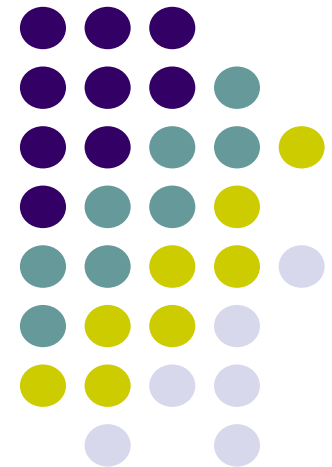
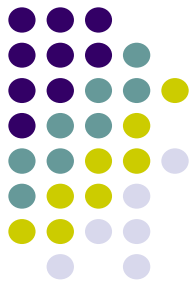


Lean Manufacturing: a new perspective

Linking Lean, Theory of Constraints and
Infor VISUAL DBR

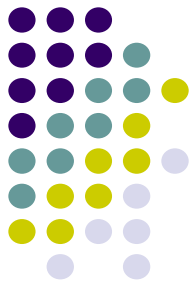
Presented by Ted Hutchin





What is the goal?

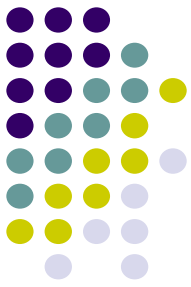
- All companies are formed for a purpose, usually to make money, now and in the future, and to do so by continually satisfying the market
 - Seems obvious but it is surprising how many companies take actions, implement strategies, buy machines and other services that do nothing to take the company closer to the goal
- So that leads naturally to the next question



What are the key objectives?

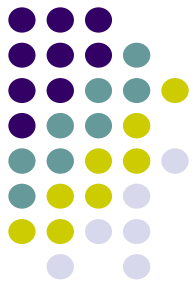
- Deliver...
 - The right product
 - At the right price
 - At the right time
 - Zero defect as a given

- Better customer satisfaction than any competitor
- Win business throughout the chosen market segment



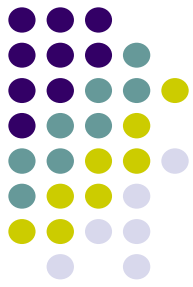
OK so how are we doing?

- So are we making good profit on our current level of work?
- Is our order book full?
- Is our plant full of WIP trying to escape to a client?
- Are we expediting most of the time?
- Is our lead time too long for sales to keep existing and new clients on the hook?
- Is our due date performance something we try to hide?
- Is there room for improvement?



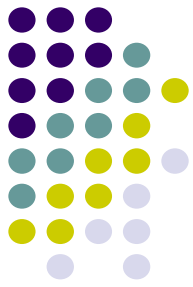
The notion of a constraint

- If we are currently under-performing against the goal then there is a real problem within our company but.....
 - Is it something physical like a machine, work centre, space or.....
 - Is it something less tangible such as the policies and procedures we have adopted to make the company more efficient, leaner, fitter.....



The five steps of focusing

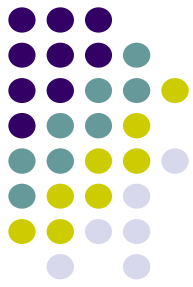
- For any manufacturing company it is necessary to understand both the location and nature of the constraint that is preventing the organisation from maximising performance against the goal
- This is what led to the development of the five steps of focusing that lie at the heart of constraint management



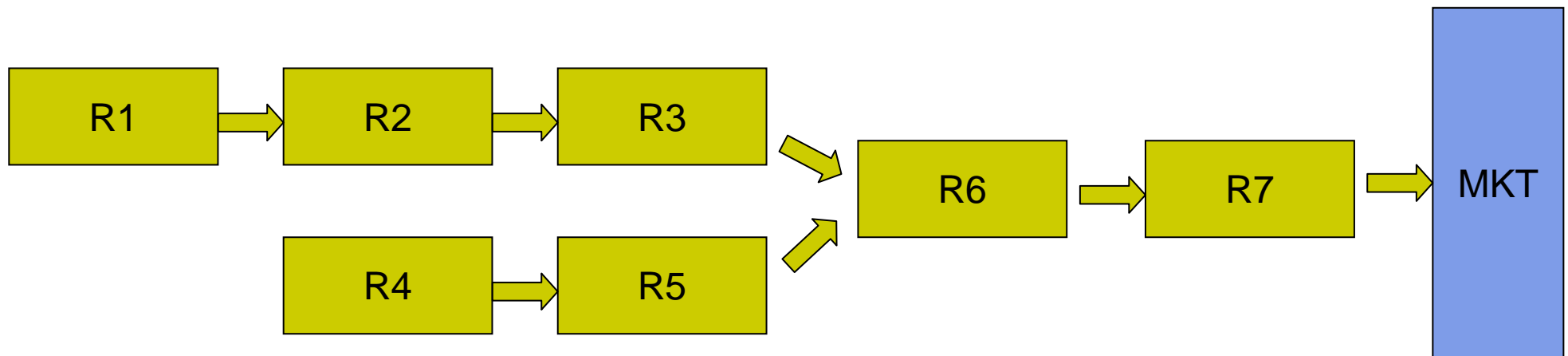
The five steps defined

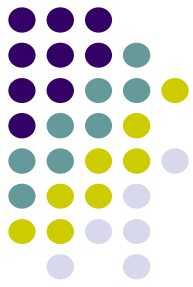
- **Identify the constraint**
 - This is the weakest link in the chain from supply to market, it might be a physical resource, or it might be a set of policies or rules
- **Exploit the constraint**
 - Once the constraint has been identified make it work effectively, attack any waste, but make sure it is doing the right work: effective not efficient
- **Subordinate to the constraint**
 - Make sure that all other activities and functions within the organisation support the operation of the constraint, this applies to every function within the organisation with no exception! The key measure for these resources is not their own, individual, efficiency but their ability to keep the constraint properly fed.
- **Elevate the constraint**
 - Once the constraint is under control and the organisation is stable it is possible to elevate the constraint, which often means...
- **Prevent inertia – go back to step one**
 - Elevation will usually mean that the constraint may well have moved so go back to step one and keep going round the loop – this is now a process of on-going improvement

The starting point: basic flow



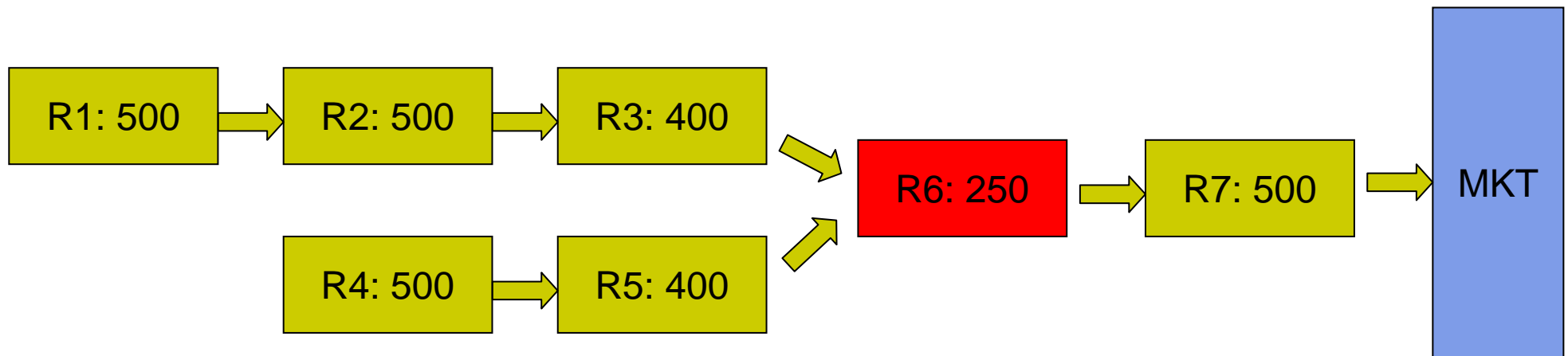
Basic flow of material from supply to market
derived from a revenue stream mapping exercise



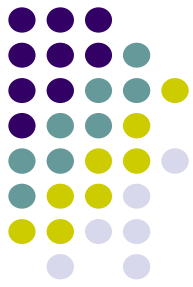


Checking capacity

- For each resource it is necessary to understand just what the capacity of each is

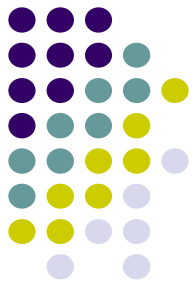


- Thus the number following the resource # shows the stated full capacity of each resource



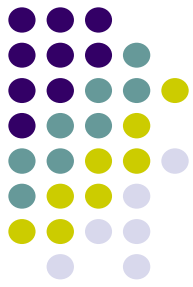
What is meant by capacity?

- Capacity has a wide variety of meaning but, within constraint management it has specific meaning:
 - Demand Capacity: that capacity required to meet the demand of the market
 - Protective Capacity: that capacity that is not used in order to protect the market from variation at the resource
 - Spare Capacity: that capacity that is not used at a non-constraint resource, but may provide an opportunity for a different product to market, or simply that which will be used when we move to elevating the existing constraint



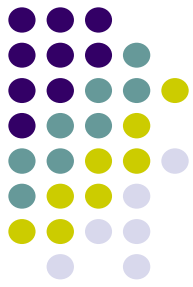
The next step

- Now that we have mapped the flow of material from supply to client and properly defined and identified the capacity of each resource in the chain it is possible to ask the first question:
 - What is the constraint of the chain (assuming no market or supply constraint)
 - Answer: R6 which has a capacity of 250, by far the weakest link in the chain



Constraints and Bottlenecks

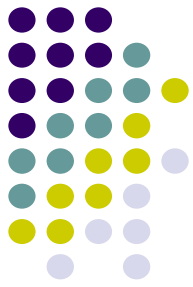
- Within constraint management these two terms have a specific meaning:
 - Constraint is usually defined as the weakest link in the chain – there can only be one weakest link!
 - Bottleneck is defined as any resource whose capacity is less than the demand placed upon it
 - Two resources whose capacities are close and which interact can form what is known as Interactive Constraints – which usually means that, between them, they form a bottleneck



Exploit the constraint

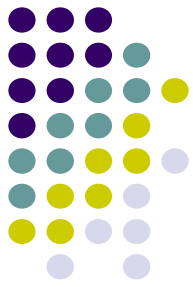
- This is where we start to gain control over operations:
 - If the stated capacity is 250, then on a good day we might get 180 – 200, and on a bad day 0!
 - We need to make sure that we obtain as close to maximum as possible, so what robs us of capacity at resource six?

Capacity thieves!



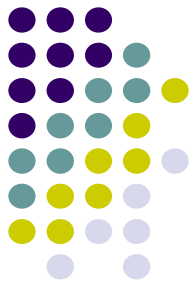
- Set-Up
 - Breakdown
 - Material
 - People
 - Defects
-
- These are the five main thieves of capacity, so what can we do about them?
 - Let's use some key lean tools and techniques

Set-Up



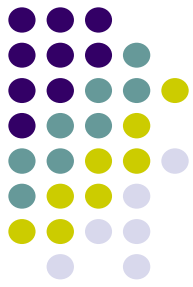
- It is part of any Lean environment to attack set-ups, particularly when they create poor performance
- But not all set-ups are an issue
- The starting point for addressing set-up is at the constraint
- In our case the constraint is an assembly which may have no set-ups, in which case reducing set-up is not an activity that has immediate priority.
- If the assembly did have a set-up then this is the place to reduce set-up time by understanding the difference between internal and external set-up time and reducing the set-up as much as possible
 - *One final thought – there is no cost attached to any set-up whatever some might argue so do not be drawn into that debate*

Breakdown



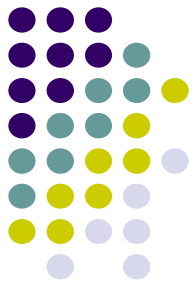
- Breakdowns at the constraint must be addressed. This involves an understanding of the six big losses that apply:
- **Down-Time**
 - Equipment failure
 - breakdowns
 - Set-up and adjustment
- **Speed Losses**
 - Idling and minor stoppages
 - Blockages
 - Reduced speed
 - Differences between actual and designed speed
- **Defect**
 - Process defects
 - Scraps and quality defects to be repaired
 - Reduced Yield
 - From machine start-up to stable production

Breakdowns ctd

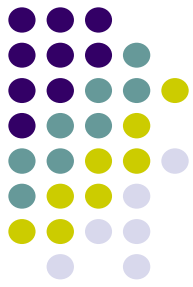


- Production Led Maintenance
 - Key measures
 - Mean Time To Repair (MTTR)
 - Mean Time Between Failure (MTBF)
 - These measures must be maintained and watched over time – they show trends of resource effectiveness and can be used to determine when new equipment will be required
 - On the constraint always schedule maintenance time in, in other words reduce the available capacity of the constraint for customer orders in order to give confidence that the likelihood of breakdown is reduced significantly

Defects



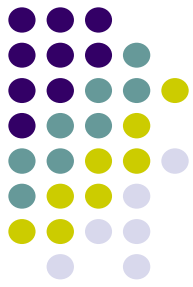
- Place quality control right in front of the constraint
- Never let a defective part be processed on the constraint – this equates to losing three times the selling price of the product to the bottom-line of the plant
- The resources after the constraint form what is called the **Red Lane** – a defect created here is not different to being created at the constraint – so treat all red lane resources in the same way as the constraint resource.



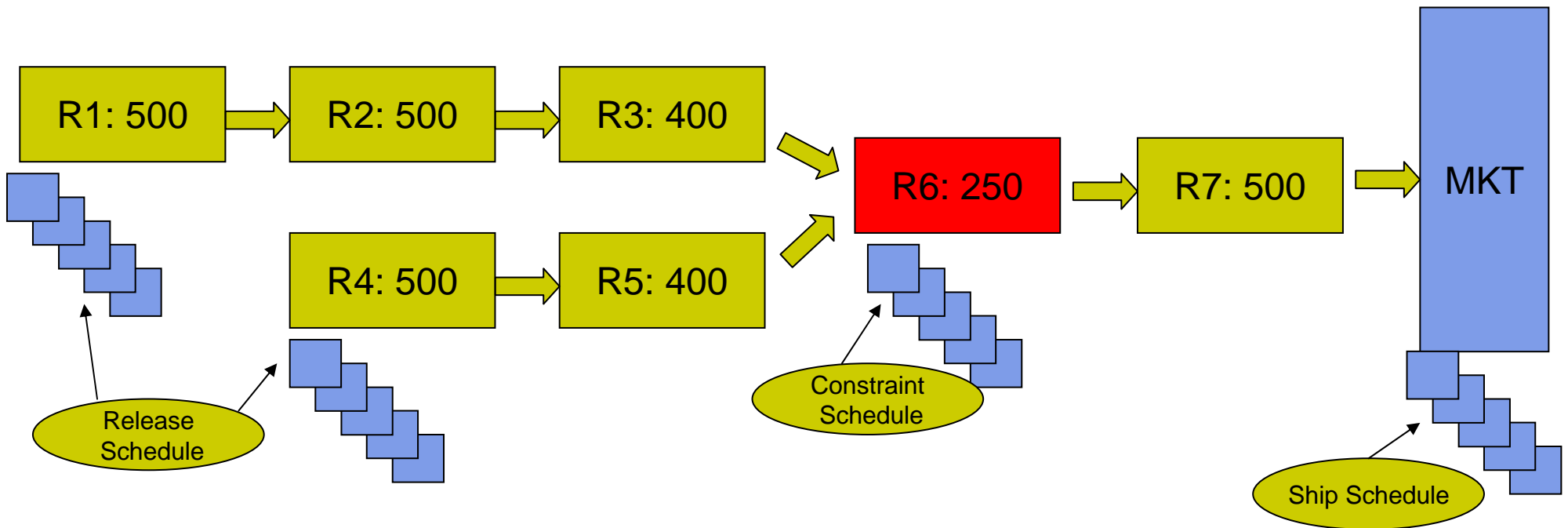
Material

- This is a function of the schedule:
 - It comprises the ship schedule which is the combined list of orders due to be shipped, say on a daily basis to clients, it includes both volume and mix, and is driven by the due date to the client. The target is 100% On Time, In Full (OTIF) defect free. The ship schedule can never be greater than the volume of the constraint, in our case (assuming the perfect plant) 250 items
 - The constraint schedule which is that material required to go through the constraint in order to meet the demand from the market.
 - The release schedule at each entry point which is that material and components required to meet the demand from the market. The measure at each release point is Material Released On Time (MROT) and the target is 100% defect free.

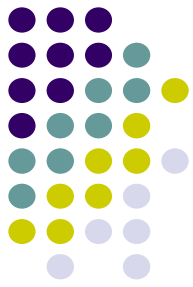
The Drum: the schedule of material



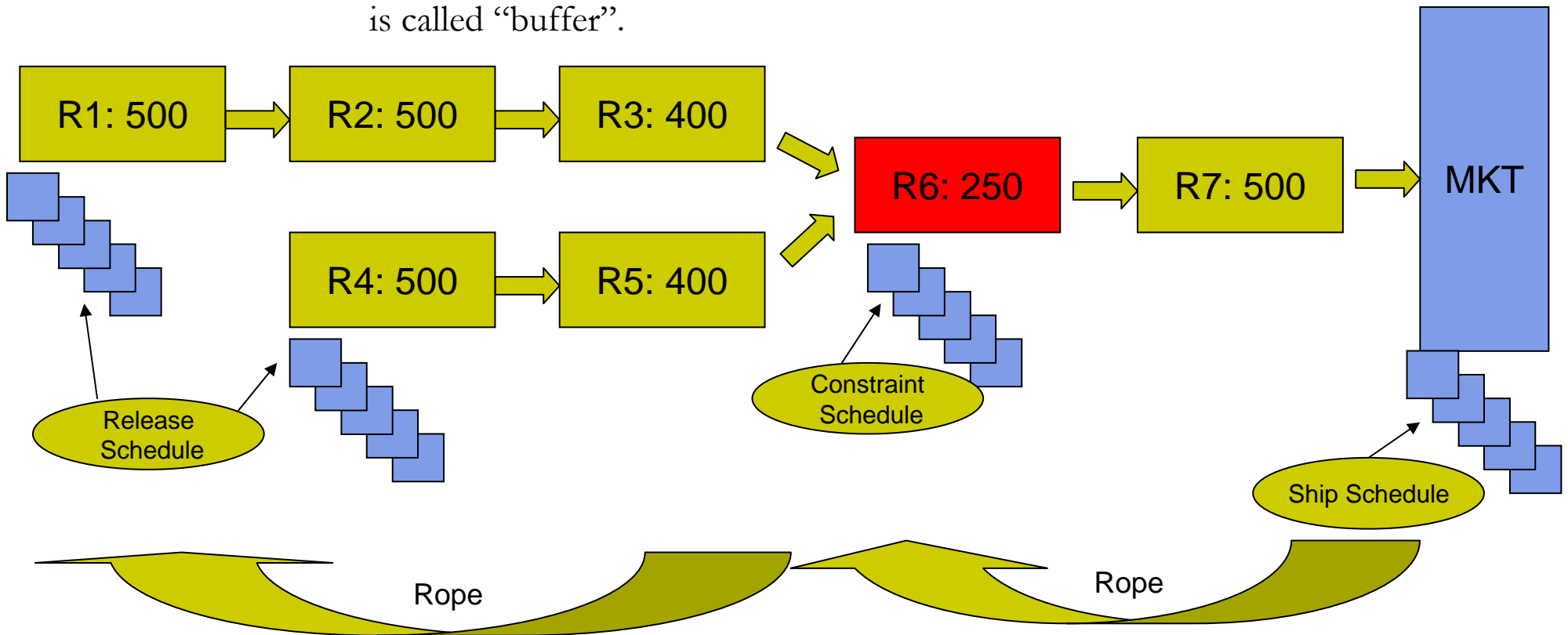
The starting point is the ship schedule – all the orders due to be delivered each day: then due to accurate BOM and Routing the constraint schedule, and finally the release schedule of raw material and components for the final product, are created

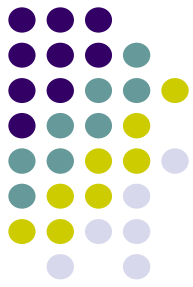


The Rope



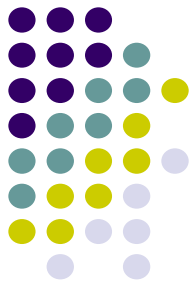
The rope is the mechanism by which the schedules are tied together, thus shipping is tied to the constraint, and the constraint tied to the release. The length of the rope is measured in time and is called “buffer”.





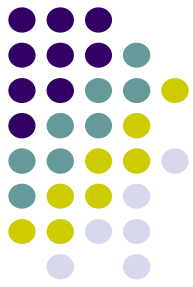
DBR – the ideal pull system

- Pull System Scheduling (DBR) provides:
 - Shorter, more competitive response time to market
 - Excellent delivery performance and customer fulfilment rates
 - Lower inventory levels
 - Greater productivity
 - Less administration and control requirements
 - Company-wide employee engagement
 - Management by exception



DBR Scheduling

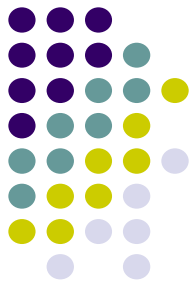
- Enables primarily MTO
- Through replenishment provides MTS capability
- Forms the basis for Vendor Managed Inventory (VMI)



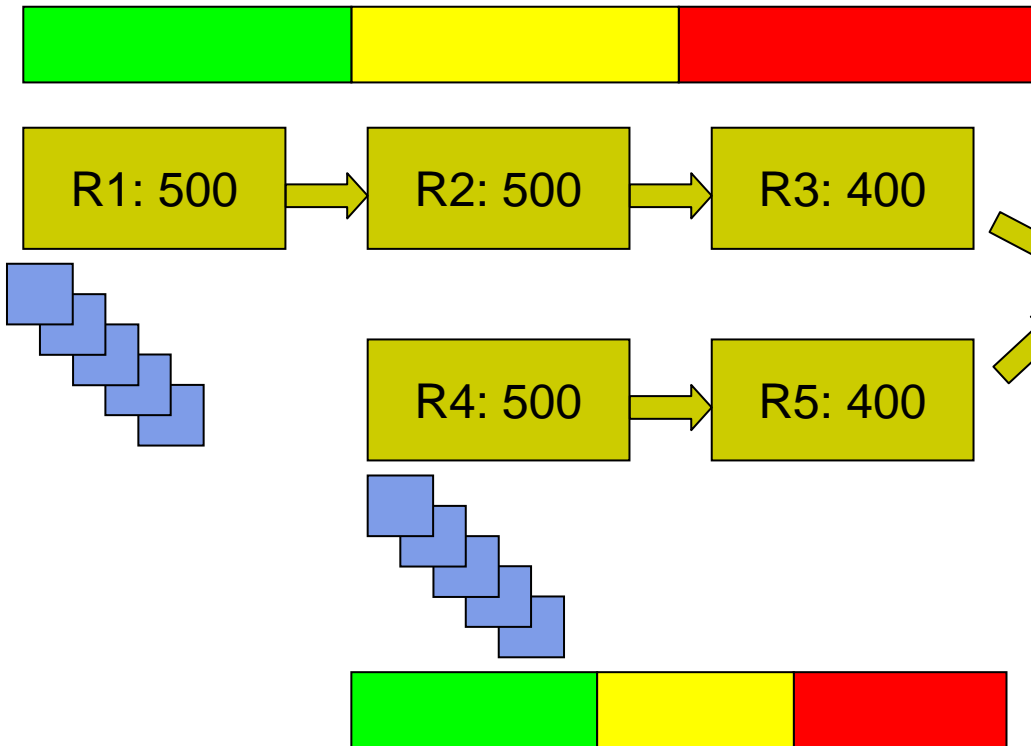
The Buffer

- This is measured in time and is designed to protect both the constraint, and the due date from problems within the operations environment
- There are three key buffers, only two in our example:
 - Constraint buffer
 - Used to ensure that material has time to reach the constraint from the time of release
 - Shipping Buffer
 - Used to ensure that material has time to reach the market OTIF after the constraint
 - Assembly Buffer
 - Used if there is an assembly after the constraint fed by non-constraint resources

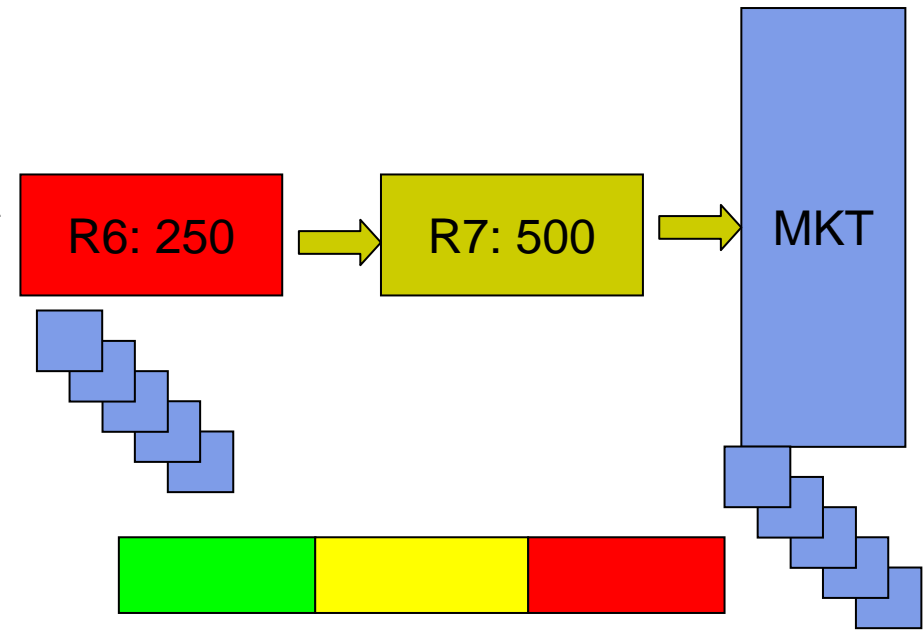
The Buffer



This is a constraint buffer

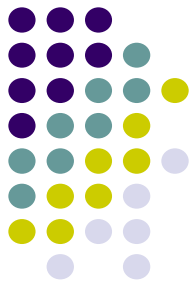


This is a constraint buffer

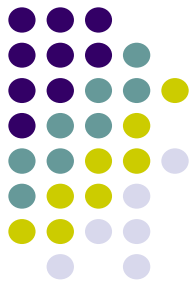


This is the ship buffer

Buffer Management



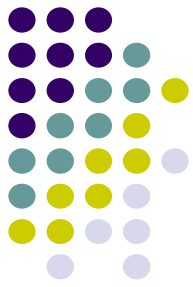
- Notice the three colours used within the buffer:
 - Green means that material is released and is likely to reach the destination (ship or constraint) on time
 - Yellow means that there has been a problem, material is late but not by much, and should still reach the destination on time
 - Red means that material has been held up for whatever reason and is likely to miss the destination time and thus has a high risk of being late to either the constraint and/or the market
- Thus the primary focal point of operations is any order that is currently in RED



Buffer Management and Lean

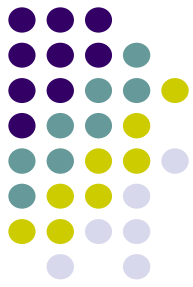
- Buffer violations are where material gets stuck for whatever reason
- Those violations that penetrate into Yellow and certainly into Red are those that demand the most attention.
- This is where we use the Lean tools and techniques, to create more capacity at the places where the violation takes place and thus enable a free flow to the constraint, or to the market

Buffer Management and Improvement

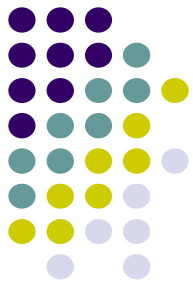


- Once under control the level of buffer violations will reduce thus:
 - We can reduce the overall time of the buffer thus reducing the overall lead time to market or..
 - Increase the levels of sales to take up the slack in capacity that the buffer management has allowed
 - At this point we are almost ready to elevate the constraint

Subordination

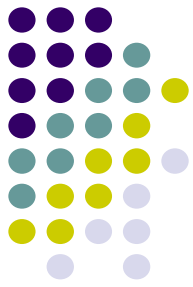


- Although all seems to be going well there are some issues that need to be addressed
 - Efficiency measures must be taken out of all resources
 - e.g. all resources other than the constraint will be operating below 100% efficiency – but if they always support the drum then they are 100% effective
 - Rules and procedures must be examined to ensure that they allow for full subordination and not restrict the focus on due date delivery (OTIF) and material release (MROT)



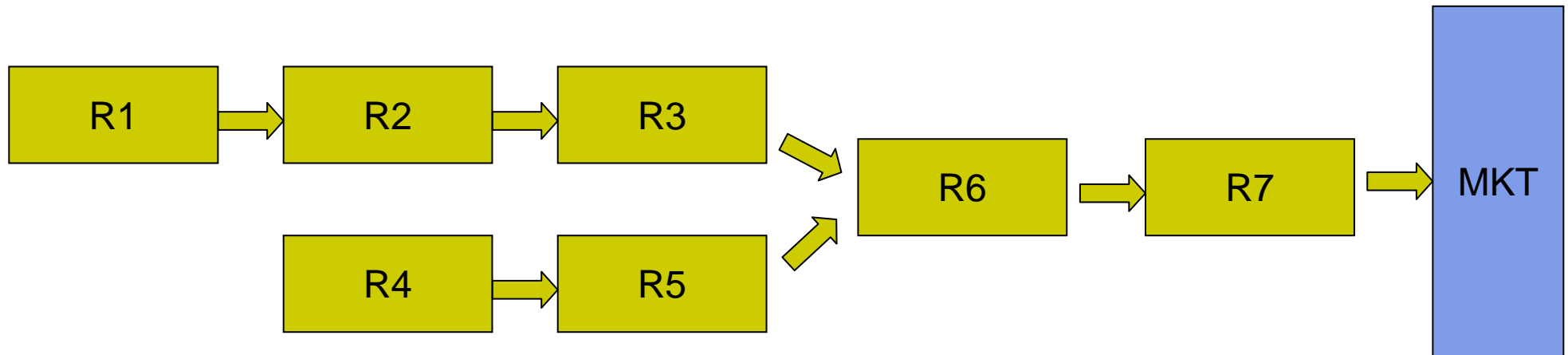
Drum – Buffer – Rope and Lean

- We now have control over operations
- We now have focus across the whole of the revenue chain
- We are now using Lean tools and techniques to properly support value flow and enable us to improve the quality of the process
- We have put in place a real process of on-going improvement

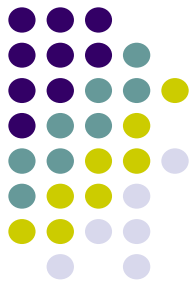


But...what if there appears to be no constraint?

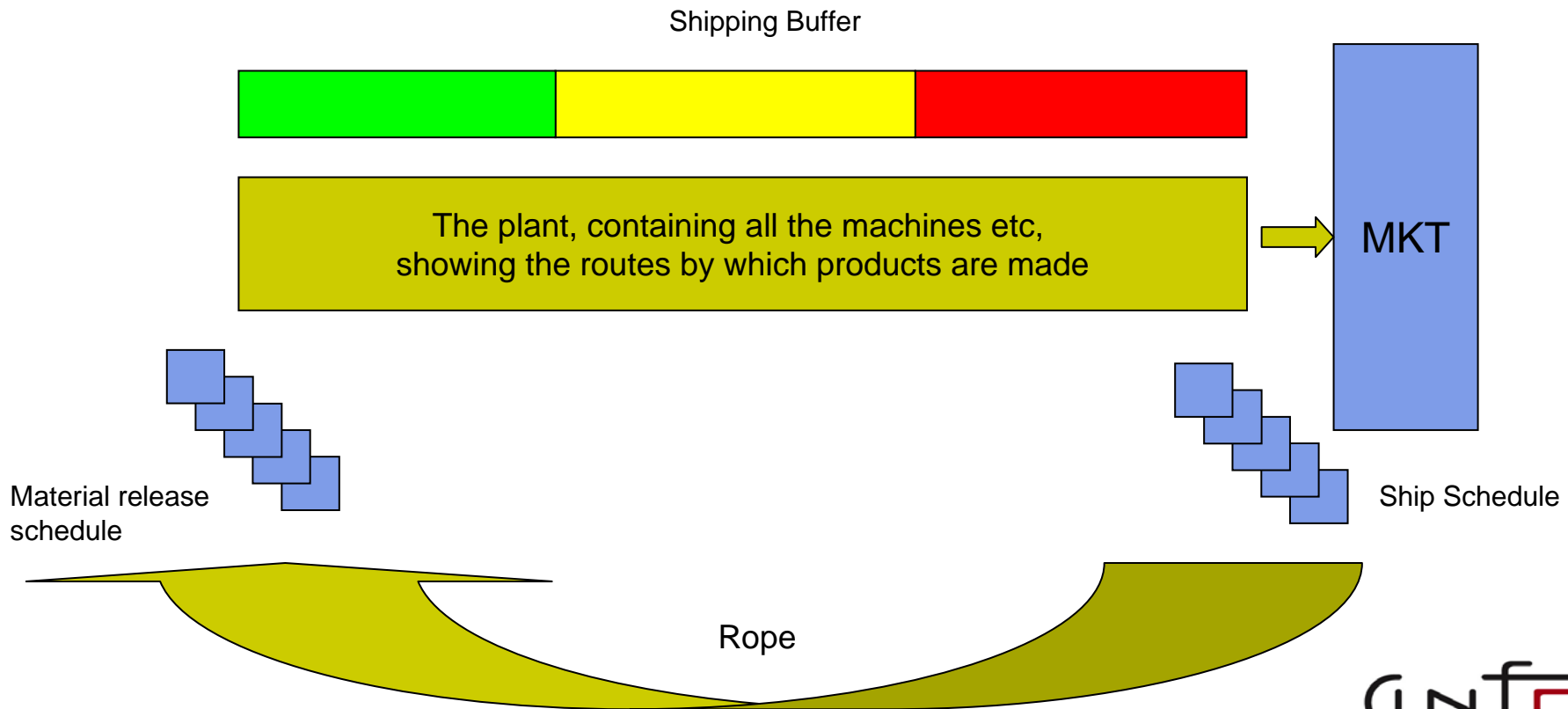
We do the mapping exercise but either the data is inaccurate, or simply not sufficient to give an indication of the presence of a constraint...what then?

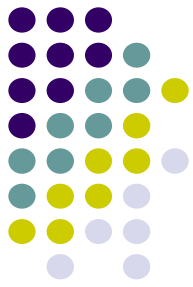


The role of Easy Lean



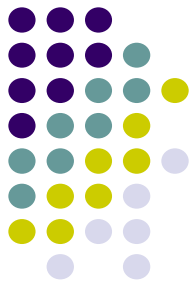
- Easy Lean assumes no internal constraint therefore the system appears as this...





Execution of Easy lean

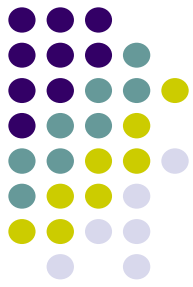
- There is still the need to properly develop the shipping schedule – thus this is still a fully developed pull schedule in line with Lean principles
- The rope is then tied back to the release point within the plant, the length of the rope being measured in time and known as the shipping buffer
- This then determines the timing of release such that the due date is always met.
- The standard measures of OTIF and MROT also apply



Moving from Easy Lean to DBR

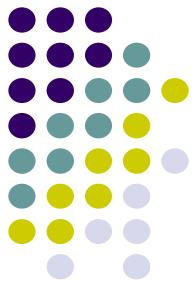
- Over time, as control is achieved within material flow, if there are any constraints within the system they will be clearly identified through the buffer management system
- Initially it might mean that such temporary constraints are simply addressed and have no further impact
- Alternatively they could well be indicative of a genuine constraint in the system and now the full control system of DBR can be implemented with confidence that both the true constraint is being properly managed, and control is maintained.

The five lean principles linked to constraints

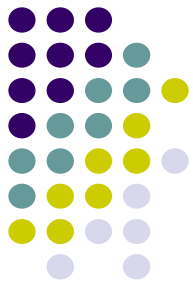


- **Specify value from the perspective of the customer** – which also means we need to define the customer and also the supply chain in which they sit; a key aspect here is that high levels of due date performance (>95%) and a reducing lead time have a beneficial effect on both the company and the market
- **Identify the value stream** – all processes along the chain must be included, this is key to the identification of the weakest link in the chain

The Five Lean Principles ctd

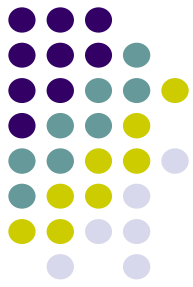


- **Make value flow** – in other words keep material flowing as much as possible from supply base to the client, again this is linked to the importance of addressing issues related to due date performance and the reduction of overall lead time which is a critical dimension of any constraint management environment
- **Use PULL not push** – pull in line with demand and schedule accordingly, which is why all schedules in a constraint management environment start with the due date and volume of customer orders
- **Perfect the process** – the application of quality management enters here.



D - B - R and Lean: The benefits

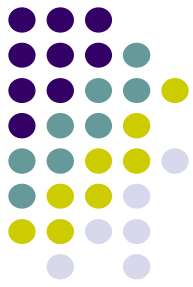
- Reduced Lead Time
- High (> 95%) Due Date Performance
- Reduced levels of inventory
- Reduced expediting
- Capability for increasing sales significantly
- Fewer materials/parts shortages
- Improved bottom-line performance (typically within 6 - 8 weeks)



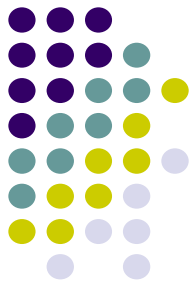
Achieving Lean Status

- Pull System Scheduling
 - Driven by Infor ERP VISUAL (Infor VISUAL Easy Lean & Infor VISUAL DBR)
- Revenue Stream Mapping
- Set-Up reduction
 - Driven by Buffer Management
- 5S/Visual Workplace/Production Led Maintenance
- Kaizen
 - Driven by Buffer Management
- Addressing the seven primary causes of Waste
 - Driven by Buffer Management
- Quality Systems
 - Driven by Buffer Management
 - Supported by Visual Quality

Implementing Lean into manufacturing



- Focus on the customer
 - Pull scheduling such as Infor VISUAL Easy Lean or Infor VISUAL DBR
- Aligned decision-making throughout the company
 - Focus provided by the buffer reports and people are guided to those problem work orders that are violating their due dates (constraint or ship)
- Adoption of Buffer Management throughout
- Application of the Lean tools and techniques to address Buffer Violators and find more capacity



The Key Building Blocks

Process of on-going improvement

Business Strategy
Development

VISUAL
Management

Production Led
Maintenance

Quality
Management

Kaizen

Team
Dynamics

Five Steps of
Focusing

Pull Scheduling
Infor VISUAL DBR

Problem Solving Tools

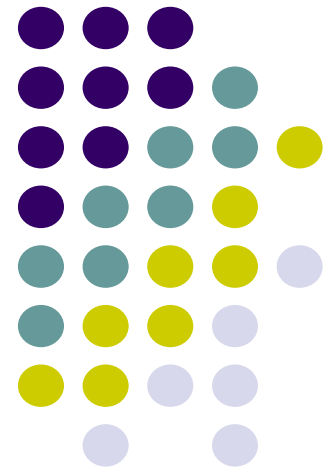
5S
Organisation

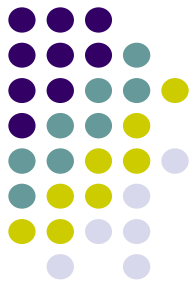
Value Stream
Mapping

Set-Up
Reduction

Linking Lean and Constraint Management

Practical application of these two
powerful techniques

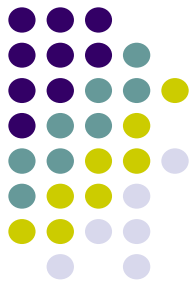




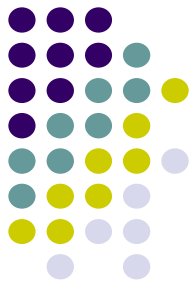
Lean Basics

- Focus on the customer
 - Due date, lead time, quality, price, service
- Address the causes of waste
- Eliminate unnecessary expenditure
- Simplify the process
- Focus on continuous improvement
- Long term not short term

Delivering the lean principles



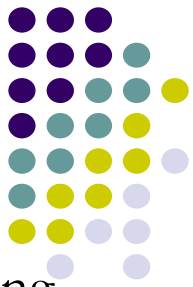
- Uppermost in the lean approach is the need for a robust and logical process of analysis – hence the application of constraint management and TOC
- The lean principles are not a sequential set of elements to be implemented, they are a robust and coherent group of principles that require a focused implementation plan in order to be successful



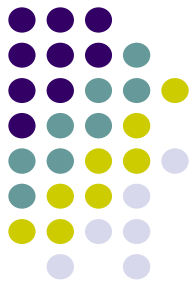
A reminder of the types of waste

- The seven basic types:
 - Overproduction
 - Addressed by the DBR schedule
 - Shipping defective parts
 - Addressed by the quality systems
 - Processing
 - Addressed by the DBR schedule, the quality systems, set-up etc
 - Delays or waiting for processing
 - Addressed by the DBR schedule and the buffer management system
 - Motion
 - Transportation
 - Excess Inventory
 - Addressed by the DBR schedule and the buffer management system

Defining the types of waste

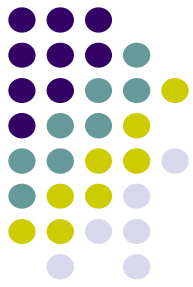


- **Waste of overproduction** – the root of many problems within manufacturing, making more than we need within the timescale
 - This is often driven by the need to maintain efficiencies on most machines within the plant – which actually adds to waste!
- **Waste of waiting** – how much time is taken up with material not moving when it could?
 - This is often a function of large batch transfer. Many machines use a process batch of one, yet in front of most machines there are pallets filled with material waiting to get on the machine, after the process there are more pallets waiting for the rest of the batch to finish. This simply extends the overall lead time and destroys high Due Date Performance
- **Waste of transporting/transportation** – how many times does material get handled when it needn't?



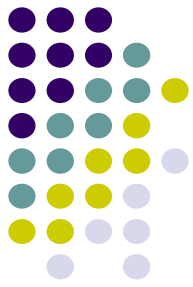
Types of waste ctd

- *Waste of inappropriate processing* – over-engineering springs to mind, using more than is necessary to achieve the objective
- *Waste of unnecessary inventory* – how much WIP do you have and what is the impact?



Types of waste ctd

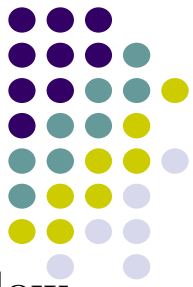
- ***Waste of unnecessary motions*** – the application of sound ergonomics to manufacturing – this is also a key health and safety area
- ***Waste of defects*** – many companies today still measure quality in parts per hundred – yet world class companies measure in parts per million if not parts per billion!!



Lean Scorecard

- A simple tool to gauge the movement forward over the next three years
 - People and training
 - Delivery, lead time and inventory
 - Layout, flow, handling and scheduling
 - Processes and Operations
 - Preventative Maintenance
 - Supply Chain Management
 - Equipment Changeover/set-up
 - Quality
 - Metrics and results

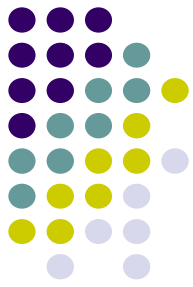
Continuous Improvement and the five steps



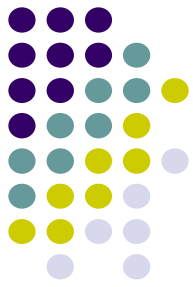
- **Step 1 – identify the system constraint:** the constraint determines the speed/flow of the entire process, improve the capability of the constraint and the whole plant is more effective
- **Step 2 – exploit the constraint:** maximise the constraint schedule, make sure that the proper volume/mix calculations have been done based on the contribution of the time on the constraint
- **Step 3 – subordinate all other operations to the constraint:** otherwise the whole system will choke with excess inventory, costs will go up, delivery performance will go down, lead-time will increase, bottom-line will go down etc
- **Step 4 – elevate the constraint:** either increase the capability of the constraint or keep the constraint where you want it to be and make sure that no other area will become the constraint, and then elevate
- **Step 5 – prevent inertia:** go back to step 1
- *Do not focus your people, time and money on a NON-CONSTRAINT operation within the process. It will only increase WIP prior to the constraint and it will not improve the profitability of the plant, in fact you will achieve the opposite.*

Conventional rules within production or **how not to do it!**

(Taken from *The Race*)



- Balance capacity, then try to maintain flow
- Level of utilisation of any worker is determined by it's own potential
- Utilisation and activation of workers are the same
- An hour lost at a bottleneck is just an hour lost at that resource
- An hour saved at a non-bottleneck is an hour saved at that resource
- Bottlenecks temporarily limit throughput but have little impact on inventories
- Splitting and overlapping of batches should be discouraged
- The process batch should be constant both in time and along its' route
- Schedules should be determined sequentially:
 - Predetermining the batch size
 - Calculating the lead time
 - Assigning priorities, setting schedules according to lead time
 - Adjusting in line with apparent capacity constraints

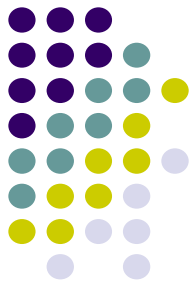


A new paradigm for manufacturing

- Focus on maximizing profitable sales revenue.
- The view of the organisation as a series of dependent links - a chain.
- Only strengthening the weakest link improves the whole.
- Most improvements, in most links, has no effect on the whole.
- The chain starts in the supply base and ends with the customer.
- Global optima rules.
- Global management is different to the sum of the local management

Global rules within production, or **how to do it properly**

(Again from *The Race*)

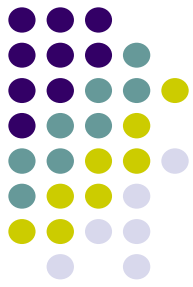


- Balance flow not capacity
- The level of utilisation of a non-bottleneck is not determined by its own potential but by some other constraint in the system
- Utilisation and activation of a resource are not synonymous
- An hour lost at a bottleneck is an hour lost for the whole system
- An hour saved at a non-bottleneck is just a mirage
- Bottlenecks govern both inventories and throughput
- The transfer batch may not be, and many time should not, be equal to the process batch
- The process batch should be variable and not fixed
- Schedules should be established by looking at all of the constraints simultaneously. Lead times are the result of the schedule and cannot be pre-determined.

Focused continuous improvement

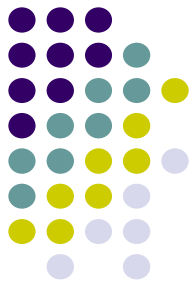


- Address causes of variability that truly impact the system, including recognising the difference between special and common cause variation
- As these improve the buffer size can be adjusted
- Tighter control limits can now be implemented – less inventory and shorter cycle times
- The cycle continues – the supply chain perspective



Book list for further reading

- Goldratt, E.M. and Cox, J. 1987 The Goal Revised Ed. North River Press MA
- Goldratt, E.M. and Fox, R.E. 1986 The Race North River Press MA
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- Goldratt, E.M. 1994 It's Not Luck North River Press MA
- Goldratt, E.M. Schragenheim, E. and Ptak, C 2000 Necessary But Not Sufficient North River Press MA
- Hutchin, T. 2002 Constraint Management within Manufacturing Taylor and Francis London
- Umble, M.M. and Srikanth, M.L 1990 Synchronous Manufacturing APICS
- Stein, R.E. 1996 Re-Engineering the Manufacturing System Dekker
- Corbett, T. 1998 Throughput Accounting North River Press MA
- Smith, D. 2000 The Measurement Nightmare St Lucie Press Boca Raton



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