# Production capacity and efficiency

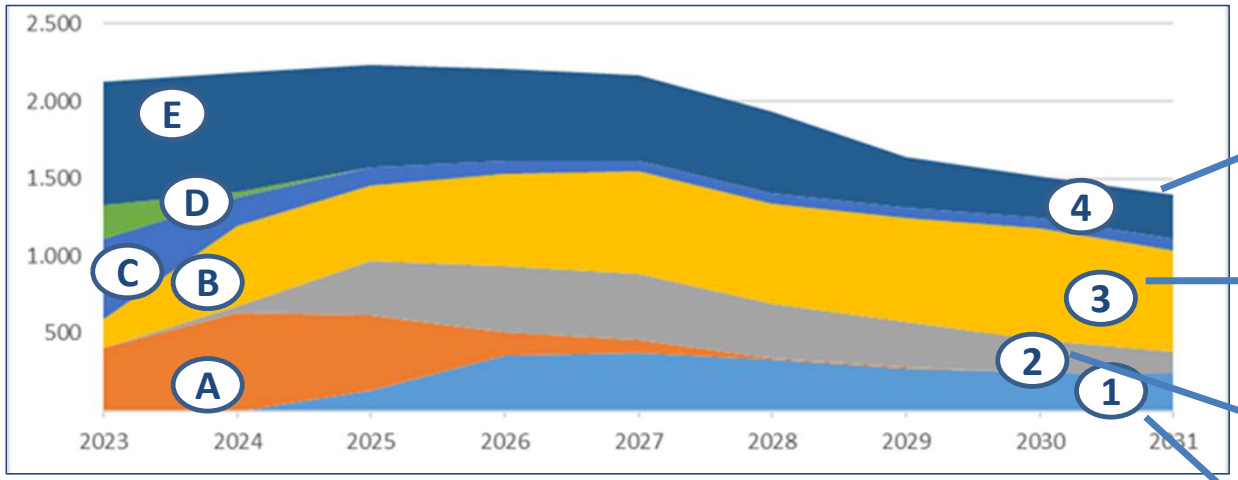
# Capacity planning

- Both estimates of future demand from Marketing and the planned production capacity of the Plant machinery must be arranged accordingly.

- The rules to deal with the issue are very simple but involve different aspects:
  - The variability of the demand
  - The possibility to adapt capacity
  - The product and process flexibility
  - The efficiency and the effect of variability on it

- To analyze the topric we have to define the tools to describe:
  - Demand
  - Production capacity
  - Efficiency
  - Cycle time

# Demand





**Evolution:**

A= phase out (Exp)

B= slow growth (=3)

C= slow phase out (Exp)

D=phase out (Exp)

E= decrease (=4)

Demand plan by year: Expressed in kupy (k/y or simply k) i.e. thousand units per year

# Demand vs capacity

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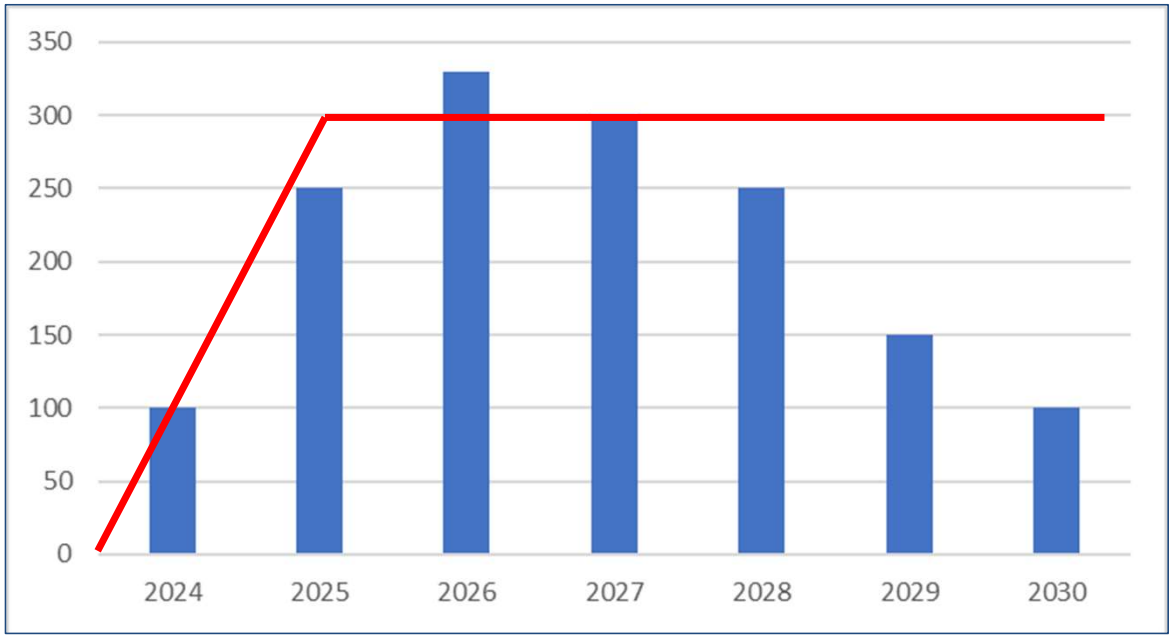


The demand has a clear peak

The answer of capacity is cutting the max peak and proposing 300k/y

If the peak is confirmed can be faced with banking or extra-time

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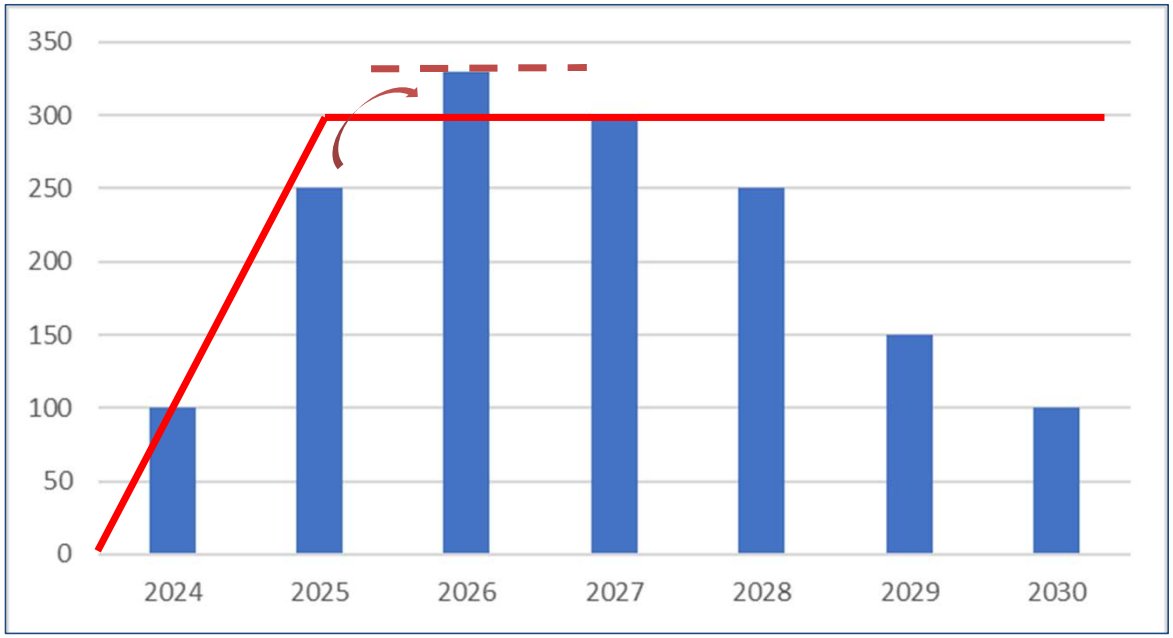


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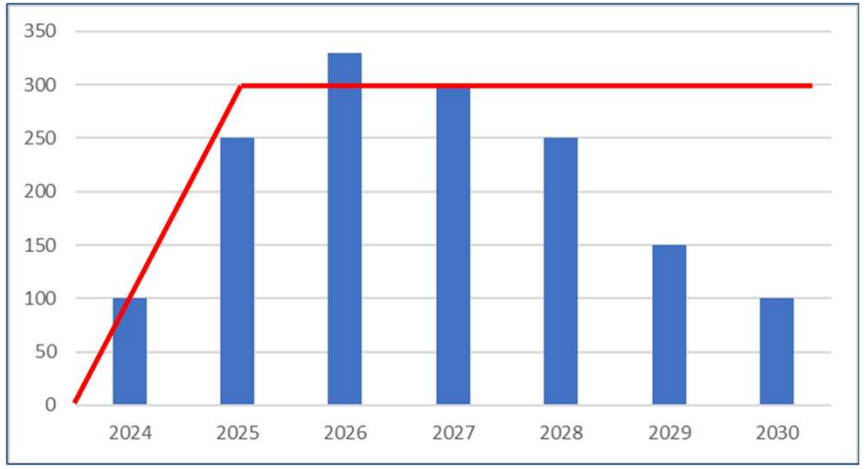
# Production Capacity

(Yearly) Capacity=equally expressed in kupy, k/y or simply k i.e. thousand units per year

- A **work year** is divided into days, weeks and shifts. It is not a global standard but each company assume its standard .
- In Italy:
  - shift =7.5 hours (in general, unless specific contract),
  - days= 3 shifts= 22,5 hours,
  - weeks= 6 days=18 shifts (18 shift is a high utilization standard but change by country/contract/holidays)
  - year =46,7 weeks= 280 days= 840 shifts= 6300 hours
- Normally to identify the used production pattern are used the information:
  - 280 days/year in general with 18 shift
  - 6300 hours/year in general
  - **Daily capacity = Yearly capacity/280 measured in unit/day**
  - **Hourly capacity or production rate = Daily capacity/22,5 measured in unit per hour= Yearly C/6300**

# Exercise

- Yearly demand, peak at 330 k/y
- **Proposed yearly capacity 300 k/y**
- Daily capacity= 300.000/280= 1071 u/d
- Hourly capacity= 1071/(3*7,5)= 47 u/h or 300.000/6300= 47 u/h




Possible also the reverse logic:

- Hourly capacity = 60 u/h
- Daily capacity= 1350 u/d = 60*3*7,5
- Yearly capacity 378 k/y= 1350*280= 60*6300

# Cycle time

- Normally we **start from the target production capacity to evaluate the necessary cycle time**.
  - The target production capacity is the net output, the actual production can be generated.
  - The machine capacity must be higher to compensate the losses.
  - The cycle time is inverse of the machine capacity or rate
  - Cycle time is different for lead time or crossing time
- We need to introduce the concept of efficiency in order to identify exactly **how much we need to accelerate the line in order to have an extra production able to compensate the losses.** The target efficiency is *mainly* based on the experience.
  - **Machine production rate = Target production rate/ target efficiency**
  - Cycle time= 1/Machine production rate = target efficiency/target production rate
  - Cycle time is expressed in a aligned metrology with machine production rate
- Most used metrology:
  - **Production Capacity** as said is normally intended as the yearly capacity and it is expressed in kupy or k/y
  - **Cycle time** is expressed in minutes and **machine production rate** in unit/minutes

# Exercise

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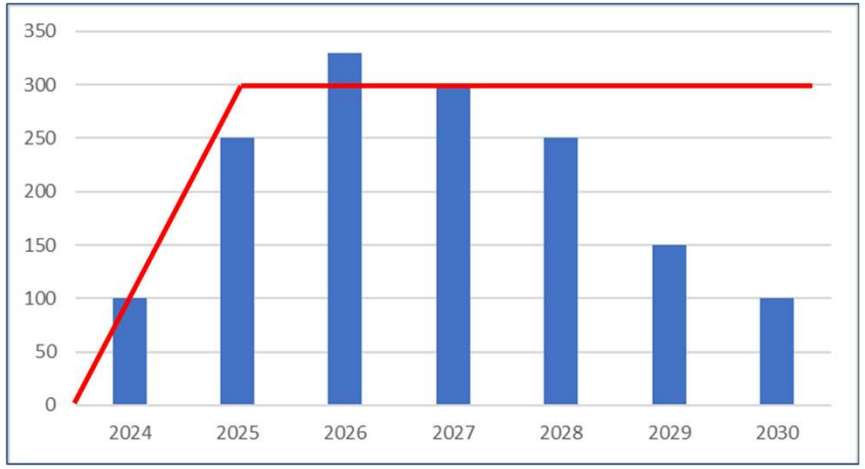


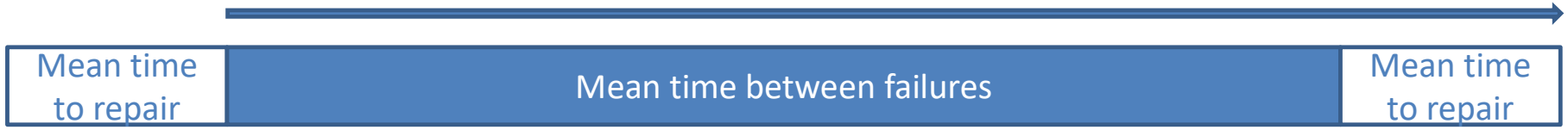

- Daily capacity= 300.000/280= 1071 u/d
- Hourly capacity= 1071/(3*7,5)= 47 u/h

Let assume a target line efficiency of 85%

- **Machine cycle time**=target efficiency /target hourly production rate= 0,85/47 = 0,018 h= **1.08 Minutes**
- or more used **60*0,018= 1,08 min= 64 seconds**
- **For simplicity in the past were more used hundreds of minutes rather than seconds**

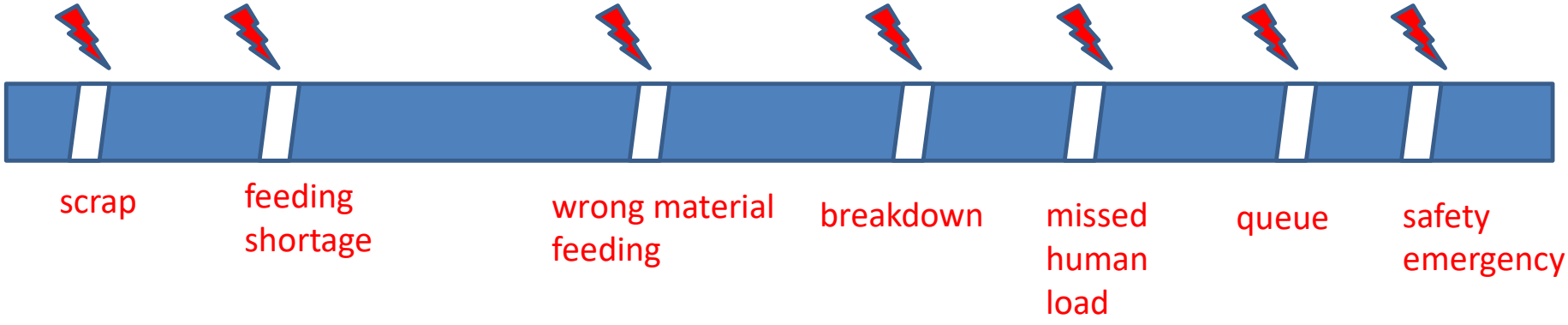
# Production data – Efficiency

The first definition of machinery efficiency is based on availability **A= MTBF/MTBF+MTTR**




Indeed, in automotive production lines there are a lot od interactions among the machines so the result in efficiency impact of several machines and other causes is not so easy to forecast.

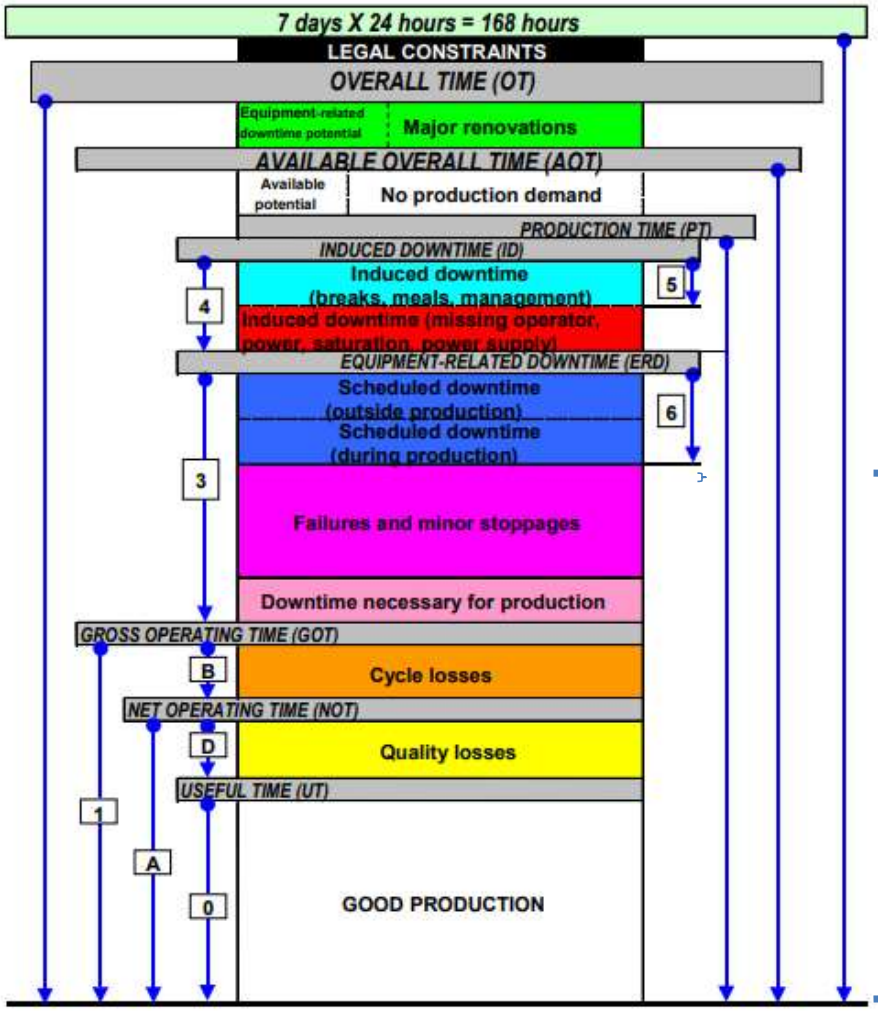
Example for an Operation “n” of a long process:



# Average OLE definition

- In a complex process the concept of OLE (Overall Line Efficiency) also called OPE (Operational efficiency) is used.
- The concept is to take the total time e.g. in a day 24 hours and detract all justified downtime e.g. holidays, external works, canteen time, induced downtime like power supply or missing production or missing operators or scheduled activities as periodical check up. It remains the **time available for the plant team to produce goods**.
- At the end of a period evaluate the actual produced good and **evaluate the official target time necessary to produce them.**
- **The ratio between Available time and Actual produced time is the overall efficiency.**
- **In case of a new line the value of efficiency is called "target" and is evaluated based on the experience of similar lines and the improvement actions in act.**

# OLE exact definition




OLE = (Actual Production * target cycle time)/ Available time

Available time =( 1 + 3 + 4 ) – ( 5 + 6 )

Available time

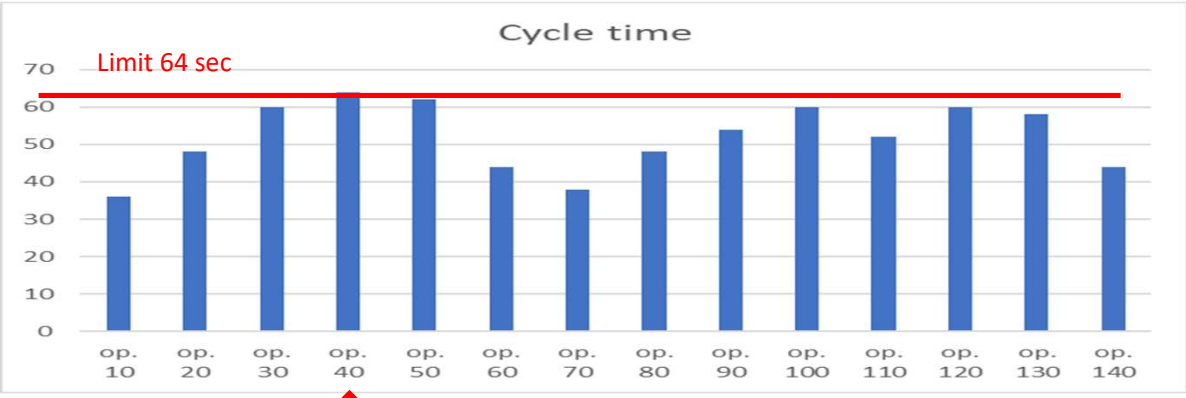
Actual Production* target cycle time

# Machine and line efficiency

- For Vehicle the target capacity intended as **Line =**hourly capacity and it is expressed in Job per hour (jph) being lines more homogeneous.
- For Powertrain most used is identify gross capacity, so **cycle time in minutes**. The reason is given by the fact that the lines are made by **single machines** with technology very different each from the others.

# Machine/line cycle time distribution

- The target cycle time is a constant for all the line but very often it is not possible have a mathematical alignment of all the cycle times.
- Since each operation is different the only possibility is to ensure that all the operation of a lines have a cycle time < or = to the target.
- This means that some operation will have a shorter cycle time , in some case even much shorter.
- To describe this aspect and study it, normally a diagram reports the line cycle times



# Production profile per operation

- The diagram per cycle time is very used but normally it is considered the efficiency too.
- In the practice of Plant Management, the data about breakdown, scraps and maintenance are collected per each operation. They are elaborated in order to define the value of efficiency per each operation.
- Combining efficiency per operation and cycle time per operation, a production profile per operation can be obtained where is used a short-term capacity mainly the daily capacity.

  **P (i) = Eff(i) / Cycle time (i)** where
  - P(i) is the expected production of operation i
  - Eff (i) is the calculated efficiency of operation i

- This diagram is very important to focus the improvement activities in order to increase the productivity

# Exercise

- Cycle time 64 sec
- Operation 1 has a better efficiency (0,9) but a longer cycle time (64 s). Operation 2 has a minor cycle time (53 s)  but also a lower efficiency (0,6). Which is the most productive?
- Daily P(1)=21,5* 3600* 0,90/64= 1088 u/d
- Daily P(2)=21,5* 3600* 0,60/53= 876 u/d **so the logic of cycle time is completely overturned**

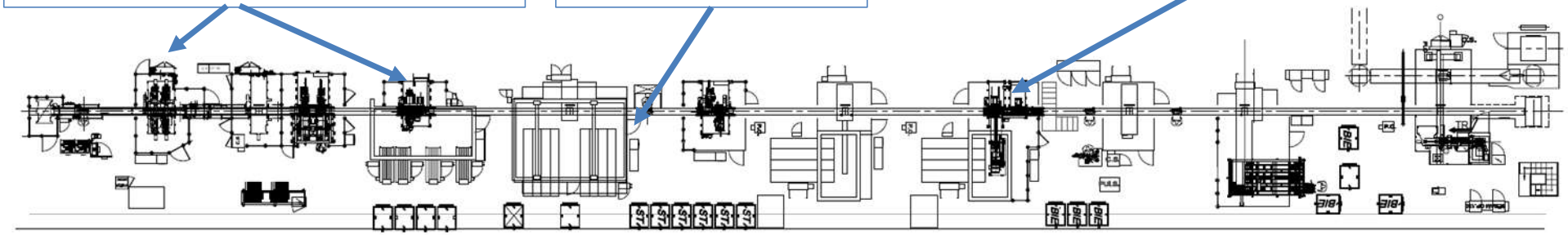
# Simulation

- It has been said that the efficiency is a data given by experience. It is true but in the last 40 years a lot of simulation tools have been developed in order to identify with growing precision the efficiency of a complex system.
- If the operations are independent (like infinite warehouse in the middle) the total efficiency is the one of the bottleneck. But in real conditions there are interferences and the result is lower than the bottleneck.

A breakdown of the previous station or the followers stops the flow (shortage of feeding or queue) – **only simulation can identify**

Some time material not loaded or wrong - other random distribution

**Efficiency of the single operation defined by the machine builder.**
Distribution of defect exponential with possibly multiple root causes (scrap, jamming, breakdown, safety emergency)



# Transport and Warehouse impact on efficiency

- As we said before there is a great impact of warehouse and transport on the efficiency since there is an interference between the operations (both in assembly and machining)
- There is not an analytic method the define them and the best tool identified so far has been the simulation even if with the queuing theory attempts to base the project on probabilistic evaluation has bene done but without concrete results.
- In general, the assembly designer propose a line with certain transport and warehouse dimensions that are tested through a simulation, creating an iterative process that ends when a satisfactory result in term of efficiency forecast has been reached.
- There are two different simulation tools: discrete events and analytic
- The first is more precise IF an intelligent logic of management system is introduced into the tool, otherwise the results are equivalent
- Lean manufacturing highlighted the danger behind an overstock in line but nevertheless the result is always linked to MTBF and MTTR of the machines

# Impact of efficiency on investment

- Let’s do now a different exercise.

- We have a line with a cycle time of 64 seconds.
- We have seen that with an efficiency of 85%, the yearly capacity is 300 k/y.

- Let’s now assume we can improve the efficiency from 85% to 95%, the capacity increases

Cap (95%)= (0,95/0,85)* 300 k/y= 335 k/y

So, improving the efficiency we improve **directly** the capacity **WITHOUT ANY INVESTMENT**
This is the reason of the importance of Improvement methodologies.

Further, if there is just one bottleneck to invest in improving efficiency of the bottleneck (said in Europe **de-bottlenecking**) can give a good improvement with a limited investment.