FROM PUSH TO PULL PRODUCTION
Coping with the Demand

PUSH VERSUS PULL PRODUCTION

Until the 1980's-1990's companies were used to manufacturing products in quite stable markets or even markets in continuous growth. Therefore, it was not that difficult to work with **demand forecast**.

Hey Joe, how many products do we have to make next month? Jimi keeps the same amount next year or increase it by 20%....someone will surely buy the products

- ✓ When the customer demand is stable (predictable from a statistical point of view) we can usually use demand forecast and produce in **'make to stock'** mode**.** This implies to **push** into the warehouse a certain quantity of products without a customer order…in any case we are quite sure to sell quickly the quantity

- ✓ When the customer demand is unpredictable is quite better to produce only in '**make to order**' mode. Customer orders **pull** the production. However, if we produce just when we have an order we have to ask ourselves:

How long will the customer wait for the product?

PUSH VERSUS PULL PRODUCTION

Push production or Make To Stock, has been largely used during the Mass Production era. Indeed Mass Production is characterised by:

- Stable or growing demand
- Customers who need huge quantity of products
- Products very similar to each other with little customisation

Make To Stock is alive and kicking and hard to die, but what about a European company which has to sell a product personalised in 600 different ways and with requests for 2-3 or at most 10 similar products and every now and then?

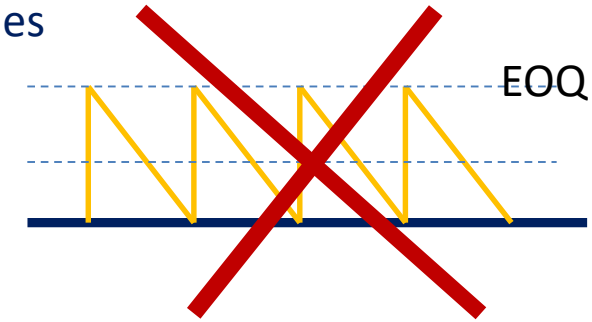
Unfortunately, many Western companies are still used to Make To Stock production

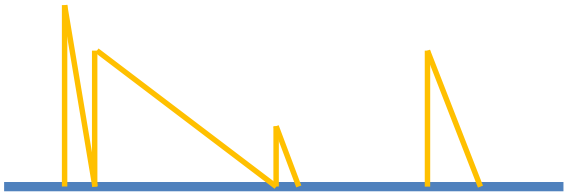
THE DISTORSIONS OF PUSH PRODUCTION

Push production or Make To Stock assumes a stability that we cannot afford nowadays

Nowadays the demand is not a constant or linear with q. Quite another thing !

The customer needs products at a highly unpredictable rate and in highly unpredictable quantities





We have to chase the so called **TAKT-TIME (Rhythm of the sales)**

For doing this we have to stop thinking about the EOQ

THE DISTORSIONS OF THE EOQ AND PUSH PRODUCTION

Every time a manufacturer receives an order for some finished products (independent demand items) is subjected to Ordering costs (O). Basically these ordering costs are related to the so-called **Set-up cost (S) .**

Especially in capital intensive industry where you have many machines, set-up cost can be very high and often it is considered a fixed cost.

Therefore, when the manufacturer receives an order it tends to impose its own EOQ to the customer:

$$EOQ = \sqrt{\frac{2DS}{H}}$$

But using this formula it will not be able to follow the **takt-time**.

For doing this we have to stop thinking about the EOQ and stop considering the set-up cost as a fixed cost

SET-UP COST IS A PURE WASTE, A NON VALUE ADDED PROCESS THAT LEADS TO AN INVENTORY INCREASE

HOW TO BECOME 'MAKE-TO-ORDER' MANUFACTURERS

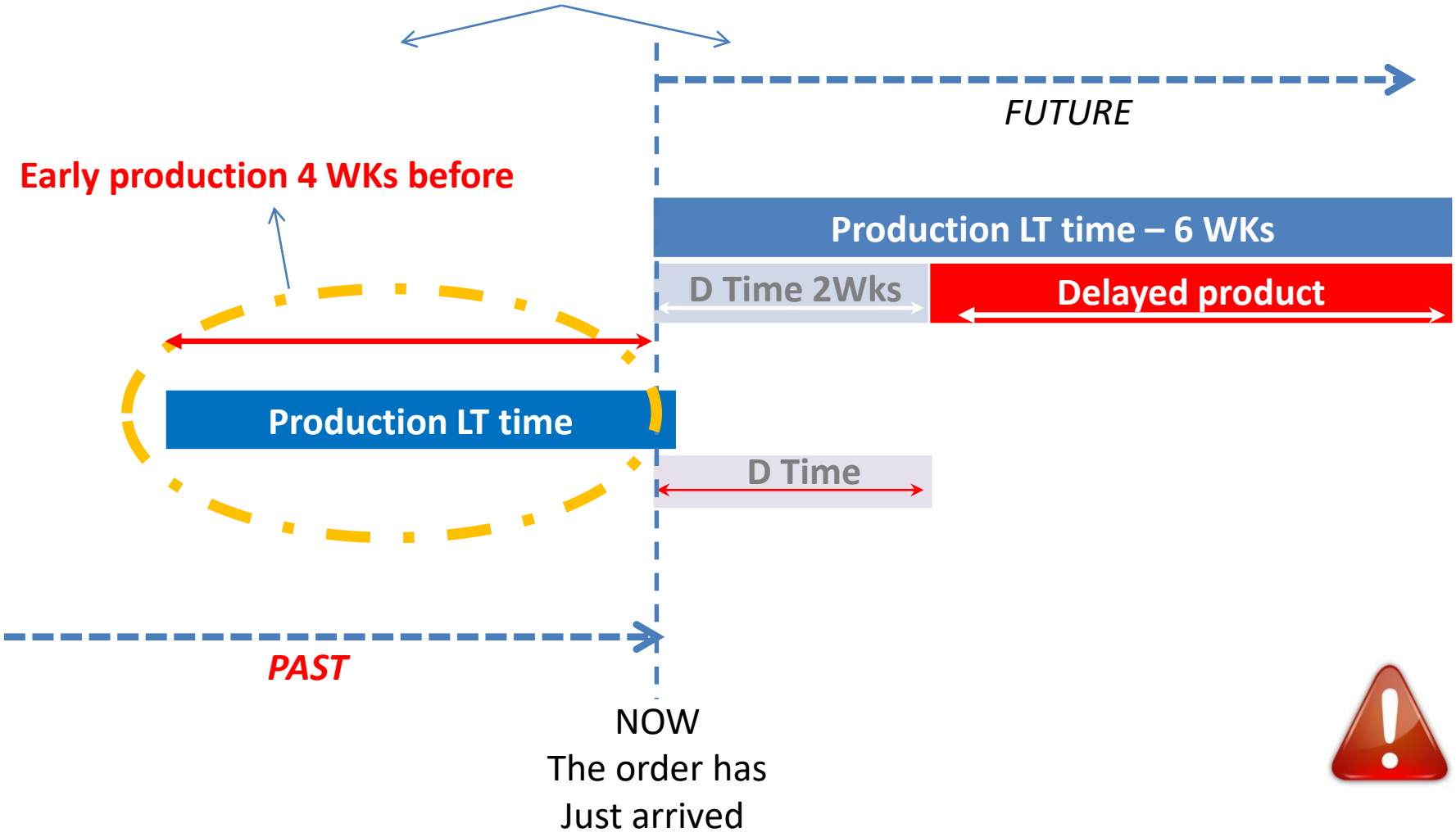
Consider two simple performances: **lead time and delivery time**

Production lead time (or simply lead time LT) = the time between the receiving of a customer order for a particular product and its delivery to the customer
Lead time depends on the type of material, product and manufacturing process

Expected Delivery time (or simply Delivery time) (D) = the time period that the customer has given the supplier between order and delivery receipt.
Make to order or Pull Production implies LT ≤ D

THE MAKE-TO-STOCK MANUFACTURER

But what about if LT > D ? Two possible solutions….



THE MAKE-TO-STOCK MANUFACTURER

But, if we produce ahead of schedule, before the order comes (if it will come…) we make only product stocks….

And if we launch production before the order comes….we need a very accurate **forecast** of the moment in which we will receive the order…..

This forecast system is called **Material Requirements Planning (MRP)** and was invented at the end of the 1970's in the US by Joe Orlicky when computers started managing production scheduling

IBM was one of the first companies to develop MRP software for manufacturing industry, when Mass Production was the most important production system in the West…

MRP uses the so-called BOM. The **Bill Of Materials (BOM)** specifies the relationship between the finished product (**independent demand**) and the components (**dependent demand**). MRP takes input information contained in the BOM

A REAL CASE STUDY – THE PUSH SITUATION

In this particular case study the company manufactures simple metallic junctions made up of a raw iron tube a screw and two bolts embedded at one end of the tube. This product can have three different lengths A, B, C (part numbers or codes). Anyhow, the production flow of the three part numbers is the same (family). Annual demand (was) is stable, on average 101,600 products/year. The factory works 240 days/year. The customers usually demand 8,500 products of the family per month (2,125 per week). The most important component is the raw tube and it comes from the supplier in about 14 days. According to the accountant's calculation we have:

C = 9.47€; H = 4.735 € and S = 105 €

EOQ E ROP (REORDER POINT)

(EOQ, Economic Order Quantity) $Q' = \sqrt{\frac{2 \cdot D \cdot S}{H}} = 2125$

(Number of orders over the year) $N = \frac{D}{Q'} = 101600/212 \quad 5 = 47.8$

(Average Time between orders) $T = \frac{\text{Working days/Year}}{N} = 240/47.8 \quad = 5$

(Average Daily demand) $d = \frac{D}{\text{Working Days/Year}} = 101600/240 \quad = 423$

(Reorder Point) ROP (for the raw tubes) $= d \cdot \text{Lead Time} + SS =$

$423 \text{ x } 14 + SS = 5922 + SS$

MATERIAL REQUIREMENTS PLANNING AND BOM

The MRP system is a software whose computation is based on the **Bill Of Material (BOM)**, the lead time of each single product part and first of all the customer demand forecast

BOM

Level 0 – Finished product
Code 0AJ

1 metallic junction
(A type)

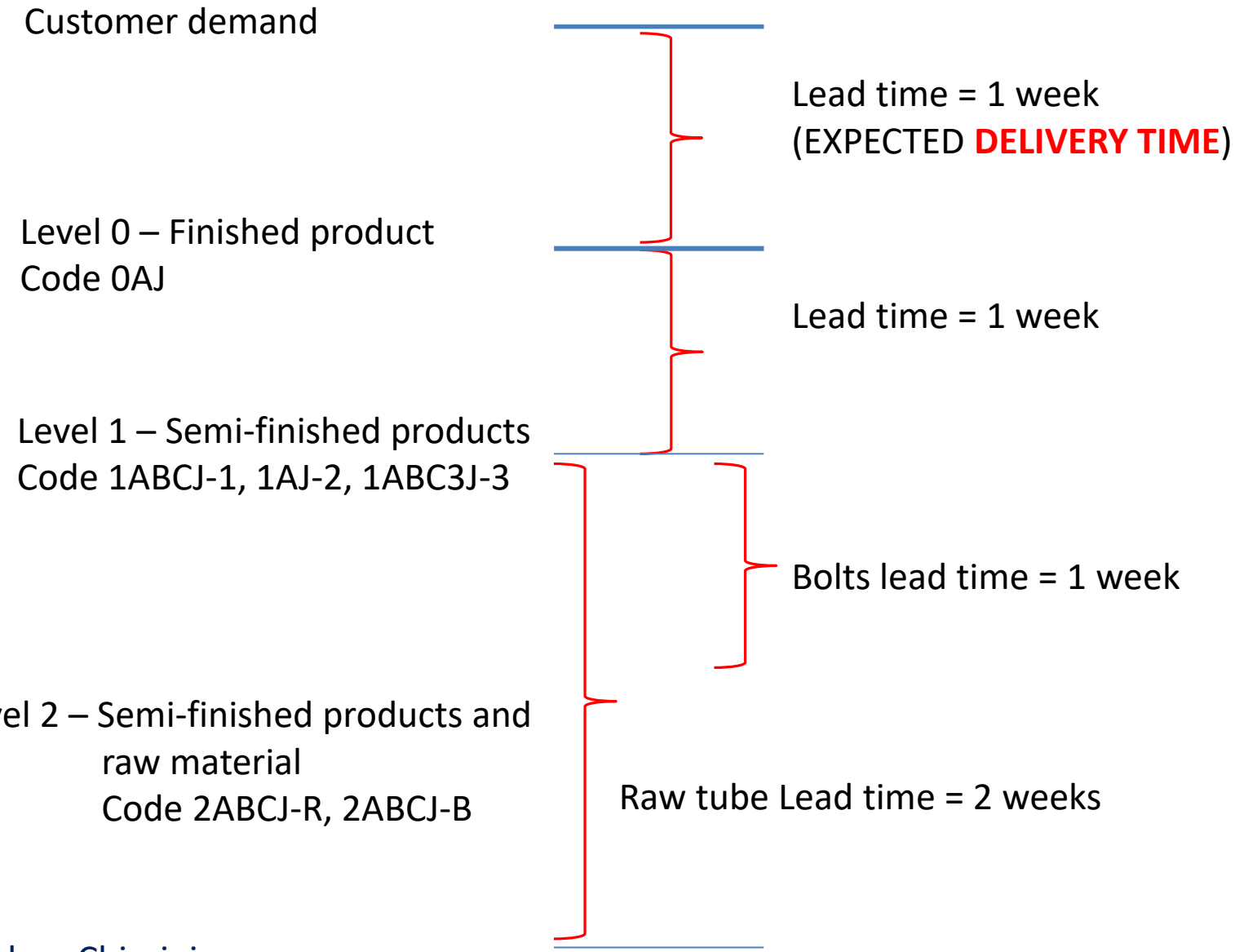
Level 1 – Semi-finished products
Code 1ABCJ-1, 1AJ-2, 1ABC3J-3

1 screw, 1 sawed-moulded tube, and 1 assembled bolt

Level 2 – Semi-finished products and raw material
Code 2ABCJ-R, 2ABCJ-B

1 raw tube and 2 bolts (from suppliers)

BOM – LEAD TIME OF THE DIFFERENT LEVELS



MPR COMPONENTS AND PROCESSES

Master Production Schedule (MPS): it allows to schedule finished products (dependent demand). It takes as inputs warehouse stock situation (finished products), received orders and forecasts

Master Schedule: it allows to schedule the production and/or the purchasing (launch of an order to the supplier) for each BOM level. It receives as inputs data from the MPS, the BOM, lead times and the warehouse stock situation in terms of semi-finished products and raw materials

MRP I assumes there is an **Infinite Capacity** of the production system. It means that you launch orders to the production system or to the supplier disregarding any existing work or commitment of your resources (people and machines)

Capacity Requirements Planning : it sequences all the production orders from the Master Schedule creating a **dispatch list** for each work center (machine, assembly line, cell, etc.). It receives as inputs cycle times, number of workers, queues (WIPs), **machine efficiency**, etc. CRP is typically based on a **Finite Capacity** of the production system

MATERIAL REQUIREMENTS PLANNING - MPS

Let's suppose the customers have demanded in the last 3 years on average 8,500 products per month or 2,125 per week (forecast linked to the EOQ). The MRP, through the BOM levels, manages the production and purchasing scheduling . First of all the MRP issues the **Master Production Schedule (MPS)** for the finished product (independent item). In this case it is issued once a week (**time bucket**)

MPS

	Week				
	NOW	1	2	3	4
Forecast – Code 0AJ		2125	2125	2125	2125
Actual orders		*1000*	*1800*	*1000*	*400*
On hand (inventory forecast)	2400	2425 (275+2150)	2300 (300+2000)	2325 (175+2150)	2200 (200+2000)
Available-to-promise (actual inventory)	*2400*	*3550 (1400+2150)*	*3750 (1750+2000)*	*4900 (2750+2150)*	*6500 (4500+2000)*
Master schedule	2150	2000	2150	2000	2150

Lead time = 1 week

If we do not receive other orders our inventory will increase

Master schedule is a production or purchase order. For example we need an assembled bolt

We need 2125 assembled bolts + 25 as a safety stock

PRODUCTION MANAGEMENT

Now we explode the MPS for the level 0 (finished product) through the BOM levels

MPS

		Week			
	NOW	1	2	3	4
Forecast – Code 0AJ		2125	2125	2125	2125
Actual orders		*1000*	*1800*	*1000*	*400*
On hand (inventory forecast)	2400	2425 (275+2150)	2300 (300+2000)	2325 (175+2150)	2200 (200+2000)
Available-to-promise (actual inventory)	2400	*3550 (1400+2150)*	*3750 (1750+2000)*	*4900 (2750+2150)*	*6500 (4500+2000)*
Master schedule	2150	2000	2150	2000	2150

Shifted 1 week (1 WK Lead Time)

1AJ-2
(Sawed-moulded tube
Barra segata e pressata)

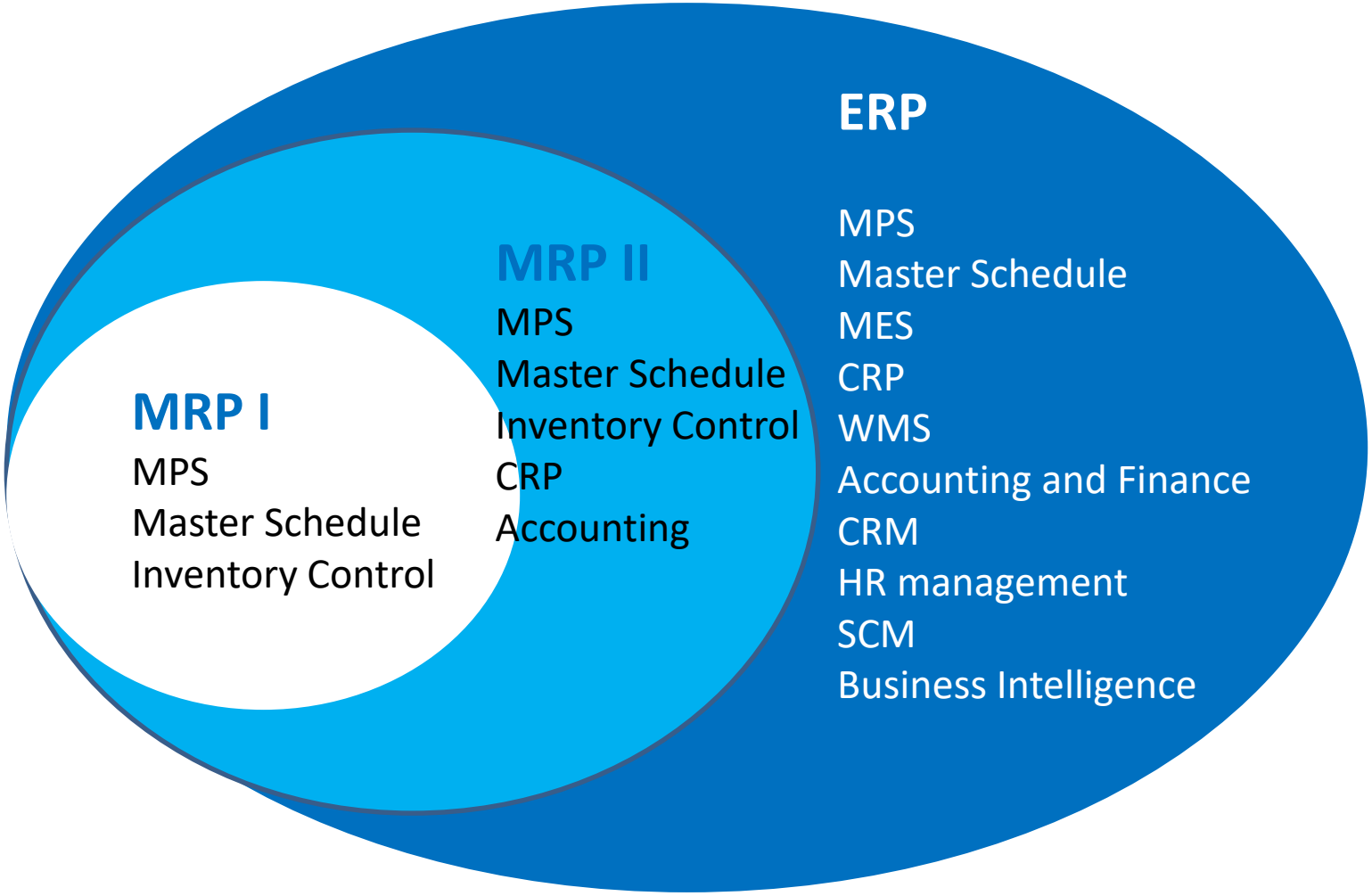
	Week				
	NOW	1	2	3	4
Requirements (Richiesta)		2150	2000	2150	
Scheduled receipts (Entrate programmate)				5000	
On hand (Disponibilità a magazzino)	8000	5850	3850	6700	
Order release (Lancio Ordini)		5000			

This is the order launched to the supplier.
The order is launched when we have reached approximately the ROP

The supplier lead time for the raw tube is 2 weeks
2ABCJ-R

PRODUCTION MANAGEMENT

MANAGEMENT SOFTWARE EVOLUTION



CRP = Capacity Requirements Planning; ERP = Enterprise Resource Planning;
MES = Manufacturing Execution System; MRP II =Manufacturing Resource Planning
CRM = Customer Relationship Management; WMS = Warehouse Management System

MANUFACTURING EXECUTION SYSTEM

This (relatively) new software is very important for both Push and Pull Production Systems

- ✓ It allows to track down and measure in real time data and information from your shop-floor such as:
  - Machine availability
  - Machine efficiency
  - Machine quality
  - OEE
  - Machine status
  - Machine capability (Cp and Cpk)
  - Cycle times
  - Labour
  - Scraps and reworking
  - WIPs
  - Internal transport times
  - Etc.

It is fundamental for:

- a correct scheduling of your orders (finite capacity)
- registration and retrieval of data for product traceability
- Business Intelligence and PMS inputs

FROM PUSH TO PULL PRODUCTION – MARKET HAS CHANGED

In this particular case study the company manufactures simple metallic junctions made up of a raw iron tube a screw and two bolts embedded at the one end of the tube. This product can have three different lengths A, B, C (part numbers or codes). Anyhow, the production flow of the three part numbers is the same (family). The customers usually demand 8500 products of the family per month (2125 per week). The raw tubes come from the supplier every 2 weeks. In fact, the supplier has its own EOQ and it supplies around 5000 raw tubes. The tubes are firstly sawed for getting the right length (Cycle time 30 sec). Then they are molded by means of a press (Cycle time =60 seconds). Unfortunately, the press produces around 10% of scrap and the set-up time is on average 1 hour. At this point two identical bolts are assembled together (Cycle time = 60 seconds) and then assembled with the screw into the tube. The bolts and the screw are blocked within the tube through a small manual press (Cycle time = 62 seconds). The finished products are afterwards inspected (Cycle time =70 seconds) and finally put into a warehouse waiting for the shipping to the customers. On average they stay in the warehouse for 5 days before the shipping.

For scheduling the production process, the company uses a typical MRP system and the production flow is completely pushed lot by lot. The average D time is 5 days and the customers do not want to buy multiples of the EOQ any more !

How can we improve the current situation?

'GO TO SEE' – THE VALUE STREAM MAPPING (VSM)

In order to evaluate how much waste and VA in your flow you have, Lean usually starts with the **VALUE STREAM MAP.** VSM:

- ✓ Is managed by family of products (a family is made up of products which have similar production flow)
- ✓ Maps all the manufacturing processes from product incoming to shipping
- ✓ Is managed by a team made up of production managers and workers (not only managers!)
- ✓ Is initially drawn in the 'AS-IS' state (*Where are we now?)*
- ✓ Is then drawn in the 'FUTURE STATE or TO-BE' (*How the flow should be without waste*)

The FUTURE STATE is linked to actions for reaching such an ideal state

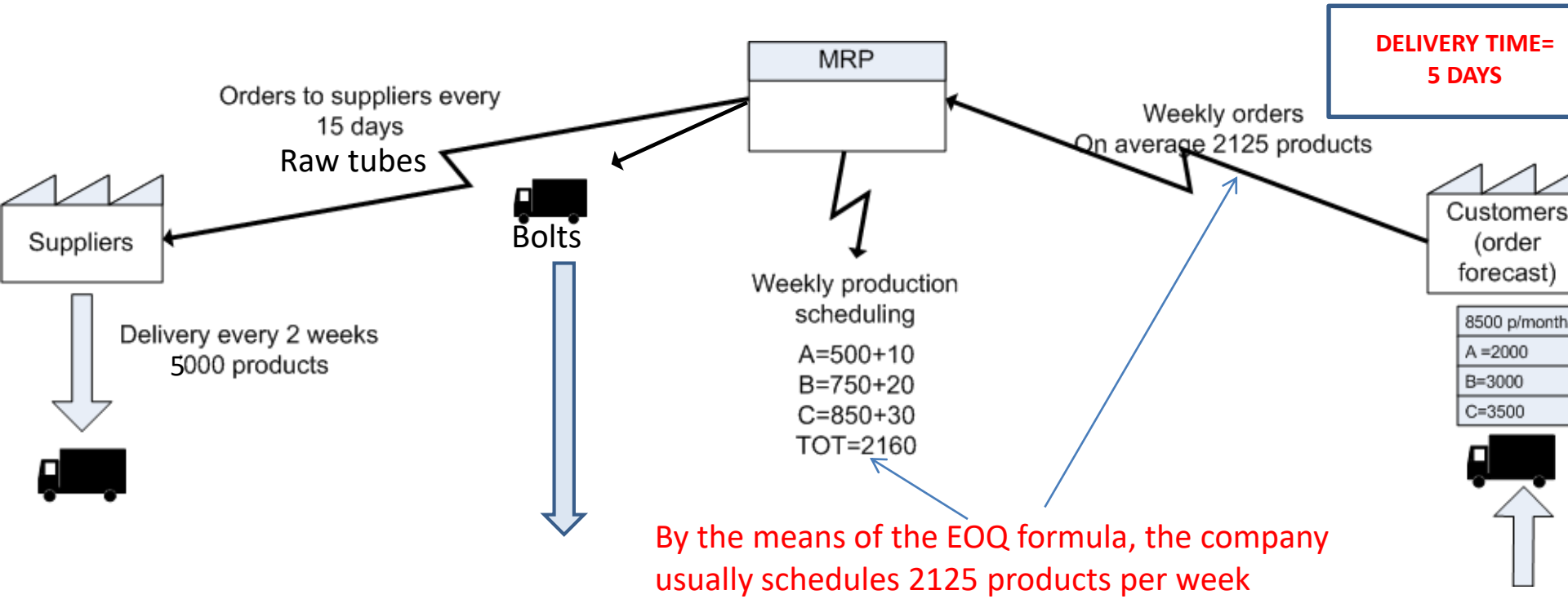
The actions are called **KAIZEN WORKSHOP** or KAIZEN EVENTS

The team dedicated to the VSM should periodically draw a new AS-IS state

'GO TO SEE' – THE VALUE STREAM MAPPING (VSM)

VSM is based on specific icons for better understanding the physical flow of the product in the lower part of the map. Instead, in the upper part there are information/data about production scheduling

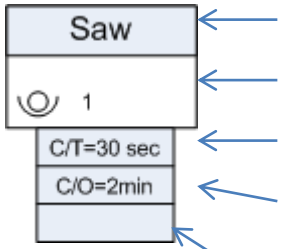
STEP 1: Production scheduling data/information about customers and suppliers



By the means of the EOQ formula, the company usually schedules 2125 products per week
…and imposes this quantity to the customers !
The MRP has scheduled 2160 instead of 2125 because there is some scrap (safety stock)

'GO TO SEE' – THE VALUE STREAM MAPPING (VSM)

STEP 2: Inserting the process boxes from incoming to shipping (from left to right)



Process name

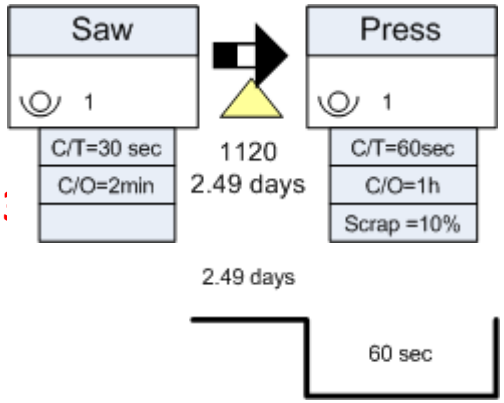
Number of dedicated operators to the process

*Cycle time or process time (**usually the real VA time !**)*

Change Over time or set-up time (time for changing the production from product A to B)

Other useful information such as scrap, rework, availability of the machine, failure time, etc.

STEP 3: Measuring WIP quantities (**Work-In-Process**) between the processes . Once you get WIP you can calculate Process Lead Time using **Little's law**.

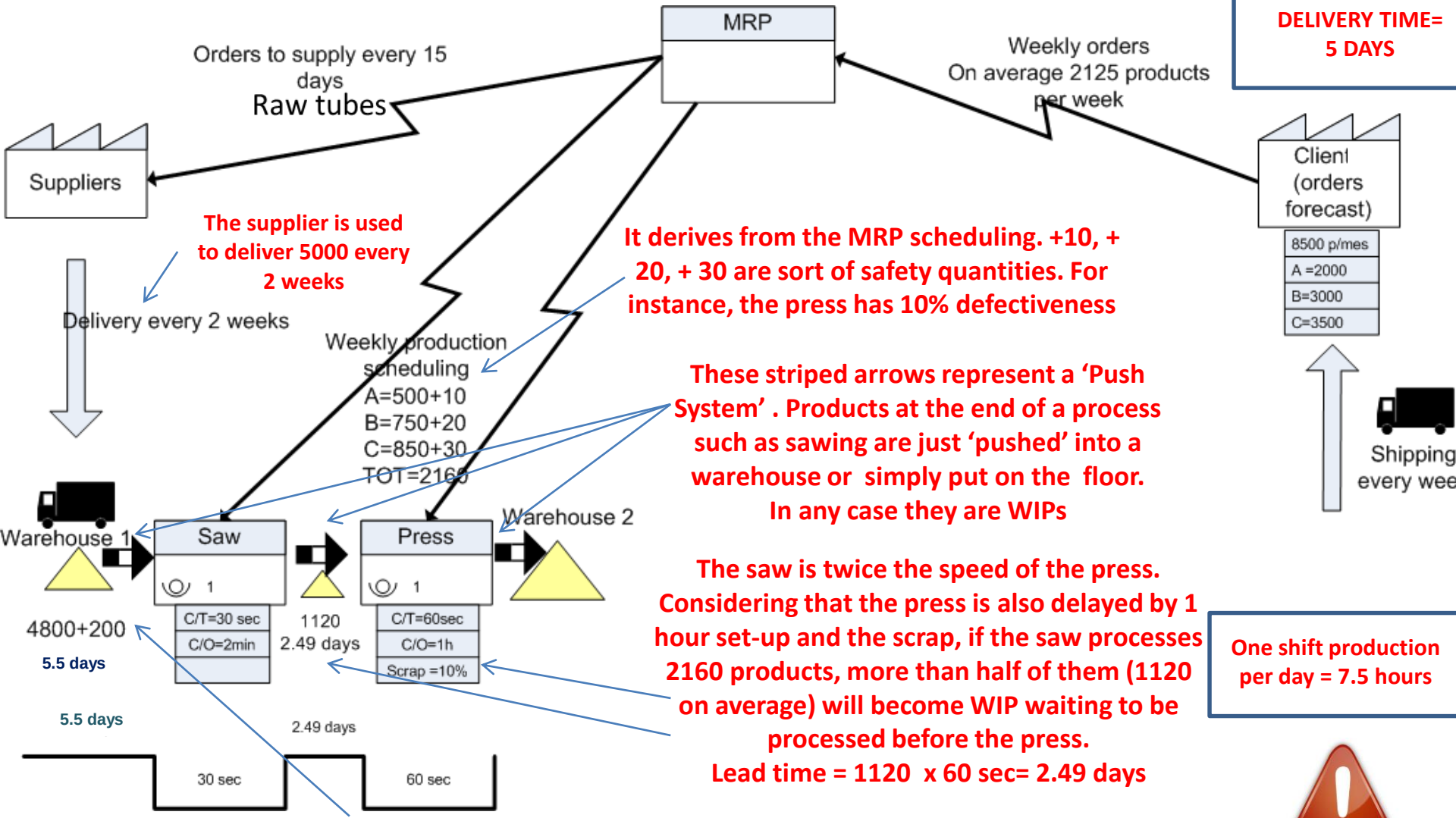


LITTLE'S LAW: LEAD TIME = WIP QUANTITY x CYCLE TIME

(EXAMPLE: LEAD TIME = 1120 x 60 SEC = 18.67 HOURS = 2.49 DAYS – CONSIDERING 7.5 HOURS/DAY)

STEP 4: Drawing the time line, Lead time above and Cycle Time below

'GO TO SEE' – THE VALUE STREAM MAPPING (VSM)



DELIVERY TIME= 5 DAYS

The supplier is used to deliver 5000 every 2 weeks

It derives from the MRP scheduling. +10, + 20, + 30 are sort of safety quantities. For instance, the press has 10% defectiveness

These striped arrows represent a 'Push System' . Products at the end of a process such as sawing are just 'pushed' into a warehouse or simply put on the floor. In any case they are WIPs

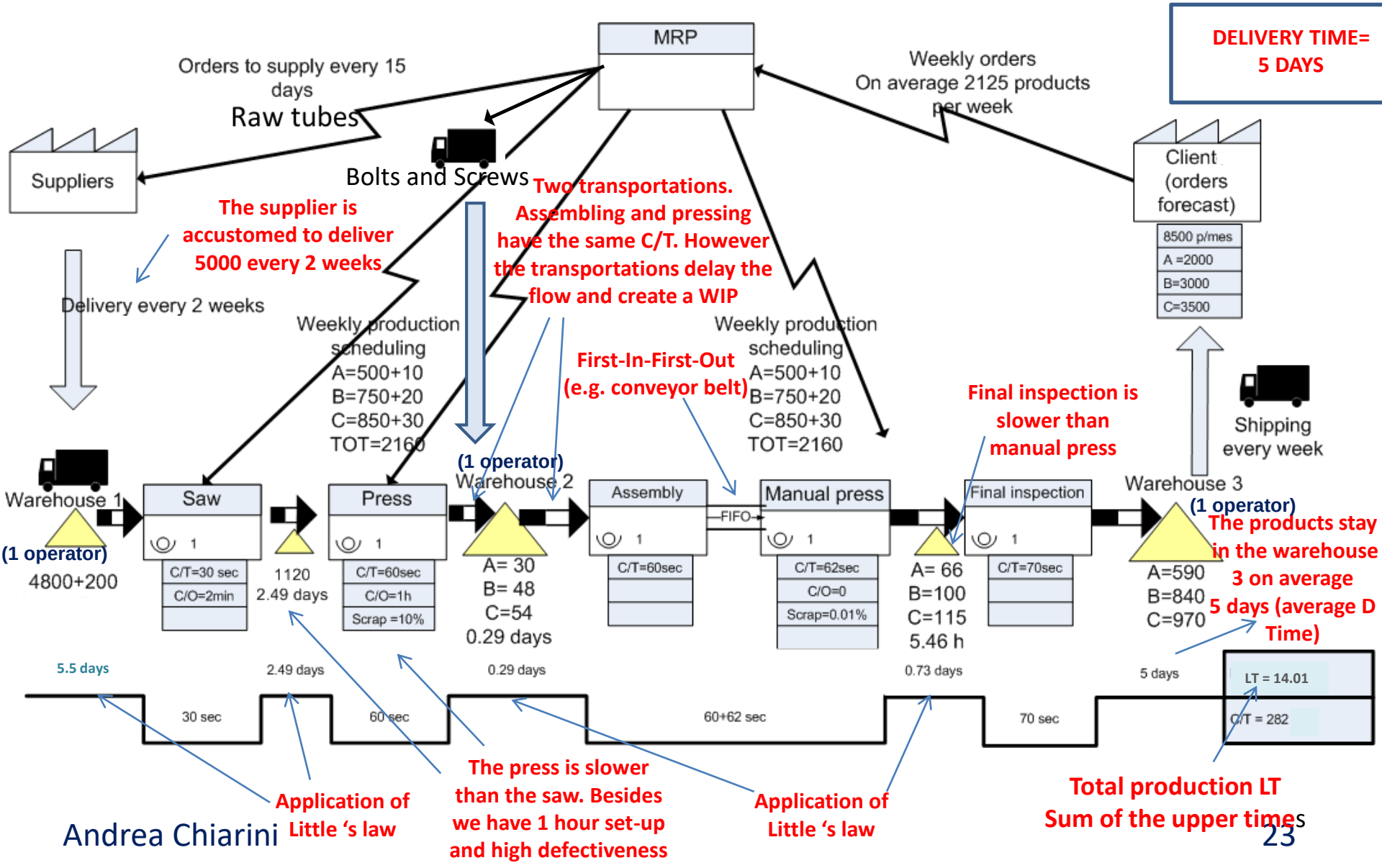
The saw is twice the speed of the press. Considering that the press is also delayed by 1 hour set-up and the scrap, if the saw processes 2160 products, more than half of them (1120 on average) will become WIP waiting to be processed before the press. Lead time = 1120 x 60 sec= 2.49 days

One shift production per day = 7.5 hours

Due to the not complete reliability of the supplier, there is a safety stock of 200 products. Lead time = 5000 x 30 sec= 5.5 days

PRODUCTION MANAGEMENT

'GO TO SEE' – THE VALUE STREAM MAP (VSM) – AS IS



How much VA are we producing ?

Total CT/LT = 282 sec /378,270 sec = 0.0007 = 0.07%

VSM AND ITS RELEVANCE TO LEAN

VSM is very important because it gives you these items of information and data:

- Lead Time
- Cycle Time
- Synchronisation between processes
- WIP
- Change Over time (set-up)
- Quality
- Machine availability and downtime
- Etc.

VSM does not allow you to 'see' wastes such as transportation, motion and overprocessing
For transportation you can use the **Spaghetti-Chart**

THE FUTURE STATE – HOW TO REDUCE LEAD TIME

According to Little's Law, if we want to reduce our production Lead Time we have to reduce WIPs between processes

WIP reduction is mainly a matter of **synchronisation (avoiding overproduction)** among processes (**balancing**). They have to 'pulse' (to work) at the same pace or rhythm (**Takt-Time)**

In order to synchronise our processes we can:

- First of all trying to reduce relevant wastes in terms of:
  - ✓ Waiting - stoppages (e.g. set-up time, failure, people working faster and/or slower, etc.),
  - ✓ Worker's movements and product transportations
  - ✓ Defectiveness (rework and scraps)
  - ✓ Overprocessing

- Then we can better **balance** assembly processes (e.g. **multiskills operators and job-rotation**)
- As a very last decision we can organise double shifts or double machines