

The Distinction between Manufacturing and Multi-Project And the Possible Mix of the Two

By Eli Schragenheim and Daniel P. Walsh

The floor looks similar to any other manufacturing floor. Work in process is spread all over the place. Work centers are doing specific jobs along the way to produce end products. Lots of raw materials ... the usual problems with shortages and quality. This is certainly a manufacturing shop floor.

Is it really? The end products are very large systems. Every customer order is for one unit of a specific system, fully customized according to the customer's needs. The final testing job is a complicated operation that takes between one and four weeks. It should not surprise us to learn that the engineering effort of such an order takes longer. From this perspective it looks that fulfilling the customer's order is a project.

So, is it manufacturing or projects?

It is very important and relevant that we find a good answer to the above question. Planning the manufacturing floor is clearly distinct from running a project. Just for illustration, 'critical path' is an important concept in managing a project. There is no equivalent concept in MRP/APS for manufacturing. Manufacturing planning totally and universally avoids the identification of the longest path of operations for delivering an order. We better choose the right planning and control methodologies.

Why do we have such a different approach for projects than what we do for manufacturing? As Figure 1 demonstrates, the basic description of what is needed to deliver a customer order is about the same. If that's the case, why were such distinct methods developed?

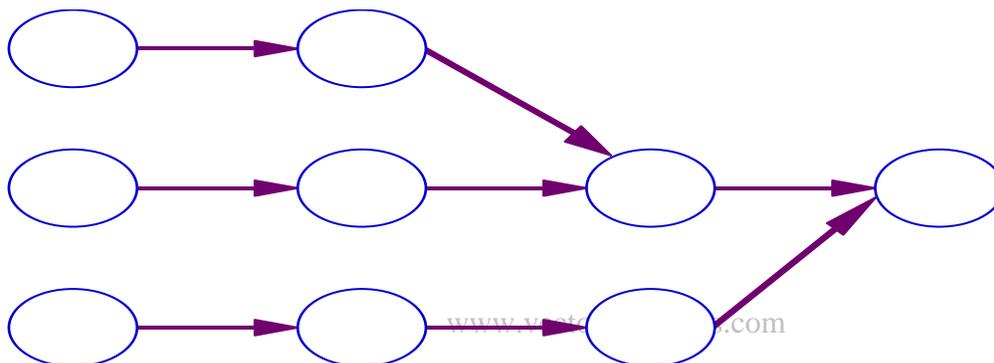


Figure 1: A broad description of how to deliver an order. Each node describes a part or an operation. This description applies to both projects and manufacturing orders.

A better understanding of how the difference in environments lends itself to different planning methodologies can yield a better overall planning methodology; meaning planning that is fairly robust and still draws the most from the system when necessary. This is certainly true if a unified planning methodology is established. However, if we conclude there is a derivative cause and need for different planning methodologies then there is tremendous value and benefit in pinpointing which methodology best fits our environment.

And, if we need to have two distinct methodologies then this leads to another question. Are there hybrid environments? Do certain products need the output of both multi-project planning AND manufacturing planning?

The Rationale for the Different Methodologies

There are a number of differences between project and manufacturing oriented environments. Projects are defined as “each one is unique”. However, some manufacturing environments fully customize their products as well and the logic of MRP can work well in these make-to-order environments. Projects generally tend to have longer lead-times and the typical project resource is the human expert. Manufacturing planning on the other hand usually centers on machines and equipment rather than on the human operator. Still, those characteristics don’t fully explain the distinction of the planning methods.

In order to understand the differences, let’s examine some of the key terminologies for both PERT/CPM, the main methodology for project management and the CPIM material which centers on manufacturing.

The critical path is a central part of the project management methodology. The term recognizes that parallel operations are quite common in projects (likewise in regular manufacturing) and hence the activities along the longest path are more critical to the project lead-time than the others. Another term associated with project planning is the notion of late-start versus early-start. These scheduling terms refer to the flexibility of non-critical paths to start. Again those terms do not exist in manufacturing.

Consider now an important term in manufacturing: *queue time*. As most readers are aware, the queue time is the largest portion of the manufacturing lead-time. Queue time represents the time an order has to wait until a resource becomes available to work on it. Even a dramatic reduction of inventory, done with the intent of reducing the

manufacturing lead-time, does not fully eliminate the likelihood that an order will wait a significant amount of time for a resource. Hence, when you analyze the actual lead time after the order is processed; you see frequent stop and go processing times.

For instance, suppose that the actual lead-time is a week. You might find out that the order is processed for an hour in the first day, 30 minutes the next day, – no processing the third day; 15 minutes the fourth and an hour on the last day. All in all, 2:45 hours of processing spread along an entire week.

The critical path of that order might be only 1:15, however, in order to do that we'd have to make sure the resources are available when needed. In other words, the utilization of the resources would have been quite poor in order to provide the required amount of resource readiness to eliminate all the queues in the system.

Lean manufacturing strives to achieve such continuous flow for very short lead-times, but not to the extent of using the order's critical-path to achieve even superior results. All in all even in Lean implementations the overall lead-time of an order is significantly longer than the critical path.

When we check typical project environments we see a different attitude. Is it tolerable to have a project in a queue for a resource? That means the next critical path activity has to wait for a resource that is currently busy elsewhere. Of course, we all know that this occasionally occurs. Nonetheless, it is still highly undesirable. This intolerance towards queue time is prevalent in the project world where every single project needs to be completed as soon as possible. It also reflects the fact that most activities (operations in manufacturing terminology) in a project are fairly long.

Just suppose that an expert is supposed to do three activities, for three different projects, at the same time. Each activity takes, on average, two weeks. This means one project will have to wait 4 weeks for that expert. If that activity happens to be on the critical path, then the whole project halts for 4 weeks waiting for that expert, and we all know that these four weeks might turn into eight weeks or more. When a project has to halt due to the non-availability of an available human expert, not because of very expensive equipment, it is so unbearable, that in a true multi-project environment that expert is practically "forced" to do multi-tasking. In other words, to work on all three tasks concurrently. Of course, all three would now take 6 weeks to complete. Multi-tasking is devastating, but, we just can't stand seeing a project on hold because of an expert being tied up on another project.

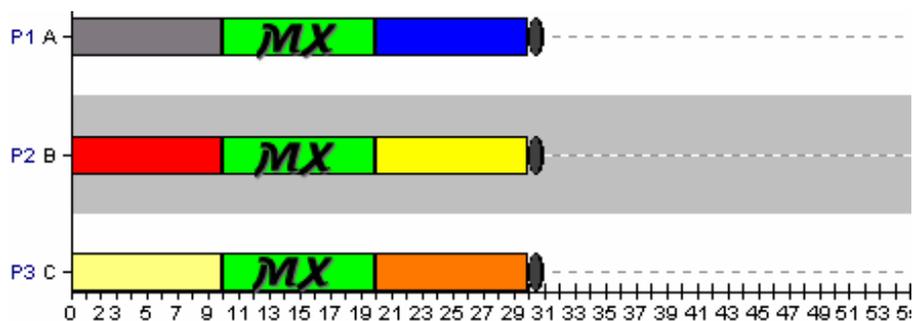


Figure 2: Resource MX has three jobs competing for it.

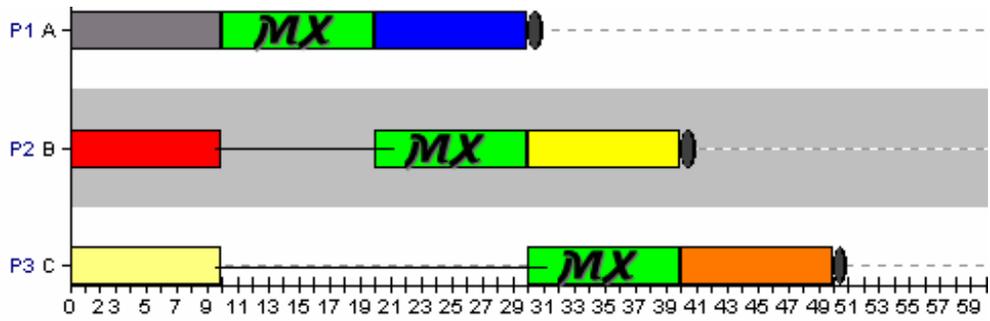


Figure 3: The manufacturing approach – queue of work before MX

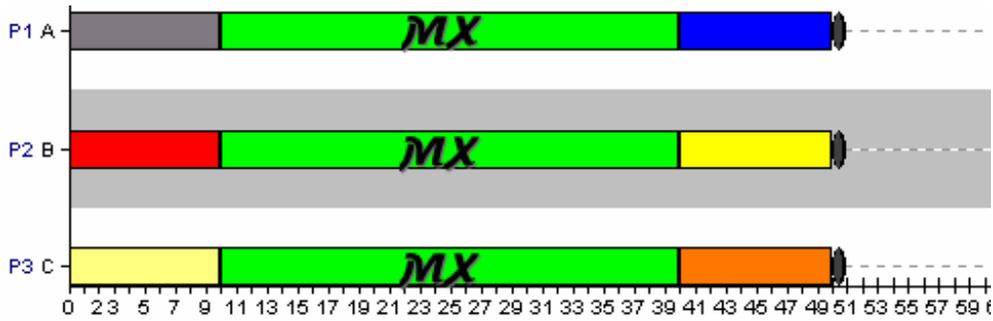


Figure 4: Multi-project common approach: MX performs multi-tasking

The difference in approaches is demonstrated by comparing figure 3 to figure 4. Of course, the multi-tasking does not solve the problem; on the contrary it makes it worse. Still, the strategy in a multi-project environment is to avoid the queues that are typical in manufacturing in order to have the projects finish and deliver as soon as possible. On the other hand the focus of planning in manufacturing is to extract the most out of the available resources. This means high utilization of the resources. Meeting the market requirements is very important. So, the manufacturing planning dilemma is how much can be shipped within the norm of response time. Remember that in manufacturing the net processing time is short relative to the lead-time. The following table maps the differences between manufacturing and projects that unavoidably leads to different planning algorithms.

<u>Key Differences</u>	<u>Manufacturing</u>	<u>Multi-project</u>
Importance of delivering every order as soon as possible	Response time should be faster, or at least equal to the competition	Every delivery gains from being early. Any delay is critically negative.
Average runtime of a typical operation/task	Relatively short: usually quoted in minutes or hours	Relatively long: usually quoted in days or weeks
Queue Time	By far the most significant part of the lead time	Intolerable, hence either relatively short or hidden as multi-tasking instead of queue
Resources Planned	Mainly machines and equipment	Mainly the human experts
Level of uncertainty (Murphy)	Relatively medium. The largest impact comes from fluctuations in the market demand	Relatively high. Most uncertainty and risks lie within the estimation of the duration of the tasks
Importance of tasks	According to critical resource	According to critical path
Focus of the planning	Proper utilization of the internal resources, while meeting the market demand	Delivering every project on time or as early as possible, while being on budget and within specifications

Table 1: The differences and the resulting change of focus between manufacturing and multi-projects.

The TOC Angle

The Theory of Constraints (TOC) provides distinct planning and control methodologies for manufacturing and multi-project that are focused on the right objectives for both methods.

The TOC manufacturing planning methodology is called Drum-Buffer-Rope (DBR). The capacity of the whole shop is the same as the capacity of the weakest link in the manufacturing link. Hence, whenever the market demand comes close to the capacity of the “capacity constraint resource” (CCR) it is critical to exploit the limited capacity of the CCR. One of the challenges is preventing ‘starvation’ of the CCR. Because of Murphy and unreliable data there is a need to ensure that most of the material reach the CCR somewhat earlier than the time the CCR is scheduled to work on them. This requirement, called ‘CCR time-buffer’, is illustrated in the following figure. It creates a planned queue at the CCR, at the expense of the product lead-time (from material release until order completion) making it significantly longer than the net-processing time along the longest chain of operations.

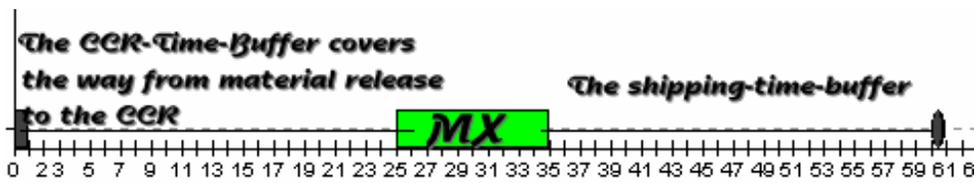


Figure 5: The basic DBR planning: fixing the time of the CCR while allowing sufficient time to move to the CCR and from the CCR.

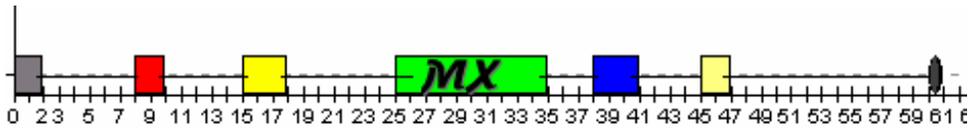


Figure 6: The times when resources actually worked on the particular order

The TOC solution for multi-project management provides a global plan where each project is kept as one entity with a continuous flow of operations along the critical path/chain¹. The buffers, which provide protection against Murphy/uncertainty, are used somewhat differently than in DBR. In projects one cannot assume that the net-processing time is just a small fraction of the total lead-time. But, the main difference is in the scheduling and managing of multi-projects. The most loaded resource is used to smooth the total load on the system, but the projects are moved as one entity. Here is the result of the TOC scheduling of the three projects of figure 2:

¹ The Project Management in the TOC Way defines the term ‘critical chain’ as the longest chain of operations that are dependent either through finish-to-start connections or by resource dependency.

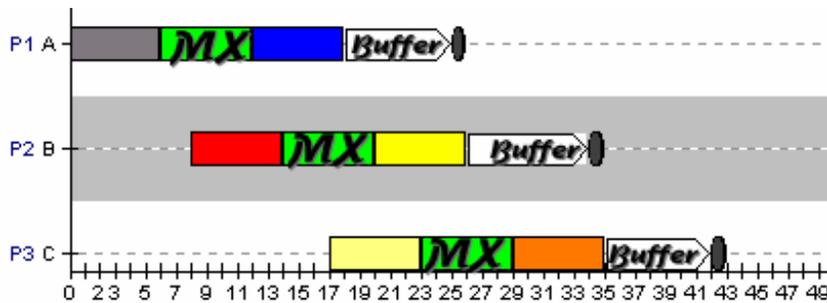


Figure 7: The projects are scheduled according to the availability of the MX resource

The projects are kept as one entity, so once they start they are executed continuously, unless resource contention or other problems interfere with the plan. According to the TOC project planning, the tasks are shortened to eliminate the individual safety time. Instead, a portion of the safety time is aggregated and a time-buffer is inserted at the end of the project. The end of the Buffer is the expected completion time of the project.

Note that there is no real effort to fully utilize MX, the most loaded resource. As a matter of fact, the availability of MX for the second and third projects is protected by allowing a time-buffer between the start of MX on a project and the planned finish time of the previous one. This is because we must guard against impacting the subsequent projects if MX is still tied up, due to some delay, on the previous project.

The multi-project planning according to TOC represents a distinct and very different methodology than TOC for manufacturing. They have a different focus on their objectives. While in manufacturing the objective is to fulfill as much of the market demand as the internal capacity allows, in multi-projects the main objective is to shorten the actual lead-time of every project as much as possible. TOC seems to be the only global methodology that leverages this critical difference and thus provide a clear multi-project planning scheme that addresses the unique needs of multi-project environment.

Projects that include Manufacturing Tasks

Consider the manufacturing of a large system such as, a ship, an aircraft or a complete communication system. Every one of these systems will provide greater benefits if delivered as soon as possible. Certainly we can agree that the earlier the system becomes operational the earlier your customer leverages its value. Within the basic structure of such systems we'll find tasks like: engineering design of various parts, integration of large number of parts and final testing are typical project tasks. These are classified as project tasks because they use specific resources for significant amounts of time. If these resources are tied up during execution working on a task that is not the highest priority task and this delays working on a higher priority task, it will result in a **major delay** in a project.

However, other tasks within such projects might seem closer to manufacturing. For instance, the production of a number of components that are needed in several places within the ship, or even checking the quality of subsystems purchased from a contractor.

These tasks are usually done at shops or dedicated plants. The manufacturing of a component is normally accomplished by several work centers that do many different types of components. The actual “touch time” is short, but producing a set of components might take several weeks. Such a task, within the overall structure of a project, is a manufacturing task.

Merging the TOC multi-project and the DBR methodology yields superior overall planning for such environments. The multi-project planning is done first, accepting the quoted lead-times used for the manufactured parts as the approximate times for the multi-project timing. According to the DBR methodology the default buffers automatically yield good approximate timings. Once, the multi-project planning is completed, every manufacturing task is entered into the DBR system as an order. The completion date of the manufactured order is synchronized to when it is needed by the project.

Merging of the DBR and the multi-project environment also necessitates merging the execution systems (buffer management) of the two TOC planning methodologies. The details of that merging are beyond the scope of this article.

Conclusions

Clarifying the basic assumptions and rules behind the planning method is critical for developing the correct relationship between multi-project environment and manufacturing. The critical differences we have found have very little to do with some classical definition as “every project is unique while manufacturing is mainly repetitive”. Another common cited difference is that projects usually work on just one unit of output, but even this has very little to do with the planning algorithm. It also has little to do with the fact that the main resources planned in projects are the human resources, while in manufacturing the main resources are machines.

The critical difference lies in the focus of the planning algorithm. The main cause for the different focus is the time frame when a resource has to be dedicated to a particular task/operation. In projects, most tasks take days, weeks and months, while in manufacturing we usually speak in minutes or hours. Hence, projects cannot tolerate a queue of several tasks waiting for a (usually human) resource. This leads to the desire to finish every project as soon as possible and to maintain the continuity of work on each project. A quick measure to assess whether a certain environment is closer to a multi-project than to a manufacturing environment is calculating whether the net processing time across the critical chain/critical path is pretty close to the actual lead-time.

We find that many environments that should be considering multi-projects are using regular ERP packages. The lack of common multi-project overall planning was certainly a cause to move to the manufacturing planning type of software. This now appears to be satisfied by the TOC methodology and the emergence of supporting software now available. Ignoring the need for proper material requirements is still a huge common problem in project management software; hence organizations that run projects that produce large systems have a real need for MRP/ERP support. But, if they choose this

alternative, the resource planning is not adequate and some of those organizations run parallel project management programs to support that need.

We submit that eventually the ERP packages will have to incorporate multi-project planning into their manufacturing planning and execution systems. The two distinct systems should be integrated to provide support for multi-projects with manufacturing tasks and, of course, fully support the inventory management and material requirement needs. Specific industry sectors that produce large systems, like some of the high-tech companies and certainly the aircraft industry need both project management and manufacturing planning as integral parts of their IT system.

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