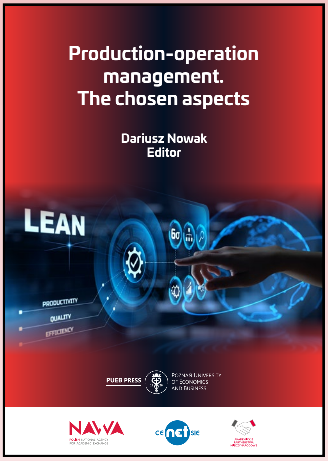

Production-operation management. The chosen aspects

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Editor

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2.

THE OPERATIONAL MANAGEMENT EVOLUTION AND ITS ROLE IN THE INDUSTRIAL ENTERPRISE

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Abstract: The topic introduces within the field of operational management from the standpoint of its historical-evolutionary definition context. The essential aspects are clarified, and the levels of operational management are presented. The principles of operational management are formulated in a short, systematized form. The nature and types of production systems are clarified, as well as their main elements. Definitions regarding the production process, organization of the enterprise and its main subsystems, forms of organization of the production process, forms of arrangement of the production units in space are clarified, too. The recommended fields for identifying good practices in the organization of the production process are also defined. It has been presented the main links that need to be made in terms of good practices, derived in theoretical terms and their main contributions to the enterprise to achieve the desired results by applying the good practices.

Keywords: definitions of operational management, good practices of organization of the production process, levels of operational management, organization of the production process, principles of operational management, production system.

2.1. Introduction

As an independent scientific discipline, operational management began in the '80s of the last century. The path that goes through the concept of management of operations is quite long and marked by both significant revolutionary changes and the gradual accumulation of knowledge and skills (see Table 2.1).

Table 2.1. Main stages of operational management

Years	General feature	Key approach
1700–1900	Stage 1. Manufacturing Management	Craft Production, Mass production, Scientific Management
1900–1980	Stage 2. Operations Management	Operations Research, Human Relations School
1980–1990	Stage 3. Operations and Supply Management	Post-mass production, Early imitation of ad hock Japanese approach
1990–2000	Stage 4. Integrated Operations Management	Lean Operations based on Japanese approaches

Source: (Piercy, 2012, p. 178).

As an **independent scientific discipline**, operational management could be classified as one of the "relatively new" economic disciplines. The main prerequisite for its development and validation is the awareness of the need for the implementation of effective and timely management decisions in the emergence of similar management problems in very different in nature organizations.

As a **type of management activity**, it has been practiced for a long time as the first time the term "operational management" was used in English literature, dates as far back as 1852.

Each of the periods in the development of operational management is distinguished by its strictly individual specificity and lasting reflection in both theory and business practice. In the first stages, the foundations of both modern management and economic theory are laid, as well as the scientific organization of the production activity. The beginning was related to the publication of the works of two of the most famous scientists in the field of economic knowledge—Adam Smith and Frederick Taylor. By developing the theory of the division of work, Smith enables a new approach to the construction of the production activity of the enterprise. Frederick Taylor, with his research, launched modern management and the foundations of the scientific organization of production. The role and place of another major researcher from this period—Elton Mayo, who based on an experiment in a specific production structure—the Hawthorne experiment, studied the impact of the environment on labour productivity should not be overlooked (Stevenson, 1993, p. 27). No less is the importance of the theory of standardized elements presented at the time by Eli Whitney, which helped to significantly increase labour productivity.

As a result of these developments and the practical activities carried out (such as the creation of the computer, the development of tables for the representation of dependencies, research and design of production operations), significant progress is made in terms of labor productivity. The main merit of these initial stages is in the search and development of methods to increase the efficiency of production processes.

After 1910, the development of operational management was associated with its mathematization and computerization as a matter of priority. A significant share of developments lead to the creation of specific models such as EOQ (Economic Order Quantity), MRP (Material Requirements Planning), PERT (Program Evaluation and Review Technique), CPM (Critical Path Method). Again during this period, operational management became an independent scientific discipline. The initial names of this discipline are "production management" and "operational management". It becomes clear that production operations are an essential element of the organization of the production activity.

Practical research is also a significant boost in this regard. The beginning is associated with the production line, used by Henry Ford and Charles Sorenson. A number of specific activities follow in the development of different standards and schemes for stock management, as well as for detecting and overcoming the tight spots in production. Their logical conclusion is the models already mentioned above: "Just-In-Time" (JIT). In the late 1970s one of the most famous models in operational management—5P was developed.

Historically, the development of operational management has been presented in Table 2.2.

Table 2.2. Historical retrospection of operational management

Year	Event / Theory	Author
1733	start of the British Industrial Revolution	James Kay
1764	introduction of steam power	James Watt
1774	machine tooling	John Wilkinson, Henry Maudsley
1776	*Wealth of Nations* book / Division of Labour	Adam Smith
1790	interchangeable parts	Eli Whitney
1832	*Economy of Machinery and Manufacturers* book	Charles Babbage
1911	scientific management *Principles of Scientific Management*	Frederick Taylor
1912 1920	time and motion study	Frank and Lillian Gilbreth
1912	applied Taylor's ideas to organization structure	Harrington Emerson
1912	scheduling and charting procedures	Henry Gant
1913	first moving assembly line / Ford's mass production	Henry Ford / Charles Sorensen
1915	the first mathematical model for inventory management	Ford Harris
1930	human resource based approaches / Hawthorne experiment	Elton Mayo

Year	Event / Theory	Author
1931	*The Control of Quality of Manufactured Products* book	Walter Shewhart
1938	first computer	Jon Atanasoff
1940	quality control techniques	Harold Dodge
1947	linear programming / simplex method	George Dantzig
1950s	Toyota production	Taiichi Ohno and W. Edwards Deming
1950s	first wave of Quality Gurus	Deming, Juran, Feigenbaum
1951	UNIVAC I mainframe computer / Universal Automatic Computer (UNIVAC)	EMCC
1957	critical path method (CPM)	M.R. Walker / J.E. Kelly
1958	Program (or project) Evaluation and Review Technique (PERT)	M.R. Walker / J.E. Kelly
1960s	second wave of Quality Gurus	Ishikawa, Taguchi, Shingo
1960	Material Requirements Planning (MRP)	Joseph Orlicky
1966	*GERT: Graphical Evaluation and Review Technique* book	A.A.B. Pritsker
1970	Just-In-Time (JIT)	Taiichi Ohno Toyota manufacturing plants
1971-	E-commerce	
1980s	third wave of Quality Gurus	Crosby, Peters, Moller
1981	6-Sigma	Motorola
1980s	Manufacturing Resource Planning / Management Resource Planning (MRP I and II)	George Plossl; Oliver Wight
1982	Supply Chain Management (SCM)	Keith Oliver
1990	*The Machine that Changed the World* book	Dan Roos, James Womack, Dan Jones
1990s	agility, mass customisation	
	Computer Aided Design (CAD); Computer-Aided Manufacturing (CAM); Computer-Aided Engineering (CAE)	
1990	Enterprise Resource Planning (ERP)	Gartner Group
1995	Siebel customer relationship management (CRM)	Thomas Siebel Siebel CRM Systems, Inc.

Source: (Sterligova & Fell, 2009, pp. 8–9; Tsvetkov, 1996, pp. 14–18; Kovacheva, 1972, p. 25; Mirchev, 1996, pp. 19–20; Piercy, 2012, pp. 154–178).

Operational management peaked in the 1980s and 1990s, when the integral approach in management began to apply and its new economic paradigm began to be implemented. The beginning is marked by the development of the TQM system, which delivers significant results in the field of quality management. With the appearance of the global network and the Internet, it becomes possible to develop a number of modern operational management systems such as PPS (Practical Project Steering), CAD (Computer Aided Design), EDI (Electronic Data Interchange), ERP (Enterprise Resource Planning), SCM, etc. The development of e-commerce and e-business is provoking new changes in the field of operational management related to supply chain management.

The events played a key role in the emergence and development of operational management are several:

1. The industrial revolution in England of 1770, led to the entry of machines into the production activity of humans and the creation of the first production structures.
2. The promotion of the capitalist, the dominance of the market principle and triggered the emergence of the first commercial companies.
3. Recognition of the role of the human factor in the production activity resulting from the validation of the behavioural theories in the period between the two world wars.
4. The need to economic recovery after The Second World War, including substantial improvement of existing infrastructure.
5. The service revolution related to the modern application of information systems in the economy.
6. Global competition, the completion of a single European market and the expansion of global trade.

2.2. Definition of operational management

Initially, operational management developed as rules and principles, the most famous of which were those of Frederick Taylor. Subsequently, the emergence of new schools in management, the separation of its different directions, the wider application of statistical methods, linear programming and informatics significantly changed its nature and scope. A significant part in shaping its modern vision falls on mathematical modelling, statistical analysis and quality management. The emergence and approving of numerous approaches and management systems requires two main perceptions of the role of modern management: as *science* and as a *practice*.

As a *science* production and operational management (POM) is a set of written rules, principles, and methods of organization management. It is characterized by its certain internal structure and organizational unity. As a *practice*, POM brings together many methods and approaches to manage productive activity of the people. This includes both well-known mathematical models, game theory, computer simulations, and more specific elements such as information technologies, institutions, etc. As a practice, it is defined first and foremost by the interests of individual companies and not by the political interests of the other stakeholders.

The goals and objectives of operational management are to provide basic knowledge about the implementation of the production process of an order in prespecified terms and quantities. In this way, it defines this process in the "time" and "place", in the direction of the general to the private (Tsvetkov, 1996, p. 21). In the case of time, the time limits for carrying out the production tasks, which may be within the range of several hours to one year, shall be understood as "time". In turn, "area" is nothing but an element of the production structure such as enterprise, workshop, section, workplace.

Operational management can also be seen as one of the main *management functions* of the enterprise and as a *network of management decisions*. As a *function*, it is one of the three main functions of each business organization—finance, marketing and operational management of the production activity (Stevenson, 1993, p. 6). Each of these functions is directly related to the entrance and output of the production system and provides the necessary prerequisites for the implementation of the production activity. In parallel with these main functions, a number of other accompanying functions are performed such as accounting, planning, staff management, public relations, etc., which, in their unity and integrity, are a condition for the normal functioning of the enterprise.

Operational management as the main management function includes many different activities directly influencing the production of goods and services. We can refer to them the supply of raw materials and materials, the repair work, transport, production planning, control, etc. They are all directly or indirectly linked to the main subsystems of the enterprise—incoming, transformative and outgoing and ensure the continuity of the production process.

The presentation of operational management as a *network of management decisions* focuses on the place and role of the management decision-making process in the modern enterprise. In this context, the importance of one of the three main subsystems of operational management—the operational regulation of the production activity, is at the scheduling. Its main objective is to ensure continuity of production activity, to eliminate tight production places and to create conditions for compliance with the deadlines for production. For these reasons, significant attention is paid to problems related to both the nature and specificities of management decisions and the algorithms for their construction. The different types of models that greatly facilitate the management decision-making process are widely represented.

The introduction of the integral approach in management requires the separation of four different levels of integration of production activity directly related to operational management (Sterligova & Fel, 2009, pp. 23–27):

- **Operational level**: integration is carried out in separate operations and functions that are not directly related to each other. This requires the use of operational production cards and Gant tables.
- **Functional level of integration**: related to activities such as supply management, stocks, logistics, etc. In this case, attention is focused on controlling how resources are used, the design of the main material flows, etc.
- **Interfunctional level**: aimed at optimizing the final results of the company's activities. Its main tools are MRP, JIT, ERP, etc. At this level, the establishment of a single information system is of particular importance.

- **Inter-organizational integration**: related to ensuring the sustainable development of production systems, development of cooperation between different business structures and the implementation of common business processes. The applied toolkit includes MRP, JIT, ERP, etc. models.

In addition to science, operational management can also be seen as a *practice*. In this aspect, it is seen as a priority associated with the activities of the specialists in operational management. The basis for its implementation is the availability of knowledge and skills in the field of management and organization of production. Their main functions are related to:

- planning of the production activity,
- organization of production,
- control,
- management decision-making.

The main key areas of action of the operational managers are the production process, the efficient use of the resources of the enterprise, technological provision, logistics, quality of production, control of production activity, etc. A mandatory principle in carrying out their activity is complexity. They are responsible for both the material and cash flows of the enterprise. Moreover, it is these managers who break down the production tasks into parts, control their overall implementation and ensure compliance with the deadlines. It is not accidental that over 50% of the top managers of large corporations necessarily go through the position of the operating manager.

2.3. Levels of operational management

The key role of operational management in the enterprise requires the construction of its own system, including many different internal and external subsystems related to the functioning of the enterprise. In economic theory and practice, there is still a lack of common sense with regard to the subsystems that make up it. Some of the authors talk about two main subsystems—for the *management of the production operations* and *the finances* of the enterprise (Bandurin, Basalay, & Lee, 1999, pp. 22–26).

The first ones cover the production processes in the enterprise and aims at the operational management of operations, supplies and costs for the purchase and storage of raw materials. The management of operations includes—control and regulation of equipment, production facilities, deadlines for carrying out production operations, production stocks, etc.

Supply management includes the logistics of the enterprise, the supply of raw materials, warehouse processes, transport operations, the supply of spare parts and semi-finished products, the repair of machinery and equipment, the information services of the enterprise, etc.

Cost management is associated with the choice of supplier, delivery conditions, price of deliveries, distribution of delivery orders, delivery times, etc. The purpose of this management is to ensure a higher level of use of raw materials and to reduce the cost of raw materials.

The second ones include the management of debit indebtedness, short-term financial investments and the cash availability of the enterprise.

According to other authors, the operational management system includes three main subsystems—planning, organizing and control (Kumar & Suresh, 2008, p. 10). The *planning subsystem* covers the operational strategy of the enterprise, the forecasting, the selection of products and technologies, the development of different types of plan-schedules. The *organizing subsystem* aims at designing operations, project management, etc. The main task of the *control subsystem* is the implementation of in-house control, quality management and supply management.

Aggregate planning provides and realizes optimal proportions between the individual structural elements in the production process. It is an important part of the overall planning process. Its ultimate goal is to eliminate the negative effect of uncertainty and change, to focus on the main tasks and to facilitate the control of production. It finds expression primarily in the development of different types of plan schedules.

Operational control is a link between aggregate planning (AP) and operational regulation. Its main function is to collect information on the deviations between the actual and the forecast base state of the production system. Objects of this control are the movement of material flows, the completion of the finished product, the use of resources and the quality of the production.

The main function of the **operational regulation** is to eliminate the undesirable effects in the production and to bring the system into balance. Object of operational regulation are resources, the production process and the output.

Like any economic system, the system of operational management has its own internal structure. Due to the specifics of the place and the role of the operational management system, it is necessary to distinguish between two main types of structure within it—*organizational* and *functional*.

The *organizational structure* is essential for the efficiency and competitiveness of the company. Its proper formation is a testament to the skills of the managerial staff of the enterprise. In order to properly build the organizational structure, it is necessary to coordinate it in advance with the goals of the business organization and its capabilities. According to Peter Drucker (2010, p. 39), every organizational structure must meet two basic requirements:

– to create an organization of a business action,
– have as few levels of government as possible.

The organizational structure exposes the horizontal structure and the established hierarchical levels of the operational management system. It corresponds to the existing levels of management in the business unit and depends entirely on the production structure built in it.

This structure includes three main subsystems:

1. Inter-plant operational management—carries out ongoing coordination of processes between individual plants, jointly preparing the finished product.
2. Inter-shop operational management—performs current coordination within the enterprise, between its workshops. The main unit is the workshop, and the object of coordination are the completion of the finished products, the beginning and completion of the individual operations, the technical preparation of the production.
3. In-house operational management—the object of current coordination are the processes taking place within the individual sections and workplaces within the workshop, and more precisely the beginning and completion of the operations carried out in them.

The *functional structure* of the operational management system is formed as a set of all tasks and activities performed in it. The main task is to carry out ongoing coordination of processes and activities within the system "resources-finished products". The purpose of this coordination is to ensure the maximum continuous movement of material flows and maximum use of resources in the individual micro periods of time.

In other words, the current coordination is a synchronization of production and consumption between the micro-units of the enterprise in the different micro-periods. Its characteristic features are:

1. Satisfaction of the needs for materials, technical documentation, equipment, labour force, units and details of the i-th micro-unit (workshop, section, brigade, workplace).
2. Synchronization of the needs in the j-th micro periods of time (hour, shift, day, week, month). This synchronization can be performed by quantitative parameter (by stocks), or by time parameter (by calendar terms).

Objects of the current coordination are main production process; servicing this process with the necessary equipment, repairs and transport services; the completion of the finished product.

This main function, in turn, decomposes into several main functions (see Figure 2.1).

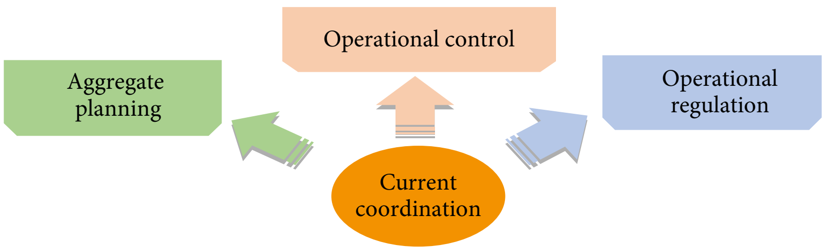

Figure 2.1. Main functions of the current coordination

Source: Own work.

These functions are also broken down into smaller partial functions, which cover individual sides of the main one.

In terms of aggregate planning, these are: *standardization* of the quantity and determination of the terms for movement of the material flows in the separate phases and operations; *forecasting* the state of production for the individual micro periods (calendar planning), etc.

The *partial functions of the operational control* are:

- operational control of the products,
- operational control of resources,
- operational control of reserves.

The *partial functions covered in dispatching* are respectively:

- preliminary coordination of plans with resources,
- making management decisions.

The last stage of the decomposition of the main function is the formulation of the tasks, namely:

- determining the size of the batches,
- determining the duration of the production cycle,
- rationing of stocks.

The 5P model: The construction and maintenance of optimal proportions both between the different types of resources and between the structural elements of production are the basis of production management. Its essence can best be expressed through the "5P" model. It was developed by Pryor, White and Toombs as a strategic management model focusing on 5 key areas for the organization's success (1999). Each of these areas is studied by separate disciplines. Enterprises or buildings are the object of industrial engineering, people—management of human resources, products and production operations—production engineering, planning—production planning, control—controlling, etc. The main elements of this model are:

- **Plants**: various organizations producing products or creating services; it is usually understood as a place for placing machinery and equipment for the purpose of production activity. Its synonymous terms are enterprise, factory, factory, service establishment, etc. Enterprises must provide opportunities for future development, provide offices for the implementation of the activity, to be distinguished by their internal design, security of installations and equipment, etc.
- **Processes**: design of business processes; represent a pre-designed sequence of production operations leading to a change in the properties and type of raw materials used. There are always different alternatives in its design, but the ultimate goal is to choose the most profitable among them. To this end, factors such as available capacity, staff skills, production costs, type and type of production, safety, maintenance, etc. must be taken into account.

- **Parts**: products and services; are generally defined as something that can be offered on the market and is designed to meet different groups of needs. The products are produced by the enterprises, going through the transformation from raw materials to finished products and services. They have a number of characteristics such as quality, quantity, price, appearance, production time and more.
- **People**: staff; human resources engaged in the operational management of the enterprise. From the point of view of the organization, they represent not only specific executors of the production activity, but also managers and controllers of the ongoing processes inside the enterprise.
- **Plan and control systems**: management functions related to the planning, control and regulation of production processes. Planning is mainly associated with the preparation of various types of schedules related to the supply of raw materials, transport, warehousing, production support.

2.4. The principles of operational management

The establishment of an optimal scheme of operational management requires the consideration and observance of a number of basic principles that determine the final results of the enterprise. The first principles of scientific management of organizations were formulated by Taylor in 1911 in his fundamental work *Principles of Scientific Management*. They are gaining popularity and are being widely implemented in American companies.

The development of management as a science has a significant impact on the principles of management. There are known attempts to group them by a number of authors: Emerson, Mooney, Peters and Waterman and others. According to Emerson (1973), the principles of management should be mutually conditioned and interconnected, emphasizing clear goals and objectives, common sense, strict discipline, normal working conditions and others. Mooney's rich practical experience is the basis for the formulation of his 4 basic principles of governance: coordination, power, delegation and specialization (Kravchenko, 2002, pp. 124–125).

In their book *Towards the Perfection of Corporate Governance*, Peters and Waterman (1988) present a newer classification of **governance principles**. They include the following principles:

- action orientation,
- facing the user,
- autonomy and entrepreneurship,
- increasing labour productivity thanks to people,
- attachment to one's own activity,
- simplified form, small management staff,
- simultaneous rigor and freedom of action.

A slightly different classification of the principles of operational management, consistent with real practice, presents Schaeffer (n.d.). According to it, the main principles are:

- **reality:** should focus on the problem, instead of the techniques;
- **organization:** processes in manufacturing are interconnected. All elements have to be predictable and consistent, in order to achieve a similar outcome in profits;
- **fundamentals:** the main part of the success is due to strict adherence to precisely maintaining records and disciplines;
- **accountability:** managers are expected to set the rules and the metrics, and define responsibilities of their subordinates, as well as regularly check if the goals are met;
- **variance:** variance of processes has to be encouraged, because if managed well, they can be sources of creativity;
- **causality:** problems are symptoms: effects of underlying causes;
- **managed passion:** the passion of employees can be a major driver of company growth, and it can be instilled by the managers if not coming naturally;
- **humility:** "get help and move on";
- **success:** what is considered success will change over time, but always consider the interest of the customer;
- **change:** there will always be new theories and solutions, so you should not stick to one or the other, but embrace the change, and manage for stability in the long term.

A number of other classifications of management principles can be mentioned. They are implemented on the basis of various features and criteria such as: needs of practice, level of competence of managers, specifics of the organization and others. According to the most common classification, modern management principles are divided into *fundamental* and *specific*. The *fundamental* ones are of fundamental importance for the organization and are related to its purposefulness, efficiency, flexibility and adaptability. The *specific* ones have a complementary role in relation to the fundamental ones. They are directly related to the new models of enterprise management and are aimed at decentralization, coordination and interaction between different sectors of the economy, etc.

The evolution of management principles also leaves its mark on the principles of operational management. In modern conditions, these principles ensure the normal functioning of the operational management system. The most important among them are:

1. The structure of the operational management system shall be determined by the type of production and not by its type.
2. The simpler a product, that is with fewer components and components, the simpler the operational management system.
3. The shorter duration of the production cycle reduces the complexity of the operational management system.

4. Simplification of reporting—the information submitted for each upper management level is consolidated and summarized according to pre-fixed sustainable indicators.
5. The maximum possible interval of operational management may not be less than the cycle of preparation of the finished products.
6. The production structure of the enterprise does not affect the structure of the operational management system.

2.5. Production systems and its elements

Operational management as a target orientation is aimed at the management of production systems, different in content, purpose, size and degree of complexity. From the abstract level, the production system is "a transformation process" of resources (labour; capital for machinery and equipment, materials, etc.; space as land, buildings, etc.) into useful goods and services. According to Chase and Aquilano (1992, p. 12) the **production system** can be considered as a network of components whose function is to transform the set of input resources into desired results, within the so-called transformation process. Babu (2012, pp. 1–13) defines a production system as a set of interconnected input-output elements and is made up of three components, namely inputs, processes and outputs (see Figures 2.2 and 2.3).

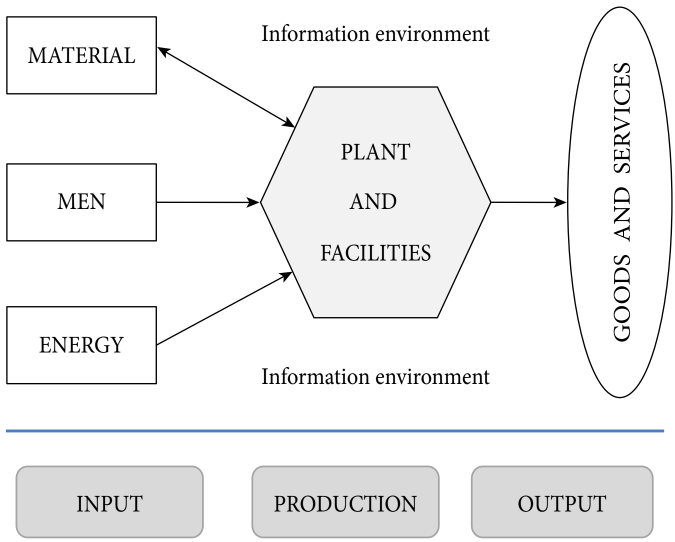

Figure 2.2. Production system

Source: (Babu, 2012, pp. 1–13).

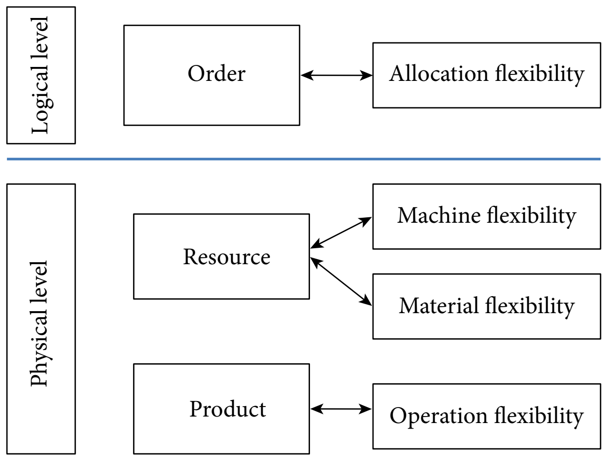

Figure 2.3. Basic elements of the production system (as a common logical and physical view)

Source: (Babu, 2012, pp. 1–13).

Based on the common definitions, Sindhuja (2020) constructs a simplified scheme for the production system, in which the emphasis is on the relationship between the inputs, outputs, series of operations or processes, storages and inspections (see Figure 2.4).

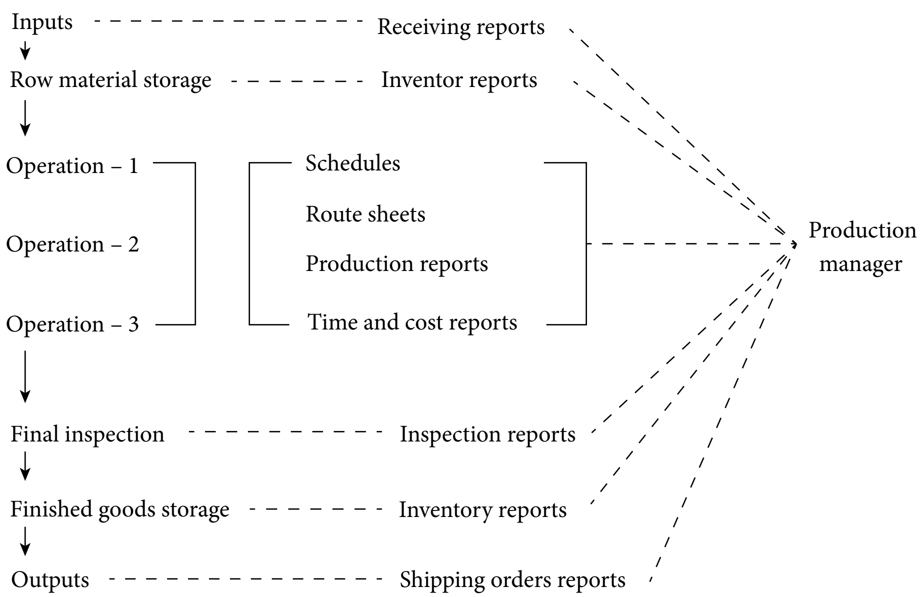

Figure 2.4. A simplified production system

Source: (Sindhuja, 2020).

The production system can also be defined from different points of view. In the Figure 2.5 has been shown simplified versions of these different understandings, with an emphasis on the specifics of each.

Production system	*Technical meaning:*	Transformation process of some goods in other.
	Economical meaning:	Transformation process of some goods in others of higher monetary value.
	Informatics meaning:	Transformation process of some data into more valuable data.

Figure 2.5. General understanding of the production system

Source. Own work.

From the **technical point of view** the production system is a set of any methods used in industry to create goods and services from various resources (Tanenbaum & Holstein, 2020). At the technological level "the current developments in manufacturing systems stem from the advances in machine tools, robots and controllers" (Tzafestas, 1997, p. 1).

From the **economic point of view**, as a value creation module, the production system may be described as a system transforming input (material, energy, information, and monetary means, etc.) into value-created output (a fabricated or assembled product), achieving through the synergy of value creation factors (process, organization, equipment, human resources and product) on the basis of organization procedures for managing enterprise activities. The processes include an amount of different technical operations (machining, assembly, testing, handling, conveying, sorting, collecting, packaging, storing, distributing, etc.). The operations are performed or supported by equipment and human resources. They are linked and involved within material flows (production, processing and distribution of goods within specified areas). It covers all forms of work objects (e.g. substances, parts, and carriers) movement in the production system either by manual or using automation (Rahman, 2020). From the **informatics point of view** it is carried out the transformation process of some data into more valuable data giving multiple benefits due to a synergy of data collection, proceeding and using as the based on the characteristic ubiquity. Computer-integrated manufacturing (CIM) "implies a systemic approach to the operation of a manufacturing enterprise, i.e. it involves: research engineering—plant functions—production—business functions—administrative functions" (Tzafestas, 1997, pp. 1–2).

Within the transformation process, very diverse impacts and changes can take place, leading to Chase and Aquilano (1992, p. 12):

- physical (mechanical / material / thermal) transformations (e.g. in production or industry),

- localization transformations (e.g. in transport),
- exchange transformations (e.g. in trade, especially in retail trade),
- transformations related to storage (e.g. in storage holdings),
- physiological transformations (e.g. in healthcare),
- information transformations (e.g. in the telecommunications sector).

The production system is a part of the system "industrial enterprise". Within the operational management and in a general organizational context, the transformation processes can be carried out in **four main types of production systems** (see Table 2.3).

Table 2.3. Analysis of production systems

Factors	Types of production systems			
	jobbing	batch	mass	process
Equipment	standard machinery size depending on whether the enterprise is engaged in light, medium or heavy engineering	similar to jobbing production but there may be some equipment	machinery designed for one range of product, largest product generally not greater then medium engineering	the entire "enterprise" is completely integrated at all stages. generally no isolated items of equipment
Type of buildings	in heavy and medium engineering will be single store and either single or multi-storey for light engineering; floor area per worker will be high	similar to jobbing production	similar to jobbing batch production the mass manufacture of light engineering products will be single or multi-stored buildings	quite often the equipment in progress manufacture will not be enclosed inside buildings
Layout of factory	similar machines will be arranged in groups—known as process or functional layout	similar to jobbing production but in some enterprises different machines may be grouped together to suit families of parts	all machines and processes will be arranged in operation sequence to suit the product—known as line layout	the entire enterprise will be designed like one huge machine and to produce a certain rate of a specific product
Type of flow	because of the difficulty of balancing demand with capacity work will wait between operations—known as intermittent flow	similar to jobbing production but a family grouping type of layout may reduce waiting but will also reduce machine utilisation	demand and capacity will be reconciled so flow will be continuous	as the complete layout has been designed for a specified flow production will be continuous
Cost and time required to make product	cost of one product in relation to turnover will be high; total time to make will be high and can be expressed as: total operation time total time to make this will always be less than 1	similar to jobbing production but the ratio of total operation time to total time to make will be better	cost of one product in relation to turnover will be small; the total time to make will be low and the ratio of total operation time to total time to make will be near to 1	cost of one unit of output in relation to total output will be very small and the ratio of total operation time to total time to make will be theoretically near to 1
Work-in-progress	the amount of W.I.P. in relation to total output will be high	similar to jobbing production	the amount of W.I.P. in relation to total output will be small	there will be theoretically be no W.I.P. between operation stages

Factors	Types of production systems			
	jobbing	batch	mass	process
Materials handling	standard equipment and will depend on whether the enterprise is engaged in light, medium or heavy engineering	similar to jobbing production; but there a be some special purpose equipment	extensive specialised equipment	materials handling and processing will be completely integrated
Foremen	large technical content is supervisory function; ratio of supervision to operators about 1:30	specialists in the functions supervised, e.g. milling or capstans ratio of supervision to operators about 1:50	specialists in the particular aspect of flow production; ratio of supervision to operators about 1:50	concerned with co-ordinating and communicating; ratio of supervision to operators about 1:15
Sales and design	technical, large staff orders made to customers requirements	products and jig and tool design, orders made to customer's requirements	research and development product testing market research to test customer's requirements	research and development for products and process market research to test customer's requirements
Type of industry	ship building, civil engineering, process engineering, castings	machine tools, furniture, clothes, drop forgings	food, cigarettes, TV electric lamps vehicles	chemicals, oil petrol

Source: (Sindhuja, 2020).

In addition, the specificity of each production system depends also on the type of products and their purpose, the availability of resources, the market demand for industrial products and services, etc.

2.6. Organization of the production process (best practices)

Enterprises can achieve different results, which should be taken into account when organizing their activities, i.e. the final results of the outcome of the enterprise may have a tangible substance or no material equivalent or substrate (idea, decision, advice, service, etc.). For example, in enterprises with a material result, a rational combination in space and time of technological equipment, material resources and labour is carried out, which in practice finds expression in the *organization of production and labour processes.*

The **production process** in an industrial enterprise is a set of interconnected production-technological, labour and naturally occurring (e.g. time for ripening, drying, cooling, fermentation, baking) within which there is a direct or indirect impact on raw materials and semi-finished products and their transformation into finished products. This includes also the processes of storage, distribution and transportation, maintenance of workplaces, maintenance of machinery and technological equipment, control of the production process, etc. (For more information see Varamezov, 2017, pp. 16–17; Kanev & Hristova, 2008 p. 22; Varamezov & Gutsev, 2017, pp. 31–32).

As a system, the **organization of the enterprise** includes **three subsystems**: organization of production (production processes); labour organization and management organization. Its content covers:

- design, implementation and subsequent improvement of the organizational structure of the enterprise and in particular the management structure, production structure and infrastructure,
- organization of the production process,
- application of effective forms of organization of production,
- organization of the production preparation,
- organization of the control of the processes in the enterprise,
- organization of the labour process,
- design and implementation of effective management systems.

The **organization of production processes** takes into account their specifics, i.e. whether they are main, auxiliary or service, manual, machine-manual, machine or hardware, intermittent (periodic) or continuous; as well as the type of production (unit, batch, mass and continuous).[1] (For more information see Varamezov, 2017, pp. 17–20; Varamezov & Gutsev, 2017, p. 31; Kanev & Hristova, 2008, pp. 23–25).

Several **forms of organization of production processes** are applied in industrial enterprises: individual, group, subject, flow, etc. In the **individual form**, all or almost all operations are performed by one employee. In contemporary conditions it is applied to a very limited extent, mainly in handicrafts, in the assimilation of new products or in the framework of some non-productive activities (Kanev & Hristova, 2008, p. 37). In the **group form** a universal type of machines is used, which are grouped by homogeneity in production sections or workshops; the operations are combined mainly in a sequential or parallel-sequential manner within an interruptible production process; the products are moved in batches; the contractors have a wide profile professional training; there is a wide range of products. In the **subject form**, the workplaces have a subject attribute; relatively universal equipment and personnel with general training are used; there is no uniform rhythm of production; the operations are combined by the parallel-sequential method. In the **flow form**, the production of the products is organized on the basis of a predetermined *pace* (the number of products made per flow per unit time) and *time* (the time interval during which a finished product comes out) of the process, and synchronization of operations, regardless of the degree of mechanization and automation of workplaces. The workplaces are specialized and are arranged mainly

[1] The type of production shows the degree of specialization of production and the stability of the workload with the same operations. It is determined by the volume of production, its serial (batch) number, repeatability of production, the type of technological equipment.

in a line of products. Staff training is also specialized; specialized transport is used (conveyors, conveyor belts, platforms, etc.).

The **form of the spatial arrangement of the units** in the industrial enterprise can be *pavilion or block (hull)*. In the ***pavilion form***, the workshops are located in separate buildings (usually in large enterprises). The main workshops are located depending on the course of the technological process, facilitating the transportation of the processed material resources and leading to cost reduction. The auxiliary workshops are located close to the main workshops and the users of their products, not to hinder the movement of material resources between the main workshops and to promote the rational formation of freight flows and the location of the warehouse. In the **block form**, the units are located in a single-storey or multi-storey building. In the one-storey layout, the processes are arranged in a line according to the course of the technology, avoiding the cross and return movements of the processed material resources and finished products of the enterprise. The multi-storey layout saves space and time but presupposes the presence of cross and return movements (Varamezov, 2017, pp. 10–11).

The application of various good practices should not be a specific private option for optimizing business processes, but should follow the general philosophy of a comprehensive economic approach, looking for opportunities to take advantage of the many business solutions within:

Facility management: It is aimed at maintaining property, buildings, equipment and other assets, as well as organizing their inclusion in the production processes carried out by staff to achieve a certain level of productivity. It aims to impact on the operational efficiency of the enterprise, facilitate and assist in maintaining and increasing the productivity of facilities and personnel, risk management of the use of facilities and personnel, counteraction and adaptation to external influences, application of good practices for long-term management of the costs, achieving the desired correspondences with indicators of other systems, providing a timely response to limit and overcome the consequences of natural disasters, implementation of adequate technological solutions, etc.

Manufacturing & assembly: A number of good practices are possible, covering the whole process of processing raw materials and semi-finished products, assembly of components, parts, assemblies, units, etc. in the form of finished products, ready for sale. Practices are applied for design, production and marketing of products for the shortest possible time for creation and assembly of products, lower costs for assembly, removal of technological waste and increase the reliability of products.

Production engineering: It covers the entire process of designing and moving product development activities to their exit from the production system of the enterprise, including activities of manufacturing engineers, design, selection of the best technologies and processes for the creation of products; planning and design of equipment and provision of machines for the production of products; control, management, maintenance of the production system and search for opportunities for its continuous improvement.

Production planning: Practices for planning, distribution and use of raw materials, machines, equipment, personnel, etc. are applied. in order to optimize the time for execution of works and achieve completion of orders on time.

Quality assurance: It covers the cycle called PDCA cycle (Deming cycle), whose main phases are: Plan (planning and establishing the process related objectives and determine the processes that are required to deliver a high-quality end product), Do (Development and testing of Processes and doing processes changes), Check (Monitoring, modifying and checking the processes) and Act (implementing necessary actions for achieving process improvements).

Systematizing the purely scientific knowledge and business empiricism, the following **good practices** can be summarized (MANTEC, n.d.):

Implementing Lean Manufacturing: Enterprises use lean practices to achieve efficiency based on cost optimization by reducing waste without reducing productivity. Lower costs for stocks are realized, the term for development and expulsion of the products is shortened, higher efficiency is achieved, the quality of execution increases, an increased level of customer satisfaction is reported. In the end, a higher profit is realized.

Becoming More Environmentally Friendly: These practices are aimed at achieving compliance, maintenance and compliance with environmental regulations, thus avoiding financial sanctions and legal problems. Modern enterprises strive for waste recycling, application of non-waste technologies or a closed cycle of full utilization of all raw materials, introduction of environmentally friendly production and more.

Implementing Automation: In production systems and their organizational maintenance, automation and robotization of processes are widely used, achieving accelerated execution of works, improved quality of processes and finished products, almost without human intervention.

Implementing a Quality Management System: Timely changes and improvements are made in the preparation, organization, course and control of the production processes in order to maintain the high quality of the production systems and the results of their functioning. Effective quality management systems are being implemented.

Making Ongoing Training a High Priority: Continuous assessment of the achievements and progress of the staff and timely increase of knowledge, skills and competencies as a guarantee for maintaining the necessary correspondence between new trends and good practices, and the poor educational and qualification parameters of the staff. In this way, the aim is to ensure the maintenance of up-to-date knowledge and production experience related to the latest trends in the field of production processes and technologies.

A number of **specific good practices** can be applied in the industrial enterprises, the specific choice of which depends on the managerial decisions. Among the most commonly applied good practices are the following: lean, Just-In-Time, continuous improvement, *kaizen* and *kaikaku*, Total Quality Management and ISO 9000, ISO 14000, health and safety, Six Sigma, 5S, failure mode and effects analysis, Quality Function Deployment, new product development, Total Productive Maintenance, supply chain management, etc.

In Table 2.4 has been presented the main links that need to be made in terms of good practices, derived in theoretical terms and their main contributions to the enterprise to achieve the desired results by applying the good practices (in the other enterprises and the competitors).

Table 2.4. Linking between the best practice, its main contributions and enterprises performance

Researchers	Key concept to best practice	Results regarding practice-performance relationships
Swamidass and Newell (1987)	cross-functional co-operation, design for manufacturability	corporate performance is positively related to the role of manufacturing managers in strategic decisions
Voss (1995a)	world-class manufacturing, bench-marking, business process re-engineering, TQM, learning from the Japanese, continuous improvement (CI)	implementation of best (world class) practices leads to superior performance and capability
Ahmed and others (1996)	TQM, JIT, FMS, CE, bench-marking	when practices (operations strategies) are examined individually, companies using any of seven practices (FMS, CE, benchmarking, TQM, JIT, manufacturing cells and computer networking) have higher performance than those not using them
Bolden and others (1997)	WCM, employee development	the classification of manufacturing practices taxonomies developed provides insight into the role of individual practices, implementation and outcomes
Flynn and others (1997)	WCM, TQM, JIT	the best users of unique TQM practices, combined with common infrastructure practices, are capable of solving problems to improve production processes
Harrison (1998)	WCM, CI	WCM appears to facilitate operator commitment to continuous improvement, but leaders become more frustrated because they expected to achieve more. Cellular manufacturing in a UK-based company acted as a powerful change agent, which has led to more in terms of manufacturing improvement than previous initiatives, such as MRP II
Flynn and others (1999)	WCM, CI, JIT, TQM	the use of WCM, alone and together with other new practices, leads to improved competitive performance

Researchers	Key concept to best practice	Results regarding practice-performance relationships
Kathuria and Partovi (1999)	Cross-functional co-operation	better performing manufacturing managers strongly demonstrate relationship-oriented practices, such as team building and support, participative leadership and delegation, especially when the emphasis on flexibility is high
Rondeau and others (2000)	Work system practices, time-based competition	time-based manufacturing practices tend to lead to standardisation, formalisation as well as integration
Davies and Kochhar (2002)		best practices, performance, manufacturing planning and control; a structured approach used to identify direct qualitative relationship between practice and performance
Garver (2003)	Benchmarking, CI	integrating customer performance measures with internal performance measures (internal quality, productivity etc.) to identify improvement opportunities is found to be critical
Ketokivi and Schroeder (2004)	TQM, JIT, WCM, contingency	there are only few best practices contributing to competitive manufacturing performance in multiple dimensions

Source: (Boer, Frick, & Acur, 2005).

The choice of form of organization of the production process and the respective production system in which to implement this process is made on the basis of a multi-directional analysis of the appropriate prerequisites for the particular enterprise, the established restrictive conditions of production and specifics of products. Managers study the good practices in the industry, their advantages and disadvantages, the possibilities to achieve the set goals and realize benefits.

Questions / tasks

1. What are the main stages in the evolution of operational management?
2. What are the main theories in the field of operational management?
3. What are the key elements of the evolution of operational management?
4. What is the operational management system?
5. What are the features of operational management as a science?
6. What are the features of the organizational structure of operational management?
7. What is ongoing coordination? What does time and place coordination mean?
8. What elements does the functional structure of operational management include?
9. What are the partial functions included in the functional structure of operational management?

10. Identify the various tasks that complement the functional structure.
11. What are the principles of operational management?
12. What are the elements of the 5P model?
13. What is the production system? What are the different accents in the definitions clarifying the term from different points of view? And what is common between them?
14. What types of changes are taking place in the transformation process within the production systems in different sectors of the economy?
15. What types of production systems can you specify and what are their features?
16. If you are the manager of an industrial enterprise, what type of production system do you choose to apply and what arguments can you give to justify your choice?
17. What is the production process in an industrial enterprise?
18. What forms of organization of the production process are most often applied in industrial enterprises and what are their features?
19. What solutions can industrial enterprises apply in choosing the appropriate form of organization of the production process—in general, within individual areas and specific business practices in the field of operational management?

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