Goran D. Putnik
University of Minho
Department of Production Systems Enginnering
4800-058, Guimarães
Portugal
putnikgd@dps.uminho.pt

Cátia Alves
University of Minho
Department of Production Systems Enginnering
4800-058, Guimarães
Portugal
catia.alves@dps.uminho.pt

Paulo A. Ávila
ISEP – Instituto Politécnico do Porto
DEM
4200 Porto
Portugal
psa@isep.ipp.pt

A contribution to clarification of definitions and relationship between processes, operations, process plans, jobs, tasks and orders

Abstract

The terminology and semantics concerning process plans, operations, orders, jobs and tasks are unfortunately not used in a canonical way, and many times there is misunderstandings, confusion or even ignorance of the relationships between the terms, among the practitioners and students. This paper contributes to clarification of basic canonical definitions and relationship between processes, operations, process plans, jobs, tasks and orders. The paper presents the concepts of "Process Plan", job, task, orders and their relationship. It is suggested that adoption of canonical forms of these concepts, definitions and relationships will facilitate implementation of advanced methodologies and technologies and techniques and integration with other systems and partners (networking).

Keywords

Processes, operations, process plans, jobs, tasks, orders.

1. Introduction

In many companies, and within the academe as well, which is quite surprising, the terminology and semantics concerning process plans, operations, orders, jobs and tasks are unfortunately not used in a canonical way. This leads to a confusion on terminology use and meaning, especially in communication, observed many times, among the practitioners and researchers from different organizations and communities.

The main purpose of this paper is to contribute to unification of perception and terminology use, on processes, operations, process plans, jobs, tasks and orders, through clarification of definitions and relationships between them.

The correct and coherent use of concepts and terminology is fundamental for integration of production systems within the domain of these concepts, as well as a whole.

This paper is further organized as follows. Chapter 2 define the concepts of (1) process and operation, (2) process plans, (3) jobs and tasks and (4) orders. Relationship between these concepts, process plans, jobs, tasks and orders, is presented in Chapter 3. Conclusions are presented on Chapter 4.

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2. Definitions

2.1 Process and Operation

Before definition of the Process Plan, it is necessary to specify the differences between process and operation.

Process is a technological concept that abstracts the concrete physical machine/workstation for effective execution, to which the process will be allocated, i.e. abstracts the allocation to the concrete machine/workstation. It means that process can refer machine on which it will be executed, usually referred to an abstract machine, or type of machine, and without referring the effective execution machine.

Operation is an organizational concept that implies the allocation to the concrete machine/workstation. Operation is defined by three parameters: unchanged machine, unchanged work-piece, and continuity, see e.g. Wang and Li (1991), p.4.

The same set of processes can be organized in different operation, depending on the sequence of processes, and their allocation to a concrete machine/workstation.

For example, let us considered four different processes:

1. Drill hole 1 (p1)
2. Drill hole 2 (p2)
3. Drill hole 3 (p3)
4. Drill hole 4 (p4)

These four processes can be organized in different orders, for example, <p1, p2, p3, p4>, <p4, p1, p2, p3> , <p1, p3, p4, p2>, etc., meaning 4! possible permutations for sequences of the processes. Actually, 4! permutations are possible only in some special cases, as usually from all 4! permutations some, or even many, are not feasible because of technological and other constraints. In the following example, it is considered only the sequence (permutation) <p1, p2, p3, p4>, for the explanatory purpose.

After the processes sequence, they can be organized in different number operations, where the process inside the operation are called operation element, for example:

1. 1 operation with 4 operation elements,

   OP1 (<p1, p2, p3, p4>)

2. 2 operations – for example, the first operation with 3 operation elements and the second with 1 operation element,

   OP1 (<p1, p2, p3>), OP2 (<p4>),

   or other arrangements of referred four process in two operations OP1 (<p1, p2>), OP2 (<p3, p4>); OP1 (<p1>), OP2 (<p2, p3, p4>)

3. 4 operations - the first operation with 1 operation element, the second with 1 operation element, the third with 1 operation element, and the fourth with 1 operation element,

   OP1 (<p1>), OP2 (<p2>), OP3 (<p3>), OP4 (<p4>)

2.2 Process Plans

Process plan is the output of the Process Planning process. In manufacturing context, process planning is defined as "*the activity of deciding which manufacturing processes and machines should be used to perform the various operations necessary to produce a component, and the sequence that the processes should follow*" (Marri, Gunasekaran, & Grieve, 1998), for "converting raw materials into a final product to satisfy the design requirements and intent and respect the geometric and technological constraints" (ElMaraghy & Nassehi, 2014). Further, Process Planning is "*a bridge between design and manufacturing of a mechanical product.*" (Wang, 2013).

As the result of process planning, process plan has the detailed operations specifications, including the operations sequence and the operations' elements, setups, tools and process regimes, for each part/component/assembly of the same product produced by the company. By Process Plan (differentiating from process plan) it will be referred the document that presents process plan.

Usually there are considered two types of process plan: the manufacturing process plan and the assembly process plan, although, in general, assembly is part of manufacturing and this distinction is not necessary on general level, except they have different form in a part of document only – the conceptual structure of the document Process Plan is the same.

The representation of the document Process Plan is consisted of two types of sheets:

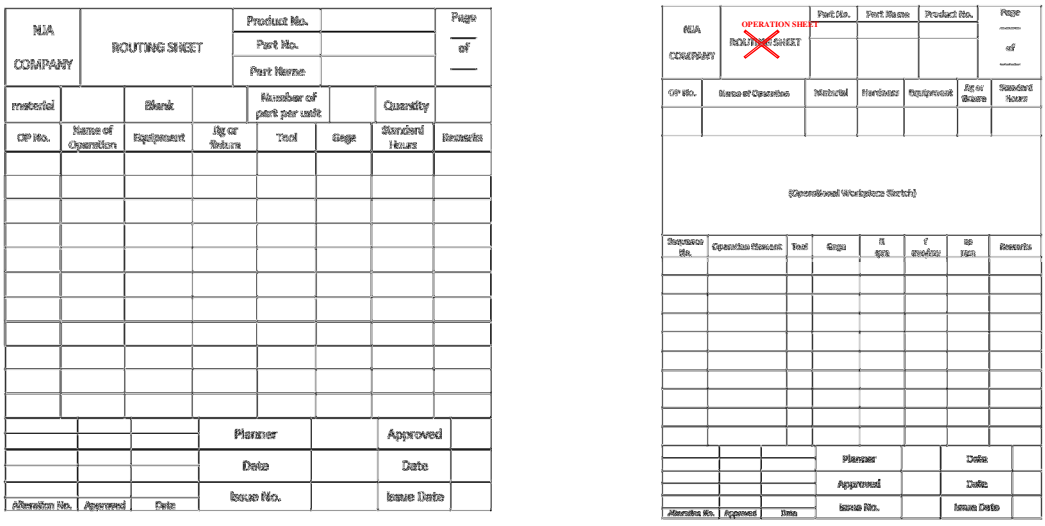
- "Rooting sheet" – where all operations are listed (and for each operation it is included the machine, tools, calculated time and other information) and to each operation is attributed an ID number.
- "Operation sheet" – where each operation is detailed described (identified with their ID number) with the operation elements, tools, regimes and machines.

The "rooting sheet" is conceived to be used by the production manager, who manages production operations. The production manager has to know what is the rooting for the part, i.e. the sequence of the machine on which the part will be machined and the time by which each machine is occupied, as a condition for scheduling. For the purposes of scheduling, the information of what is going on within each operation is not necessary.

The "operation sheet" is conceived to be used by the machine operator. Machine operator has to perform the machining operation defined for the machine he operates. It means that the machine operator has to know all process, i.e. operations elements, including machining regimes, setup conditions, each tools to use, and others (for example which CNC program to run). The number of "operation sheet" is equal to the number of the operations described within the "rooting sheet".

The tools to be used in each operation and specified for each operation element within the "operation sheet" are also listed (copied) in the "routing sheet" for the production management purposes, meaning that the production manager need this information in order to provide the set of tools to be used in operation to the machine before the start of the operation, saving time for the machine operator. Otherwise the machine operator would need to spend time to take the tools from the warehouse and loosing productivity. Actually, different information could be repeated in the "routing sheet" and the "operation sheet" for two reasons: (1) to relate one document with other, and (2) from management reasons.

Figure 1 (a) and Figure 1 (b) presents an example from literature of a rooting sheet (a) and an operation sheet (b), as the document sheets of the Process Plan.



(a) (b)

Figure 1. Example of a routing sheet (a) and an operation sheet (b) (in original the title of the operation sheet is wrongly typed "ROUTING SHEET") (Wang and Li, 1991, pp.151-152).

Although these sheets are conceptually correct and one of the best found in literature, these still has particularity and do not represent a general model. The reason why this example do not represent the general model, i.e. a canonical model, is that in the header of the sheets is referred “Part No.” and “Product No.” implying that the belonging the part “Part No.” to the product “Product No.”, which is a special case when a part “Part No.” belongs to only one product, e.g. in OKP (One-of-a-Kind Production) or mold making industry where, usually, the production volume is 1 (do not confuse with “lot size 1”). In general, the part “Part No.” can be the part of different products.

As different products can have different process plans, in the Process Plan document it is included the mandatory information field for the process plan variant for each product.

Putnik (2000) proposed a documentation for the Process Plan (Figure 2) as a proposal for its canonical form. The darkest grey color is the information that can be optional for consider within the Process Plan. The light grey color is the information that is mandatory to have filled within the Process Plan.

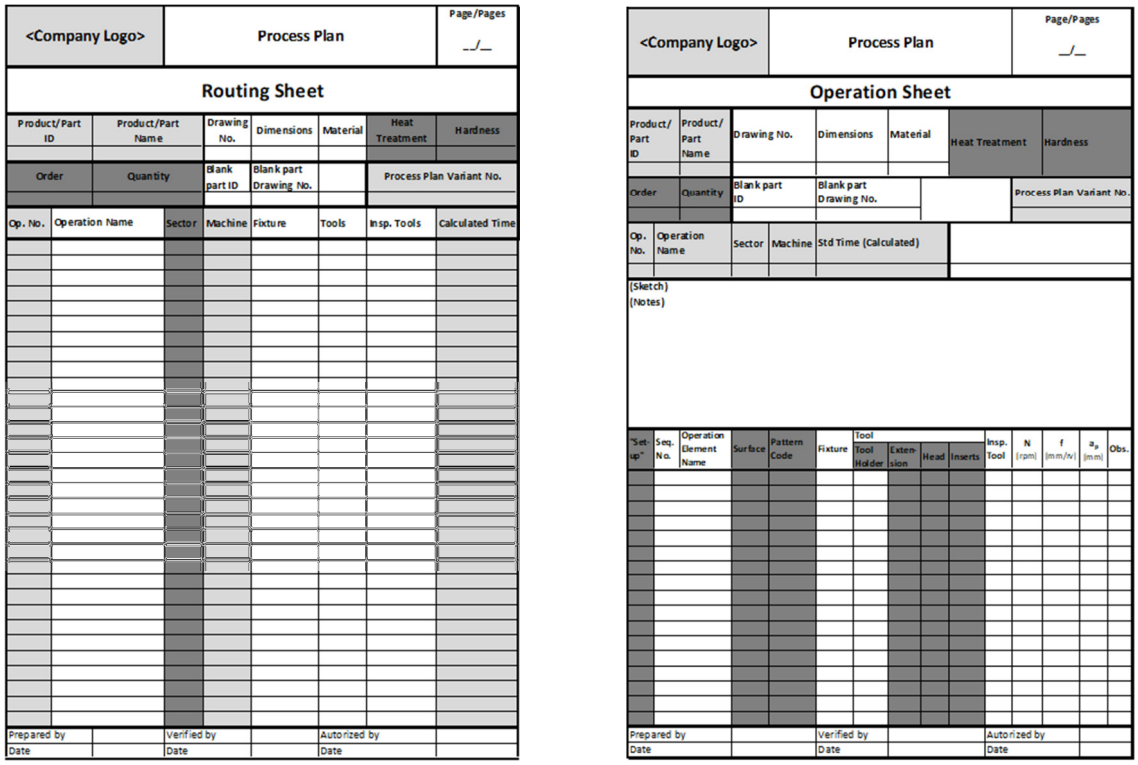


Figure 2. Process Plan: routing sheet (a) and operation sheet (b) (Putnik, 2000)

For example, let us consider a product with four operations.

The Process Plan document for this product is represented by five sheets: one routing sheet and four operation sheets, that is, one operation sheet per operations. Within the routing sheet it will be filled only four rows, one line per operation. For each operation described in the routing sheet corresponds one operation sheet (Figure 3).

Operations are numbered by 10, 20, 30, 40 for first, second, third, fourth operation respectively, instead of 1, 2, 3, 4. This is from practical reasons. In the case of need to include new operation between the second and the third operation, the new operation will be numbered as 15, without needs to renumber subsequent operations and operation sheets, which would be necessary in the case of numbering by 1, 2, 3, 4.

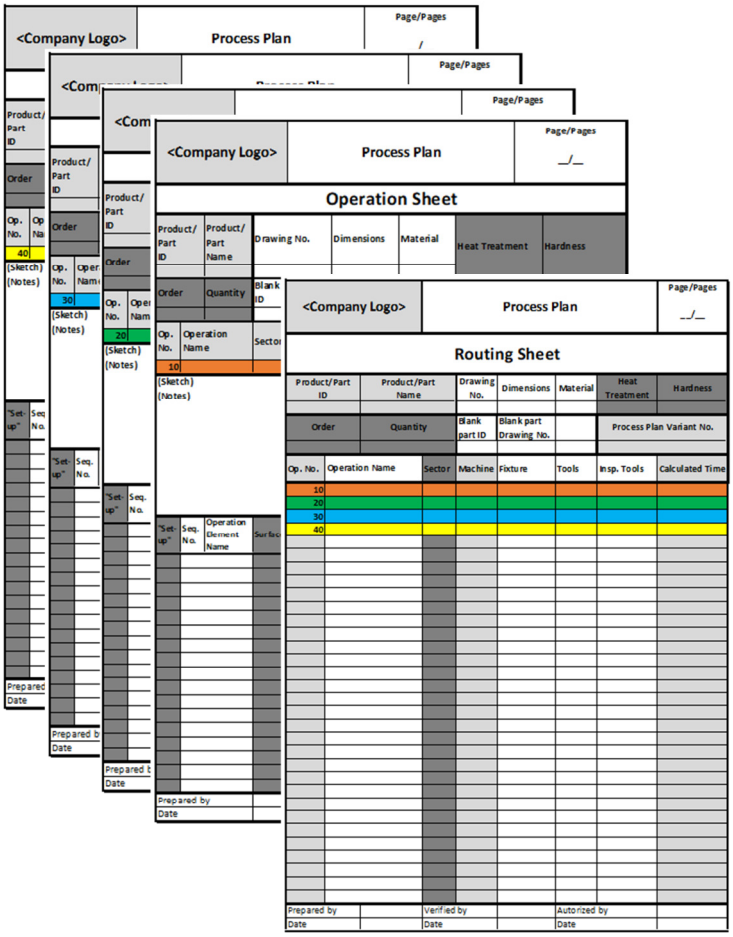


Figure 3. Example of a Process Plan for one product with four operations

2.3 Jobs and Tasks

Job could be defined as the work to produce one lot or a part, determined by the "order" for one lot or the "order" for one part, although in practice there could be different associations between orders and jobs. Additionally, it is assumed that there is a correspondence between a lot and the job.

Each job corresponds to one process plan and to one part, in other words, each job is one execution of the process plan. It means if the volume of production is for example 100 parts or product, it means that the process plan for that part is executed 100 times, i.e. there are 100 jobs.

On the opposite, to one process plan corresponds different jobs (with the same operations).

Task is the job element, i.e. job is composed by sequences of tasks necessary to complete the job.

Each task corresponds to one operation of the process plan. In other words, each task is one execution of the operation of the process plan.

On the opposite, to one operation in process plan corresponds different number of the tasks of the same contents.

Figure 4 presents a schematic representation of the jobs and tasks, for one example with 5 jobs.

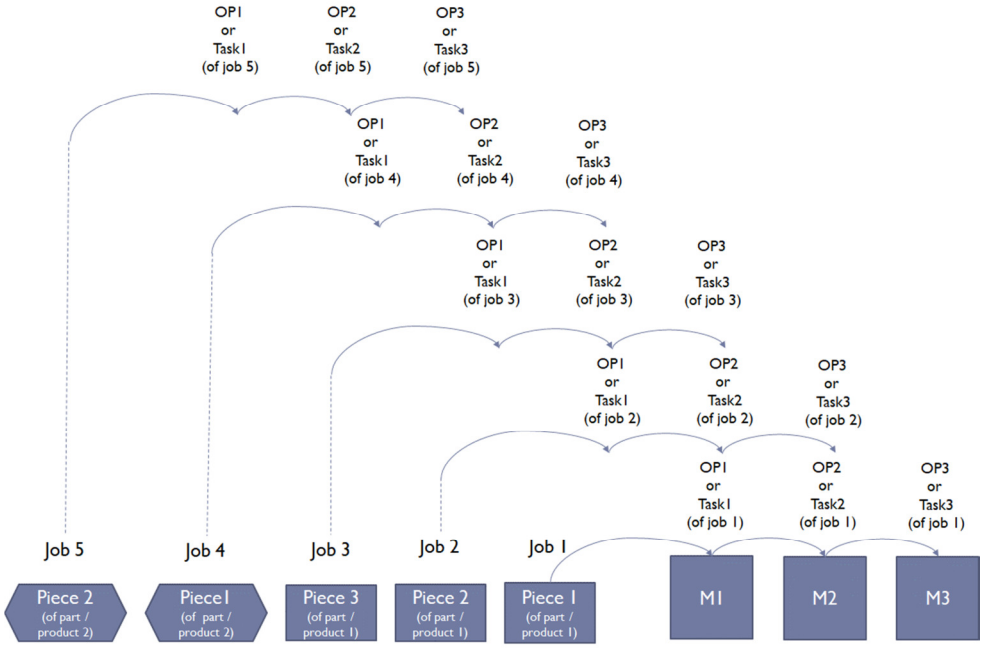


Figure 4. Jobs and tasks representation

2.4 Orders

No one activity, i.e. no one execution of some production, job or tasks, should be started without an "Order".

Order is the instrument that trigger, in other words, command the (start of) execution of production or job or task, or any other activity.

There are different types of orders, corresponding to different management levels in the hierarchy. On the lowest level is the machine operator whose executes the operation tasks upon reception of the operation order. On the first higher level, is e.g. production manager whose job is to distribute the operation orders, and he starts his activity upon the reception of the production order. On the second higher level (in the relation to the machine operator level) is the production planning manager, whose job is to make the production plans and to issue the order for starting the production, upon reception of the order by the top management to make the production plans in accordance with marketing and other functions.

It means that among of different types of order there is a hierarchy, i.e. the highest level of the order is composed by the number of lower level orders, in accordance and corresponding to the execution of the Bill-Of-Material (BOM) of Quantities for production (this BOM of Quantities is derived from the BOMs of the products and aggregate production plan). Below is given a simple hierarchy of the main types of orders:

- order for production plan,
    - order for the product (production),
        - order for the job (production of a piece of a product),
            - order for the task (of the job).

Wiendahl (1995) cited by Berlec and Starbek (2010) presented a similar schema for types of orders and corresponding lead time (Figure 5), where the "Production order" corresponds to the "order for production plan" above, "Manufacturing order" and "Assembly order" corresponds to the "order for the job" above, and the "Operational order" corresponds to the "order for the task" above.

In Figure 5, there is not referred the product order "order for the product", which in fact is just an aggregation of the "order for the job" for the same product, and serves only in the context of planning organization.

On the Figure 5, the schema referrers the orders' lead times, which, the lead times are essential elements of the orders for production scheduling.

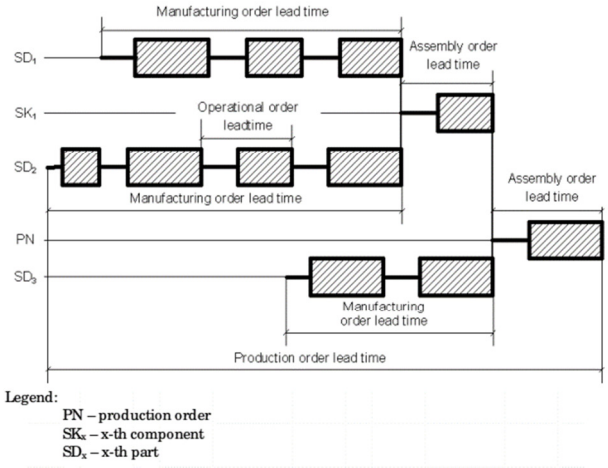


Figure 5. Types of orders and their corresponding lead times (Wiendahl (1995) cited by Berlec and Starbek (2010))

3. Relationship Between Process Plans, Jobs, Tasks and Orders

Many times, among the practitioners and students, there is misunderstandings, confusion or even ignorance of the relationships between the terms defined in the previous section.

Following, the relationship among process plans, jobs, tasks and orders is presented.

Process plan defines, or better, inform the job in terms of the number of tasks that must be executed, on which machine the tasks must be executed, and duration of each task.

On other hand, the "operation" (within the process plan) represents detailed definition of the task, i.e. how to execute the task (through the sequence of the operation elements and associated tools and work/machining regimes), on which machine (where) task should be executed, and the duration of the task (some information, such as the machine on which operation is to be executed, is repeated from the "Routing Sheet" document for the purpose of correspondence).

Other synonym for task is activity (Emmons, 1987).

So, in the context of process planning and production planning and control, job has the same structure as the process plan, with the difference that:

- one process plan is referred to the same work to apply to each piece of the same part/product, while
- one job is referred to the work (described in the process plan) to apply to each one piece individually of the same part/product.

For example,

let us consider two different Process Plan for 2 types of products: Product 1 and Product 2, where Product 1 has 3 operations and Product 2 has 2 operations. Also let's consider that it is necessary to produce[1] 3 pieces of Product 1 and 2 pieces of Product 2.

In total there are 5 pieces that should be produced: Piece 1 of Product 1, Piece 2 of Product 1, Piece 3 of Product 1, Piece 1 of Product 2 and Piece 2 of Product 2.

As one job is referred to the work (described in the process plan) to apply to each one piece of the same product/component, it can be said that Job 1[2] corresponds to work to apply to Piece 1 of Product 1, Job 2

[1] The quantity to be produced is given within the Production Plan. The quantity referred in this paper is only for exemplification.

corresponds to work to apply to Piece 2 of Product 1, and so on, and Job 5 corresponds to work to apply to Piece 2 of Product 2.

Figure 6 represents a scheme of relationship between process plans, jobs (Putnik, 2017).

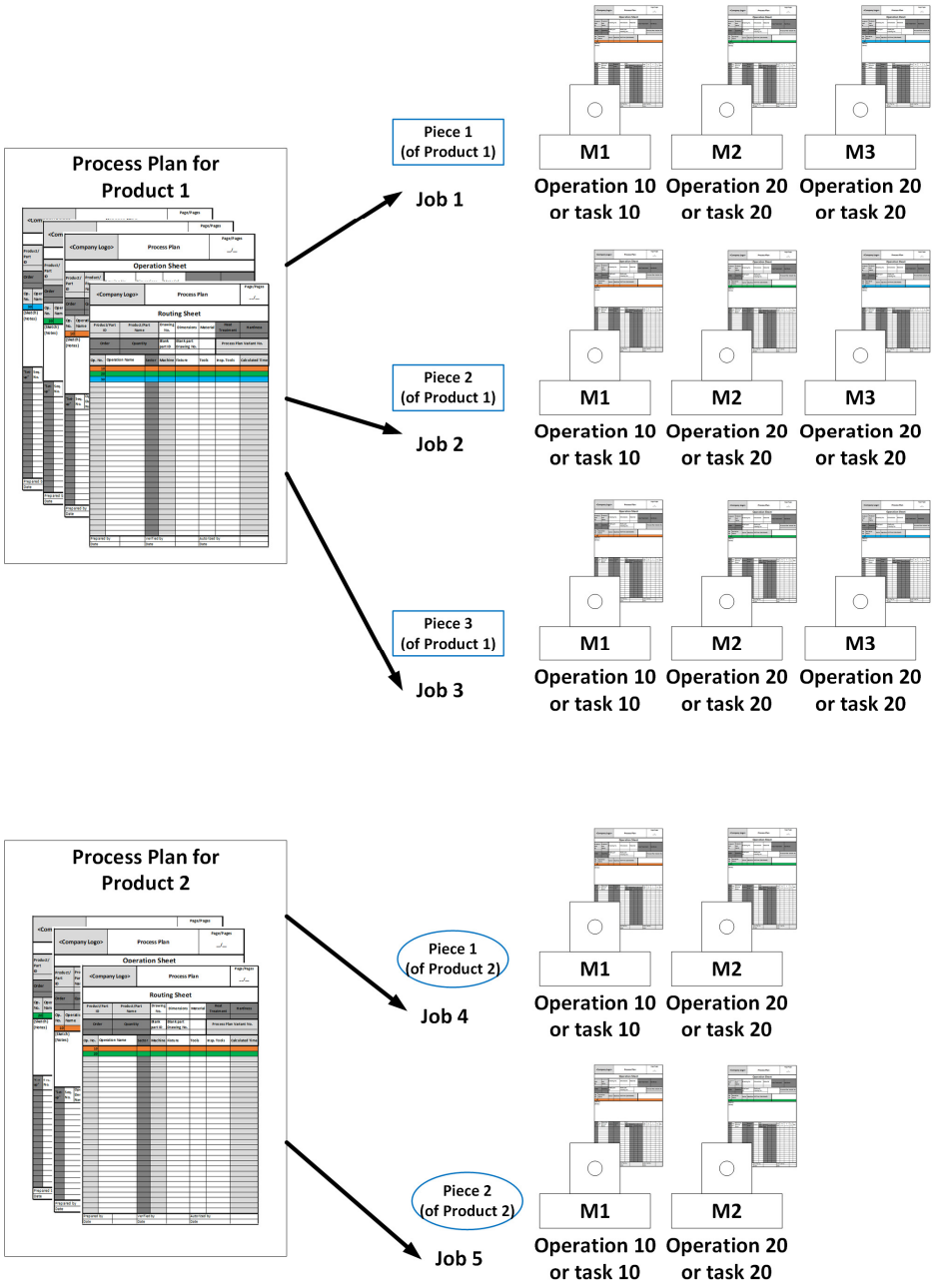


Figure 6. . A scheme of relationship between the process plans, jobs and tasks in the given example

Figure 7 shows execution of the jobs for the example given above along the time.

[2] The sequence of the jobs for the production is defined by the Scheduling. In this paper, it is considered the presented sequence of the job as above only for exemplification, abstracting the Scheduling.

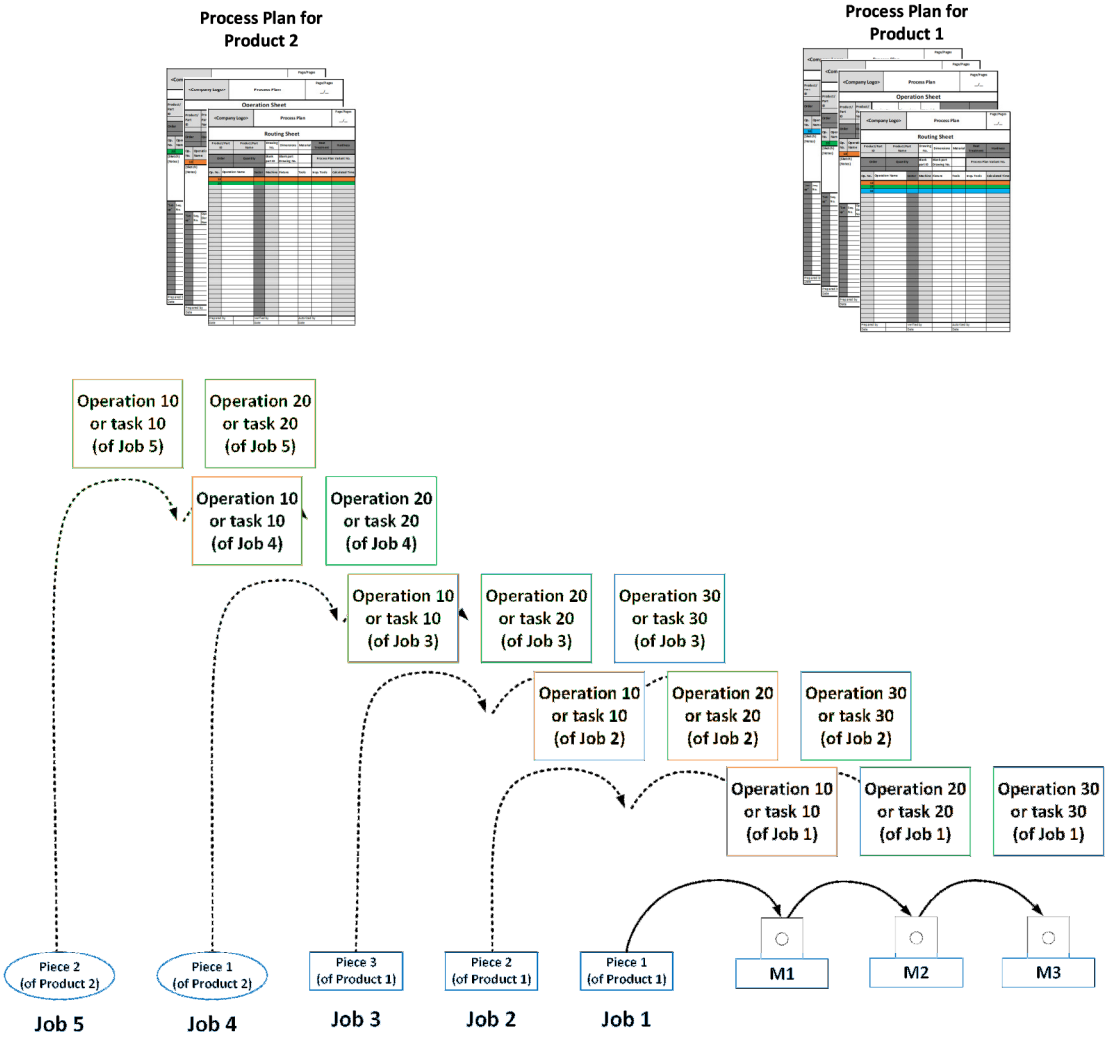


Figure 7. A scheme for execution of jobs and tasks for the given sequence example (Putnik, 2017)

To trigger the production related to the given example, whose volume is consisted of 3 Pieces of product 1 and 2 Pieces of Product 2, it is necessary the "Order for Production Plan".

The "Order for Production Plan" should be expanded in corresponded "Order for the product", "Order for the job" and "Order for the task".

For the production of the production plan by the example above, below is represented a list and hierarchy of the orders to be generated. The complete set of orders to be issued is consisted of 21 different orders:

- Order for the production plan (to trigger the production of 3 pieces of Product 1 and 2 pieces of Product 2)
    - Order for the product (production) of 3 pieces of Product 1
        - Order for the job for Piece 1 of Product 1
            - Order for the task for Operation 1 (task 1) of Piece 1 of Product 1
            - Order for the task for Operation 2 (task 2) of Piece 1 of Product 1
            - Order for the task for Operation 3 (task 3) of Piece 1 of Product 1
        - Order for the job for Piece 2 of Product 1

- Order for the task for Operation 1 (task 1) of Piece 2 of Product 1
- Order for the task for Operation 2 (task 2) of Piece 2 of Product 1
- Order for the task for Operation 3 (task 3) of Piece 2 of Product 1

▪ Order for the job for Piece 3 of Product 1

- Order for the task for Operation 1 (task 1) of Piece 3 of Product 1
- Order for the task for Operation 2 (task 2) of Piece 3 of Product 1
- Order for the task for Operation 3 (task 3) of Piece 3 of Product 1

○ Order for the product (production) of 2 pieces of Product 2

▪ Order for the job for Piece 1 of Product 2

- Order for the task for Operation 1 (task 1) of Piece 1 of Product 2
- Order for the task for Operation 2 (task 2) of Piece 1 of Product 2

▪ Order for the job for Piece 2 of Product 2

- Order for the task for Operation 1 (task 1) of Piece 2 of Product 2
- Order for the task for Operation 2 (task 2) of Piece 2 of Product 2

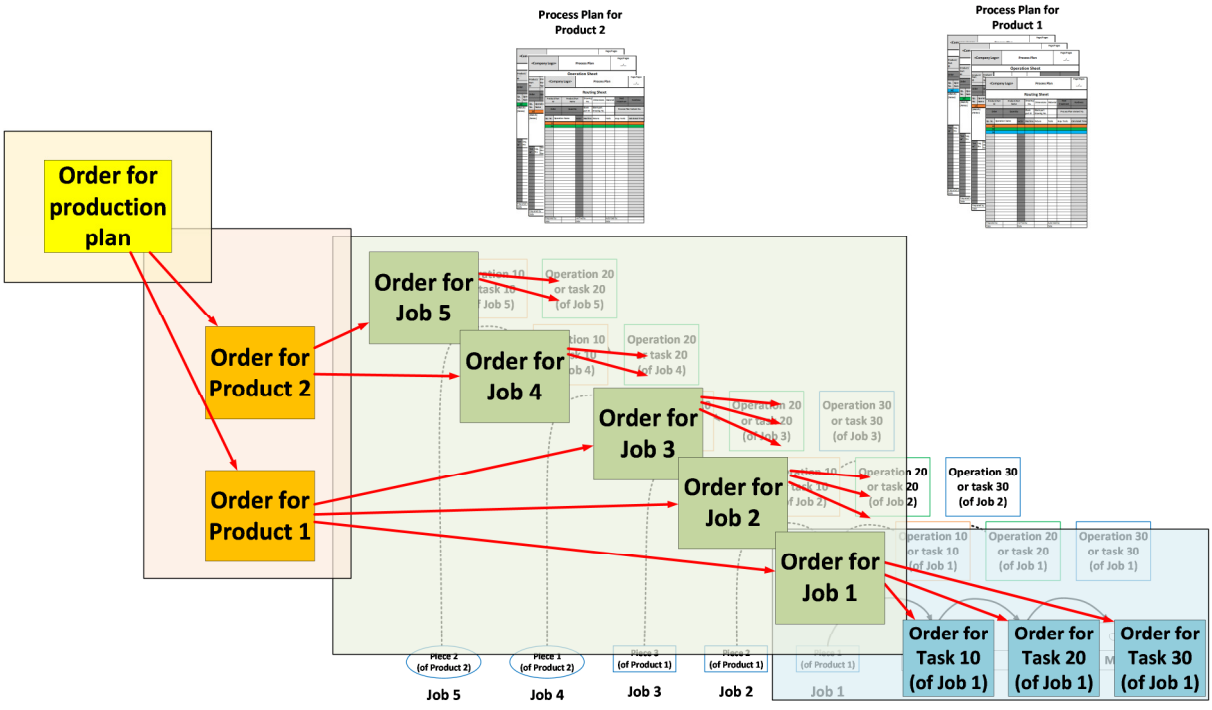


Figure 8. A scheme of relationship between the process plans, jobs, tasks and orders in the given example (Putnik, 2017)

4. Conclusions

In this paper it is presented a most simple canonical structure of the concepts and relationships.

In practice there are more complex forms for representation of more complex product and production plans structures and requirements. However, the elements presented must be presented in more complex models.

It is also to refer that in this paper job is always related to one piece of part / product, while in practice it could be related to a "lot". In the case of reference to the "lot" actually, the lot is treated as management and organizational unit.

Further, this paper should contribute to the adoption of the canonical forms of the concepts and relationships presented as the standard constructs in production planning and control and integration with the product design and process planning functionalities. Adoption of canonical forms of the concepts and relationships presented:

1. Facilitates implementation of advanced methodologies and technologies and techniques and
2. Facilitates integration with other systems and partners (networking).

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