regard to manufacturing enterprises focused on custom production, where it is vitally important to have exact amount of necessary production resources for the best price. To guarantee the stable execution of the procurement process the right identification of its information requirements is needed. The paper shows an approach to identify the information requirements of procurement process of manufacturing enterprise, using elements of the enterprise architecture concept and mathematical models of inventory management. The approbation of the given approach is made in the Case Company.

*Key-Words:* Procurement, purchasing and supply, enterprise architecture, information service, business process, mathematical tool.

## 1 Introduction

Manufacturing enterprise is a complex organizational and technical system that provides full cycle of production of outputs. The manufacturing process is supported by and depends on a number of support activities: infrastructure, procurement etc.

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.

Traditional management usually relies on accounting methods rather than optimization ones. As a result, information systems, supporting traditional management, reflect the movement of inventories, but do not contain built-in mechanisms to manage them. Mathematical models of inventory management allow not only to meet requirements for customer satisfaction (internal or external) but also to reduce the cost of resource procurement on one hand and to lower production costs by means of reduction of stocks and amount of work in progress. In this regard, it is reasonable to implement the system of mathematical models in procurement planning and implementation. The article describes the approach to modeling procurement processes of the manufacturing enterprise and to setting requirements for procurement information services involving the use of optimization mathematical models.

## 2 Problem Formulation

According to the Value Chain Model [1] 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 (Figure 1). 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 [2].

Today however, the expectations of Procurement are shifting. As referred to in "A global survey of Procurement functions" of KPMG, not so long ago

Procurement became an add-on service. 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 [3].

According to [4] all firms (including Just-In-Time operations) keep the supply of inventory for the following reasons:

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. Within planning 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 and the list of mathematical models to be used within the certain steps of the algorithm. Such an approach would help to provide a certain level of IT-support of the procurement process.

# 3 Problem Solution

## 3.1 Planning the amount of inventory

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. [4]

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. What can be the consequences? Of course, this 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.

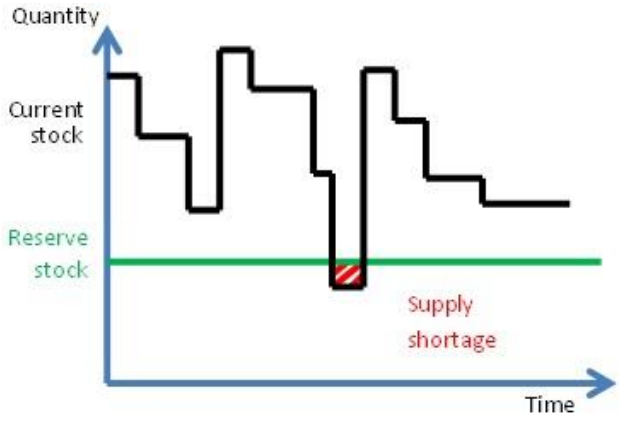


Fig. 1. Example of current stock dynamics

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.

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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.

### 3.2 The role of Business and IT in identifying information requirements of the procurement process

Let's consider the Enterprise Architecture concept to understand the importance of identifying information requirements of Procurement process.

There are several standards, frameworks and methodologies of enterprise architecture management such as Zachman Framework for Enterprise Architecture, Extended Enterprise Architecture Framework, GERAM, ISO 19439-2006 and others [5]. All these methodologies have different point of views about how many layers the enterprise architecture model should extend.

The layers show the main elements of the enterprise. Authors of this paper rely on the TOGAF (The Open Group Architecture Framework), which declares following layers of the enterprise architecture [6]:

- 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.

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 [8, 9]. 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).

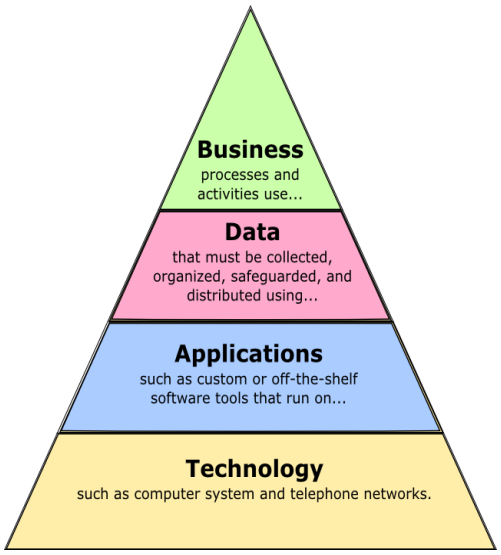


Fig. 2. Layers of Enterprise Architecture [7]

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 [10], 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.

If talking about 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 [11]. 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.

### 3.3 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:

1. Analyse and model the procurement process (preferable business process modelling notation – EPC);
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.

### 3.4 Mathematical models of inventory management with deterministic demand

To improve the inventory policy of the company for when and how much to replenish the inventory the following steps are used (the 4th step of the approach presented above):

- Formulate a mathematical model describing the behaviour of the inventory system;
- Seek an optimal inventory policy with respect to this model;
- Use a computerized information processing system to maintain a record of the current inventory levels;
- Using this record of current inventory levels, apply the optimal inventory policy to signal when and how much to replenish inventory [12].

"The purpose of an inventory control system is to determine when and how much to order. This decision should be based on the stock situation, the anticipated demand, and different cost factors." [13] In order to support this activity properly, procurement module the enterprise IT system should realize the IT services of calculation and reporting of all the key data of the procurement process. Thus, the main objectives of the inventory management IT services are:

- Calculating optimal size of order ($Q^*$);
- Calculating optimal frequency of orders ($T^*$);
- Take into account different types of costs while calculating ($TVC$) and minimize them.

There is a vast variety of inventory models classification [14, 15]. The most common models used in practice are those based on the economic order quantity (EOQ) model – static model with deterministic demand [13, 14]. Main prerequisites of the models with deterministic demand are:

- Demand is known;
- Instant receipting of product;
- Discounts aren`t considered;
- Deficit isn`t admitted;
- Resources may be analyzed separately.

Basic EOQ model, also known as Wilson formula:

$$Q^* = \sqrt{\frac{2KD}{h}}, \quad T^* = \frac{Q^*}{D} = \sqrt{\frac{2K}{Dh}},$$

$$TVC = K\frac{D}{Q} + h\frac{Q}{2} \to min \qquad (1)$$

The EOQ model with planned shortage:

$$Q^* = \sqrt{\frac{2KD(1+{}^{h}/_{p})}{h}}, \quad T^* = \frac{Q^*}{D} = \sqrt{\frac{2K(1+{}^{h}/_{p})}{hD}},$$

$$S^* = Q^*\frac{h}{h+p},$$

$$TVC = K\frac{D}{Q} + h\frac{(Q-S)^2}{2Q} + p\frac{S^2}{2Q} \to min \qquad (2)$$

The EOQ model with quantity discounts:

$$TVC = cD + K\frac{D}{Q} + h\frac{Q}{2} \to min \qquad (3)$$

The EOQ model with gradual replenishment:

$$Q^* = \sqrt{\frac{2KD}{h(1-{}^{D}/_{R})}}, \quad T^* = \frac{Q^*}{D} = \sqrt{\frac{2K}{hD(1-{}^{D}/_{R})}},$$

$$TVC = K\frac{D}{Q} + h\frac{Q}{2}\left(1-\frac{D}{R}\right) \to min \qquad (4)$$

where $P$ – purchase cost,
$K$ – ordering (setup) costs,
$h$ – holding costs per unit and time unit,
$D$ – demand per time unit,
$p$ – unit shortage cost,
$S$ – maximum shortage,
$c$ – unit acquisition cost,
$R$ – production rate if producing continuously.

The other important inventory management question after the optimal order size is "when to order", i.e. re-order point:

$$ROP = D \times L \qquad (5)$$

where $D$ – demand per time unit,
$L$ – lead time (delivery time) – the time between the placing and receipt of an order.

This means, an order is placed when the inventory level reaches the ROP, and the

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new inventory arrives at the same moment the inventory is reaching zero. When a safety stock is maintained, then the reorder point is written as the following:

$$ROP = D \times L + SS \quad (6)$$

where $SS$ – safety stock. [16]

### 3.5 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. [17] 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.

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.

The analysis of the Case Company allows modeling the process landscape (Fig. 3), which helps to identify the environment of the purchase and supply 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 (Fig. 4).

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.

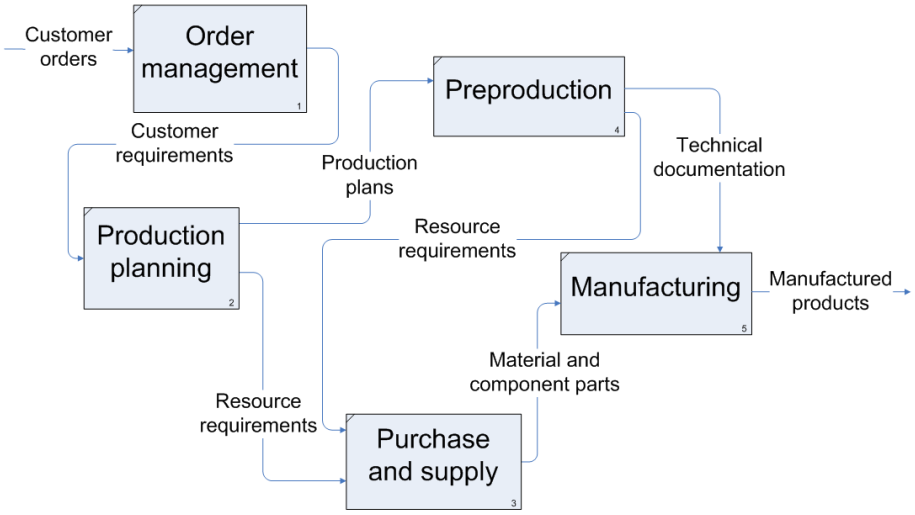


Fig. 3. Context diagram of purchase and supply process

The most complicated function of this process is "Estimating the optimal order size and period". By this function the Supply Department has a list of resources, which are needed for production, and has to decide when (estimating the optimal period) and how much (estimating the optimal order size) the resources will be bought, trying to minimize expenses. It is very important to use adequate mathematical tools, because every mathematical model of supply management has implementation conditions and limitations. Using the information about the prices of resources, average lead time, minimum and maximum batch size and the document "Purchase Plan" a document "Optimal purchase strategy" is created. The latter is supposed to content mathematical models of inventory management with deterministic demand (mentioned in the 3.3) for calculating the parameters of resource and component parts purchasing.

In simple terms, the main aim of the purchase and supply process is to deliver resources with right characteristics, by the right time and to the right place. The consequences of mistakes within the document "Optimal purchase strategy" can be of

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two 2 types and both can cause big losses:

1. Suspension of production – in case the needed resource have not been delivered in time or delivered in time, but has another characteristics;
2. Increase of carrying costs – in case it was purchased more resources than needed which means the need to store more, than it was planned.

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 [18]. 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 [19].

The supplier selection procedure of the Case company is described in internal documents. Generally, each position has its rating. While analyzing a particular supplier, every position is evaluated and by means of multiplying position ratings the total supplier's points are calculated. The supplier, who gained the best score, is concluded a contract. Traditionally this procedure is used only for new suppliers evaluating. The long-term partners do not need to go through this procedure.

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.

It is easy to see that purchase and supply process is very information demanding. It requires a certain documents to be created as well as collecting and keeping of external information for next analysis. Mathematical models are supposed to be used in order to increase work capacity. 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. For example, report "Inventory level diagram" – a diagram for every resource, which shows the inventory level changing in dynamic, report "Days till new order" – a table that indicates reaching the day of placing a new order, etc.
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;

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- 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 are presented in the 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.

## 4 Conclusion

In order to provide uninterrupted manufacturing process all the supportive activities should be appropriately organized and computerized where it is needed. Procurement process is very important for the manufacturing and it is very information demanding. To provide the efficient IT support of procurement process it should be analysed carefully from the information requirements point of view. Clearly defined information requirements form the foundation for further development of appropriate IT services.

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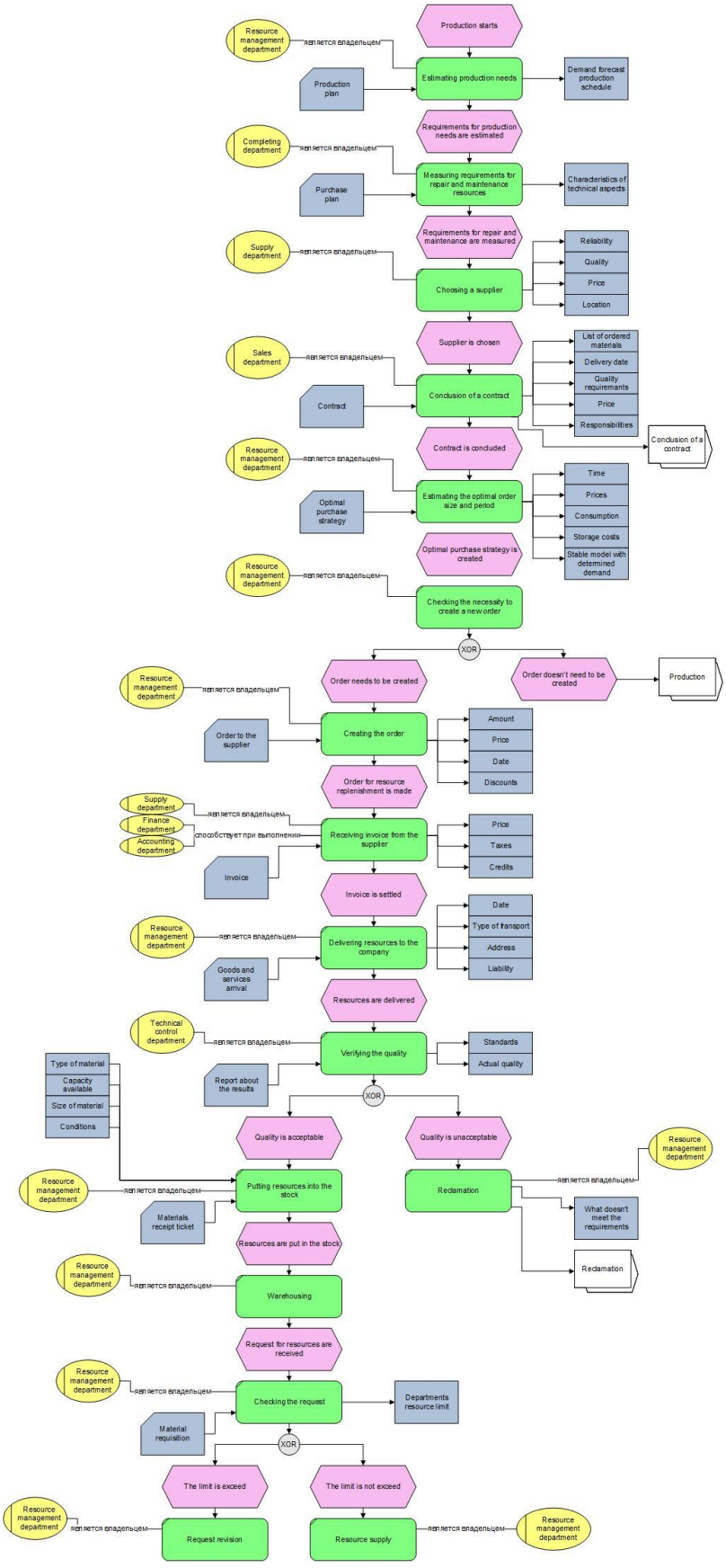


Fig. 4. Example of procurement process of custom production (Lenpolygraphmash manufacturing enterprise (St. Petersburg, Russia)

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Appendix 1

**Description of the information services of supplying process and their content**

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)

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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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