Pipeline Management

A theory of constraints approach

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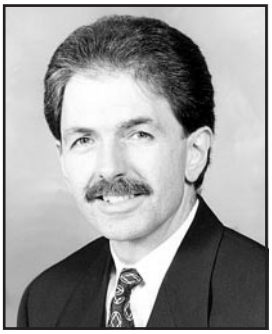
It is no secret that effective Pipeline Management is a key factor for success in NPD. The Theory of Constraints (TOC) has yet to "cross the chasm" as a mainstream approach, but a cadre of innovative, early adopters from telecommunications to pharmaceuticals, has found TOC to be a powerfully ally in their pursuit of NPD excellence. Using TOC Pipeline Management, Gene Kania introduces two new NPD measurements — the Pipeline Impedance Index and the Constraints Summary Chart — which provide management with a powerful means of managing their NPD constraints in real time. This directly supports the ultimate goal of NPD: maximizing throughput.



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Pipeline management, by its simplest definition, is the management of the finite development capacity of a new product development organization. Typically, NPD organizations have a limited amount of scarce resources that they try to apply to too many projects. This results in over-allocation or exceeding the capacity of those scarce resources. In TOC terms, the NPD system is constrained by a limited capacity of scarce resources (human or physical).

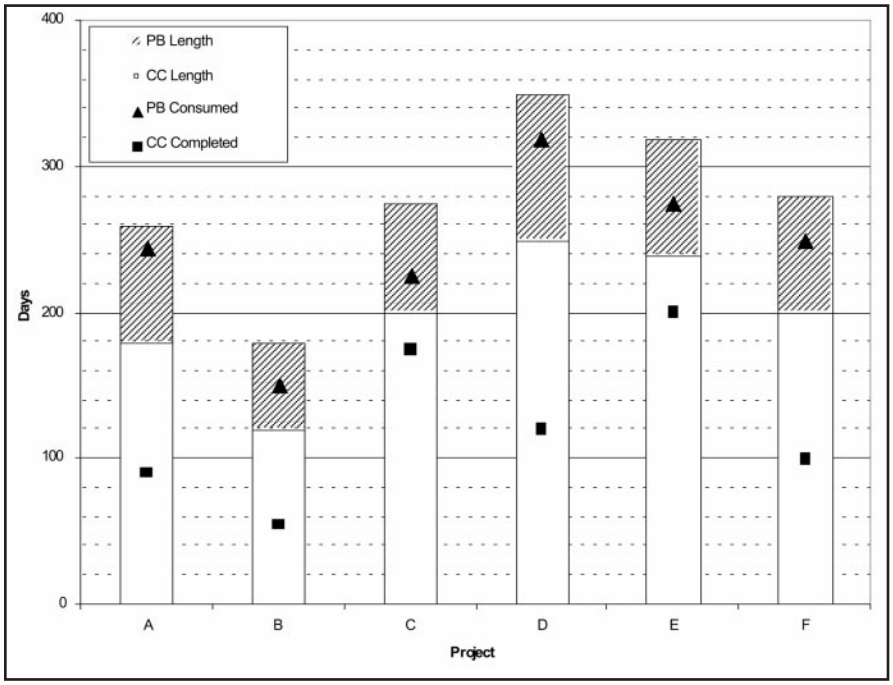
The goal of pipeline management is, therefore, identical to the goal of TOC: to manage the constraints of the system most effectively in order to maximize the throughput of the NPD system.

In fact, traditional pipeline management approaches are no different than TOC approaches at the executive level. First, using portfolio management techniques, we try to prioritize or rank in order the projects such that they are aligned with the strategic goals of the organization. Second, using a phase or gate review process, we try to cancel projects whose value has diminished over time and to re-allocate those resources to other projects which are better aligned with the organization's portfolio.

However, at the functional management level, we find that resources in a typical NPD organization have *many* demands placed on their time. Even if management, through traditional pipeline management or just plain common sense, is able to dedicate a resource to one or two projects, there are still many "non-project" demands that are made on the time of that resource. In fact, these "non-project" demands may be so large that they can significantly impede a resource from making expected progress on a project to which they are dedicated. In one organization where non-project demands were recently measured, it was found that subject matter experts could spend 80 percent of their work week satisfying non-project demands while spending precious little time on the project work to which they were originally assigned.

This article will explore the TOC approach to pipeline management. Buffer Management is the enabling technique that allows direct linkage of the strategic goals of the NPD organization, which are made at the executive level, with the day-to-day operational decisions made at the functional management level regarding the effective utilization of the limited capacity of scarce resources. Buffer Management distills the complexity of a real NPD environment into a simple and powerful decision-making tool to manage the NPD pipeline most effectively. This article will also introduce a new NPD measurement called the Pipeline Impedance Index (PII), which is designed to quantify "non-project" demands made on NPD resources and give management the information necessary to better control the deployment of resources in order to keep key projects on track in support of the strategic goals of the organization. The PII, developed by this author, has been successfully utilized by NPD clients in telecommunications, finance and other industries.

Exhibit 1: NPD System Buffer Report



The Traditional Pipeline Model

No NPD organization ever classifies *all* the work in its system as project work. So, the implementation of portfolio and pipe-

line management necessarily forces management to draw a line between project work and non-project work. In some cases, answering the question, "What is a project?" is easy: "It's the Alpha 3000 project!" — a big, "bet the company" type of project. In many cases, projects are defined by how long they are in duration and/or how many resources are required. For example, projects that are at least three months long and use six or more full-time resources. In some cases, projects are restricted to those that generate revenue for the company.

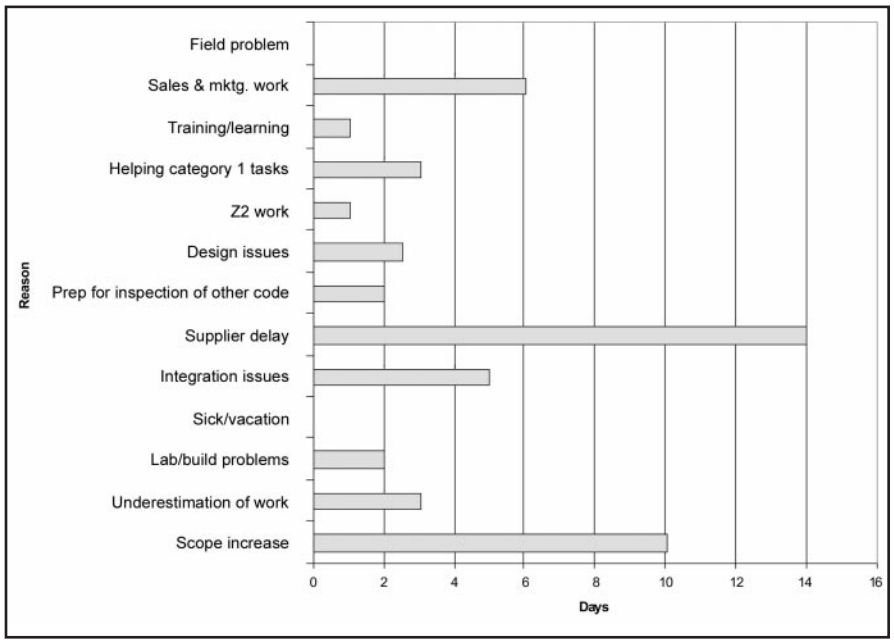
But what do you do with the high margin, customer-requested project that requires three full-time resources for two months? What do you do with projects that *do not* generate revenue for the company, such as ISO certification, training/mentoring of new employees, field issues that arise from customer problems, etc.? By definition, if this work is not "projectized", it becomes non-project work.

At the executive level, the project work will be explicitly tracked and managed. The non-project work, *which may in sum be a significant amount*, will lie "under the radar". Executives will expect non-project work to be done, but they will not know how much of the finite capacity of the system is required to do the work, since this work is not being explicitly tracked and managed in their portfolio and pipeline management system. Often, executives assume that this non-project work does not take a lot of capacity or that there are plenty of niches of capacity to slide the work into without impacting the real project work.

However, at the functional management level, *all* the work in an organization must be completed whether it is for a project or not. Functional managers recognize that the non-project work collectively represents "impedance" to the progress of project work in the NPD system. The impedance can be very high or very low depending on how much non-project work exists in the system. Dealing with this impedance is the conflict that functional managers typically face when traditional portfolio and pipeline management systems are implemented.

Some forward-thinking executives set aside a portion of capacity to account for this non-project work. However, tempered by the expectation of full resource utilization or high efficiency in their NPD operations, very often, they only set aside 10 percent or less of their capacity for non-project work. While this is commendable executive behavior, it is usually not enough, due to the nature of product development work.

Exhibit 2: Constraints Summary Chart (CSC)



This leads to another conflict that functional managers face when implementing traditional portfolio and pipeline management. These traditional approaches often model project tasks at a gross, deterministic level (usually a top-down view) that does not account for the statistical variation inherent in product development tasks. As a result, the top-down, executive view of NPD operations is based on rational, uniform resource deployment that does not appropriately reflect reality. In the real time, day-to-day, bottom-up, functional manager view of NPD operations, due to the statistical variation inherent in product development tasks, resource demands ebb and flow, causing peaks and valleys of work.

To eliminate this conflict, functional managers need a real-time system that reflects this reality and will allow them to make appropriate operational decisions, especially regarding resource deployment, in order to keep key projects on track in support of the strategic goals of the organization. This same system must satisfy the needs of executives as well and must complement the portfolio and pipeline management activities for which they are responsible.

TOC Pipeline Management

The Theory of Constraints (TOC) approach to pipeline management provides the missing link. The TOC construct of Buffer Management [1,2,3] is the enabling technique that allows direct linkage of the strategic goals of the NPD organization that are made at the executive level to the day-to-day operational decisions made at the functional management level, with regard to the effective utilization of the limited capacity of scarce resources. Buffer Management distills the complexity of a real NPD environment into a simple and powerful decision-making tool to manage the NPD pipeline most effectively.

Buffers are aggregated safety days, which are located at strategic points in a project plan to protect a few, key deliverables against the inherent statistical variation and uncertainty of the upstream sequence of project tasks. By measuring the percentage of each buffer consumed relative to the percentage of the work completed on the chain of work associated with that buffer, a manager is able to measure the status or health of a project at any given time. A survey of all the buffers provides a measure of the status or health of all the projects in the NPD system. See Exhibit 1 on page 16.

Buffer Management is the process of using this information to make day-to-day, operational decisions that will maximize the probability of having all projects in the pipeline completed on time without cutting scope or adding system cost. Buffer Management simultaneously takes into account the statistical variation inherent in project work as well the "impedance" in the system.

Buffer Management can be illustrated using Exhibit 1. For Project A, the Critical Chain (CC) is only 50 percent completed, but the Project Buffer (PB) is 80 percent consumed. This project is in jeopardy of missing its due date. However, for Project C, the CC is already 90 percent completed, but the PB is only 33 percent consumed. This project is ahead of schedule. Functional managers would recognize this situation as an opportunity to perhaps move resources from Project C, which would slow its progress, to Project A to help get it back on track. Their goal, in all cases, is to keep all of the projects on track in support of the strategic goals of the organization.

Managing Constraints in Real-Time

In order to obtain the Buffer Report shown in Exhibit 1, the TOC Pipeline Management process requires periodic task updating for each active task across all the projects. The task owners provide this information to the project managers. In this process, if a task does not make expected progress during the reporting time period (usually weekly); then the task has been prevented or, in TOC terms, *constrained* from making expected progress. In these cases, the following question is asked, "What prevented you or *constrained* you from making progress on the task?" The reply can take many forms, such as:

- The lab was not configured properly for the testing I needed to do.
- The supplier of the main assembly has delayed delivery.
- I was told to work on this field problem.
- Sales and marketing asked me to provide technical input for a new proposal.

Whatever the answer is to the question, the important thing to realize here is that the TOC Pipeline Management process yields a rich harvest of useful management information.

The responses (or "reasons") for all the tasks that were constrained along with their buffer impact (usually in days) can be summarized in a Pareto chart, sometimes called the Constraints Summary Chart (CSC), as shown in Exhibit 2 on page 17. The CSC is usually reported weekly and cumulatively.

With the CSC, it is possible not only to surface the issues that are in real time constraining the projects (i.e., look for the longest bars), but also to quantify their impact on the buffers, that is to say, on the probability of completing the projects on time. This helps management to focus on the few key issues or constraints that must be resolved this week, or over the next few weeks depending on the nature of the problem, in order to maximize the project performance of the entire NPD system.

The Pipeline Impedance Index

When project tasks are *constrained* from making expected progress as described above, the same information that is gathered in the normal TOC Pipeline Management process can be manipulated to measure the "impedance" in the NPD pipeline or system. This new NPD measurement is called the Pipeline Impedance Index (PII). The PII is the ratio between the actual amount of progress made on active tasks during a reporting time period and the maximum possible amount of progress that could have been made on active tasks during the same reporting period. A sample calculation of the PII is shown in Exhibit 3 on page 18. The PII is an aggregate number, which is used to measure the amount of impedance present in the NPD pipeline at a given time. A PII of 100 percent indicates that active tasks are making, in aggregate, *no* progress. A PII of 0 percent indicates that active tasks are making, in aggregate, *full* progress. One can plot the PII over time to measure the change in pipeline impedance (Exhibit 4 on page 19).

Exhibit 3: Sample Calculation of Pipeline Impedance Index (PII)

A	B	C	D	E	F	G	H
Task	Projected Start (Date)	Remaining Duration (Days)	Updated Duration (Days)	Weeks End (Date)	Calendar Days Available E-B	Maximum Days Available Min. (C,F)	Actual Days Progress (Days)
A	8/6	10	5	8/11	5	5	5
B	8/6	12	12	8/11	5	5	0
C	8/6	3	1	8/11	5	3	2
D	8/7	8	5	8/11	4	4	3
E	8/7	2	2	8/11	4	2	0
F	8/8	10	8	8/11	3	3	2
H	8/9	10	5	8/11	2	2	5
J	8/10	1	0	8/11	1	1	1
K	8/10	10	10	8/11	1	1	0
					Column Totals	26	18
					PII	[1-(18/26)]x100%	31%

Referring to the CSC in Exhibit 2, while there are many, many reasons as to why an active task makes little or no progress, all the reasons can be summarized into one of two categories: the resource on the task ran into a problem (i.e. Murphy struck) or the resource on the task did not get the opportunity to work on the task. That is to say, there are two main sources of impedance: (1) Murphy and (2) Non-Project Work. This is reflected explicitly in the PII Chart (Exhibit 4).

In a real NPD system using Critical Chain project plans, it is unlikely that a PII of 0 percent will be achieved. This would mean that Murphy never strikes in the organization or that no one is ever called off of a project to do non-project work. So a natural question arises: "Is there an acceptable impedance (or PII) level for an organization?" The answer is "No." There are a number of factors that account for a project or system PII. These factors include the amount of work in the system that has been "projectized," the staffing levels for customer field support, the amount of specialized knowledge residing in subject matter experts, etc. Every organization must weigh these factors to settle on their own acceptable PII level.

More importantly, using the PII as a performance measurement for a project or a NPD system is an erroneous use of the measurement. If people are measured to achieve a PII of 20 percent, for example, people will "cook the books" to meet that measurement. In the process, they will lose sight of the real objective, which is to manage the Project Buffers so that all projects finish on time or early and that the system throughput is maximized.

The PII is really more of a diagnostic or operational measurement. When it goes up (more impedance in the system), it should prompt management to look at the CSC to identify the constraints in the project or NPD system that need to be eliminated or managed in real time. When it goes down (less impedance in the system), it is an opportunity to confirm that a constraint

was eliminated or, perhaps, that the system now has additional capacity to take on more work.

Real-Life Examples

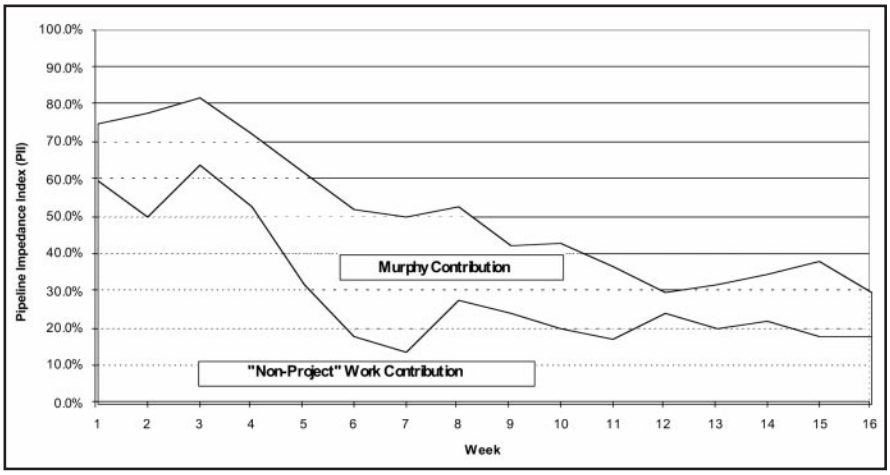
So, in TOC Pipeline Management, Buffer Management, used in concert with measurements like the PII Chart and the CSC, provides management with a powerful means of continuously identifying and trying to eliminate (or at least manage) the constraints in the NPD system in real time. By doing so, they should be able to measure a reduction of the impedance in the NPD system that will, in turn, support the ultimate goal of the NPD system: maximizing throughput. These tools have been used successfully in various forms by numerous NPD organizations.

A manufacturer of hardware systems for the banking industry used TOC Pipeline Management on a major, new platform project. Early in the project, while buffer consumption was still low, the PII and CSC showed that several, key resources were being quietly siphoned off to other, smaller projects. By being able to quantify the loss, the project team was able to convince upper management to ask permission before siphoning key people off the project. By knowing the request in advance, the functional managers were able to shuffle capacity around adequately to keep the major project on track while continuing to serve the other, smaller projects with only minor impacts on the project buffers.

In another example, a software development organization that provides products to the financial industry immediately gained benefits using TOC Pipeline Management. Early in their largest project to date, the PII Chart showed a total impedance level of 50 percent, with a significant component of that total due to Murphy (See Exhibit 4, Week 6). Analysis of the CSC quantified how project progress was being impeded or constrained by an inadequate load-building process. Within a few weeks, they put in place a solution, which included a dedicated load-building machine with some formal procedures that fixed this problem permanently (See Exhibit 4, Week 9). Without the PII and CSC, they concluded that they would never have recognized the problem as early as they did and would have suffered the consequences for several more months before they could justify the cost of the fix.

Another organization, which makes sophisticated printers for a number of specialized markets, used the tools of TOC Pipeline Management to quantify the impact of the delay caused when a key firmware engineer required for their new printer project was detained on an earlier project. A review of the Buffer Report showed that, while the resource delay did not have an immediate impact on the target end date for the project, the delay did jeopardize a "system gate review" of the project. This review is part of the company's portfolio management process to decide on funding/staffing levels for projects moving through their NPD pipeline. A delay in the "system gate review" would have upset their budget process as well as their ability to forecast revenue for the new printer. In this case, the decision was made to use the existing firmware architecture for the new printer, which would minimize the need for the key firmware engineer on the new printer project. Management was thankful that Buffer Report highlighted the problem immediately, and that a very high PII coupled with the CSC pointed them directly to the resource contention issue.

Exhibit 4: Pipeline Impedance Index Chart



Finally, a large supplier of software for the telecommunication industry was using TOC Pipeline Management across all of its software development projects. Using another form of the PII and CSC, they were able to ascertain that their NPD pipeline was overloaded. This forced them to make project priority decisions, which put some projects on hold. The result was that the pipeline was unclogged and the projects that stayed in process completed faster than usual.

Conclusion

Traditional pipeline management is totally compatible with the Theory of Constraints (TOC), in that they share a common, fundamental goal, which is to manage the constraints of the system most effectively in order to maximize the throughput of the NPD system.

Buffer Management is the enabling technique that allows direct linkage of the strategic goals of the NPD organization, which are made at the executive level with the day-to-day operational decisions made at the functional management level, regarding the effective utilization of the limited capacity of scarce resources. Buffer Management distills the complexity of a real NPD environment into a simple and powerful decision-making tool to most effectively manage the NPD pipeline in real time.

The TOC Pipeline Management process naturally provides two powerful and useful management tools to foster effectiveness and continuous improvement in NPD operations: the Pipeline Impedance Index (PII) and the Constraints Summary Chart (CSC). The PII used in concert with the CSC provides management with a powerful means of continuously identifying and trying to eliminate (or at least manage) the constraints in the NPD system in real-time. By doing so, they can effectively manage the finite development capacity of the NPD system in order to support the ultimate goal of the NPD system: maximizing throughput.

References

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2. http://www.scitor.com/Products/PS_Suite/critical_chain_concepts.pdf
3. Kania, Eugene. *Measurements for Product Development Organizations*, PDMA VISIONS, April 2000, Vol. XXIV, No. 2.