DBR Drum-Buffer-Rope
Operations Scheduling & Execution

An explanation of the *Thoughtware* and TOC interpretation behind CMG's DBR+™

Every manufacturing schedule has a limited life. If you think about it, a schedule is really only an attempt to synchronize efforts and resources ahead of time. It is based on a set of assumptions, most of the time very solid assumptions, but assumptions nonetheless. Every schedule and the assumptions it is based on is subject to "Murphy" – variations and unforeseen issues that break down at least one of those assumptions. If you do not believe these "Murphys" exist, stop reading right now. In most manufacturing scenarios, these deviations begin almost immediately after the release of a schedule. Additionally, they tend to accumulate and/or amplify each other to create major synchronization issues throughout the entire resource base.

What is most environments response to this phenomenon? "We have to reschedule!" And when the new schedule breaks down? "We have to reschedule!" The result is a constantly changing schedule and set of priorities that impact the company's ability to meet customer due dates, limit additional expenses such as overtime and fast freight and effectively manage purchasing and materials requirements. All of which come back around to introduce more variation and schedule volatility!

Is this really a scheduling problem? Yes and no. It is scheduling problem that quickly moves into an execution problem.

In most cases, our default response to poor schedule performance is to have better, MORE PRECISE scheduling. We feel we have to get better forecasting data, examine and rebuild routings, adjust standards, schedule concurrently at every resource center, and carefully account for every resource minute. If you review the majority of manufacturing scheduling software on the market and carefully examine the sales and marketing emphasis what you will see is that many of them are highlighting scheduling precision and the ability to quickly reschedule.

Constraints Management Group (CMG), LLC is one of the world's largest providers of TOC based applications and solutions. Headquartered in Seattle, WA, our large pool of unique and diverse resources, allow CMG to effectively operate throughout North America and Western Europe in a wide range of industries and organizational sizes.

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Take the output of these precision based scheduling techniques and what you will find is that most of the time it simply says, "We will hit this date if every thing

goes according to schedule." At the same time almost everyone in manufacturing readily admits that everything NEVER goes according to schedule. That means that the schedule is PRECISELY not realistic. This schedule is then used to communicate and make commitments to customers, suppliers and the resource base. You know the rest of the story from here.

What we have to understand is two things. First, trying to be more precise everywhere is leading us directly into being imprecise as a whole. This is especially true as concepts such as LEAN have proliferated and companies have dramatically dropped inventories making materials availability more of a challenge in the face of an unrealistic schedule.

Second, Murphy will not be eliminated. Despite what some manufacturing "gurus" may say, the elimination of random events and variations is completely unrealistic. Yes, major sources of disruption can be systematically attacked and eliminated through a concerted effort, but at what cost in terms of time and money and at which area should we begin? And, what should we do in the meantime – continue to schedule and reschedule?

Step 1: Schedule for Murphy.

How can we plan for random disruptions that can and will occur anywhere? We cannot plan for these events at a resource level. If we fall into that trap, lead times will expand as we attempt to insert additional time at each operation in order to account for things that might happen there. Additionally, while we are aware that every thing NEVER goes accordingly to schedule, we also accept that never does EVERYTHING go wrong at ALL places. Disruption and variation can occur anywhere but will usually not occur everywhere. If we cannot plan for them at a resource level, we must plan for them at a higher level. Let's examine how.

The Shipping Buffer

The key is to isolate these disruptions from effecting what is critical for our customer commitments (due date performance) and control (scheduling and execution). Let's deal with our customer commitments first. This stage is relatively simple from a scheduling perspective. Essentially, what we have to do is isolate the accumulation of variable events in the facility from directly impacting the shipping date. The key is to realize that we should schedule an order to ready a certain period of time BEFORE the actual required shipping time. This is called a Shipping Buffer. How large should the shipping buffer be? It depends on the complexity and variability of that specific manufacturing environment. One thing is clear, however, minimizing this time buffer will require much better scheduling and control within the manufacturing facility.

The "Drums"

A manufacturing plant is a system often containing a substantial number of interdependent events. Within any system of interdependent events, there is usually one or, at the least, a limited number of resources/factors, that truly affect the output of the system – a leverage point. Many have called these areas "constraints" or "bottlenecks." In fact, Dr. Eli Goldratt and Jeff Cox, wrote a business novel called, *The Goal*, thoroughly explaining this issue and giving birth to a management methodology called the Theory of Constraints.

These definitions (constraint and bottleneck), however, are much too simplistic and reactive in nature to really explain what these leverage points really represent. They are areas that make the most sense to decouple the accumulated variation of a string of events from the rest of the processes and resources. It could be an integration point in the routing (e.g. assembly), a capacity constrained area (e.g. a bottleneck) or a highly instable process that will only greatly amplify any variation as an input. It is a strategic control point. The proactive question, "Where should it be?" should always be asked and answered.

Drum-Buffer-Rope Scheduling

Scheduling begins at these strategic areas. They become the "Drums" because they provide the cadence that all other resources and areas follow. With a given customer commitment in mind (provided by the due date with a Shipping Buffer), they are scheduled before any other area. Every area has finite capacity and the Drums are no exception. Capacity testing happens here first. If there is no capacity for the given time that corresponds to the due date and allowing for a shipping buffer then the order must be scheduled before or after that time. All subsequent scheduling (e.g. material release) is subordinate in nature to the Drum Schedule.

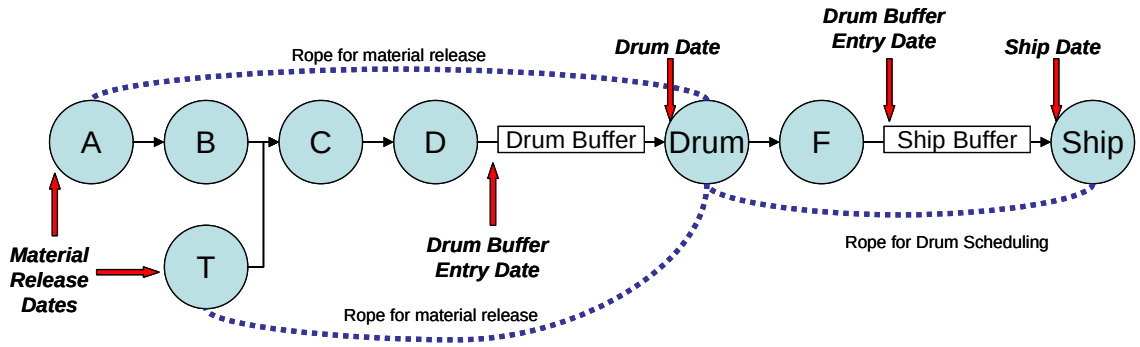
In order to protect and stabilize this Drum Schedule, a time buffer known as the "Drum Buffer" must be inserted preceding the Drum operation. The Drum Buffer serves to act as an early warning system in order to alert us to which work orders may impact the Drum Schedule. This allows a manager to intervene BEFORE there is a schedule deviation.

From this Drum Schedule the staggered release of material is back scheduled using the upstream process (traditional routing and standards) time plus the Drum Buffer time. This is called "Tying the Rope." Many times this upstream process time can be compressed by factoring for a smaller transfer batch between resources where and when it is feasible.

The result is called Drum-Buffer-Rope. It is a simple schedule comprised of a few major waypoints to manage to:

- A clearly defined, timed and sequenced material release
- An expected arrival time for orders into the Drum Buffer

- A Drum Schedule
- An expected arrival time for orders into the Shipping Buffer
- A ship date



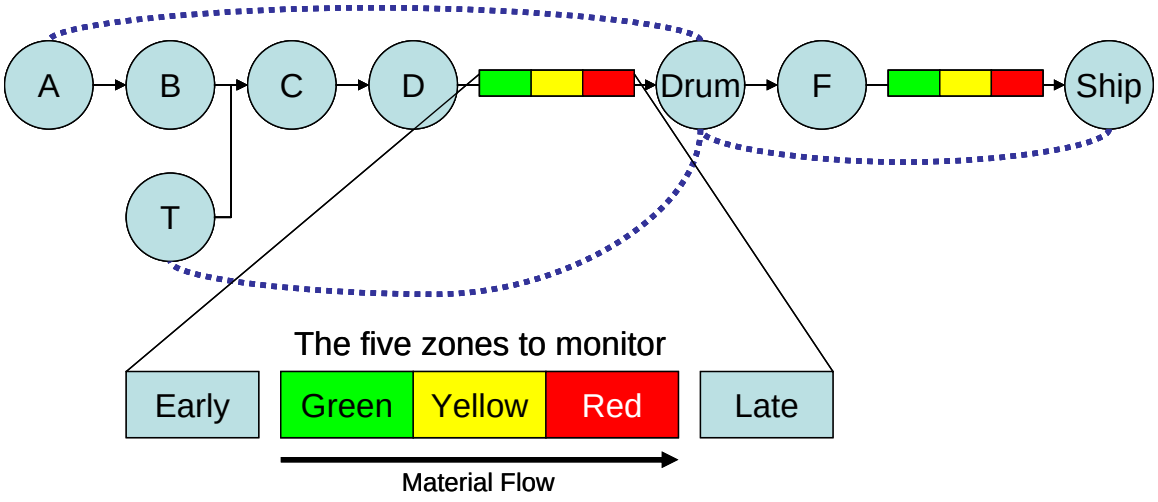
Thus, from a scheduling perspective, precision is important in only a few places. Ironically, this type of scheduling requires less computing ability and gives a clearer picture of what will actually happen because it is inherently simpler than most traditional schedules and it recognizes and seeks to protect what is critical from Murphy. “We will hit this date if many things DO NOT go according to schedule”

Step 2: Manage the Murphy - EXECUTE!!

A Drum-Buffer-Rope schedule is managed through its buffers. The buffers will tell you about the health of the system and any individual operation, the status of a work order and where to focus improvement. The buffers are visible, real-time tools that clearly depict any deviations to schedule and set priorities for corrective actions.

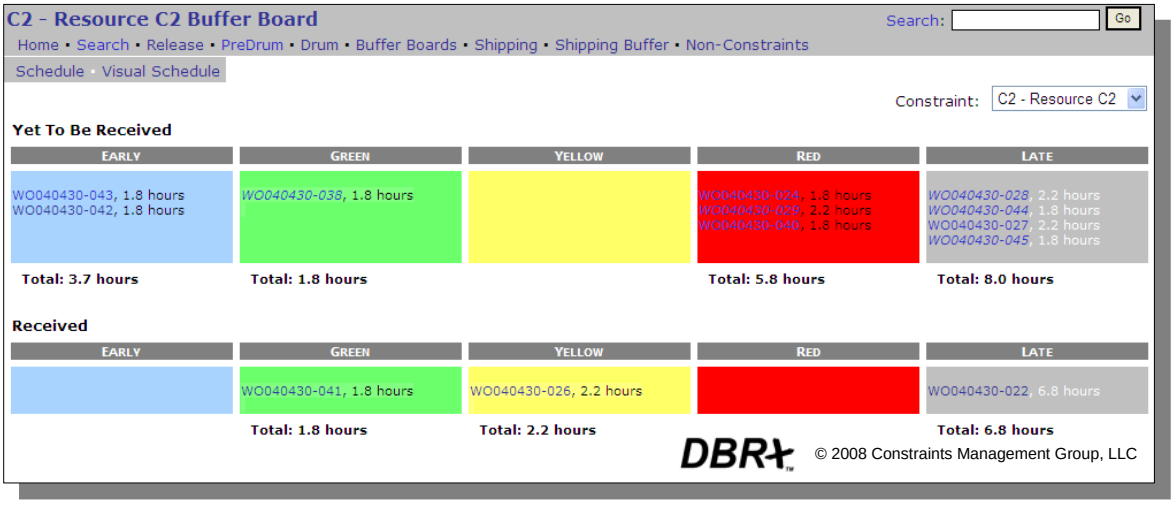
Buffer Management

To manage the buffer we divide it into three time zones: Green, Yellow and Red. The zones are not necessarily of equal proportions. We should also pay attention to other zones: Early (work order is ready before the total time length of the buffer) and Late (work order arrives after the entire length of the buffer has been consumed).



We will have to reconcile the work orders actual presence in the buffer by recording when it entered the buffer and judge that against scheduled entry to create a view about what, if any, corrective actions need to taken. When a work order is not ready and in the buffer at the start of the Green zone (scheduled buffer entry), a "hole" is created in the buffer. The severity of the hole will ultimately determine when we have to act and which work orders to act on.

This means that we have to think about the above 5 zones from two perspectives, "Yet to Be Received" and "Received." When something has been "Received," the hole has been filled. Below is a real-time buffer board that reconciles released work order against their buffer status.



Notice that when we account for the same time horizon from the two different perspectives, it actually creates a total of ten status zones. Those zones are:

1. Early – Yet to Be Received. This zone actually represents all released work orders that are on the way to the buffer.
2. Green – Yet to Be Received. This is a hole in the buffer. Not a serious hole, but a hole nonetheless.
3. Yellow – Yet to Be Received. This is a deeper hole in the buffer that should now be getting the attention of the personnel responsible for managing the buffer.
4. Red – Yet to Be Received. This is the deepest hole that we can dig without impacting the Drum schedule. This zone alerts the appropriate personnel that if corrective actions are not taken the Drum schedule will be disrupted.
5. Late – Yet to Be Received. The Drum schedule has already been disrupted by this work order and it is still not present.
6. Early – Received. The work order is physically present at the buffer and ready to be worked on by the Drum ahead of the time horizon we scheduled for. This usually means that the standards we are using to generate the schedule may be over-estimated (very common since most companies standards are highly inflated to try to combat Murphy and disruptions everywhere) or the work order was release ahead of schedule.
7. Green – Received. The work order was received within the scheduled time horizon with a, relatively, lot of time to spare.
8. Yellow – Received. The work order was received within the scheduled time horizon with a moderate time to spare.
9. Red – Received. The work order was received within the scheduled time horizon with little time to spare.
10. Late – Received. The work order was received after the time it was scheduled on the Drum. By definition, it has caused a disruption to the Drum schedule.

Step 3: Improve

Continuous improvement in a Drum-Buffer-Rope system is about focusing capital and time in order to improve the system's performance from three main perspectives; lead-time, inventory and volume.

Quite simply, lead-time gains will help a company retain and/or grow market share and/or get more money for it. Reducing the amount of inventory means that there is less captured money in the system to service the market. Growing volume will allow a company to more business with the same or relative small amounts of additional overhead. Sending them all in the right direction is the objective.

Did You Know?

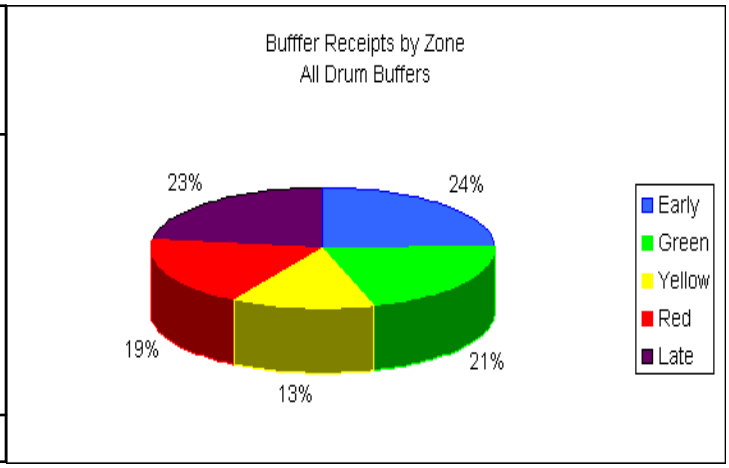
Constraints Management Group makes an elegant piece of DBR software that is not only user friendly, but is extremely robust and affordable. Combined with the proper implementation strategy and services, ***DBR+*** can make the common sense seen in **The Goal** real AND sustainable.

Reason Code Analysis

The required transactional data from Buffer Management can be used to direct improvement. By forcing reason codes when transactions (receipts) are made in certain key zones (Late, Red and Early) of the buffer and comparing them over time we can get an amazingly clear picture of how to direct improvement efforts.

Reason Code Analysis (Red Zone)

Reason	Occur	%
Equipment	50	41%
Late Release	24	20%
Material	19	15%
Labor Shortage	14	11%
Expedite	12	10%
Other	4	3%
Total	123	100%



Let's examine some typical types of zone receipts and reason codes and what some potential recommended actions might be.

Zone Receipt	*Number of Occurrences*	*Reason*	*Recommended Actions*
Late	23	Set-up delay at work center "CNC-Lathe7"	Set-up reduction program at CNC-Lathe7
Red	27	CNC-Mill18 down	Preventative mtnc program (off-hours) at CNC-Mill18.
Early	52	Released on-time, beat standards	Clean standards up of listed product families.