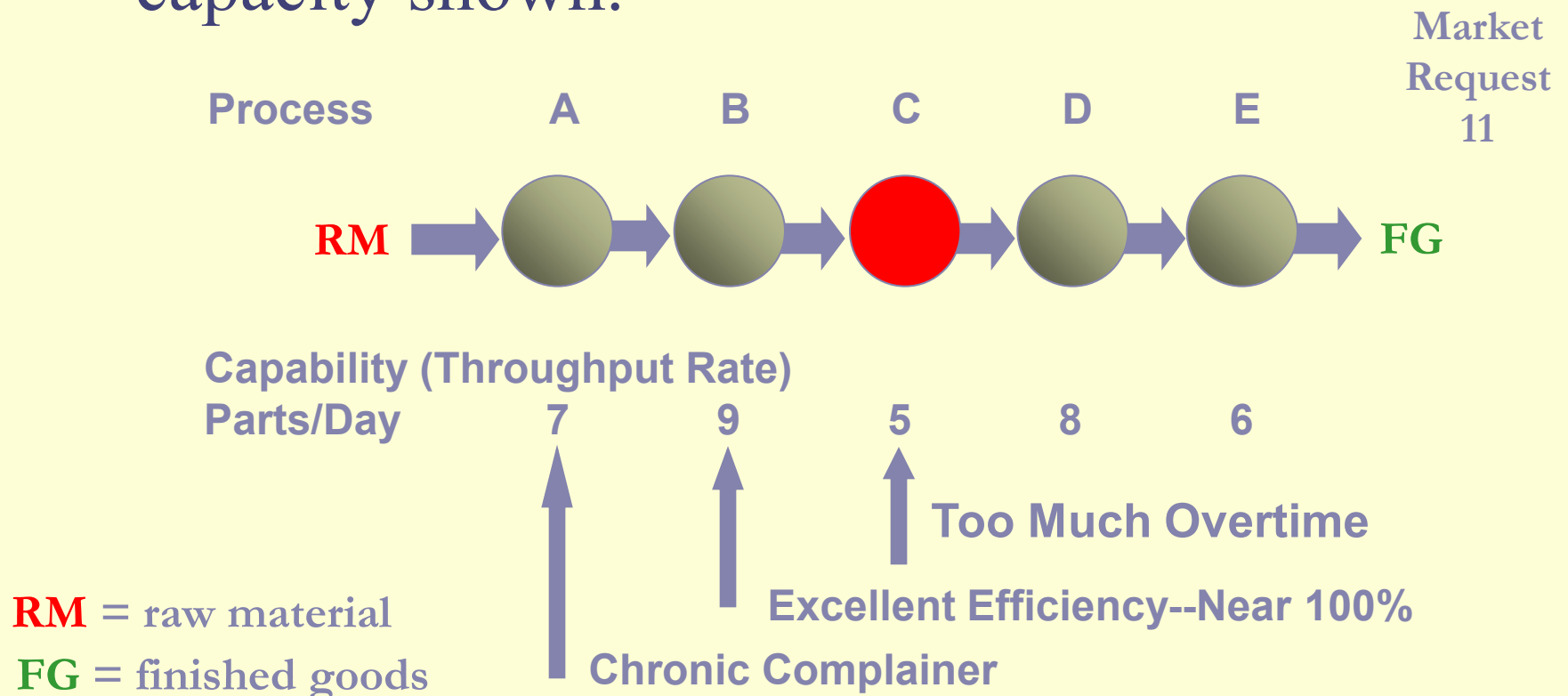# Drum –Buffer-Rope

Based on : R. Holt, Ph.D., PE
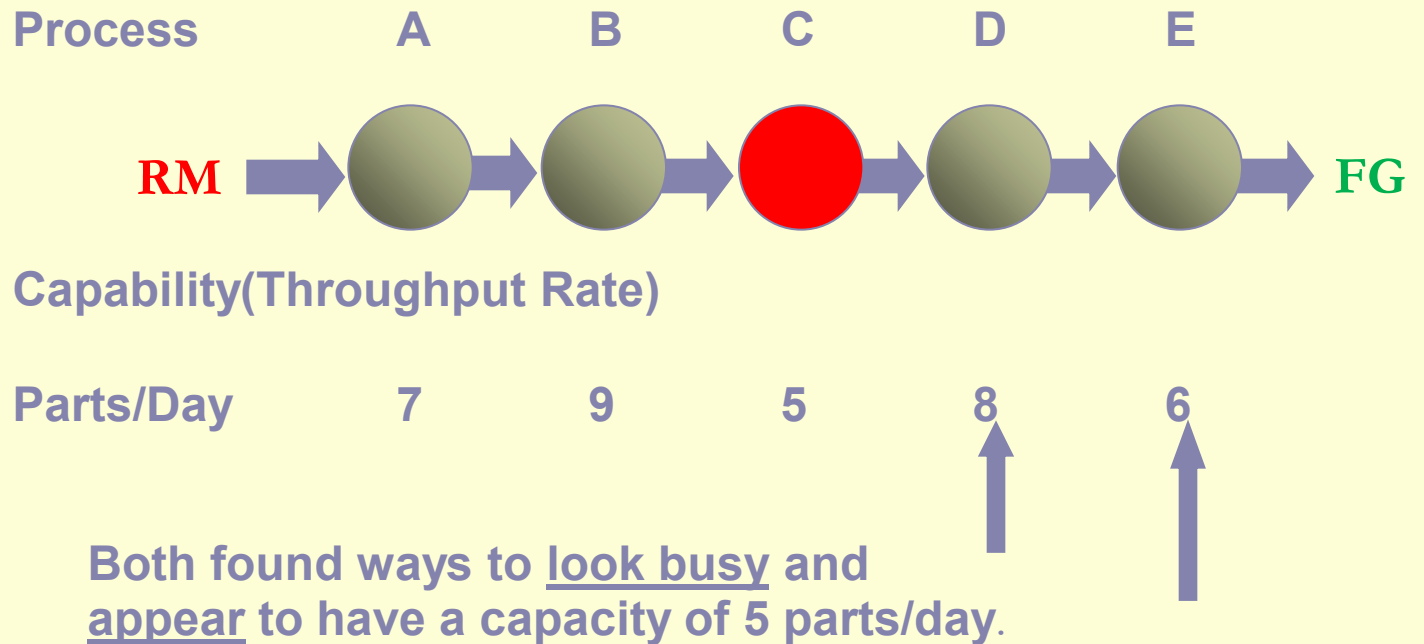
We Measure Operational Efficiency

- Work flows from left to right through processes with capacity shown.

Market Request 11

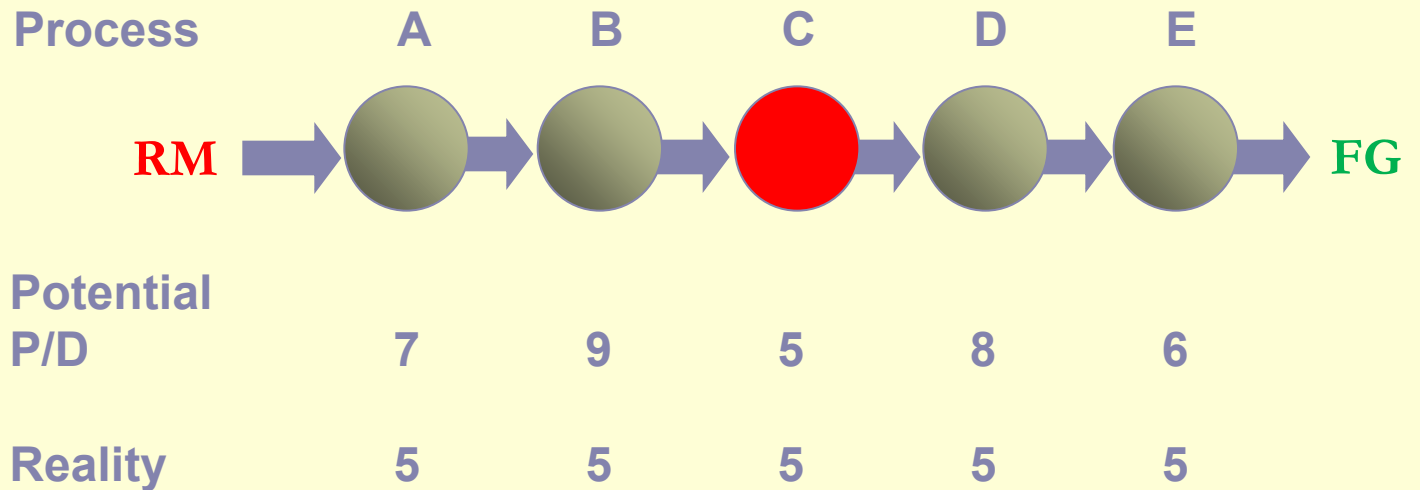| Process | A | B | C | D | E |

RM → A → B → C → D → E → FG

Capability (Throughput Rate) Parts/Day

| 7 | 9 | 5 | 8 | 6 |

Too Much Overtime

Excellent Efficiency--Near 100%

Chronic Complainer

RM = raw material

FG = finished goods

Reward Based on Efficiency

- Work flows from left to right.

Process	A	B	C	D	E

RM ➤ (A) ➤ (B) ➤ (C) ➤ (D) ➤ (E) ➤ **FG**

Capability(Throughput Rate)

Parts/Day	7	9	5	8	6

Both found ways to <u>look busy</u> and <u>appear</u> to have a capacity of 5 parts/day.

In reality...

- Processes A and B won't produce more than Process C for long.

Process	A	B	C	D	E	
RM →	⬤	⬤	🔴	⬤	⬤	→ FG
Potential P/D	7	9	5	8	6	
Reality	5	5	5	5	5	

P/D=parts/day

Then Variability Sets In

- Processing times are just AVERAGE Estimates

Process	A	B	C	D	E
RM →	7	9	5	8	6	→ FG
Reality	5 2	5 2	5 2	5 2	5 2
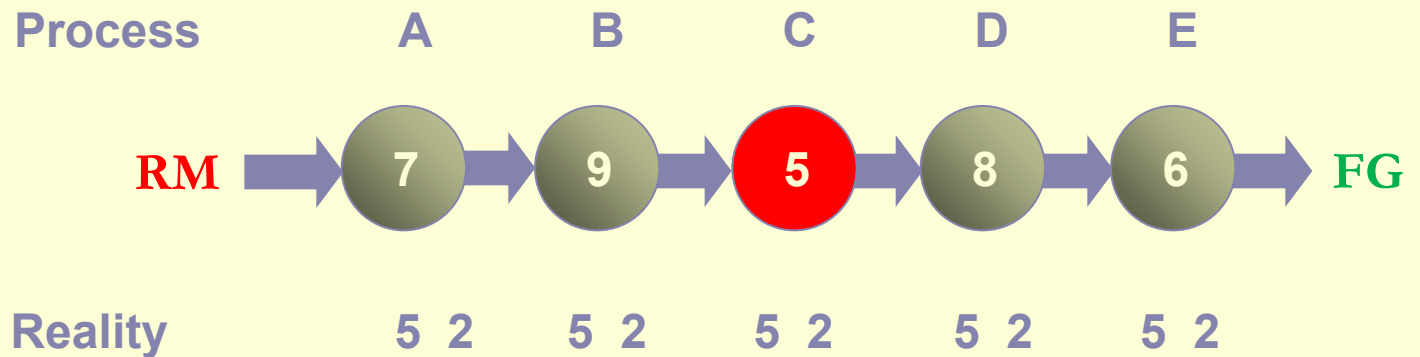
What's an Average? 50%

- Half the time there are 5 or more per day at each process--Half the time less

Process	A	B	C	D	E

RM → 7 → 9 → 5 → 8 → 6 → FG

Reality: 5 2   5 2   5 2   5 2   5 2
Probability: 0.5   0.5   0.5   0.5   0.5

Two at a time: 0.25   0.25

Over all: 0,5*0,5*0,5*0,5*0,5=0,03125=3% Chance of 5 per day !!!
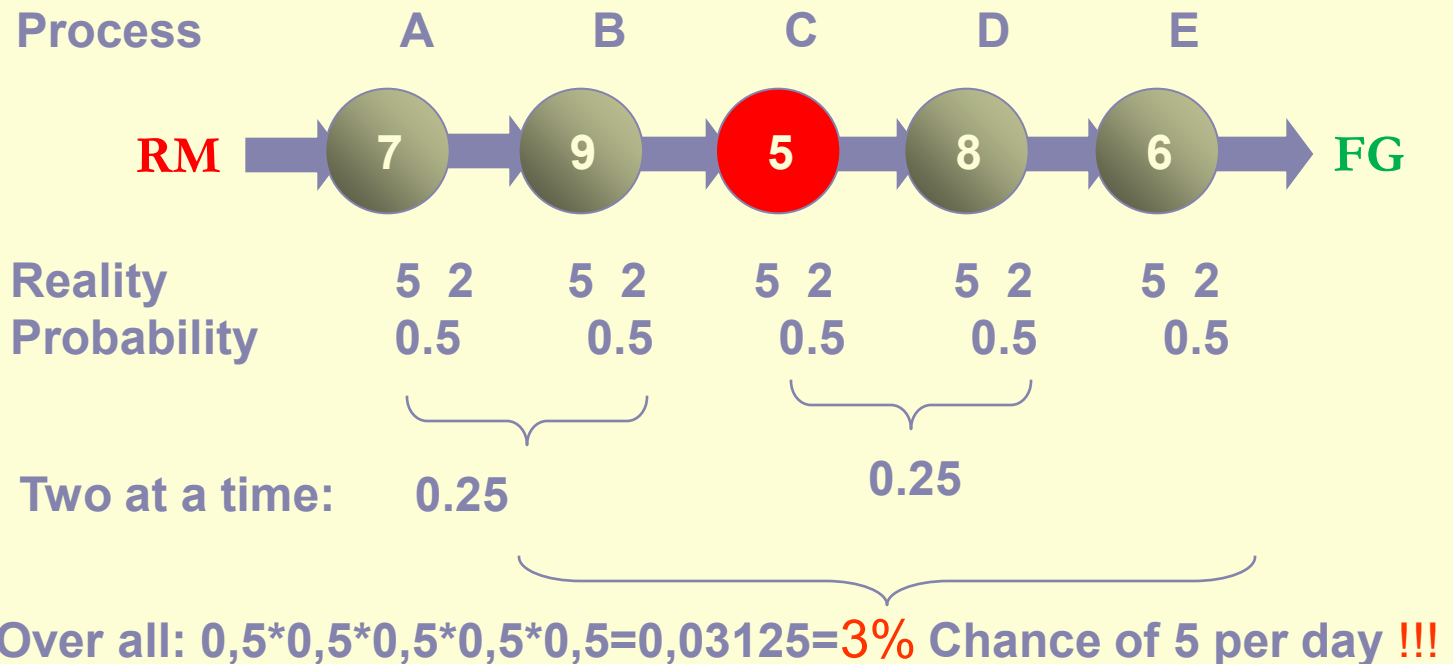
Previous Solution: Inventory

🔵 Put a day of inventory (WIP) at each process!

WIP	5	5	5	5	5	Total 25
Process	A	B	C	D	E	

RM ➤ 7 ➤ 9 ➤ 5 ➤ 8 ➤ 6 ➤ FG

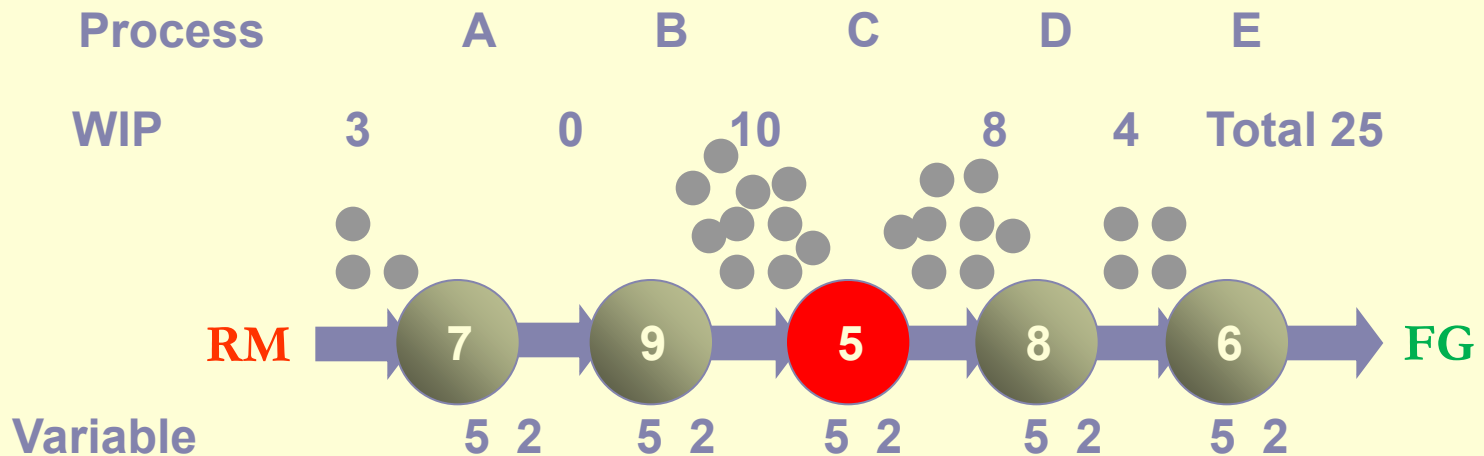| Variable Process		5 2	5 2	5 2	5 2	5 2
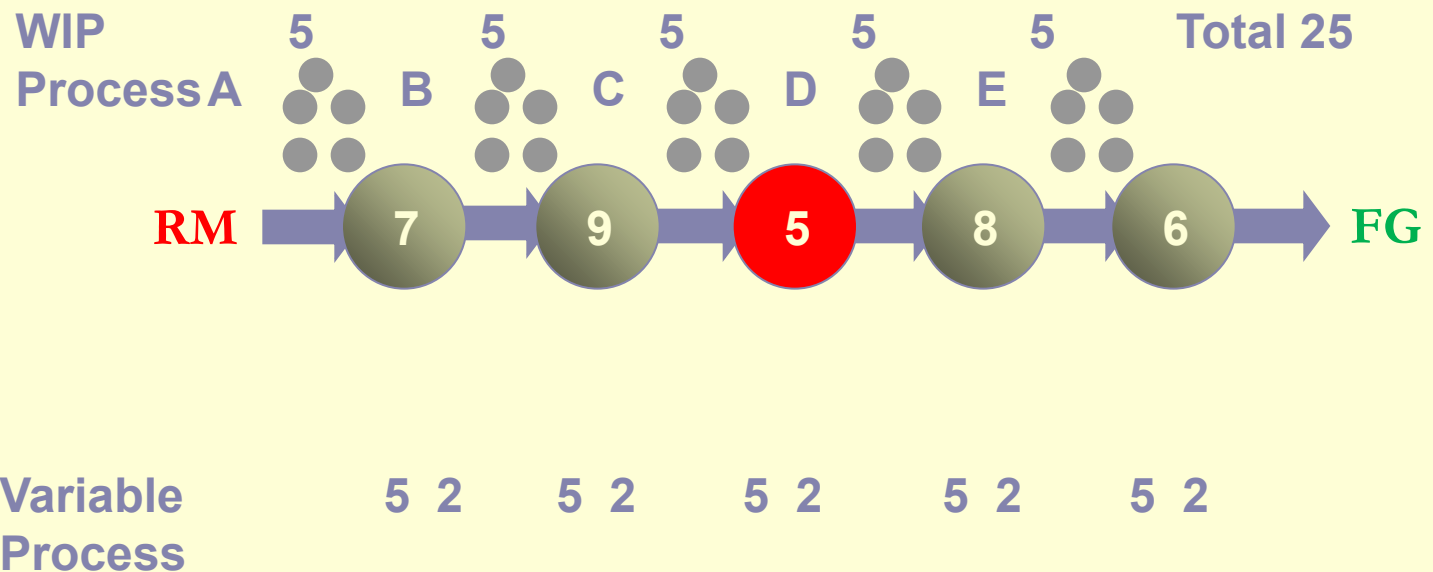
System Variability Takes Over--Chaos

Inventory (WIP) quickly shifts position.
Inventory manager tries to smooth it out.
Distribution problems result. Costs go up !!!

Process		A	B	C	D	E	
WIP		3	0	10	8	4	Total 25

RM ➞ **7** — **9** — **5** — **8** — **6** ➞ FG

Variable Process		5 2	5 2	5 2	5 2	5 2
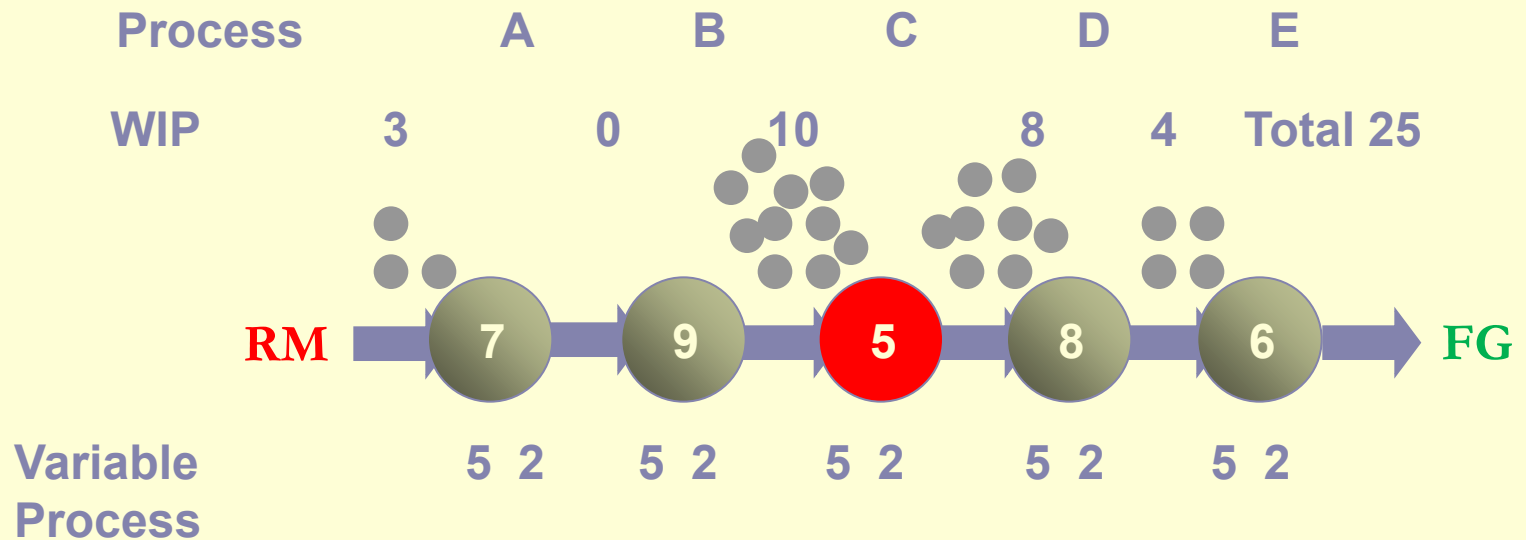
System Variability Takes Over--Chaos

An Average of 5 means sometimes 3 and some times 7

Process	**A**	**B**	**C**	**D**	**E**
WIP	3	0	10	8	4	Total 25

RM → 7 → 9 → 5 → 8 → 6 → FG

Variable   5 2   5 2   5 2   5 2   5 2

Process

Shifting work-in-process creates large queues at some locations. This makes work wait longer to be processed. (based on Little s law)

System Variability Takes Over--Chaos

Process	A	B	C	D	E
WIP	3	0	10	8	4 Total 25

RM → 7 → 9 → 5 → 8 → 6 → FG
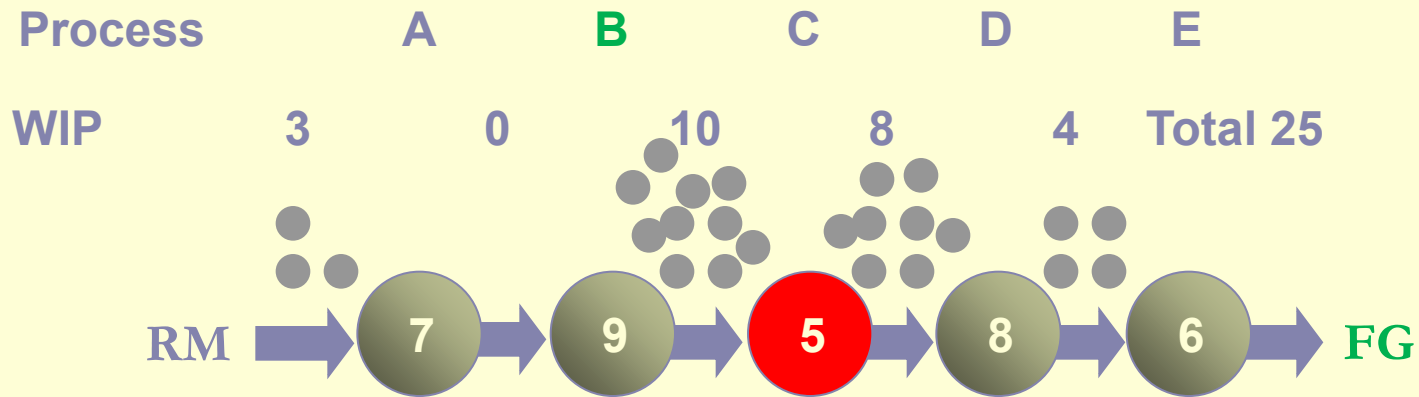
Variable Process	5 2	5 2	5 2	5 2	5 2

Shifting work-in-process creates **large queues** at some locations. This makes work wait longer to be processed.

Other workstations are starving for work (**B**) The work they could do is delayed because they have no input material. They can't take advantage of their extra capability. So....... ?

System Variability Takes Over--Chaos

Process	A	B	C	D	E	
WIP	3	5	10	8	4	Total 25 **->X 30**

RM ➔ **7** ➔ **9** ➔ **5** ➔ **8** ➔ **6** ➔ FG
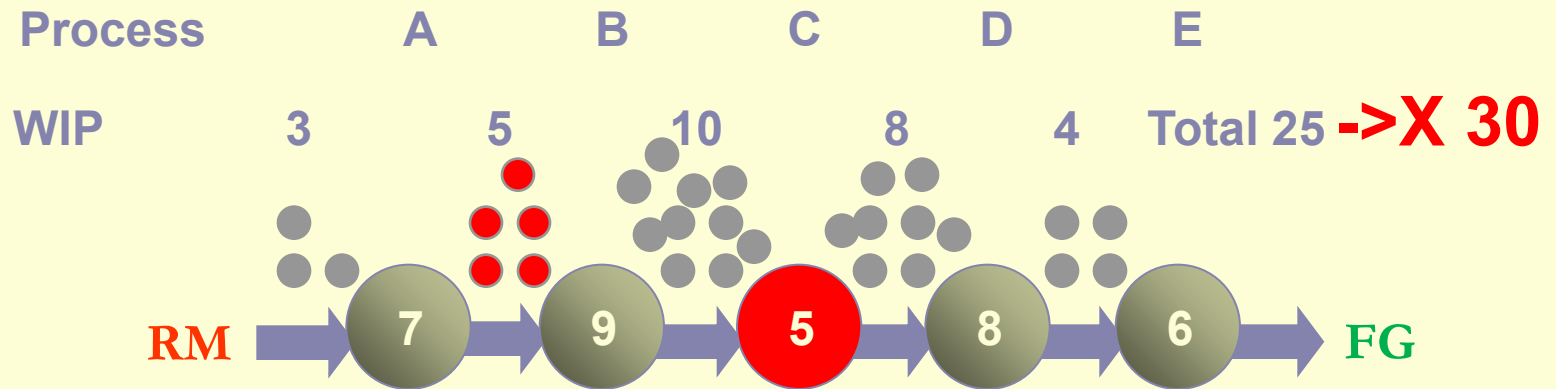
Variable
Process   5 2   5 2   5 2   5 2   5 2

So… **Management Helps!** Management puts in more work
(Inventory) (rate of input RM) to give everyone something to do (Cost world)!
Result: It takes longer and longer from time of release
until final shipping. **More and more delay!!!!!!!!!!**

TOC Steps to Continuous Improvement

Step 1. *Identify* **the system's constraint.**

Step 2. *Exploit* **the system's constraint.**

Step 3. *Subordinate* **everything else to the above decision.**

Step 4. *Elevate* **the system's constraint.**

Step 5. **If a constraint is broken (that is, relieved or improved), go back to Step 1. But don't allow** *inertia* **to become a constraint.**

Five Steps Applied to Flow Operations

WIP   **12** ● ● ●   **Total**   **12**

A   **B**   **C**   **D**   **E**

RM ➜ ➜ ➜ ➜ ➜ **FG**

7   9   5   8   6
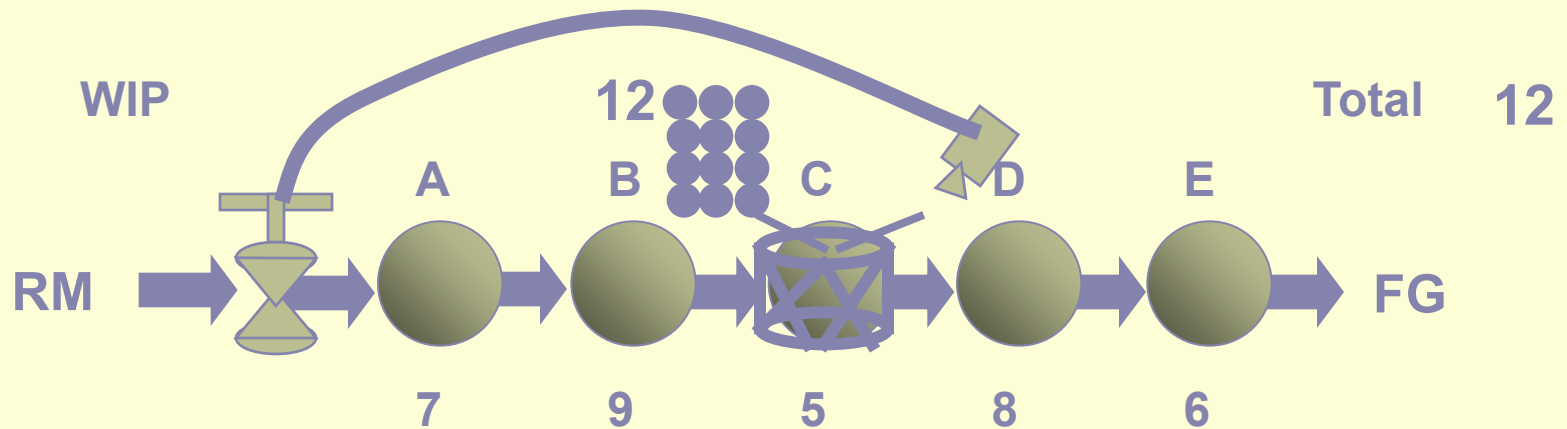
<u>Five Focusing Steps</u>

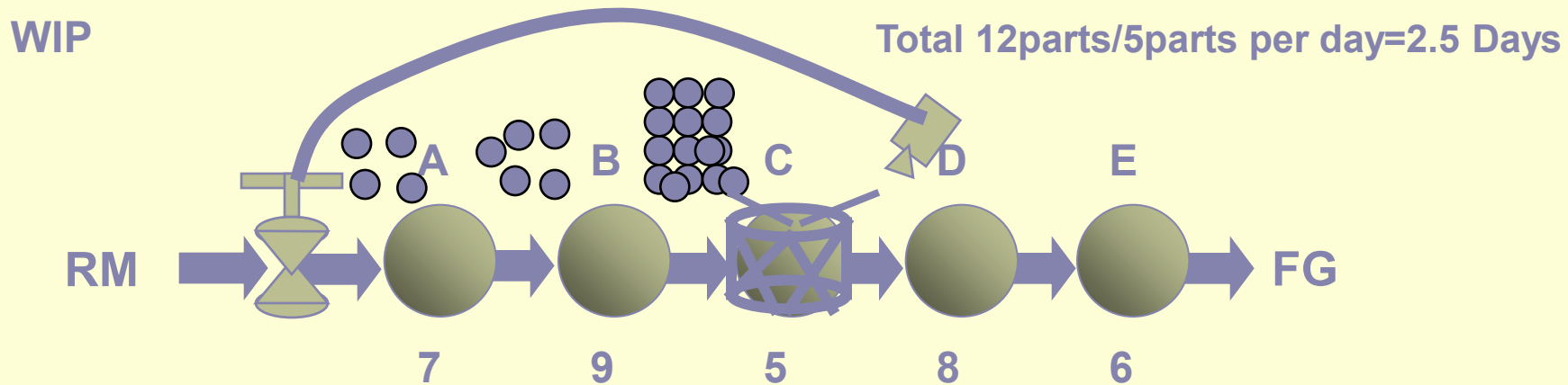**Step 1. Identify the Constraint (The Drum) - CRT**

Step 2. Exploit the Constraint (Buffer the Drum) – time reserve

Step 3. Subordinate Everything Else (Rope) - feedback

Step 4. Elevate the Constraint ($?)

Step 5. If the Constraint Moves, Start Over

Understanding Buffers

WIP

Total 12parts/5parts per day=2.5 Days

A   B   C   D   E

RM ➝ ➝ ➝ ➝ ➝ ➝ **FG**

7   9   5   8   6

- **The "Buffer" is Time!**
- **In general, the buffer is the total time from work release until the work arrives at the constraint.**
- **Contents of the buffer alters (see below)**
- **If different items spend different time at the constraint, then number of items in the buffer changes**
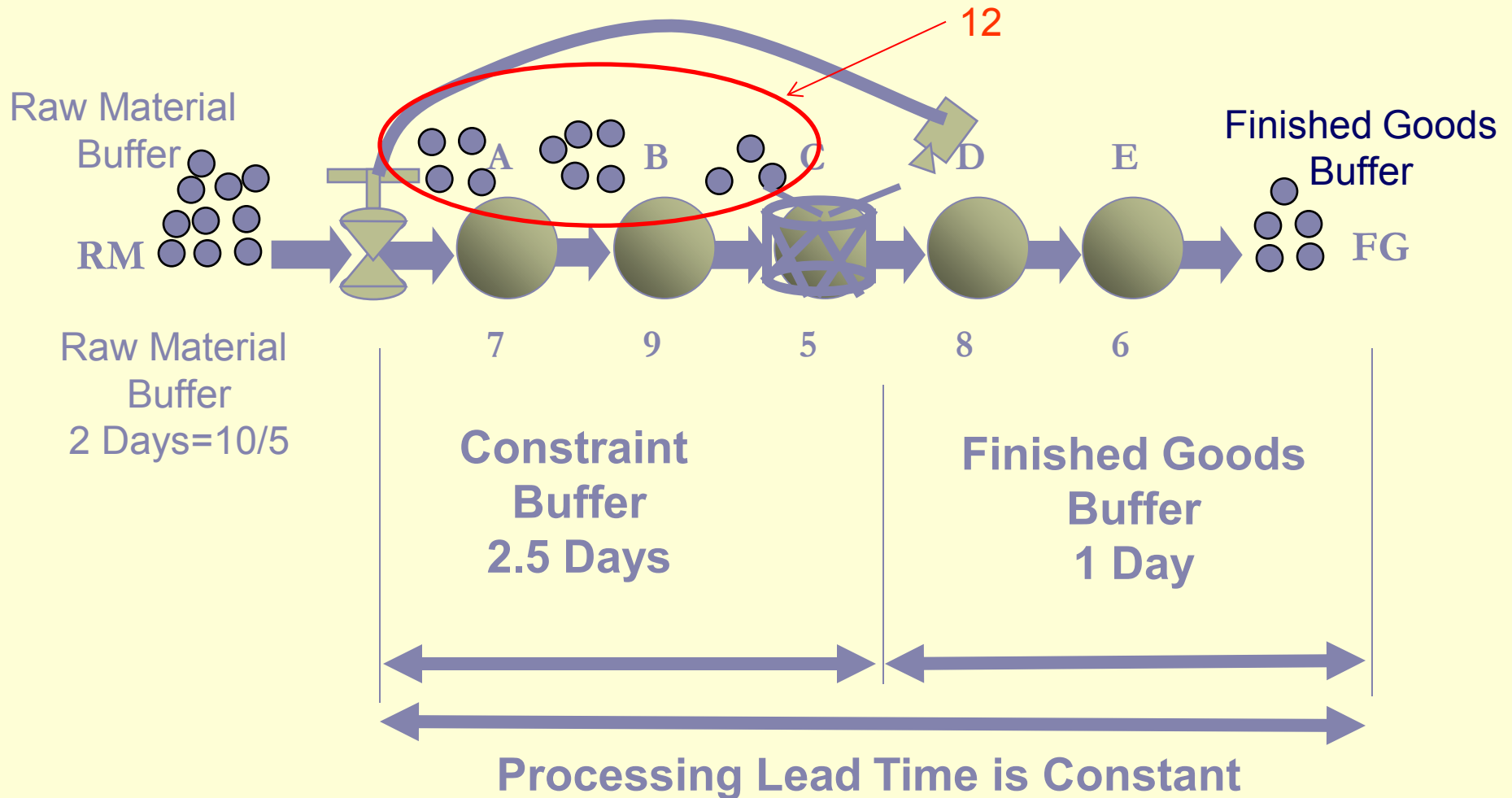- **but** **Time in the buffer remains constant.**

We need more than one Buffer

Raw Material Buffer

RM

A   **B**   **C**   **D**   **E**

7   9   5   8   6
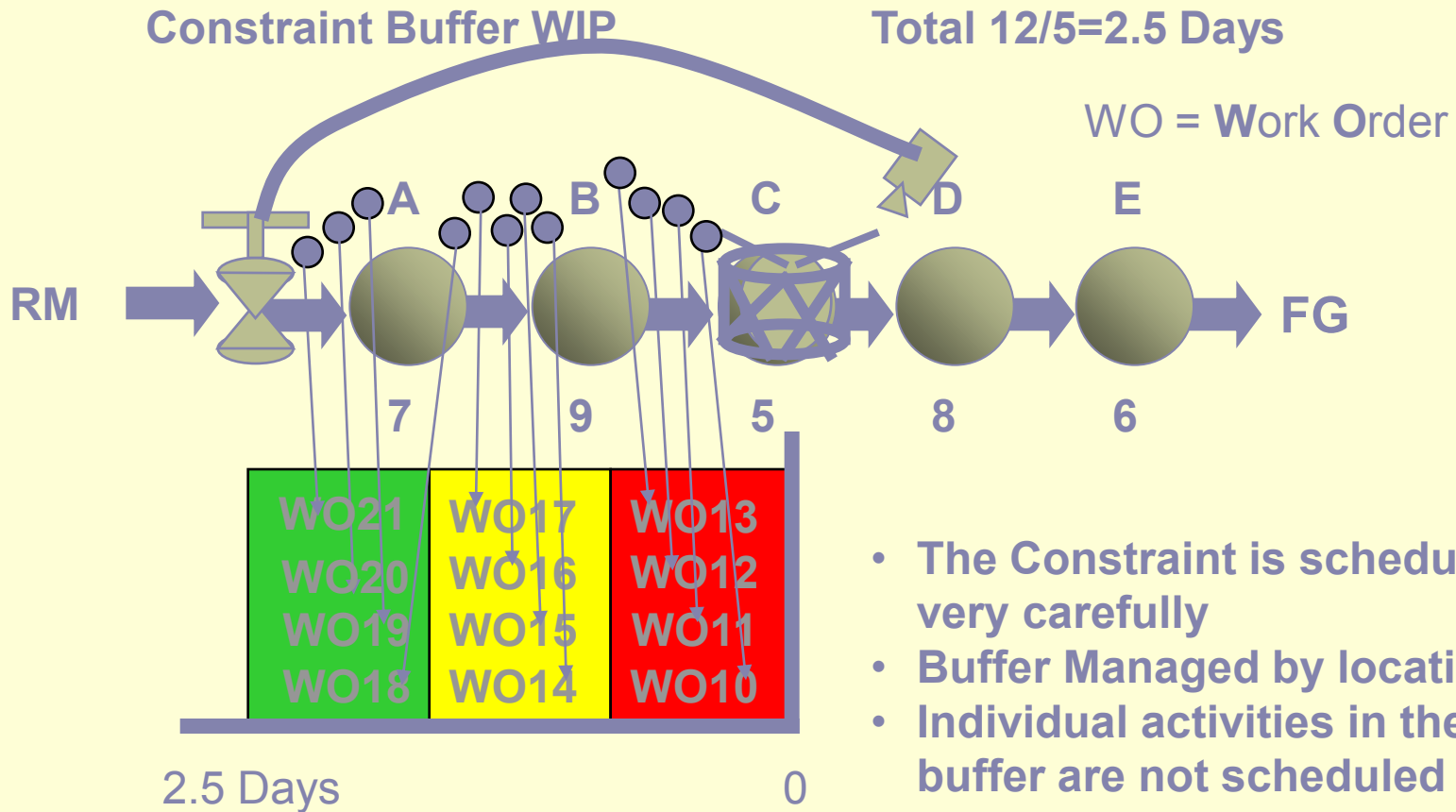
Finished Goods Buffer

FG
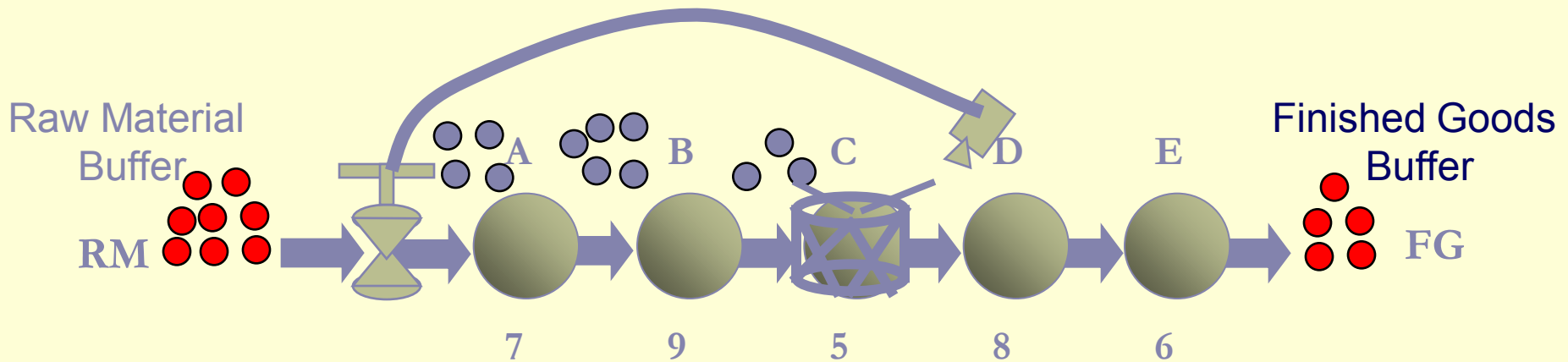
**There is variability in the Constraint.
To protect our delivery to our customer we
need a finished goods buffer.**

**There is variability in our suppliers.
We need to protect ourselves from unreliable
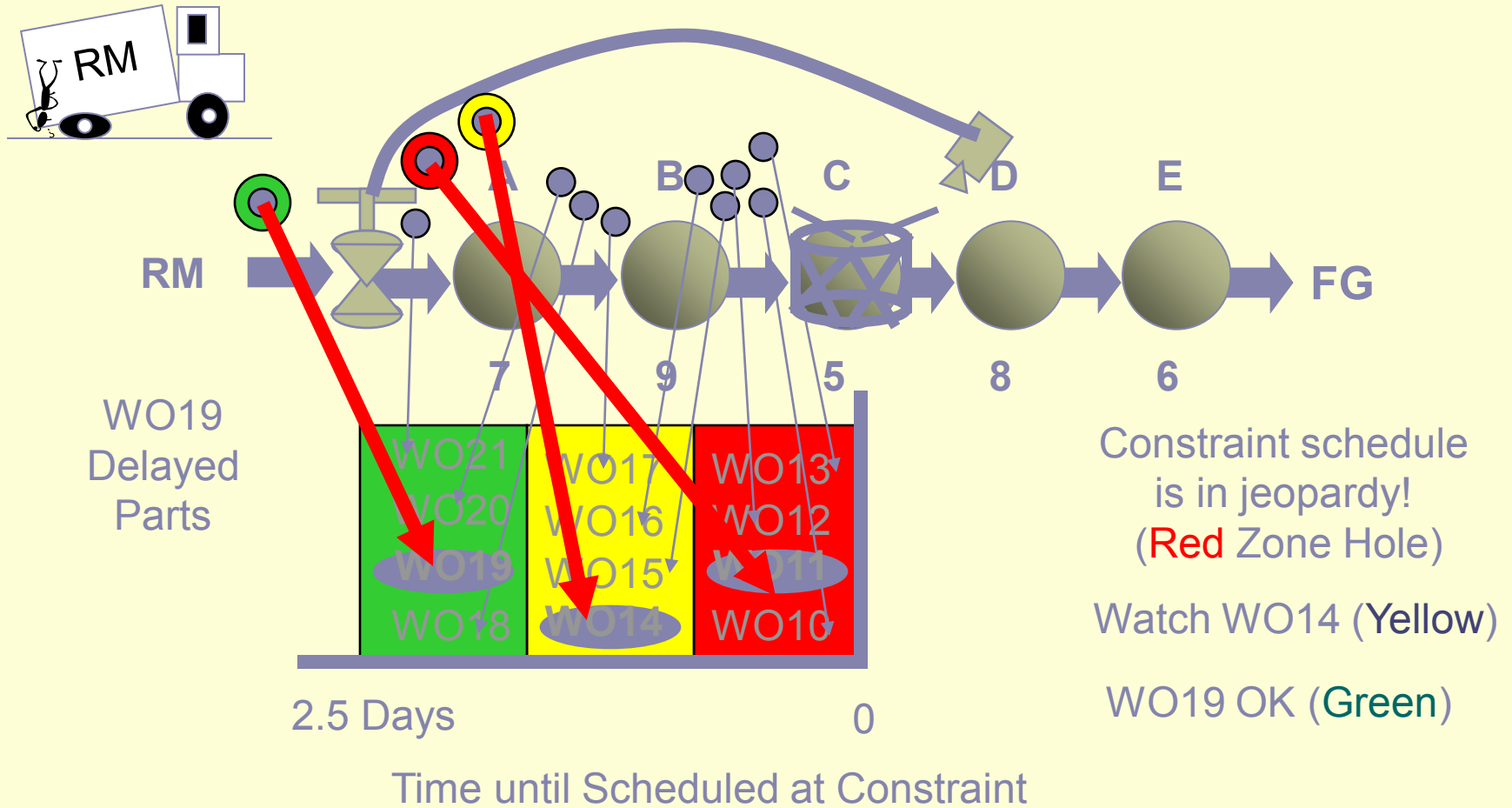delivery.**

Buffer Time is Constant-Predictable

Buffer Management

Constraint Buffer WIP   **Total 12/5=2.5 Days**

WO = **W**ork **O**rder

RM → A → B → C → D → E → FG

7   9   5   8   6

WO21	WO17	WO13
WO20	WO16	WO12
WO19	WO15	WO11
WO18	WO14	WO10

2.5 Days   0

Time until Scheduled at Constraint

- **The Constraint is scheduled very carefully**
- **Buffer Managed by location**
- **Individual activities in the buffer are not scheduled**

Problem Identification

RM

WO19
Delayed
Parts

A   B   C   D   E

RM → → → → → → FG

7   9   5   8   6

WO21 WO17 WO13
WO20 WO16 WO12
WO19 WO15 WO11
WO18 WO14 WO10

2.5 Days   0

Time until Scheduled at Constraint

Constraint schedule
is in jeopardy!
(Red Zone Hole)

Watch WO14 (Yellow)

WO19 OK (Green)

Additional Buffers

- Constraint Buffer (as we discussed)
  - Protects the Constraint from running out of work
- Finished Goods Buffer
  - Protects customer delivery from Constraint variation
- Raw Material Buffer
  - Protects the Release of material from suppliers
- Assembly Buffer
  - Facilitates speedy flow of products