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Buffer Management

The Control Mechanism for Synchronous Manufacturing

Central Minnesota Chapter

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Agenda

- ◆ What is Synchronized Production?
- ◆ 50,000 foot view of DBR
- ◆ Why Buffer Management?
- ◆ Buffer Management Mechanics
- ◆ Basic Requirements for Implementation



According to APICS

Synchronous Manufacturing

see: synchronized production

Synchronized Production :

A manufacturing management philosophy that includes a consistent set of principles, procedures, and techniques where every action is evaluated in terms of the global goal of the system

(Con't)

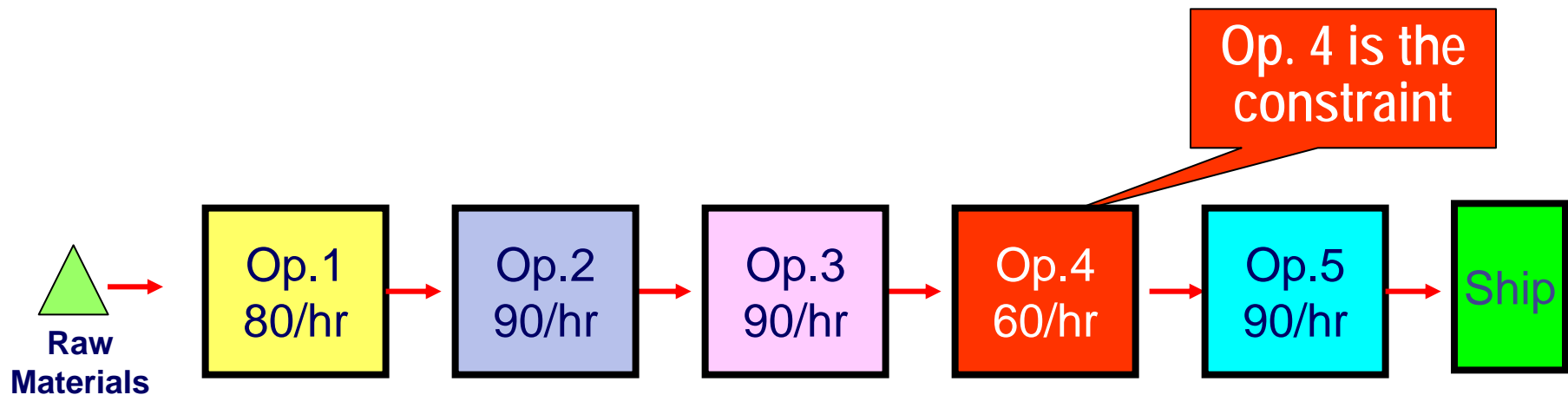
Both kanban, which is a part of the JIT philosophy, and drum-buffer-rope, which is a part of the theory of constraints (TOC) philosophy, represent synchronized production control approaches

Today, we will only focus on DBR



Drum Buffer Rope (DBR)

- ◆ DBR is the Theory of Constraints (TOC) generic production **planning** approach
 - First introduced in the book *The Race* by Goldratt and Fox in 1986
- ◆ Let's quickly review the basic DBR model
 - Assume customer demand is 100/hr
- ◆ What determines the output of this operation?



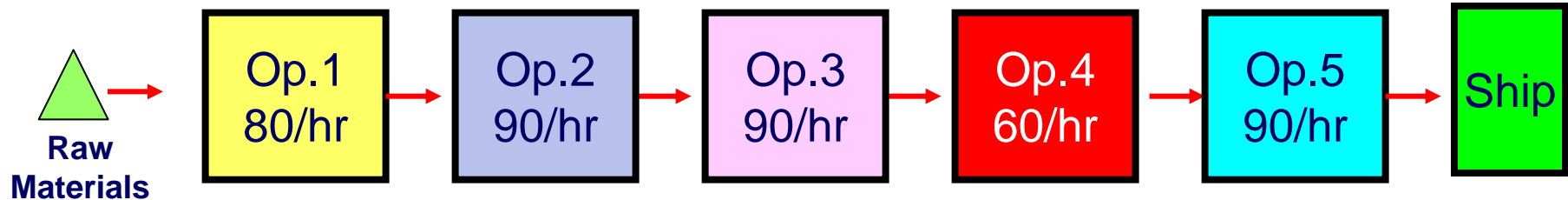
What is the Drum?

- ◆ Since the constraint dictates output, where should we schedule the operation?
 - We **finite** schedule at the constraint -DRUM
- ◆ This list acts as a drum beat dictating the pace of the operation
 - Is key for synchronization of all other resources

What factors must be considered when developing the Drum Schedule?

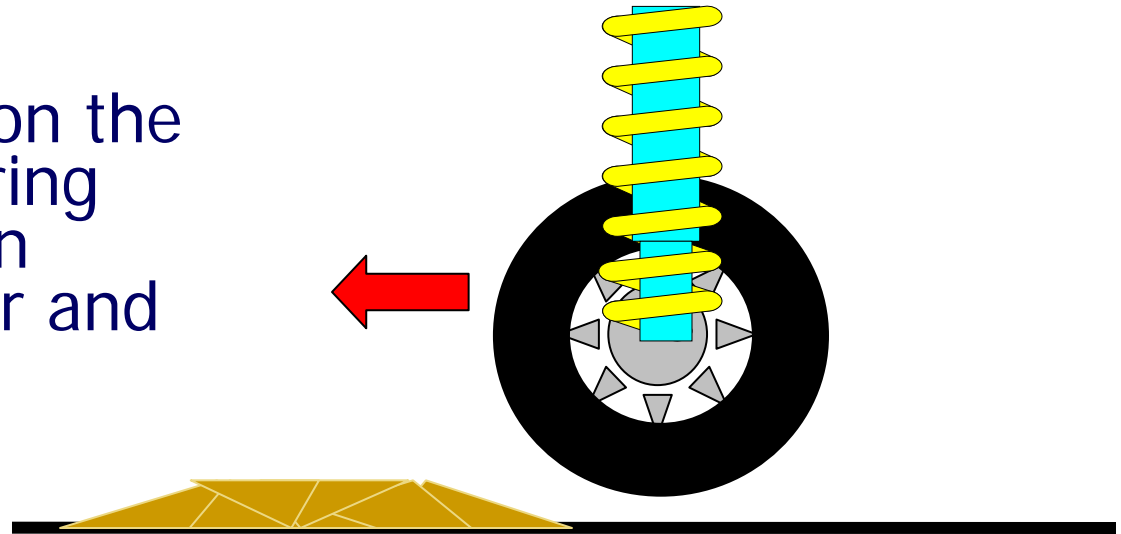


Drum Schedule		
Item	Qty.	Date
A	20	2/15
G	45	2/17
K	75	2/20



What is a Buffer?

- ◆ A buffer is analogous to a shock absorber in a car
- ◆ Without suspension the ride would be jarring and could result in damage to the car and the passengers

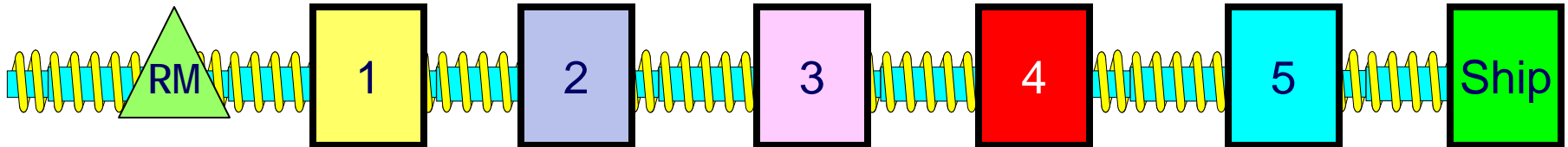


- ◆ The amount of buffer required for a car is a function of:
 - The desired ride
 - Condition of the road
- ◆ What about an operation?

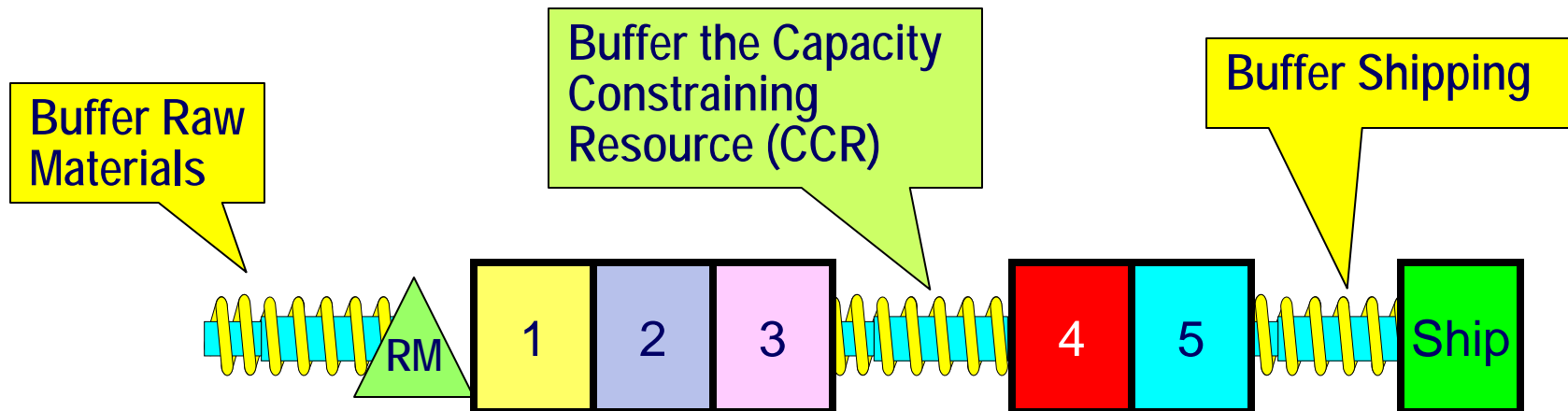


Where to Buffer?

- ◆ Everywhere?



- ◆ What is the typical result of buffering everywhere?
- ◆ In contrast, DBR buffers only in strategic points



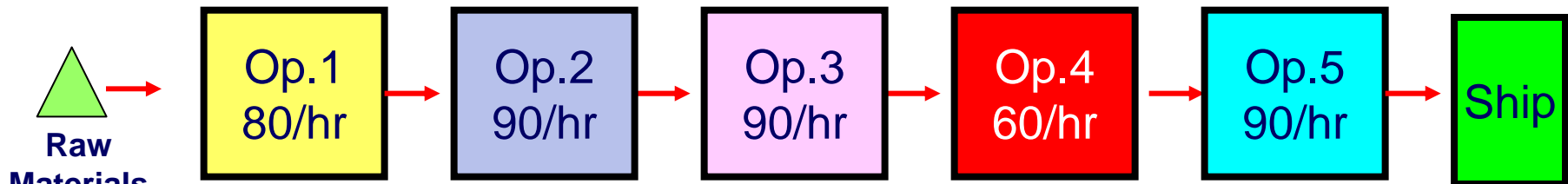
What is the Rope?

- ◆ The rope is the information flow from the Drum to the material release point which **chokes** the release of materials to match the flow through the constraint
 - A schedule derived by backward scheduling from the Drum Schedule by the time buffer
 - ◆ E.g. 5 days

Why is this important?

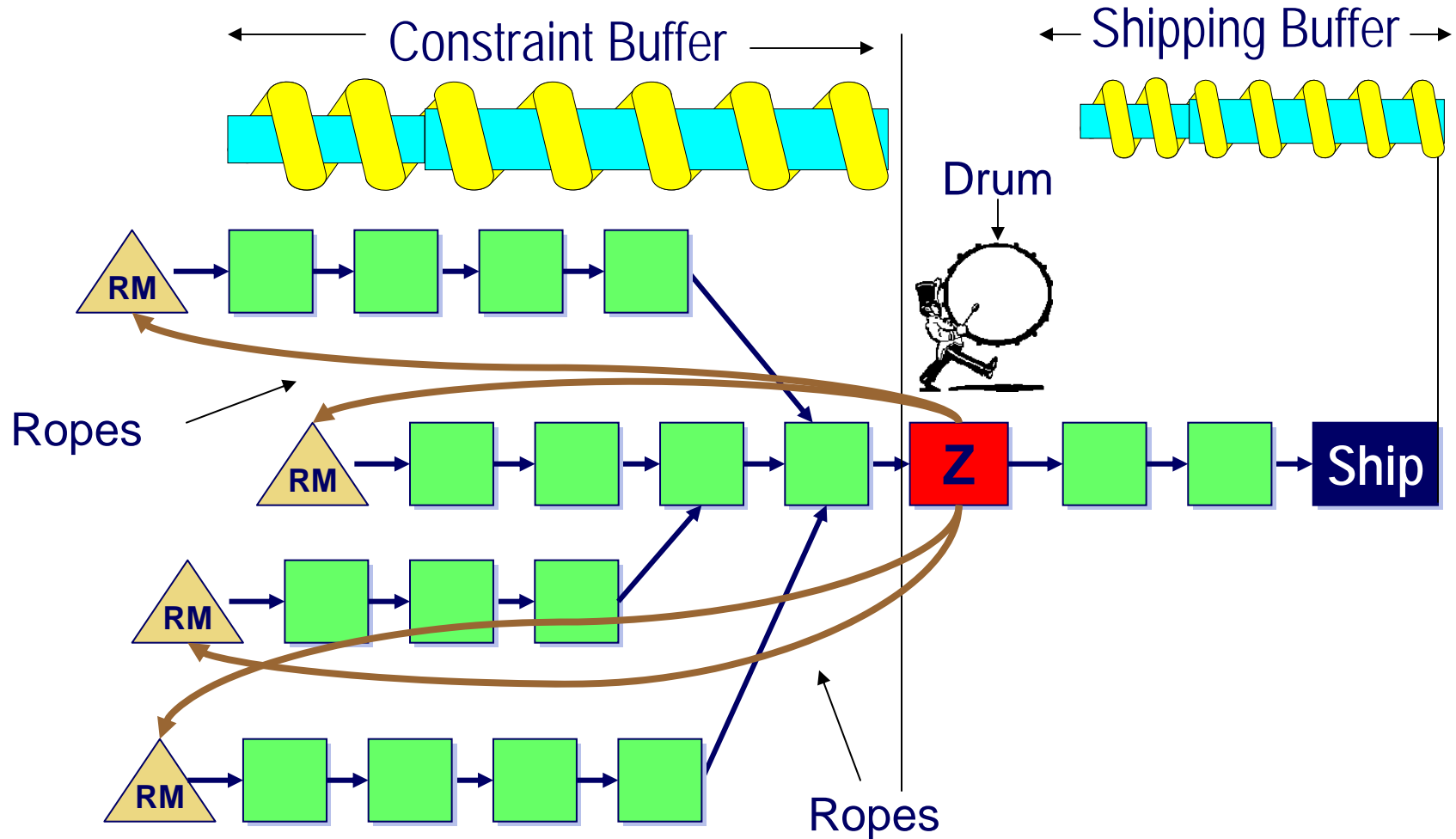
Release Schedule		
Item	Qty.	Date
A	20	2/10
G	45	2/12
K	75	2/15

Drum Schedule		
Item	Qty.	Date
A	20	2/15
G	45	2/17
K	75	2/20



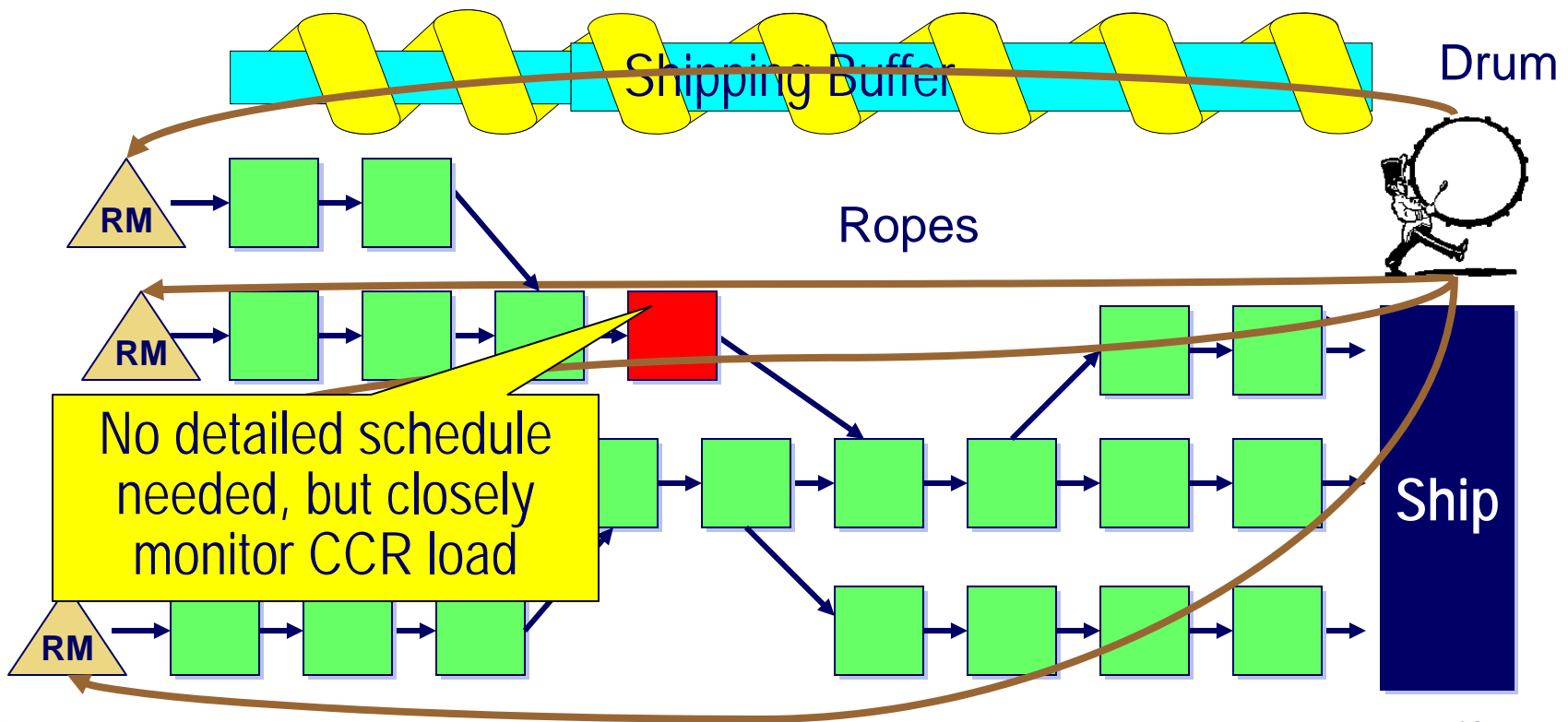
A More Complex Example

- ◆ Same concepts apply



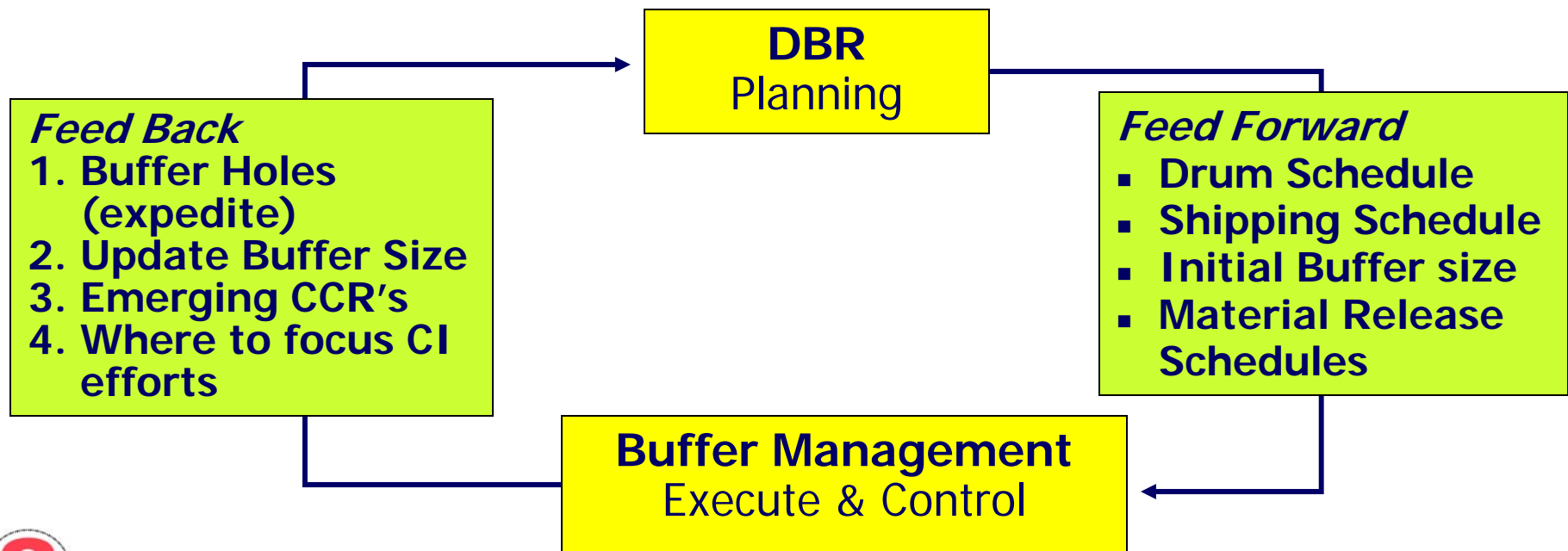
What if there is no Active CCR?

- ◆ In operations with ample excess capacity – no active capacity constraint resource (CCR) exists – we can use Simplified DBR (S-DBR)
- ◆ The Drum is simply the list of orders and their due dates
 - However, it is still necessary to monitor the most loaded resource (CCR) and limit its utilization < 80%



What is Buffer Management ?

- ◆ DBR is the TOC production **planning** methodology,
 - It is only part of the TOC Production Solution
- ◆ Buffer Management is the TOC **control and execution** methodology
 1. Provides real time prioritization of work orders
 2. Signals the need to adjust a given buffer size
 3. Mechanism to help determine continuous improvement efforts



What are we Buffering Against?

- ◆ What is the **one** thing we know about an operation?
- ◆ We are constantly fighting against
 - Uncertainty (external)
 - Variation (internal)
 - ◆ Common cause
 - ◆ Special cause
 - ◆ Tampering
- ◆ While we work to reduce variation and uncertainty, how many can claim these are no longer key issues at your organization?
 - If so, are there any openings?



There are 3 Ways to Buffer

- ◆ **Stock Buffer** - Inventories of specific products that are held in order to fulfill customer orders in less than the normal lead time
 - Raw
 - Sub-assembly
 - FGI



How else can we buffer against variation/uncertainty?

- ◆ **Time Buffer** - is the time interval by which we pre-date the release of work, relative to the date at which it is needed allowing for some level of variability - "Murphy"

90 Minutes



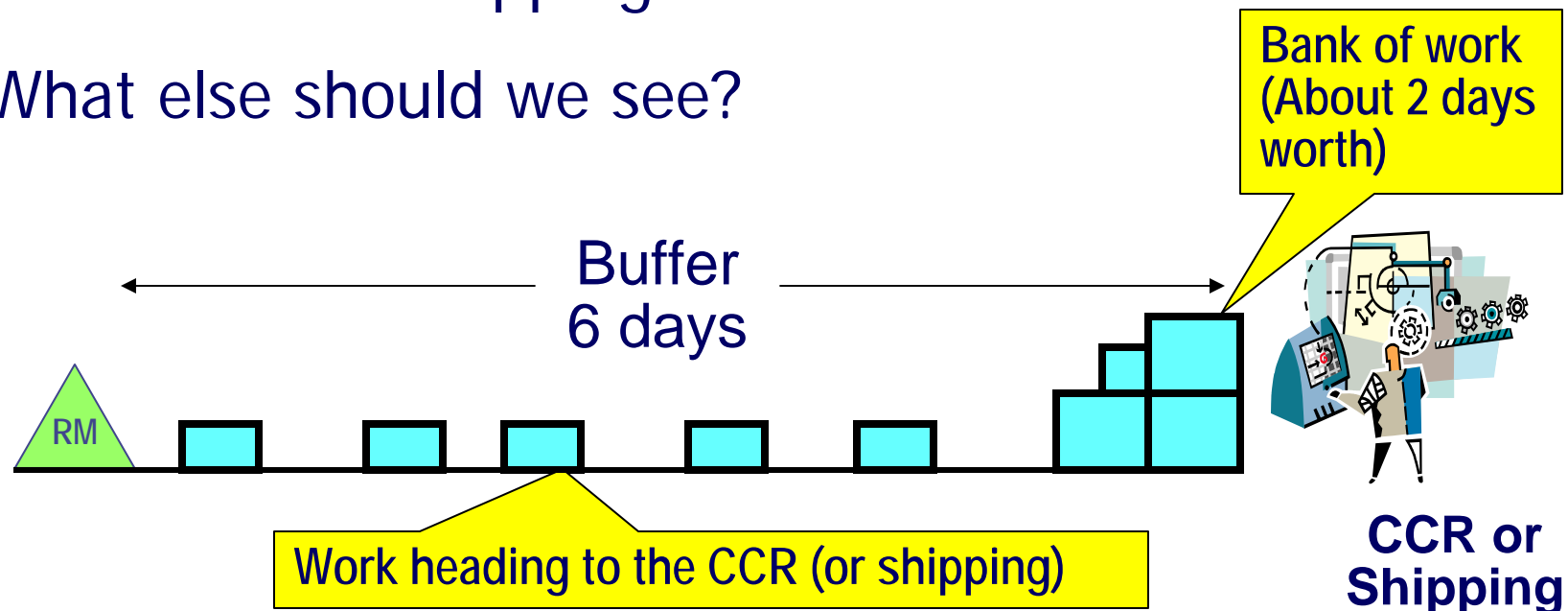
- ◆ If we know it takes 90 minutes to get to the airport, do we really leave 60 minutes before we should?

What is the third option?



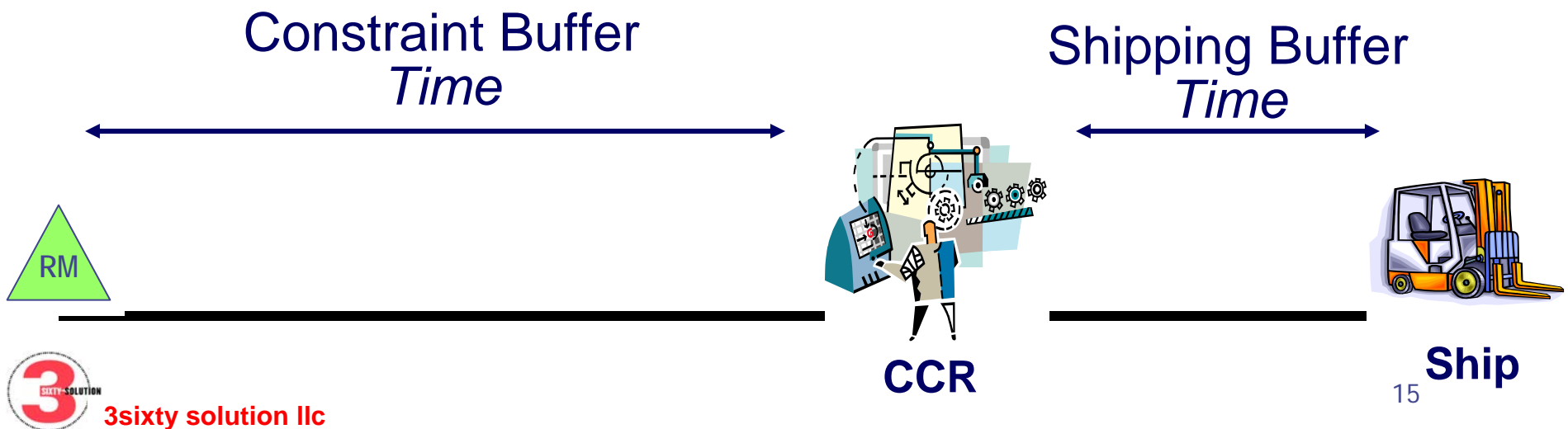
Buffers

- ◆ The buffers used in DBR are designed to overcome *common* delays; for more serious disruptions, we need something more – i.e. Buffer Management
- ◆ Assume we have 6 day buffer below
- ◆ What would we expect to physically find in front of the CCR or in shipping?
- ◆ What else should we see?



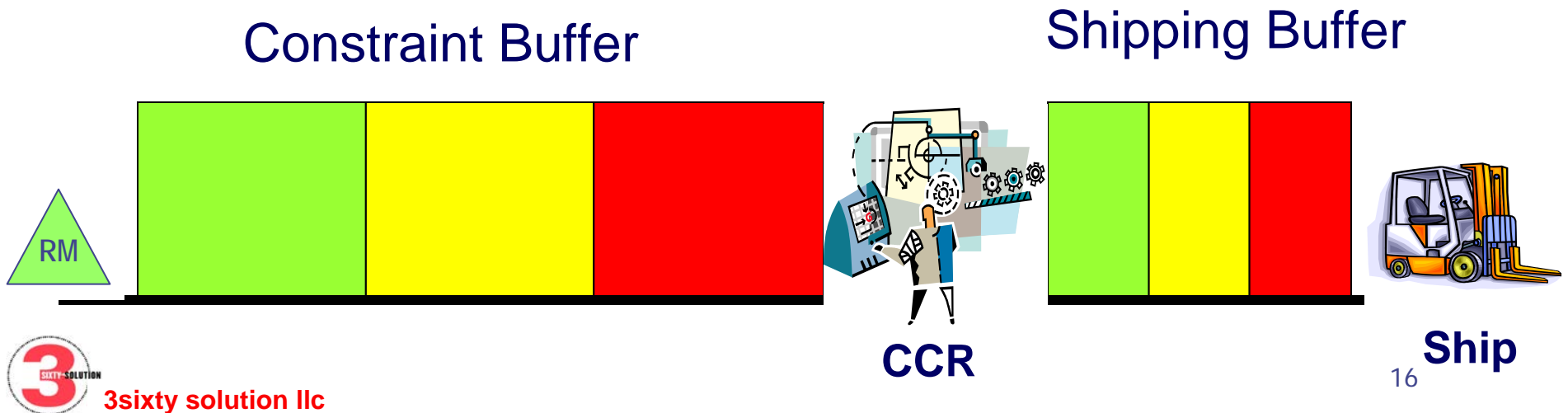
Time Buffer Mechanics

- ◆ The buffers are a continuing and changing (depending on the schedule) set of work to be processed
 - It protects the CCR and the Shipping Point from possible disruptions
 - The measurement of this buffer is always time
 - ◆ FYI- rule of thumb – pick the initial buffer to be 50% of current lead-time



Time Buffer (Con't)

- ◆ Just as a shock absorber has progressive levels of compression, we divide the time buffers into 3 zones
 - Green Zone (furthest from CCR or shipping)
 - Yellow Zone (Middle)
 - Red (next to the CCR or shipping)
- ◆ These zones will be used to determine what actions we should take if and when Murphy visits our plant
 - Acts as a early warning detection system



Time Buffer Details

- ◆ Here is the Drum Schedule, showing the Order, Product Quantity due date and time needed at the CCR (set up & run only)
 - Assume a 6 day time buffer, one 8 hr shift working weekends

Order A takes 4 hours in the CCR. It needs to start on 1/15, first thing in the morning

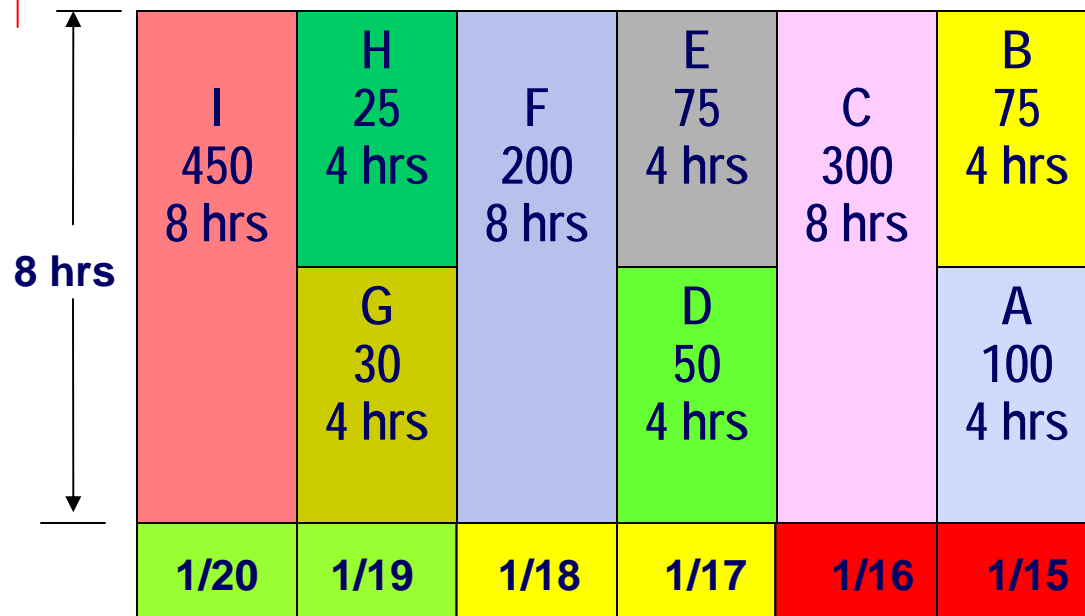
Order B takes 4 hrs. It needs to start on 1/15 at noon

Order	Qty	Due at CCR	Time in CCR
A	100	1/15 am	4 hrs
B	75	1/15 pm	4 hrs
C	300	1/16 am	8 hrs
D	50	1/17 am	4 hrs
E	75	1/17 pm	4 hrs
F	200	1/18 am	8 hrs
G	30	1/19 am	4 hrs
H	25	1/19 pm	4 hrs
I	450	1/20 am	8 hrs
J	30	1/21 am	4 hrs
K	40	1/21 pm	4 hrs



Time Buffer Details (Con't)

- ♦ Ideally, on 1/15 a.m. we would hope to see orders A, B, in front of the CCR
- ♦ We would expect to see the other orders to be in the intermediate operations moving towards the CCR or shipping



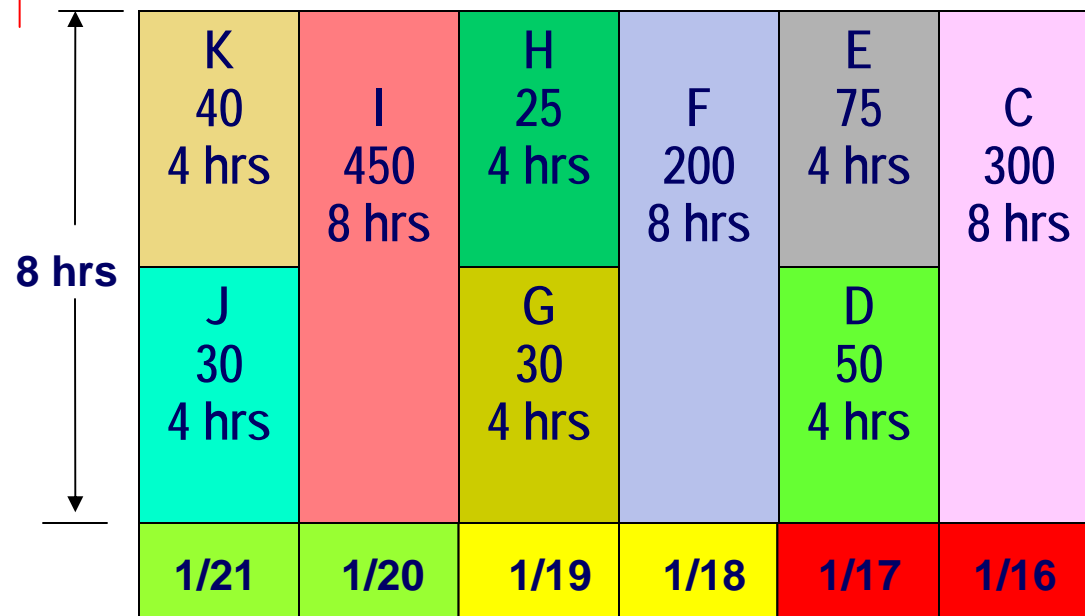
Buffer Status
as of 1/15

	Due at CCR	Time in CCR
A	1/15 am	4 hrs
B	1/15 pm	4 hrs
C	1/16 am	8 hrs
D	1/17 am	4 hrs
E	1/17 pm	4 hrs
F	1/18 am	8 hrs
G	1/19 am	4 hrs
H	1/19 pm	4 hrs
I	1/20 am	8 hrs
J	1/21 am	4 hrs
K	1/21 pm	4 hrs



Details (Con't)

- ◆ On 1/16 a.m. we would hope to see orders C in front of the CCR
- ◆ We would expect to see the other orders to be in the intermediate operations moving towards the CCR



Buffer Status
as of 1/16

	Due at CCR	Time in CCR
C	1/16 am	8 hrs
D	1/17 am	4 hrs
E	1/17 pm	4 hrs
F	1/18 am	8 hrs
G	1/19 am	4 hrs
H	1/19 pm	4 hrs
I	1/20 am	8 hrs
J	1/21 am	4 hrs
K	1/21 pm	4 hrs



Using the Buffer Zones

- ◆ A key objective of any control system is to detect potential problems **before** they impact the system
- ◆ Buffer Management uses the 3 zones to identify potential problem orders
- ◆ We expedite work when it should be in the **Red Zone but is NOT!**
 - I.e. it is **NOT** physically at CCR (or shipping) after 2/3 of the buffer time has passes
 - It is missing in action!

Orders missing
in Green Zone-
Don't worry!

Orders missing
in Yellow Zone-
Monitor

Orders missing
in Red Zone-
Expedite

Not expected to
be physically at the
CCR (or in Shipping)

Fair chance to
be at the CCR
(or in Shipping)

Expected to already
be at the CCR (or
in Shipping)



Buffer Holes

- ◆ Assume it is 1/16
 - This is the planned buffer status
- ◆ Murphy decides to show up!
- ◆ A few orders are missing!
 - These are called buffer holes



MURPHY

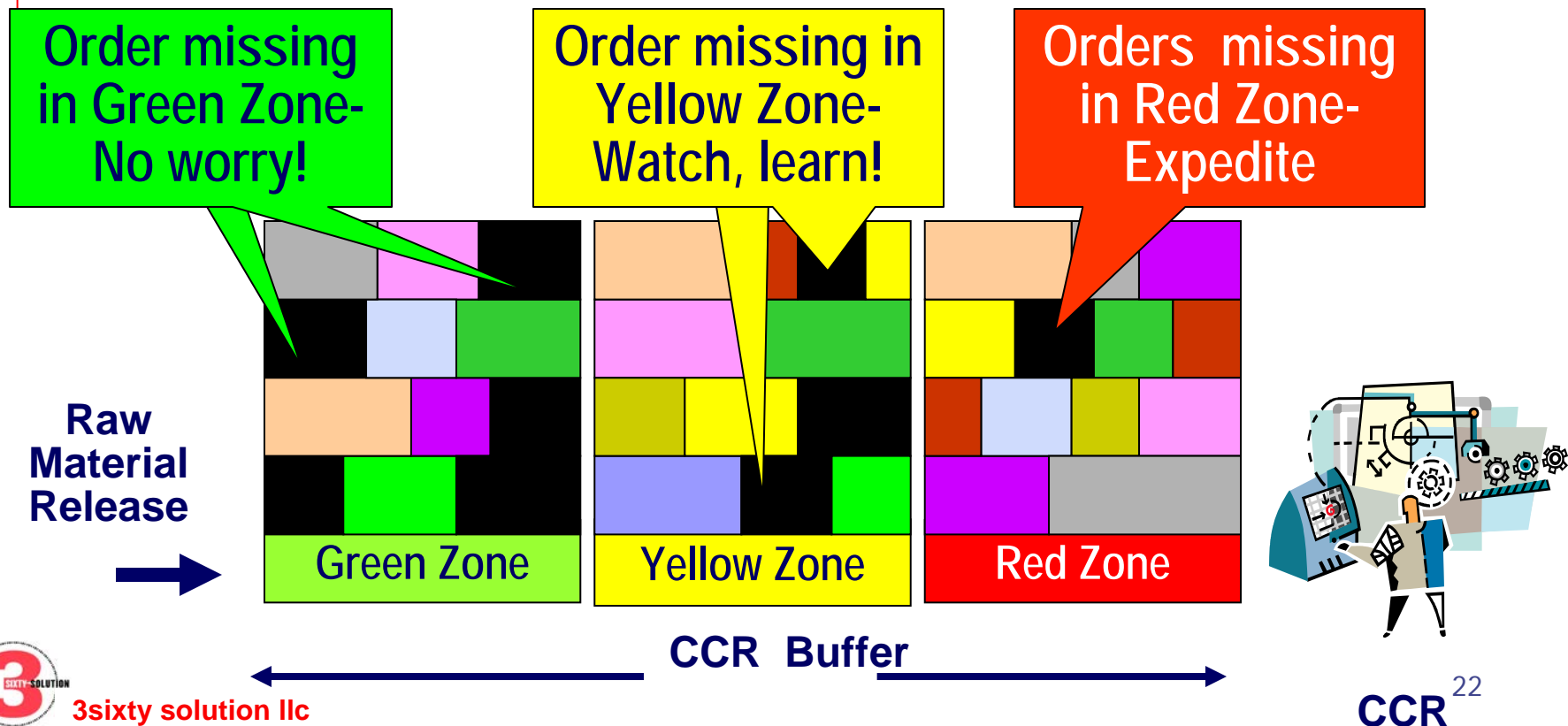
K 40 4 hrs	I 450 8 hrs	H 25 4 hrs	F 200 8 hrs	E 75 4 hrs	C 300 8 hrs
J 30 4 hrs		G 30 4 hrs		D 50 4 hrs	
1/21	1/20	1/19	1/18	1/17	1/16

Buffer Status
as of 1/16



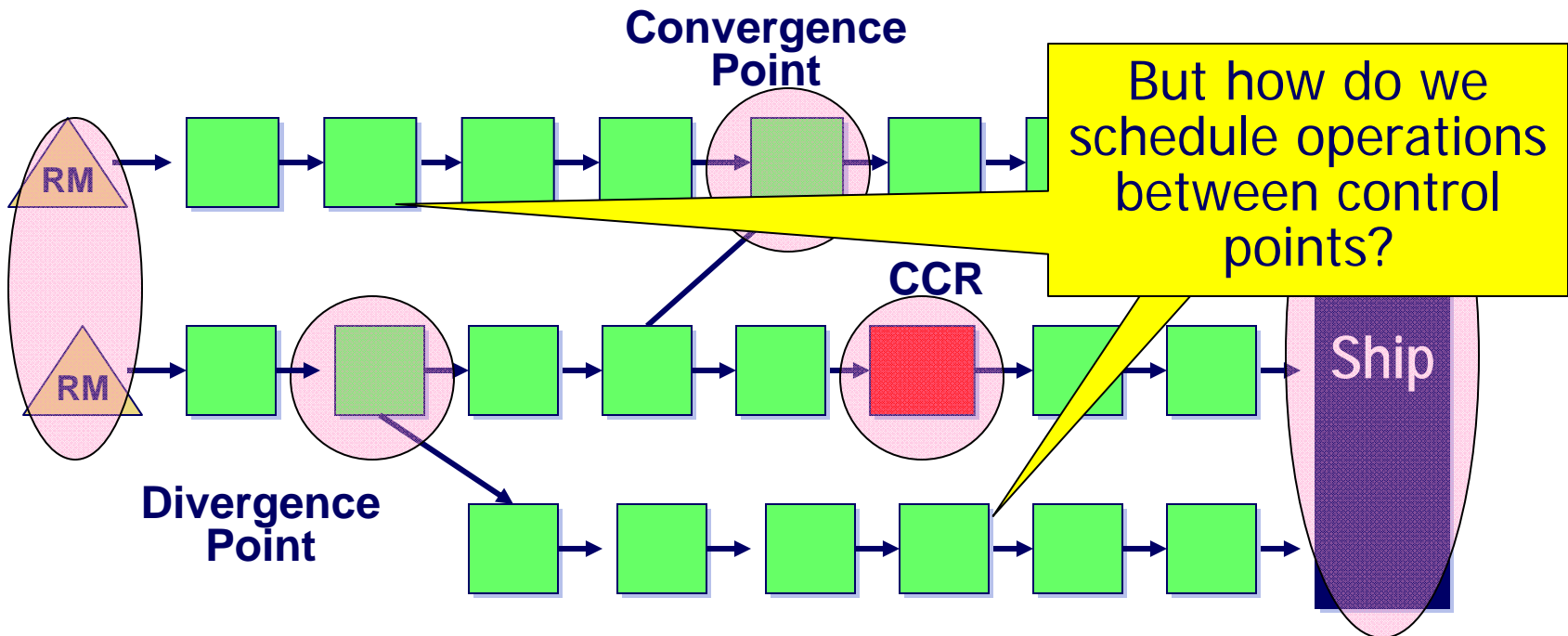
1. Prioritizes Work

- ◆ Expedites are based and synchronized to the Drum schedule – thus are global in nature
 - Usually in time to do something about it
 - Minimizes expediting (local vs. global)
 - Reduces stress levels of people



Priority Rules

- ◆ In DBR, there are only 5 control points requiring a formal priority list
 - 1. Material Release points, 2. the CCR, 3. Shipping, 4. Divergence points, 5. Convergence points
- ◆ All other resources in the operation utilize the *roadrunner* work ethic



A New Work Ethic

- ◆ Our traditional work ethic is to keep everyone busy
 - “ If a worker doesn't have something to do, let's find him something to do ”
- ◆ With synchronized production, a new work ethic is needed
 - “Road Runner” Work Ethic
- ◆ What does “Road Runner” mean to you?



Buffer Consumption

- ◆ We can quantify the buffer status to help prioritize work

$$\text{Buffer Consumption} = \frac{\text{Buffer Duration} - \text{Remaining Duration}}{\text{Buffer Duration}}$$

- ◆ For example, assume today is 1/20
 - Order A is due in shipping on 1/23, its shipping buffer is 9 days
 - Order B is due at shipping on 1/24, its shipping buffer is 6 days
 - Order C is due in shipping on 1/23, its shipping buffer is 12 days

While FIFO is the DBR default mode, here the buffer manager would re-prioritize the order

Note – we would not likely expedite order A

priority?

$$\text{Buffer Consumption A} = \frac{9 - 3}{9} = \frac{6}{9} = 66\%$$

$$\text{Buffer Consumption B} = \frac{6 - 4}{6} = \frac{2}{6} = 33\%$$

$$\text{Buffer Consumption C} = \frac{12 - 3}{12} = \frac{9}{12} = 75\%$$



Shipping Buffer Report

- ◆ Here is an example
- ◆ The negative number can be caused by several reasons
 - Order released prematurely
 - The the order released early due to scheduling consideration on the CCR.

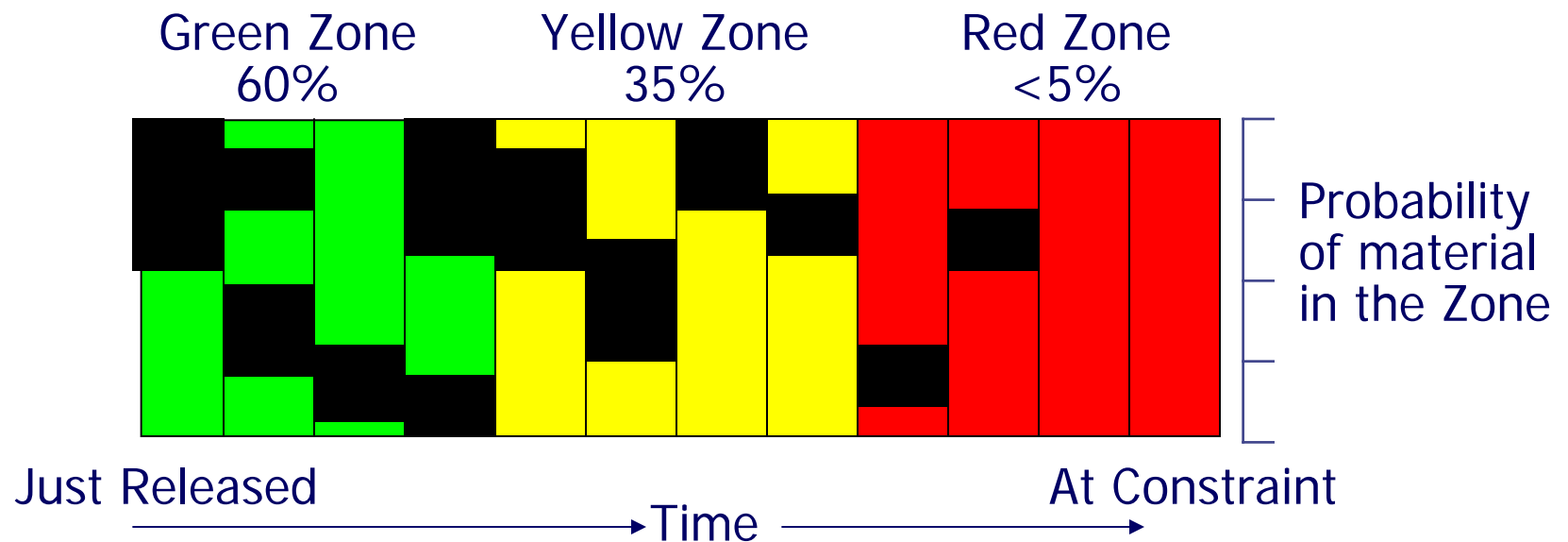
This order better be at shipping

Shipping Buffer Status			Current Time (sec)	200	Day 1			
WO#	Prod	Qty	Expected at shipping (sec)	Customer Promise Date (sec)	Buffer	Remaining Time (cust)	Buffer Consumption	Priority
WO 8	C	10	309	240	240	40	83%	1
WO 1	A	12	600	480	600	280	53%	2
WO 5	B	15	597	720	240	520	-117%	
WO 9	C	18	786	720	240	520	-117%	
WO 2	A	6	700	720	600	520	13%	3
WO 10	C	12	786	960	240	760	-217%	
WO 6	B	15	1434	960	240	760	-217%	
WO 3	A	14	900	960	600	760	-27%	
WO 7	B	20	1434	1200	240	1000	-317%	
WO 4	A	8	1000	1200	600	1000	-67%	



2. Signals if Buffer Size is Appropriate

- ◆ If the operation is typically expediting less than 5% of the work, the buffer is too big
 - Results in excessive lead-time and inventory
- ◆ If the operation is typically expediting greater than 5% of the work, the buffer is too small
 - Results in wasting efforts and putting service level at risk!
- ◆ Typical expedite percentages are shown



3. Analysis of Red Zone Penetration

- ◆ When an order penetrates the red zone, we have opportunity to understand where a disruption in the system occurred
- ◆ We can record where the expediting took place
 - i.e. department /machine /supplier etc.
- ◆ At the end of the month, summarize and create a Pareto Chart of causes of Red Zone penetrations
 - This will help focus efforts of any Lean or Six Sigma initiatives
 - May also indicate a possible emergence of a new CCR as a result of product mix changes etc.

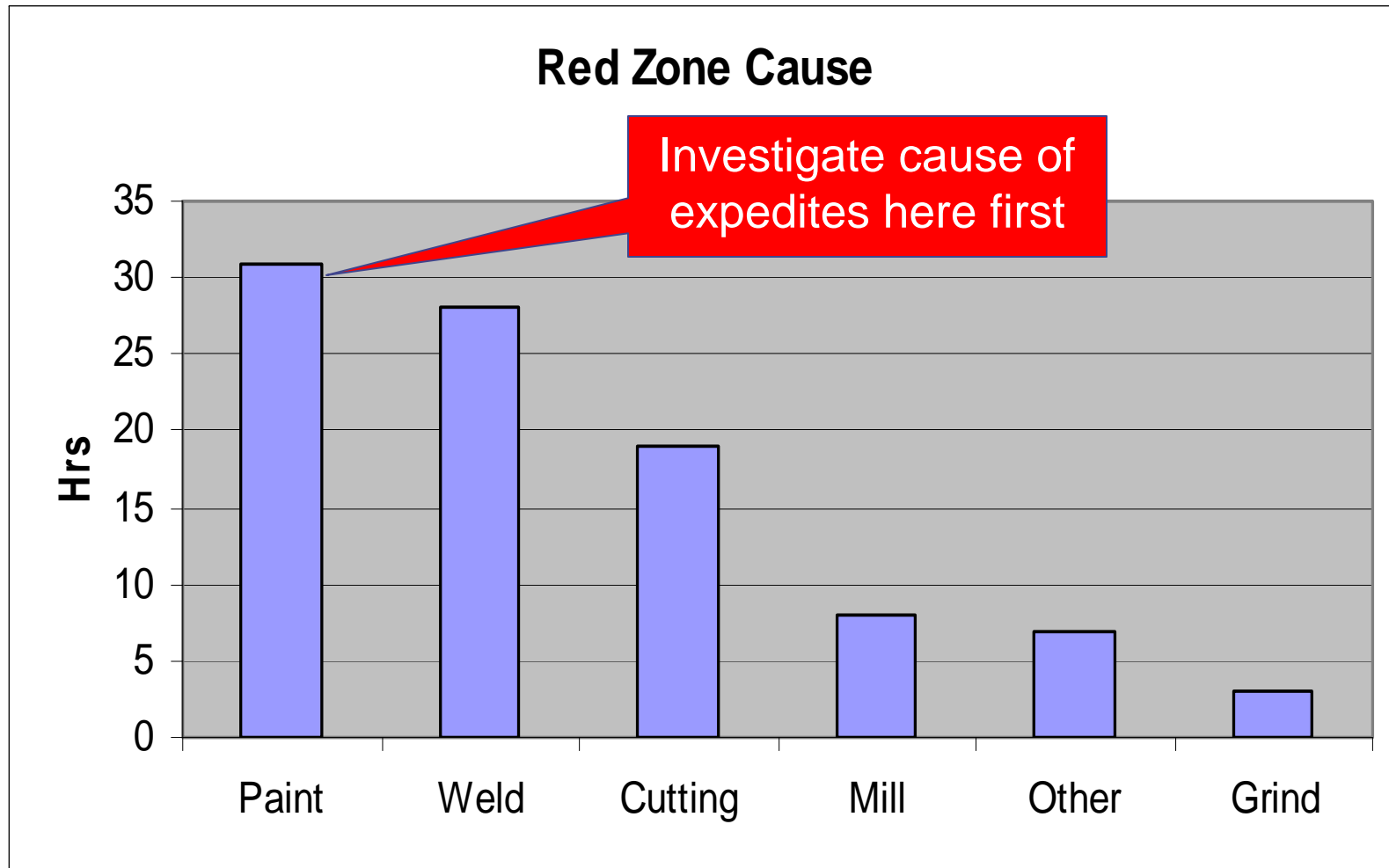


Buffer Analysis Table

Area Accountable - Drum Time Hrs							
Week	Cutting	Paint	Mill	Weld	Grind	Other	Total Hrs
1/1	2	5		2		1	10
1/8	6	3	1	1	1		12
1/15	1	4		1			6
1/22		6	2	2	1		11
1/29	1	2		1		1	5
2/5	2	3	3	2	1		11
2/12		2		1			3
2/19	1	1					2
2/26	3	2		2		2	9
3/5	1		1	3			5
3/12		2		4		1	7
3/19	1	1					2
3/26	1			4			5
4/2			1	5		2	8
Total	19	31	8	28	3	7	96



Buffer Analysis Graph



Buffer Management

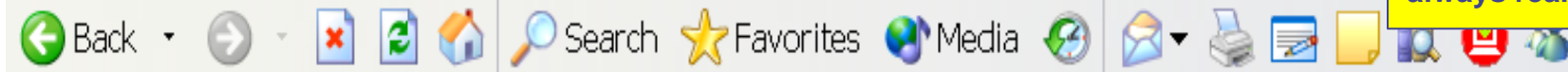
- ◆ As with any function, it must be managed to be successful
 - The 'buffer manager' concept is an important role
- ◆ How this is organized will depend on many factors
 - In a small firm the supervisor could act as buffer manager
 - In a larger firm a senior planner, production manager etc. could act as buffer manager
- ◆ The Buffer Manager must have the vested authority to determine the priority of work in the **non-constraint** areas
 - Buffer management reporting is the control mechanism that **replaces** legacy efficiency reporting
- ◆ Realistically, unless the operation is small, some software support is required to get the full benefits of Buffer Management



Real-time Priorities

Operator Screen
Operators' priorities are always real-time

File Edit



Address <http://localhost/synchrono/MfgPlannerWeb/Execution/ResourcePriority.aspx>

Planning Execution Demand Quantity Items Analysis Reports

Where do I go if I don't have anything to work on?
Just retrieve priority lists for ALL w/c and go where you see Reds. It's that simple!

Filter:
Resource Name: Release Status:
Resource Nbr: From Release Date:

Cycle consume & buffer zone colors help you focus on the problem:
Is someone not following the priority?

Results:

	Cycle Consume	Item	Item Desc	Wo Nbr	Order Nbr	Resource Name	Resource Nbr	Net Required	Total Time	Setup Type
>>	100%	1401	Econ ELEC Powertrain	WK01897-10	4226-1	Econ PT	1	6	3	
>>	100%	1210	Econ, Frame Assembly	WK01898-10	4226-1	Econ FR	1	6	1.5	
	100%	1430	Econ Car, ELEC,	WK01896-10	4226-1	Econ L	1	6	6	
>>	65%	1401	Econ ELEC Powertrain	WK01891-10	4213-4	Econ PT	1	3	1.5	
>>	65%	1210	Econ, Frame Assembly	WK01892-10	4213-4	Econ FR	1	3	0.75	
		1430	Econ Car, ELEC,	WK01890-10	4213-4	Econ L	1	3	3	
>>			Econ ELEC Powertrain	WK01885-10	4211-1	Econ PT	1	2	1	
>>				886-10	4211-1	Econ FR				
				884-10	4211-1	Econ L				
>>				894-10	4214-1	Econ PT				
>>				895-10	4214-1	Econ FR	1	3	0.75	
				893-10	4214-1	Econ L	1	3	3	

Single most important question - What do I work on next?
>> indicates you have all the material in queue that you can work on

No start/finish dates for operation/work-orders
Instills true relay-runner ethic

Pull-Based Replenishment

File Edit View



Address <http://localhost/synchono/asp/buffer/stock.asp>

Continuous Improvement
Goal is to Keep items in the
"Yellow Zone"

Planning Execution Demand Supply Items Analysis Reports

Monitor Inventory Position and Health

Item Type Code: Item Nbr: Buffer Status: Show Chevron: Planner Code:

	Buffer Consume Pct	Item Nbr	Item Desc	Item Type Code	Current Inv Qty	Supply Qty	Demand Qty	Order Policy Code	Supply Suggest	Demand Suggest	Buffer Qty	Reorder Qty	Safety Stock	Planner Code	Days Of Supply Qty
	100	507	STEERING ASSEMBLY	BUY	0	0	1	MM	20		20	10	5		0
»	100	1532	Tires, White	BUY	0	0	0	MM	140	4	100	50	20		0
»	100	1306	Econ,Club Cleaner, Beige	BUY	0	0	0	MM	30	1	20	10	5		0
»	100	5487	Glove Box, Black	BUY	0								7		0
»	73	6861	Pro, Body, Biege	BUY	28								10		1.4
»			MUD TIRES	BUY	32								20		1.6
»	62		4X4 FRONT END ASSEMBLY	BUY	8	0	1	MM	12		20	10	5		2
»				BUY	22	0	1	MM	0		20	10	5		5.5
»				BUY	25	0	0	MM	15	1	20	10	5		6.25
»	-150	201	Towing Bracket, Rear	BUY	50	0	1	MM	0		20	10	5		12.5
»	-250	6812	Pro, Motor, 48V, DC Wound	BUY	70	0	1	MM	0		20	10	5		17.5
»	-300	2202	Winshield Kit	BUY	100	0	9	MM	0		25	15	7		20
»	-375	1207	Steering Assembly	BUY	95	0	21	MM	0	6	20	10	5		23.75
»	-425	1205	Floor Boards	BUY	105	0	21	MM	0	6	20	10	5		26.25

Know when a part is starting to run low on Inventory

Easily identify stock out risks

Benefits of Buffer Management

1. DBR provides the **planning**, buffer management the **execution**
 - BM gives real-time updates and sets priorities of all resources based on global needs, not what is easy or convenient for the particular resource
 - Provides dynamic buffer sizing
2. Indicates where improvement efforts will yield the best bang for the buck
3. Gives pre-warning of the possibility of a bottleneck shift due to mix changes
4. In the event of increases sales, it will point to which resources will need additional capacity



Getting Started

- ◆ Get meaningful understanding the concept of DBR and BM (not a flavor of the month)
 - Get consensus on the concept (use video's. books, presentations etc.)
- ◆ Eliminate measurement of local efficiencies
 - ◆ Get management buy-in that measuring local efficiencies results in motivating the wrong behaviors (local vs. global)
- ◆ Get consensus on the Drum (whether an active CCR or a real Market Constraint)
- ◆ Get consensus on the initial Buffer sizes
- ◆ Get consensus on the mechanism to tie the rope
- ◆ Get consensus from those who will directly work using DBR & BM
- ◆ List key obstacles and possible steps to overcome these obstacles
 - Roadmap



Summary

- ◆ DBR-BM takes the approach that a **good-enough** planning coupled with a **real-time and robust control** system is the most pragmatic approach
 - Similar what is used in the military
- ◆ It can be implemented in less than 6 months
 - DBR software is available and is compatible with most ERP systems
- ◆ Filters real signals from the day-to-day 'noise' of the system
- ◆ Provides workers with realistic work priorities
- ◆ Alerts us to potential problems before they become real problems
- ◆ Advises when buffers are too short or too long
- ◆ Provides a focusing mechanism for continuous improvement efforts



Questions?





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