Prof. Ing. Dario Pozzetto

Department of Engineering and Architecture – University of Trieste

Via Valerio, 10 –34127 Trieste – Tel: 040.558.3805 / 7982 Fax: 040.558.3812

E-mail: pozzetto@units.it

INDUSTRIAL PLANTS II

Chapter one – part 1:

Lean manufacturing

DOUBLE DEGREE MASTER IN

“PRODUCTION ENGINEERING AND MANAGEMENT”

CAMPUS DI PORDENONE

UNIVERSITÀ OF TRIESTE

Lean Manufacturing

Brief history of Lean Manufacturing

The term "**Lean Thinking**" was proposed in 1987 by John Krafcik, a researcher at the Massachusetts Institute of Technology (MIT) in Boston, to indicate the characteristics of the production system, product development, the relationship with suppliers, assistance to customers, the quality and management methods of Toyota and other Japanese companies.

The "**Lean**" concepts were subsequently spread mainly through the books of James P. Womack and Daniel T. Jones.

The **Lean system** resumes, integrating, the previous organizational and management models, such as Total Quality Management (TQM), Total Productive Maintenance (TPM) and Business Process Reengineering (BPR), proposing techniques and tools used in Japanese industry.

Lean Manufacturing

Brief history of Lean Manufacturing

Taiichi Ohno (1912-1990), employed in the Toyoda Boshoku (Toyoda Spinning & Weaving) industries, it has given rise to this new production philosophy (Toyota Production System - TPS). He used to repeat: "**This production system originated in Japan because it probably could not have been born elsewhere**". Ohno was not initially a high-level manager, but a technician who started from the apprenticeship, working within a weaving department. It was moved by the Toyoda family in 1943 to the Toyota Motor Corporation, founded in 1937 by **Kiichio Toyoda** and intended to operate in the world of motor vehicles and means of transport

Lean Manufacturing

Brief history of Lean Manufacturing

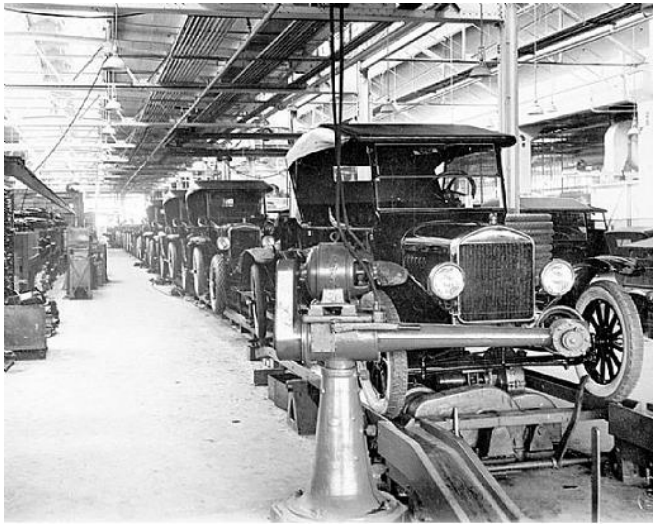
After the Second World War, the Toyoda family strove for a rebirth of the country. In this way, he set ambitious goals for improvement, so much so that he asked his collaborators to reach the same level as the American car companies in the medium term (three years), above all stimulating Ohno's search for process innovation.

Assembly line of Toyota, Koromo Plant, 1938

Lean Manufacturing

Brief history of Lean Manufacturing

This philosophy took place in conjunction with the evolution of mass production, of American influence, characterized by high volumes, significant presence of warehouses among the various processing departments organized by technology (turning department, milling department, welding department etc.), specialization of operators and rigidity of employment, with a lack of emotional involvement of the operating core, which led to a conflictual climate



Ford production line, 1925

Lean Manufacturing

Brief history of Lean Manufacturing

Mass production saw its initial application at another car manufacturer, the American Ford, and was the consequent response to a particular market situation and technologies available at that particular moment:

- **unlimited and undifferentiated market** (large demand for standard products);
- **large plants** as a response to the expansion of production volumes;
- **great availability of manpower**;
- **standardization of products** (example Ford Model T, 1908);
- **production features a tayloristic organization of work and a standardized series production with production phases organized in elementary operations**, operator learning concept through the repetitiveness of elementary operations and extensive use of assembly lines

Lean Manufacturing

Brief history of Lean Manufacturing

The **Fordist model** was exported all over the world and the Japanese industrial system also initially used this method.

The Japanese market, characterized unlike the American one by small quantities and diversified demand, put the mass production system in crisis with the increase in demand that occurred after the 1950 Korean war; Toyota itself had to change its organization. **Taiichi Ohno**, together with the management, invented and introduced new solutions into Toyota, solutions that are today the main foundations of lean production..

When the increase in demand took place, Toyota went into crisis: for half a month the materials were collected, in the second half they dedicated themselves to production; Ohno introduced the concepts of production leveling and above all of flow, thus trying to overturn the push production system.

Lean Manufacturing

Brief history of Lean Manufacturing

Ohno began the first experiments on flow in 1952 by grouping the machines according to the production process, assigning 3-4 machines to a single worker and introducing the concept of **autonomization** in the lines. **Autonomization** (**jidoka** in Japanese) is the term associated with machines capable of self-stopping if a problem arises, therefore not creating further waste, or defective pieces, in the various production phases..

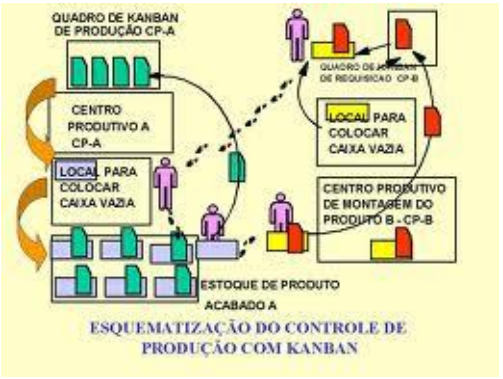
During this period, Ohno introduced two other foundations of the Toyota Production System: **Just in Time** and **SMED** (**Single Minute Exchange of Die**), both in response to the real production problems of the Japanese market.

With Just in Time (JIT) he introduced the concept of producing "**what is necessary, when it is necessary and in the quantity required**", with SMED a methodology was introduced for the drastic reduction of set-up times, with which Toyota manages to cut down two important wastes: overproduction and stocks

Lean Manufacturing

Brief history of Lean Manufacturing

It was between 1950 and 1960 that Toyota witnessed, thanks to Ohno's intuitions, the birth of new approaches and techniques, which would make the Japanese car manufacturer an example to follow for the whole world. In recent years Ohno has theorized the **seven mudas**, that is, the **wastes to fight**, the **widespread application of labor and product standards** and, following a trip to the United States, after seeing how American supermarkets were organized, the concept of **supermarket on board** and in **Kanban**.



ESQUEMATIZAÇÃO DO CONTROLE DE PRODUÇÃO COM KANBAN

The **seven wastes** arise from: **excess or overproduction, unnecessary supplies, transportation, process, inactivity, unnecessary movements and defective products**.

Lean Manufacturing

Brief history of Lean Manufacturing

The main differences that are found between "**Fordism**" and "**Toyotism**" are very evident.

Fordism was born for mass production and an unlimited market, in which costs are reduced simply by producing more. It is the factory that dominates the surrounding environment and determines the price of the product as the sum between the production costs and the profit margin.

TPS arises from a real need: to survive and compete in a limited market, characterized by zero or slow growth conditions.

Lean Manufacturing

Brief history of Lean Manufacturing

This model allowed Toyota and, in general, the Japanese production system to better cope with the oil crisis of 1973 and the consequent collapse of the car market.

At that point, western companies realized that something was happening in the Japanese production organization; the first reaction was to minimize this phenomenon by attributing this to the fact that:

- **labor costs in Japan were lower than in western countries**;
- **the Japanese had a different mentality from that of Western people**;
- **the Japanese system was not replicable**.

Lean Manufacturing

Brief history of Lean Manufacturing

Toyota's first joint venture with GM in America took place between 1983-1984 at the NUMMI plant near San Francisco (Fremont) which for the first time moved the TPS out of Japanese boundaries to this passenger car assembly plant.

It served the Japanese as a bridgehead for the American market; the Detroit giant instead used it to study Toyota's production systems.

The machines and workers were American, while the chiefs were Japanese. The production followed the rules of lean manufacturing. Over time the plant grew to become the largest car factory in the West of the United States, so much so that the Americans realized that the production activity had to be managed wisely without changing the mentality of the operators, but only following the new philosophy (**Lean manufacturing**).

Lean Manufacturing

Brief history of Lean Manufacturing

Lean Manufacturing was studied more carefully and applied since the early 90s. Womack and Jones were most active in spreading the new philosophy, with their books "The Machine That Changed The World" (1990) and "Lean Thinking" (1997).

The diffusion of lean in Italy took place in 2000 in large companies, while still in small-medium companies there is still much to do as it is necessary to overcome the size constraint of the structure, which makes its application difficult.

Lean Manufacturing

Lean Manufacturing identifies an industrial philosophy that aims to minimize waste and eliminate it. One of the fundamental characteristics is to identify, where possible, a flow in which the workings of the material follow one after the other and the material moves, in a visible way, until its transformation.

What is Lean Manufacturing?

It is a new way of organizing production in which the main objective is **customer satisfaction** and the **reduction of waste**:

1) modification of processes

- reduction in the number of processes involving the same product;
- grouping if possible;
- adoption of simple and delicate machines;
- reduction of tooling/breakdowns;
- introduction of Just in Time and kanban methods;
- reduction of waste;

Lean Manufacturing

What is Lean Manufacturing?

It is a new way of organizing production in which the main objective is **customer satisfaction** and the **reduction of waste**:

2) change of business mentality

- process modification is conducted in the correct way if implemented by the company staff;
- collective awareness that provides for a full involvement of employees in the success of the company:
  * the direction coordinates and keep the spirit alive I always keep the objectives under control
  * the worker at the machine feels responsible for his actions and acts in such a way that they are carried out in the best possible way

Lean Manufacturing

What is Lean Manufacturing?

It is a new way of organizing production in which the main objective is **customer satisfaction** and the **reduction of waste**:

2) change of business mentality

- initial problem of change of mentality for which involvement and motivation is needed:
  * full appreciation for the work done
  * feel part of the business problems
  * good level of decision-making autonomy
  * feeling an active and important part of a group
  * possibility of professional growth

Lean Manufacturing

What is Lean Manufacturing?

It is a new way of organizing production in which the main objective is **customer satisfaction** and the **reduction of waste**:

3) information and training

- all staff must be informed of the progress of production on the objectives achieved and those to be achieved
- development of a simple, but effective, visual communication system based on schemes, billboards or signs
- training must be calibrated in relation to the people concerned:
  * acquisition of knowledge of the principles of Lean Manufacturing
  * acquisition of knowledge to increase flexibility in the workplace due to changes in volumes which entails the creation of the **skills matrix**

Working groups

The **work group** or **team** is a group of people belonging to structures other than the company, with different professional skills, who come together and work together in a coordinated way, to face and solve one or more problems that may not be solved by the individual components or from the corporate functions to which they belong. The team is coordinated and controlled by a **team leader**, who works like the others, but has more responsibility for the behavior and results of the entire team.

Working groups

Starting point for the establishment of the **working group**:

- establish the objectives of the group and team leader
- define guidelines for group management (relationship between members, roles and participation of each, recognize the importance of communication within the group etc.
- define the problem to be studied, which must be adapted to the group's skills
- define a performance measurement system in such a way as to always make the distance from the objective evident
- define the end date of the activity and any steps to complete the project

Working groups

Maintaining of the **working group**:

- it is essential to keep the level of enthusiasm, participation and relationships between members to the maximum throughout the project period. It is therefore necessary:
  * agree on the method to be used to solve the problem (e.g. PDCA - Plan Do Check Act - or 5S)
  * always work with data and not with opinions
  * understand and interpret the weak signals that can lead to conflict within the group
  * assign a certain degree of responsibility to each component in order to keep his motivation alive
  * recognize the steps taken positively and congratulate you on the results achieved
  * it is important if necessary to contact an agent external to the group

Working groups

Maintaining of the **working group**:

- the working group fully expresses its potential during member meetings. It is therefore essential:
  * define the topic of the meeting
  * prepare the topic list and distribute it to the participants
  * be punctual
  * go straight to the point, without long turns of words
  * listen carefully
  * make a report of the meeting
  * establish the closing time of the meeting

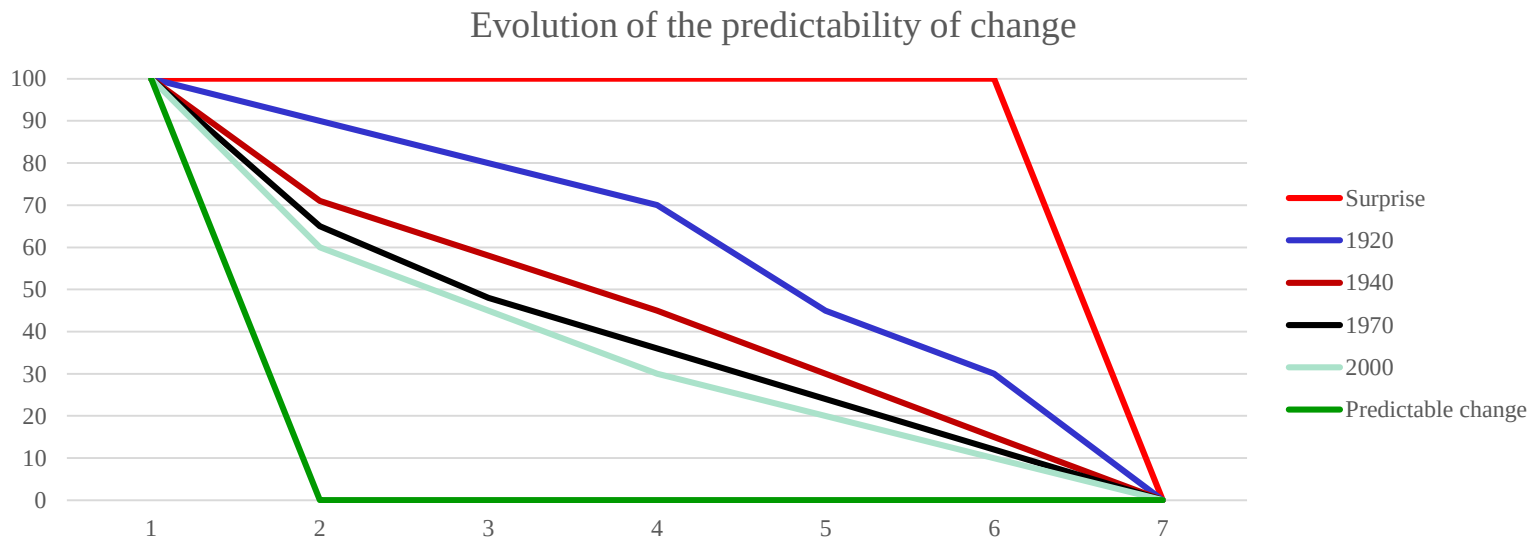
Working groups

Conclusion of the working groups project:

- compare the results with the agreed objectives
- identify any activity that still remains to be done to complete the task
- document the work done and the objectives achieved
- celebrate the achievement of the objectives and all the positive factors that emerged during the activity

Analysis of weak signals

The **weak signals** are facts, with a modest impact on the business, which are normally neglected or even not seen. They occur as a consequence of an increasingly turbulent and dynamic competitive environment.



1 - General sense of turbulence 2 - Identification of the source 3 - Identification of the plant 4 - Identification of the response 5 - Evaluation of the consequences 6 - first impact 7 - Full impact

Analysis of weak signals

From the graph you can see:

a) the **predictability of the situations is decreasing** as there is:
   - less time for reaction before full impact
   - less time to prepare the appropriate answers

b) a **greater commitment** must be considered for the **development of the skills necessary** to react due to the increase in the complexity of the situations

Weak signals can prevent both from within and from outside the company. In both cases they provide information on market changes or on the suffering situation of the production organization.

Analysis of weak signals

Internal signals relate to:

a) **competitive capacity of the products/services offered**. Corresponds to the loss of a customer. This leads to two consequences:
   - search for a new customer (much more expensive than maintaining)
   - globally most competitive competitors in the market

   As soon as the loss of the customer is known, the entrepreneur should carry out a serious and profound analysis to find the causes

b) **business climate**. Represents formal and informal relationships between employees; a heavy climate can lead to cracks or frictions in the organization

c) **efficiency of your projects**. The analysis of important factors such as turnover, profitability, cash flow, the efficiency of commercial and industrial processes etc. they provide important clues to how things are going

Analysis of weak signals

Internal signals relate to:

d) neglect and neglect. A certain neglect or neglect in dealing with the company's assets or a certain coldness or slowness in impersonal communications, often mark the employees' disaffection towards the company.

Self-assessment questionnaire

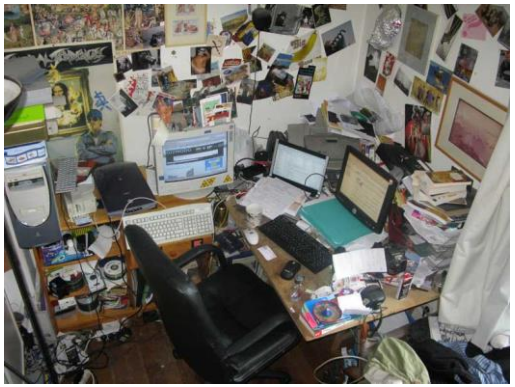
1) **disorder**: a sense of disorder is noticed when you walk the corridors of the production departments (work benches full of tools arranged in bulk, materials out of their containers or on the ground, documents arranged randomly on the counter or on products) or offices (desks cluttered with stacks of folders or scattered sheets, drawings out of their binders or archived without a logical sense etc.).

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5

Self-assessment questionnaire

2) **flow**: the flow of materials is not clearly identifiable also because the processes are not contiguous or subsequent to each other. There are returns of materials, intersections of paths, etc.

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5



Self-assessment questionnaire

3) visual management: all signs on the floor or at glance level are clearly visible to all to identify the right positions of materials, tools, safety instructions, monitoring instructions, team or department or plant performance belonging, of the quality produced, etc.)

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5

Self-assessment questionnaire

4) **machines and plants**: the time spent on tooling and lost for various reasons (waits, scraps, breakages etc.) is on average too high and leads to production batches that are more numerous than required by the customer. The machines are greasy, dusty, with rags and other materials abandoned nearby

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5

Self-assessment questionnaire

5) batches: the size of the batches in recent years has steadily decreased and this has produced tensions in the production system, accustomed to less close production changes

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5

Self-assessment questionnaire

6) **waste**: both in the production departments and in the offices, waste is evident due mainly to waste of time, displacements of materials, expectations due to the lack of information or materials, evident stocks, overproduction, defects, errors, rework, scrapping, etc.

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5

Self-assessment questionnaire

7) **standard**: the lack of standards in production and offices is evident, i.e. the lack of written notes that say how to do things, when to do them (for example work cycles, procedures, description of methodologies, lists of activities, etc.)

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5

Self-assessment questionnaire

8) order management: order management appears long and cumbersome. The order management time in the offices is comparable (or sometimes exceeds) to the production time

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5

Self-assessment questionnaire

9) customer satisfaction: there has not been a systematic survey of customer satisfaction, but direct relationships with some of them reveal difficulties in responding on the part of one's organization, difficulties in managing user problems, quality level performance does not live up to customer expectations.

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5

Self-assessment questionnaire

10) corporate climate: both through formal and informal relationships with employees, there are states of tension in relationships, dissatisfaction more or less evident on important issues, negative, malicious judgments, on absent third parties, strenuous justification of one's work, continuous emergence of the individual "I" instead of the group "we"

Not true in all cases	Often true	Average true	Often true	True in all cases
1	2	3	4	5

Self-assessment questionnaire

Once the questionnaire is completed, add the indicated scores. If the total score is:

- **greater than 40**: the organization requires rapid problem analysis because the level of response to customer expectations is on average low and risks seriously undermining the company's competitiveness
- **between 25 and 40**: the organization has significant parts to review to maintain its competitiveness
- **less than 25**: the organization responds fairly well to market demands, but has room for improvement in those points where the score is between 3 and 5

Lean Manufacturing

Customer value - Product-process development

The definition of **value for the Customer** is the first and perhaps the most important of the principles of Lean Manufacturing

Who are our Customers? What has value for them?

It is always necessary to take into account the needs of those who buy its products and those who use them.

When does the customer assign the value?

- the **purchase** in which it defines the "**balance between expected benefits and costs incurred**";
- during **use** in which there is a "**comparison between performance and expectations**".

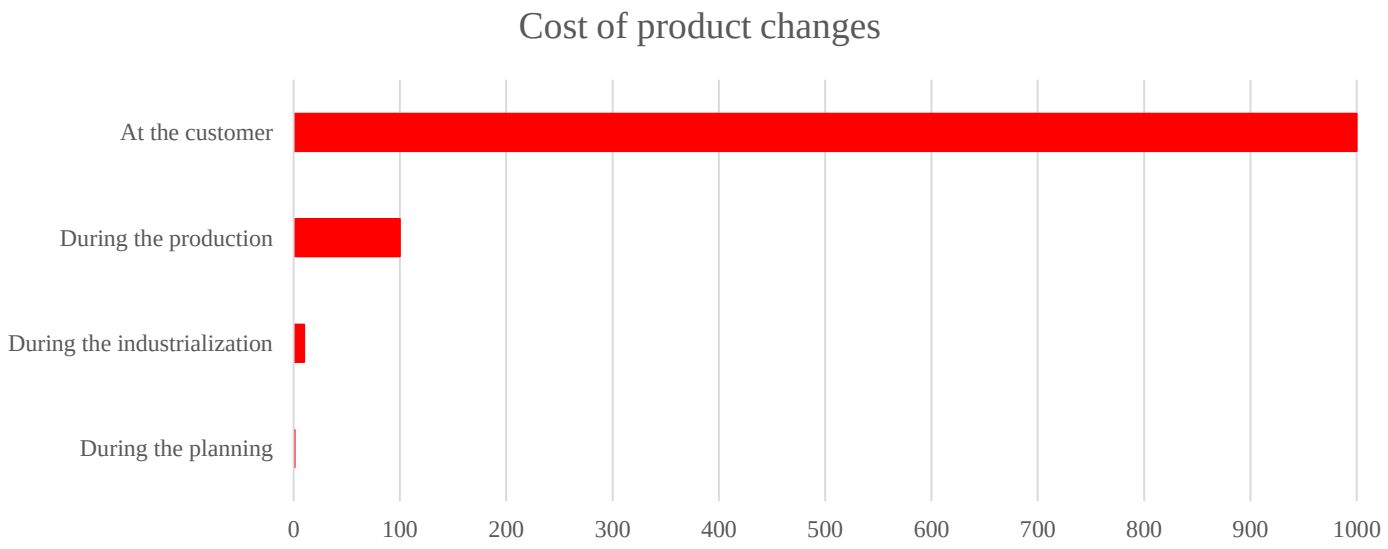
The **value** is the estimate that the Customer-Consumer assigns to the ability of a product to satisfy a series of objectives.

The company will achieve excellence and eliminate waste and carry out all activities that generate value for customers.

Customer value - Product-process development

Product development is the most important phase because:

- more than 50% of the products make lower than planned sales
- about 75% of the cost of the product is decided during product development and in particular in the initial phase



Customer value - Product-process development

The **changes made to the product are more expensive towards the end of development or even in production** (up to 1000 times) and therefore it is a very important phase.

It must therefore be carried out for the **process-product development**:

- product development closer to customer needs and greater corporate communication;
- carry out an organized procedure.

Customer value - Product-process development

The **guidelines for product-process development** are:

1) **objectives**: these are the points to be reached to aim for success. They must be reported in a document (product plan) and always kept under control:
   - **quality**: consistency between product development/customer needs
   - **precision**: compliance with specifications
   - **efficiency**: effective use of resources
   - **innovation**: search for new functions/features/performances
   - **time to market**: reduction of implementation times

Customer value - Product-process development

The **guidelines for product-process development** are:

2) **organization and management of the product**: the product is made by a working group (several external collaborators) with skills such as:
   - **marketing or sales**
   - **technical assistance**
   - **planning and design**
   - **industrialization and production**
   - **quality**

Customer value - Product-process development

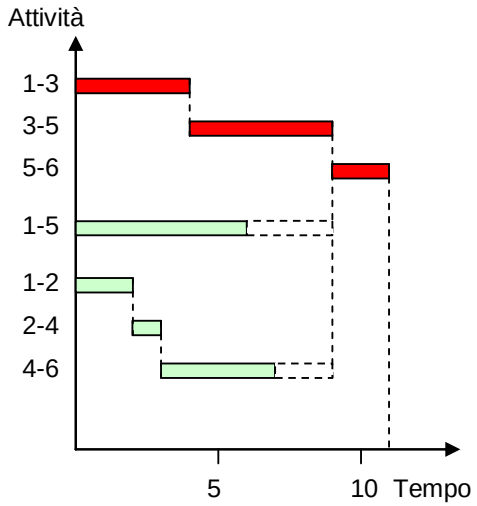
The **guidelines for product-process development** are:

3) techniques and tools:

- **Quality Function Deployment**
- **Failure Mode Effect Analysis (FMEA)**
- **Design to Cost**
- **Design for Manufacturing/Assembly (DFMA)**
- **japanese production tools**

4) method: structured and systematic approach to product generation which is based on verification meetings called Check Points

The Gantt chart is used to check the progress of the product:



Current State Map

Current State Map describes the current situation of value flow. The process must be mapped in such a way as to identify the indicators in order to measure performance directly on the field.

This makes it possible to identify problems and activities that do not generate value with the aim of identifying and eliminating waste.

The main icons used are:

Current State Map

Current State Map describes the current situation of value flow. The process must be mapped in such a way as to identify the indicators in order to measure performance directly on the field.

This makes it possible to identify problems and activities that do not generate value with the aim of identifying and eliminating waste.

The main icons used are:

Current State Map

How to **build and use a Current State Map**:

a) draw the icons of the customer, supplier and production control at the top of the sheet;
b) indicate customer requests for a significant period (e.g. year/month/week;
c) calculate the daily production and the number of containers/shipping units/pallets to be produced and sent periodically;
d) schematize outgoing shipments and their frequencies;
e) schematize the incoming supplies with the relative frequencies;
f) draw in the lower part of the sheet the basic production processes in which the material is flowing, considering the backward processes, from those downstream to those upstream.

Current State Map

How to **build and use a Current State Map**:

g) describe and report all data to the evaluation of individual processes:
   - cycle time (TC): time it takes an operator to complete his tasks before repeating them;
   - value-added time (VA): time of the elements that truly transform the product into something that the customer is willing to pay;
   - reliability (Uptime): percentage of the time in which the machines work on the total time available;
   - total time available to work (Tdisp);
   - average batch quantities if any (Lot);
   - number of shifts;
   - number of operators.

Current State Map

How to **build and use a Current State Map**:

h) track the flow of information (orders, forecasts, kanban, MRP etc.) indicate the position and the amount of the quantity (in pieces and in equivalent time) of the storage areas of the stocks that interrupt the flow of material;

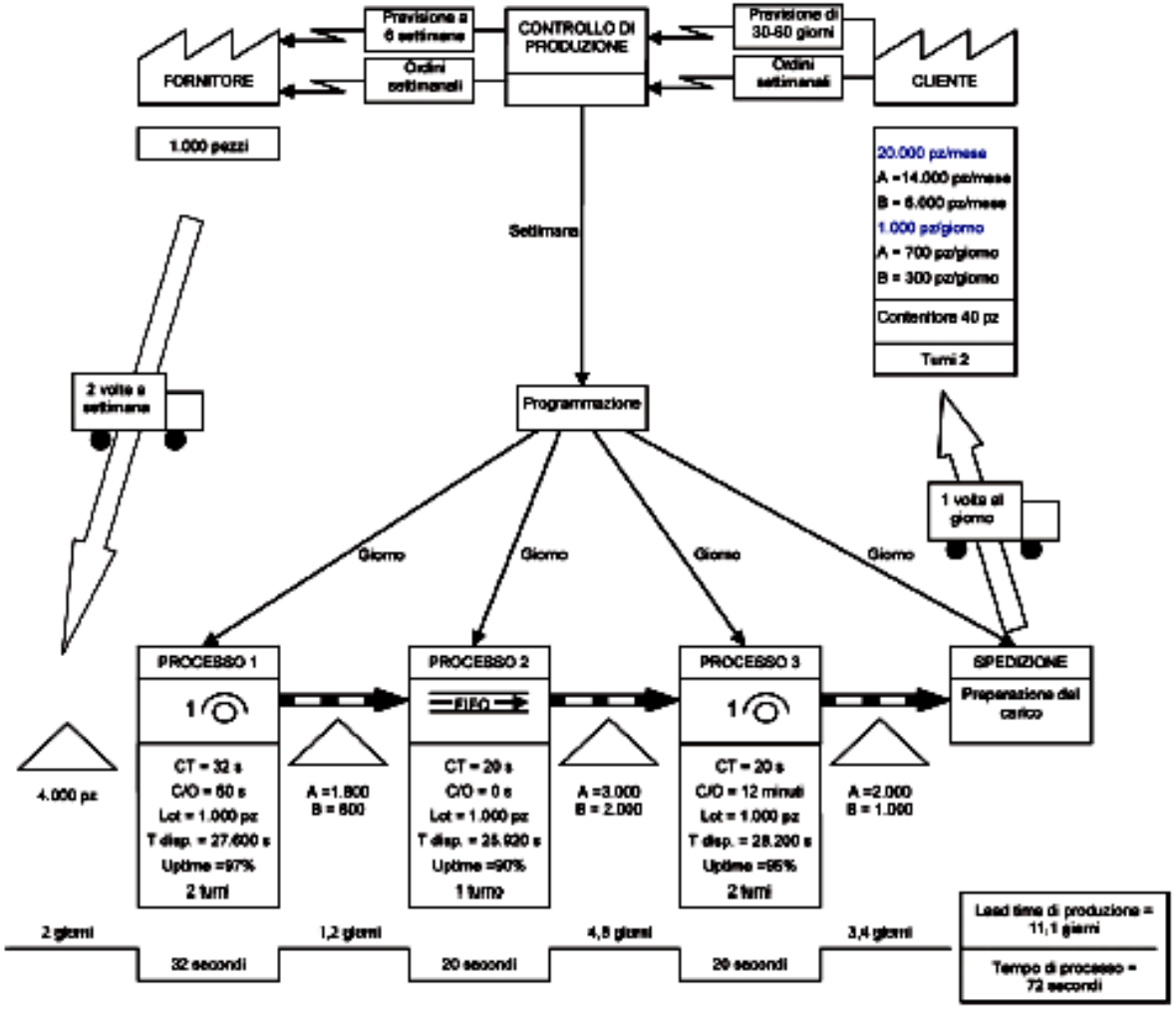
i) connect the processes indicating the push (the upstream process pushes towards the downstream), pull (the upstream process operates as "pulled" from the downstream ones) and FIFO (first in, first out) logics for programming the production;

j) draw a double timeline, the first that defines the process lead time, and the second the value-added time, that is, the time that transforms the product so that the customer is willing to pay. The **flow index** is the relationship between process time and lead time.

Lean Manufacturing

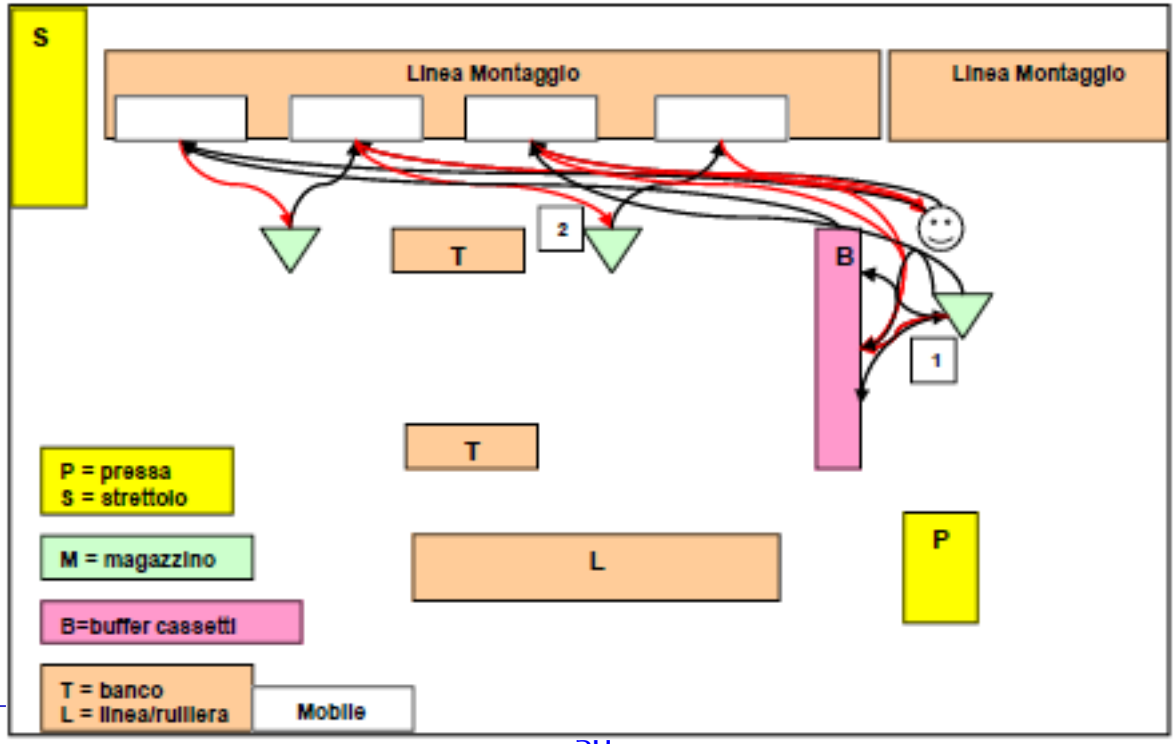
Current State Map

How to **build and use a Current State Map**:



Spaghetti chart

Spaghetti chart is a graphic representation of the movements made by a product along the value flow of a company. Correct implementation allows to improve the layout by studying the material flows and the movements of people both between the departments, but also within the individual work cells.



Spaghetti chart

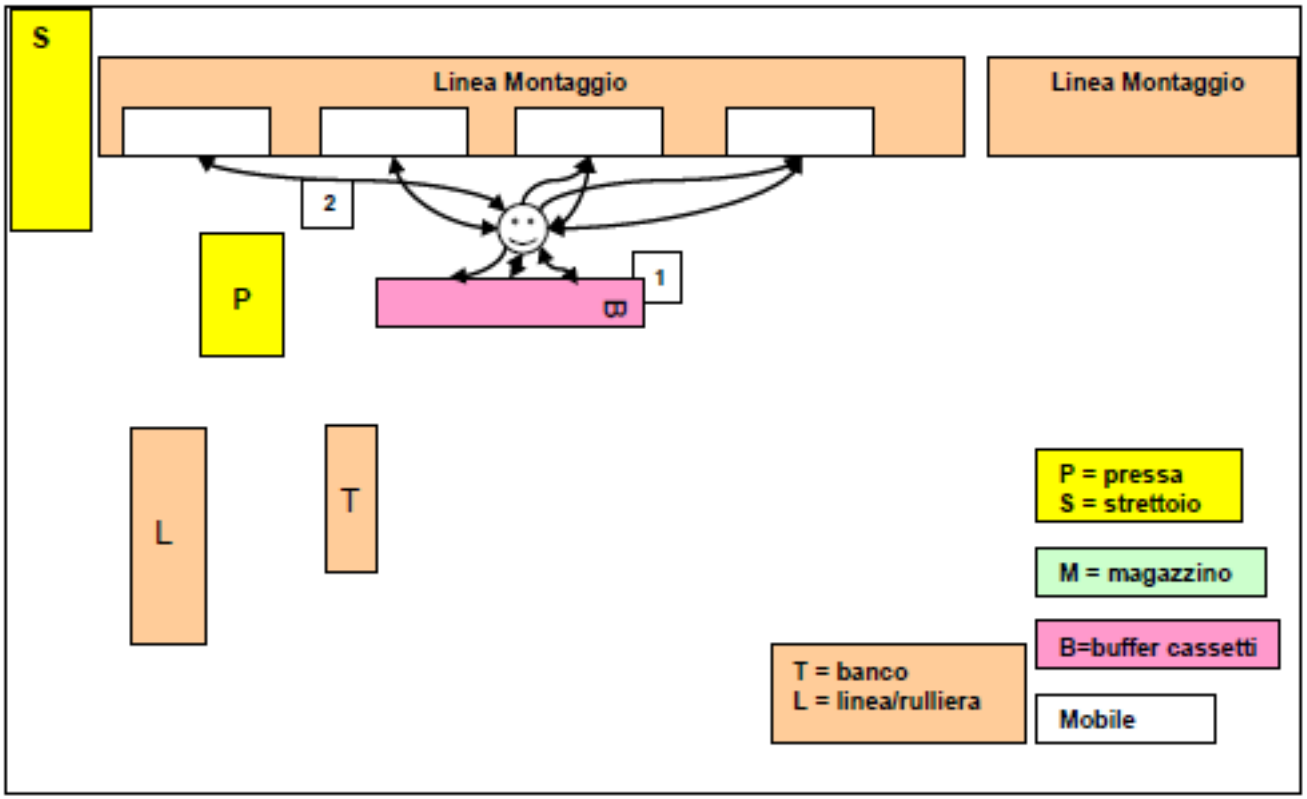
Spaghetti chart analysis:

- the drawn lines constitute the movements of the operator that the analyst has recorded. Since the layout is designed in scale, the total distance traveled is easily calculated and, consequently, the time taken by these worthless activities;
- the number of lines, their length, the number of crossings etc. highlight the lack of fluidity of the processes. The more intricate and long the routes, the more generally they are expensive and difficult to manage;
- the thickening of the lines in a single point highlights machines or work areas that can be bottlenecks, with all the related risks.

Spaghetti chart

Spaghetti chart analysis:

The results of the analysis and the example of improvement are visible in the figure



Visual Management

Visual Management is a method for generating an environment rich in immediate and visually stimulating information. The use of signs, stripes, tags, document holders, colored and clearly visible edges, the use of contrasts and graphic devices stimulate the operator and immediately communicate important information.

Visual Management

The main results obtainable with **Visual Management** are:

- immediate increase in workplace safety;
- improvement of productivity and its control;
- increased motivation of the staff involved;
- creation and maintenance of standard conditions that facilitate continuous improvement;
- strong reduction of waste without the need for investments.

Visual Management

The areas of application of **Visual Management** are:

1) **production departments and jobs**:
   - processes and machines must be arranged so that the flow is clearly and immediately identifiable;
   - the work and storage areas of the materials, corridors and walkways must be clearly identifiable by colored lines applied on the floor;
   - warning signs clearly identify exits, fire extinguishers and emergency procedures;
   - in each workplace the tools, containers and materials are identified and placed in an orderly manner, in order to facilitate selection and grip;

Visual Management

The areas of application of **Visual Management** are:

2) materials:

- the colors of packaging and containers are coded according to the destination;
- the containers are clearly labeled and accessible (the materials used frequently (every day) are organized and placed in a special area of the work space, those used less frequently are organized and placed progressively further away)

Visual Management

The areas of application of **Visual Management** are:

3) documentation:

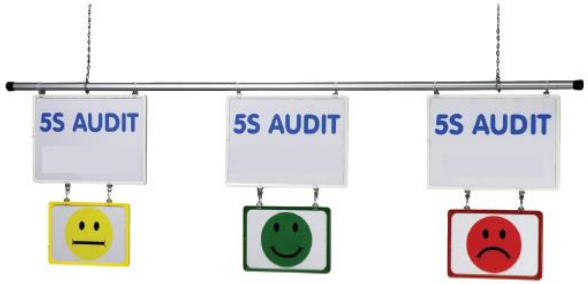
All technical documentation must be collected diligently in order to be easily available when necessary and be protected from dust and wear. Similarly, all information regarding the progress of the activity must be summarized in diagrams and graphs and be collected on clearly visible displayboards

Visual Management

The areas of application of **Visual Management** are:

4) control systems:

- production control takes place by means of luminous displays which indicate expected production, actual production and any difference;
- assistance to operators takes place through call signs that alert the rescue specialist in case of operator in difficulty;
- the process/product control boards show every problem on the line and allow to keep the quality under control;
- the kanban tags collected in visible tables show the production status and allow a control of the materials;
- the use of tags allows you to keep under control the points of the machine that need the intervention of the maintenance technician.



Kaizen or continuous improvement

The **Kaizen** guidelines are:

- **careful product design** results in less time being wasted as changes are reduced;
- non-product **process control**;
- **organization of efforts**: everyone works in a coordinated and efficient way to achieve the objective;
- **a priori verification of an operation** (before doing it);
- **business organization** places emphasis on the people who create value for the customer, the whole company structure, including management, is supportive;
- the **working group** that takes charge of improving a certain activity must be made up of people with adequate skills, or involve external people in the group who possess the skills necessary to achieve the objectives;

Kaizen or continuous improvement

The **Kaizen** guidelines are:

- **workplace** is the same as the "heart" of the company where customer value is generated;
- **fight against waste** in every department of the company (not only in the production departments)
- problem solving by researching the causes and definitive solutions to the problem (not "who did it").

Kaizen or continuous improvement

Il **Kaizen** permette quindi di:

- know what customers want and what they are willing to pay;
- find the best, safest and easiest way to meet your needs significantly reduce costs;
- involve and motivate people through activities that have the following characteristics:
  * they are fast and with no frills, aimed at the result and the elegance of the solution;
  * are made for people working in the workplace without large investments, without the need for spaces beyond what they have;
  * are geared towards solving problems, seen as opportunities to improve performance, rather than looking for culprits;
  * are based on data, facts and not opinions;
  * are based on current standards and close with the issue of a new standard, better than the previous one.

The 5S

The **5S** methodology is a methodological approach that aims to initiate and maintain a process of reducing waste present within an organization, thus continuously improving production and business processes and eliminating everything that is not strictly functional to the 'performed activity.

How to apply the 5S?

The 5S methodology is applied by a working group: the group meets in the chosen workplace and begins observing the environment. The situation that usually presents itself to observers is in general a feeling of general disorder and confusion: there are unnecessary materials and tools, more or less evident waste, sub-optimal production flow, uneven production etc.

Solution of the problem is the use of the 5S

The 5S

The **5S** are:

1) **Seiri**: it means organization and summarizes the search for unnecessary things, that is, that are not needed in that given workplace. Unnecessary objects / materials / tools are removed and removed from the workplace. The question to ask is:

"Does this object serve those who work in this workplace or not?"

The 5S

The **5S** are:

2) **Seiton**: it means order and indicates the phase in which the objects necessary for the workplace are rearranged and appropriately arranged on suitable shelves, support surfaces or supports for tools. The question to ask is:

"**Since this is a necessary object in the workplace, what's your best place?"**

The 5S

The **5S** are:

3) **Seiso**: means cleaning and indicates the subsequent stages of cleaning the workplace. In a cleaner environment, the identification of materials and tools is easier, the inspection of the machines is facilitated and above all it is easier to keep the workplace in optimal conditions

The 5S

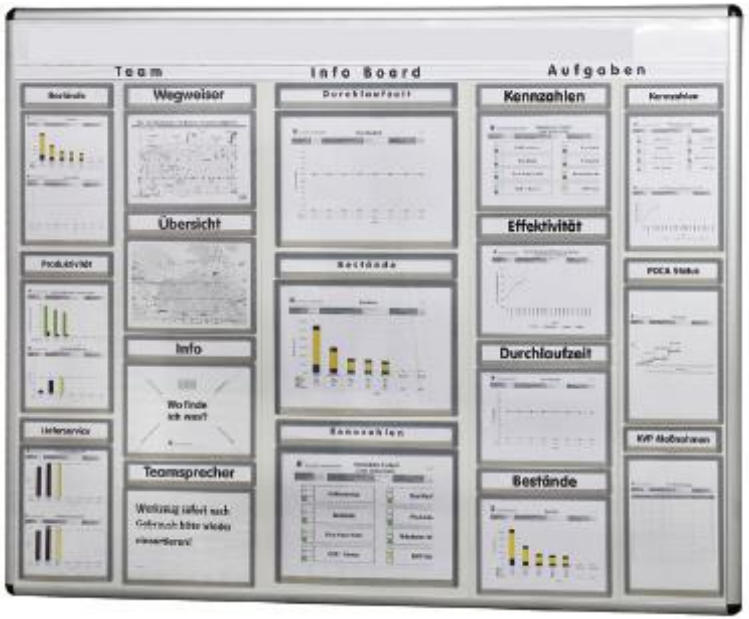
The **5S** are:

4) **Seiketsu**: indicates a standardization phase of the workplace necessary to make what has been done easily visible, by applying Visual Management. Standardization is necessary to avoid returning to the situation prior to the reorganization. The standard is set thanks to the use of process cards, production cycles, tables and explanatory photographs

The 5S

The **5S** are:

5) **Shitsuke**: determines the consolidation of the habits acquired and the continuous verification of the standards achieved thanks to the awareness of the staff and the visual display of the methodological path, the objectives and the results obtained



Total Productive Maintenance (TPM)

Total Productive Maintenance is a particular approach of continuous improvement that pursues the maximum efficiency of the production system and its means, aiming to eliminate faults, accidents, defects etc.

Starting point: the production vehicles do not produce for as long as they should due to a series of "losses" that affect the company's competitiveness. Losses such as:

- failure;
- tooling and adjustments;
- no-load operation and micro stops required for control;
- machine speed reduction;
- defects and repairs of non-compliant products;
- low yield when starting the machine.

Total Productive Maintenance (TPM)

Solution of the problem is the same as using the TPM

How to use?

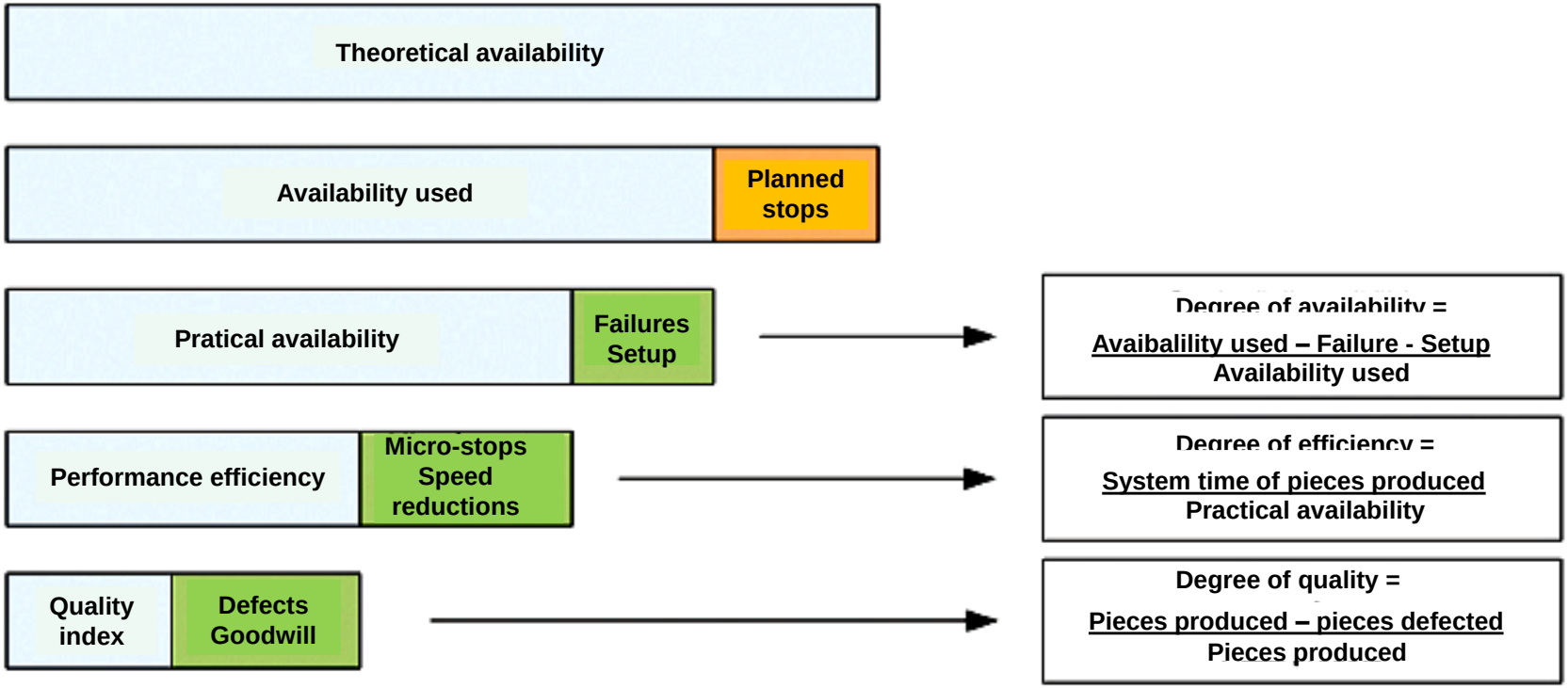
The systematic detection of "losses" allows to calculate an efficiency index of the production medium (**OEE - Overall Equipment Effectiveness**), which relates the time destined for the transformation of raw materials into finished products with the total time of use programmed in the company. This index is obtained as a product of three other indices:

1) **degree of availability**;
2) **degree of efficiency**;
3) **degree of quality**.

The goal is to try to bring this index as close to 1 as possible (high vehicle efficiency)

Total Productive Maintenance (TPM)

OEE calculation scheme



Total Productive Maintenance (TPM)

Starting phases of the TPM program

- specific improvement of machinery and production lines (machinery returns to its original state;
- autonomous maintenance:
  * inspection with cleaning: removal of dirt and knowledge of the machine;
  * dirt countermeasures: repairs of any oil leaks etc.;
  * preparation of cleaning and lubrication standards: where and when to clean;
  * general inspection: analysis of machine structure and functions;
  * autonomous inspection: formalization of the final cleaning standards;
  * maintenance management: maintain the set cleaning standards;
  * complete autonomous management: the operator is responsible for all operational aspects.

Total Productive Maintenance (TPM)

Results of the TPM program

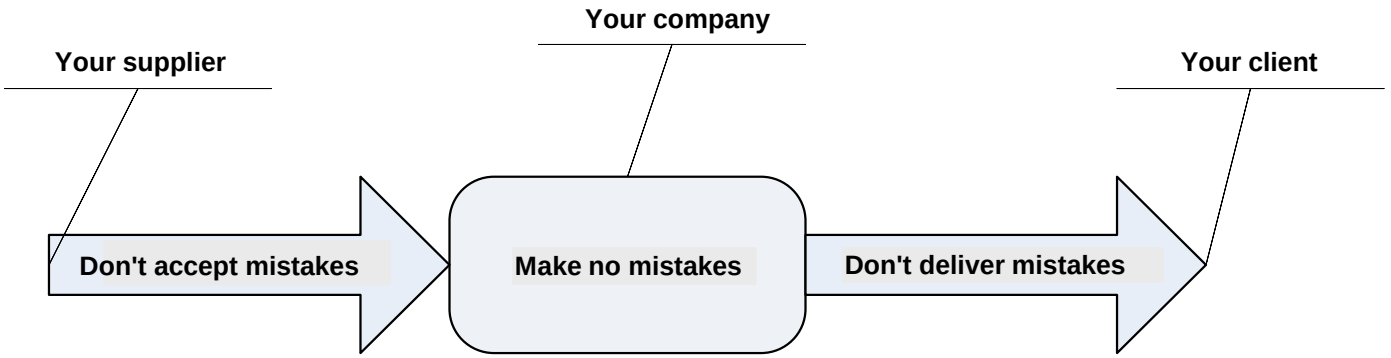
- improvement of the performance and efficiency indices of machines and plants;
- creation of a preventive maintenance system for machinery, plants etc.;
- improvement in the management of the machinery start-up;
- reduction of processing waste (zero defects);
- keeping the maintenance cost under control;
- involvement of operators in the management aspects of the production of production vehicles.

Poka-yoke - Error proof

Poka-yoke is a Japanese word that identifies a series of steps, devices or operational solutions to prevent errors or imperfections from accessing the development of activities.

Purpose:

- prevent non-compliant products from entering the production process;
- prevent the manufacture of non-compliant products;
- prevent non-compliant products from moving on to the next product.



Poka-yoke - Error proof

Ideal poke-yoke features:

- not expensive;
- simple to implement and use;
- specific to the need;
- developable by any employee.

Main types of poke-yoke:

- **poka-yoke elimination**: prevents the creation of the error, for example by making sure that the piece can be assembled only in the right way (to be preferred as it prevents the generation of waste);
- **attention poka-yoke**: highlights the presence of a possible error, for example the interruption of the fuel supply when the tank is full (technical or economic reasons could lead to this choice)

Poka-yoke - Error proof

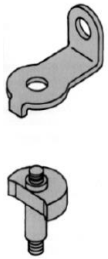
How it is made:

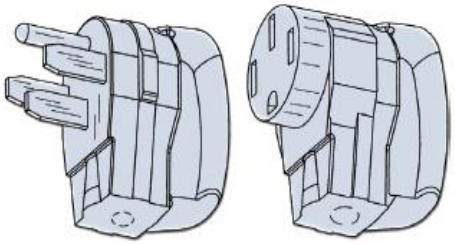
- identify the processes in which margin of error is not allowed or where customer feedback has highlighted the need for a particular action;
- decide which type of poka-yoke to activate, whether for power or activation, depending on the nature or objective of the activity;
- develop an adequate poka-yoke solution;
- try the poka-yoke on the field to see if it works. Models, prototypes, drawings, schemes, etc. should be used;
- tested the operation, make sure you have the right tools, check-list, procedures to work in complete tranquility;
- train everyone interested in using the new solution;
- after a certain period of operation, make an accurate analysis of the system performance and eventually eliminate any problems.

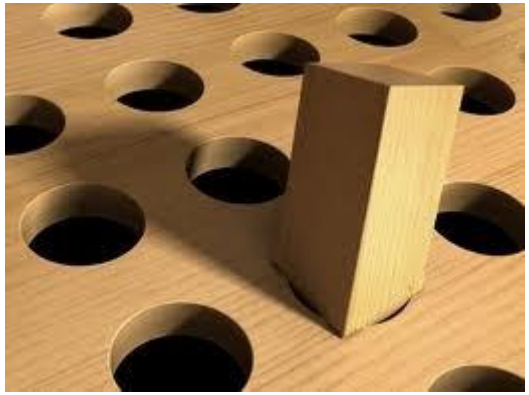
Poka-yoke - Error proof

Results of using poka-yoke:

The use of these procedures and their continuous refinement lead to the complete elimination of the error with consequent improvement of the production activities.





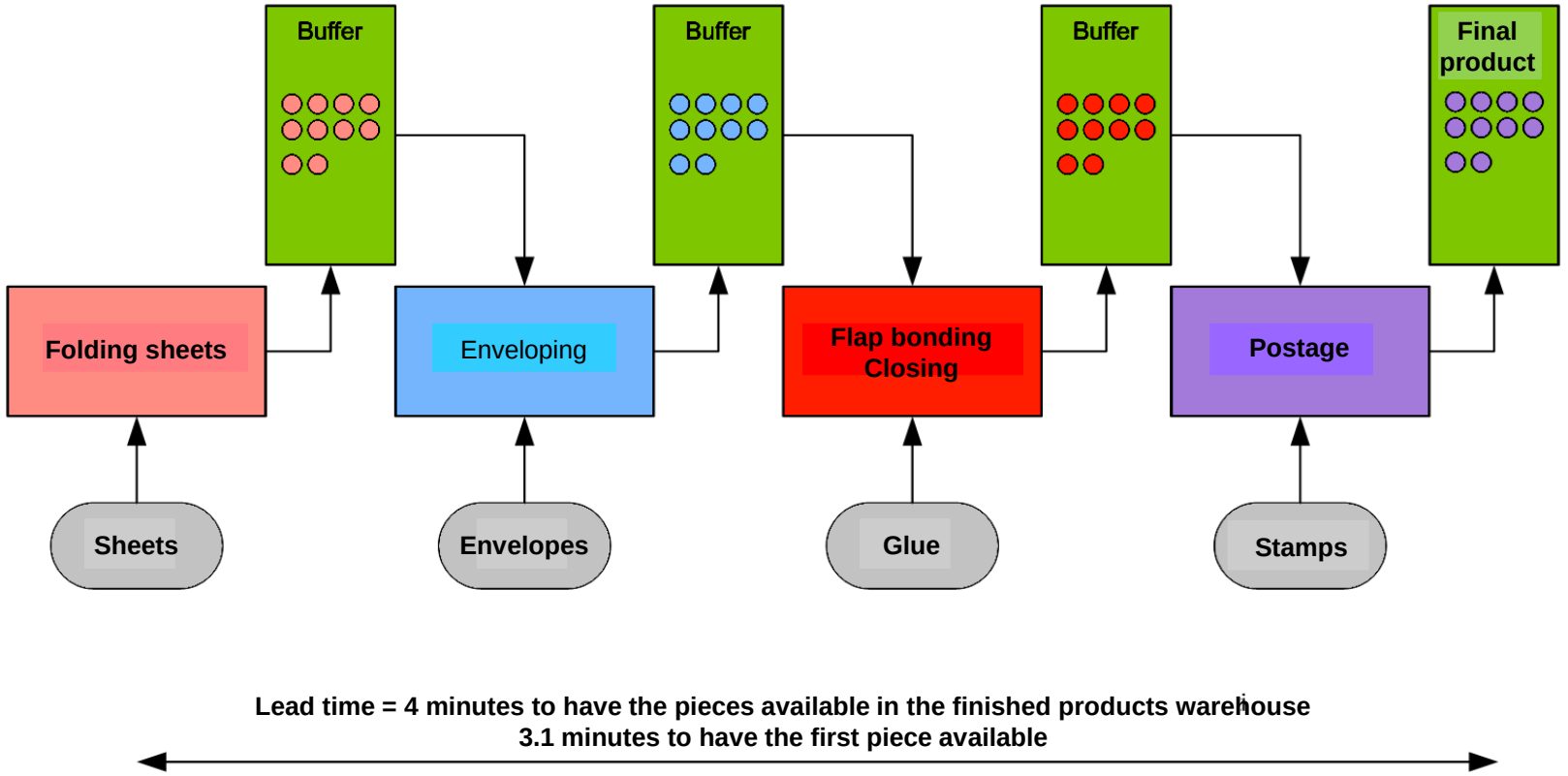


One piece flow

One piece flow highlights the possibility of organizing production by advancing the material one piece at a time with a continuous flow, rather than by batch production. The pieces then pass from one production process to the next, without accumulation in intermediate warehouses.

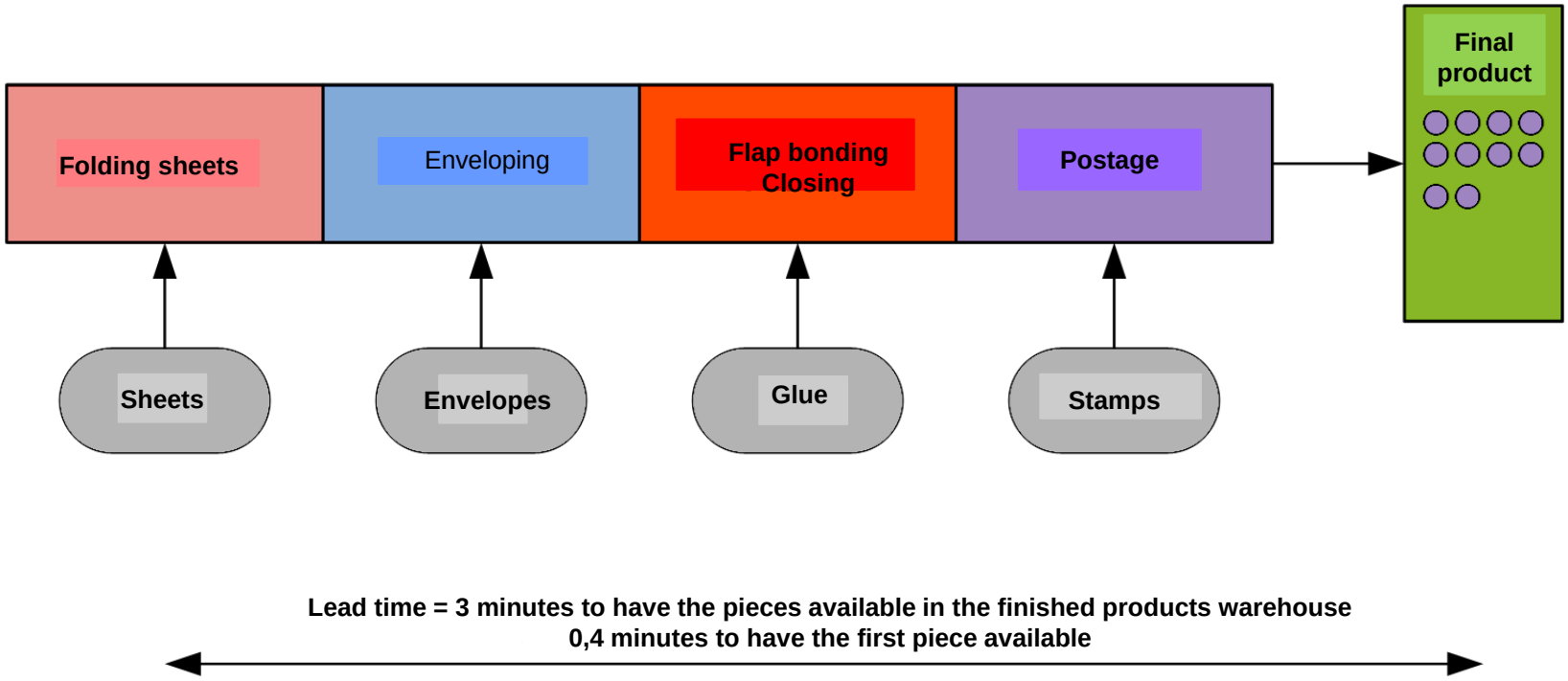
One piece flow

What is it for? From the figure you can understand what is the advantage of using the One piece flow method, If in fact we consider a batch production



One piece flow

A cosa serve? Dalla figura si può capire qual è il vantaggio dell'utilizzo del metodo **One piece flow**



One piece flow

Advantages of the One piece flow:

- **reduction of the total production crossing time** thanks to the saving of intermediate operations of "taking" and "depositing" which do not add value for the final customer;
- **sharp reduction in intermediate stocks** thanks to the elimination of warehouses, typical of batch production;
- **immediate availability of the finished product** as it is necessary to wait for the completion of the processing upstream of the whole lot;
- **reduction of scraps** as it only works on one product at a time;
- **reduction of occupied spaces** thanks to the elimination of intermediate warehouses and the achievement of processes in order to facilitate the passage of the pieces from one location to another (favor the use of cell layout);
- **improvement of safety** as it significantly limits the handling of pallets or containers in the processing departments;

One piece flow

Advantages of the One piece flow:

- **productivity improvement** thanks to the elimination of waste related to batch production;
- **improvement of the response flexibility of the production system** as it works one piece at a time;
- **simplification of the procurement of material** as the replacement of components and semi-finished products is easily foreseeable and manageable;
- **predisposition for continuous improvement** as this type of production promptly highlights any problems;
- **increased operator motivation** because the environment is more visible and better organized.

Just in Time

Just in Time (**JIT**) is an integrated set of activities designed to obtain the expected production volumes, with the use of stocks (raw materials and finished products) at the minimum value to ensure the correct flow of the flow.

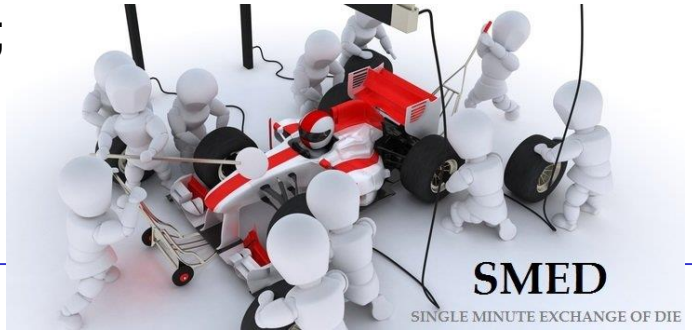
Target:

"**Produce exactly what you need, in the quantity you need, when you need it**" which corresponds to eliminating stocks.

Just in Time

Approach with JIT system

- **zero defects**: it is necessary to direct the entire production system towards a thorough control of the quality of the construction and purchased details, while at the same time involving all the staff of the company, in order to:
  * reduce waste and all consequent activities;
  * improve warehouse management;
- **zero failures**: foreseeable and eliminable failures are not acceptable as they would lead to the creation of stocks;
- **zero set up time**: it is necessary to minimize the machine set-up time in order to favor a rapid change of production, with the consequent reduction of stocks;



Just in Time

Approach with JIT system

- **zero lead time**: cancel the crossing time of materials inside the factory. It is necessary to reduce, consolidate and simplify the processes, as well as standardize the components and the organizational systems for feeding materials;
- **zero bureaucracy**: necessary to have a way of transmitting information that you know as simple as possible. This is directly related to the approval of the previous points.

Just in Time

Results of the JIT system

- increase in quality;
- sharp decrease in stocks (60-70% of the initial ones);
- better leveling of workloads in the various processes;
- increase in the standardization of components of working methods;
- establishment of strong cooperation relationships and partnerships with selected suppliers;
- increased workforce flexibility;
- business layout simplification;
- shortening of material paths and their handling (20-30%);
- reduction of internal communications and orders, documents, production declaration (up to 1/3 of the initial ones);
- increased punctuality of supplies, both internal (of the same production departments), and external (from suppliers);
- increased productivity and reduced production costs.

Takt time

The companies that adopt Lean Manufacturing work with an average time per piece determined by the customer's request; this time is called **takt time** and is calculated as the ratio between the working time available in the period considered and the average expected demand at the same time.

What is tack time?

$$\text{Takt time} = \frac{\text{Waorking time available daily}}{\text{Average demand expected daily}}$$

The available working time is the attendance time of the operators, reduced by the planned breaks and machine downtimes, but they include set up times, failures, etc. The average demand is the average sales volume, including spare parts, expected waste etc.

Takt time

How to calculate the takt time?

The question to ask is:

"**How fast do I have to produce**"

Initial data:

- customer demand: 18,400 pieces/month;
- working days: 20 days/month

$$\frac{18{,}400\ pieces/month}{20\ days/month} = 920\ pieces/day$$

- workshift: 8 hours (to which 2 breaks from 10 minutes must be subtracted):

460 minutes/day × 60 s/minute = 27,600 s/day

There is a takt time of:

$$Takt\ time = \frac{27{,}000\ s/day}{920\ pieces/day} = 30\ s/piece$$

Customers absorb one piece every 30 seconds from production

Takt time

It is important that the entire production flow aligns with the customer's request and therefore is consistent with the takt time. It is therefore necessary to evaluate the theoretical number of operators necessary to obtain the required parts from the process in the period considered

How many people?

$$Number\ of\ operators = \frac{Time\ alloted}{Takt\ time}$$

Assuming that in the work cell or in the process the assigned times of the operations total 120 seconds, the number of operators required would be equal to:

$$Number\ of\ operators = \frac{12\ s}{30\ s} = 4$$

Takt time

The **advantages** of producing at takt time are the following:

- the time (rhythm) to which the different processes conform is known;
- the flow of materials and time is regular and uninterrupted;
- the production system is synchronized with customer requests;
- we move from push to pull production;
- there is no overproduction;
- the WIP is reduced.

Critical:

Evaluation problems in the event that customer demand cannot be easily predicted, because not regular.

The 7 wastes - Muda

Waste is all that does not create value for the customer and as such should be recognized and removed as soon as possible. Japanese production strategies identify seven types of waste that will be analyzed, trying to provide the possible causes for each one in order to facilitate their removal.

What are the 7 types of waste?

1) **excess or overproduction**: everything that is produced more than the customer's request; implies the use of more resources than required (material, labor, energy etc.). Waste is easily recognized by the presence of intermediate warehouses in the production process due to overproduction.

   Possible causes: imbalance of labor loads, presence of bottlenecks, low flexibility of the production plant, long tooling times etc.

The 7 wastes - Muda

What are the 7 types of waste?

2) **unnecessary stocks**: presence of large spaces dedicated to warehouses, large quantities of raw materials awaiting processing, finished products awaiting shipment, semi-finished products and components stored on shelves etc.

   Possible causes: inadequate programming systems, absence of synchronisms between the different parts of the company, inconsistency between the response time requested by the customer and the crossing time of the production unit, too long crossing times etc.

The 7 wastes - Muda

What are the 7 types of waste?

3) **transport**: moving the material inside the factory does not enrich or increase its value. All empty transport within the plant or unnecessary movement of material must be taken into consideration. **Possible causes**: non-optimized routes, obstacles or barriers to movement, difficult recognition of materials, partial and incomplete processing, etc.

The 7 wastes - Muda

What are the 7 types of waste?

4) **process**: all the activities that are carried out during production and that do not increase the value of the product (management of rejected pieces, testing and quality inspection operations, packaging of materials, etc.)

   Possible causes: inadequate or fully functional systems, machines and equipment, limited staff training, low level of standardization, etc.

The 7 wastes - Muda

What are the 7 types of waste?

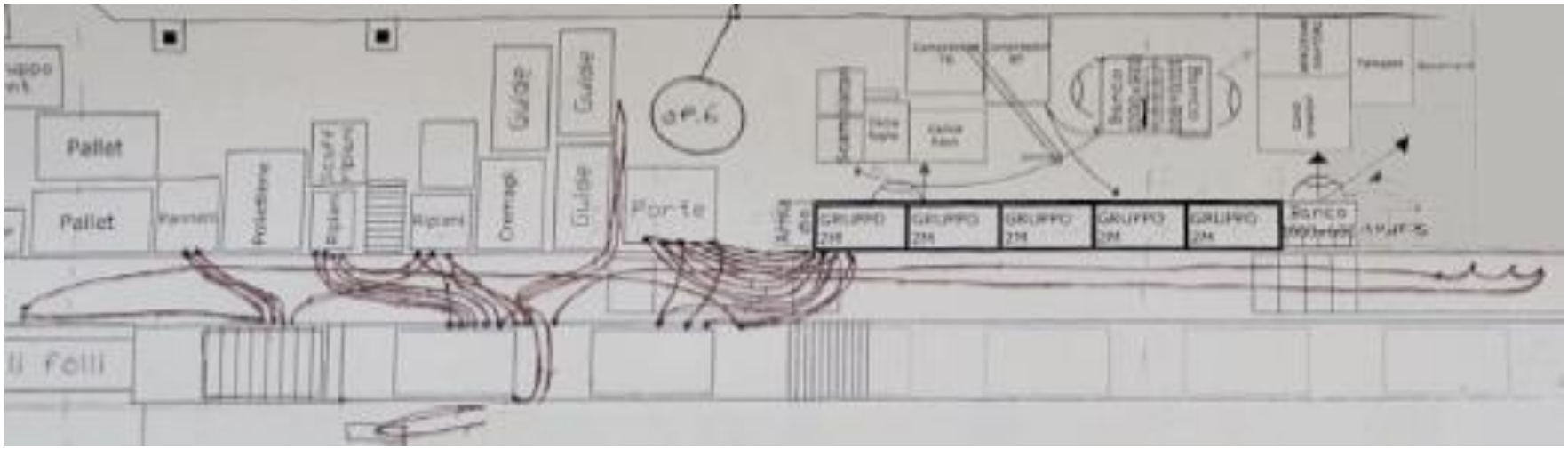
5) **inactivity**: no synchronization between operator and machine activities or between operators of the same production flow
Possible causes: inadequate work organization

The 7 wastes - Muda

What are the 7 types of waste?

6) **unnecessary movements**: groups all movements from the workplace that do not generate value (search for tools or materials, movement of material to another area of the workplace, etc.)

Solution: organize the production so that the materials, tools, containers etc. are clearly visible and immediately available. The spaghetti chart could be used for this purpose



The 7 wastes - Muda

What are the 7 types of waste?

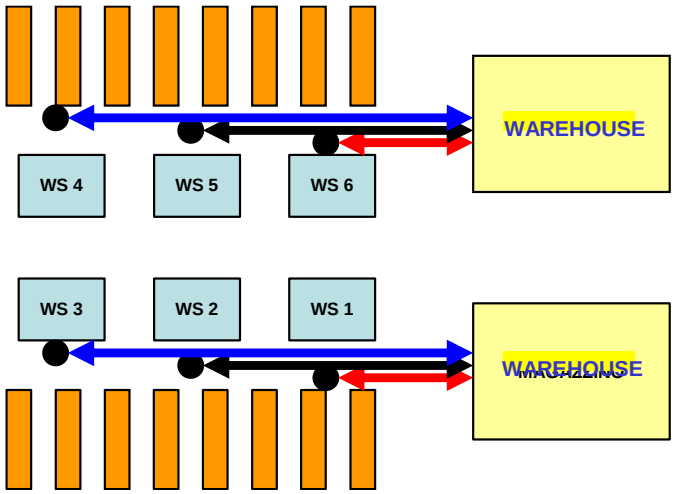
7) **defective products**: they are the most evident case of waste since their management does not generate any value for the customer
Possible causes: defective tools, equipment and materials, poor operator training, incorrect handling, wrong technical equipment, etc.

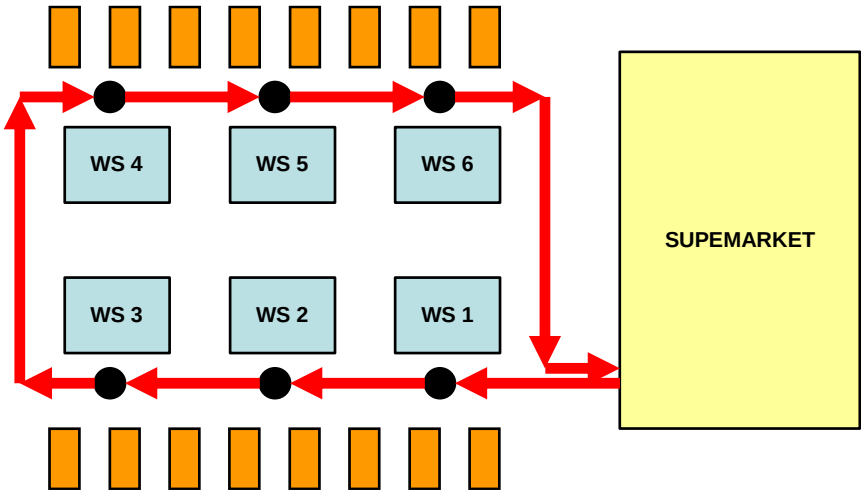
Waste search results

The continuous search for waste leads to many advantages for the company organization because it shifts resources from activities with no added value to those that can be recognized by the customer.

Milk run

Milk run (or **milk round**) is a supply management model that consists in carrying out frequently the transport of small predetermined quantities of materials, in standard containers, along specific routes that start and end in the plant, with limited distances and visiting some suppliers present along the way.





Milk run

What is the milk run?

- supply management model within the production departments;
- particularly suitable in industrial environments that have implemented just in time logic and in particular the Kanban;
- refueling takes place via a train that transports the materials strictly necessary for the next production period;
- handling with milk run is very efficient thanks to the optimization and standardization of:
  - withdrawal routes;
  - delivery routes;
  - type and codes of materials;
  - quantity of materials;
  - type of packaging or container.

Milk run

How to use the milk run?

- find the necessary code;
- detach the kanban associated with the code and deposit it in the collection point;
- the driver of the train picks up the tags at the collection point;
- collection from the warehouse of the necessary codes in the pre-established quantities;
- delivery.

Results:

- improvement of the supply material flow;
- better organization in material handling;
- transport carried out by specific means;
- general increase in the level of attention of operators;
- savings in terms of direct and indirect work.