Industry 4.0
An overview

Agenda

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What is a paradigm?

- In the common language, a paradigm is a reference model based on analogy.
- A paradigm is used to create and share a mental representation of new and not experienced
- The models are representations of reality based on idealization and abstraction(Cartwright 1989)
- Idealization is a distorted representation of reality because a feature is too underlined
- Abstraction is a distorted representation of reality because is based on key features.

What is a model?

Model, **modeling** or **modelling** may refer to:

- Conceptual Model is a representation of a system using general rules and concepts
- Scientific model is a simplified and idealized understanding of physical systems
- Anyway the objective of a model define his structure and the variables
- So the same reality can be modelisated in different way due to different objectives: for example lean production

Paradigm and model of Lean Production

- Lean Production is the model of reality: Toyota Production System
- The experience of Toyota factories is the root of Lean Production Model
- The objective is a methodology (based von a model) to lead the transformation from traditional factory to lean factory: lean thinking
- At a first glance lean thinking appears to be counterintuitive and a bit difficult to understand.
- But it will appear extremely obvious when you manage to grasp it.
- To quickly understand lean thinking it's very useful to examine the application of the **five lean principles (our model of waste)** that excellent companies use to fight against **muda** (waste)

Paradigm and model of Lean Production: The five base principles

1° principle ***Value***	**•Rethink value from the client's point of view**
2° principle ***Mapping***	**•Map the value flow to find the value-added activities**
3° principle ***Flow***	**•Creating the flow to reduce lead times (organizing by process)**
4° principle ***Pull***	**•Make production times pulled by client (if the lead times become shorter…)**
5° principle ***Perfection***	**•Pursuing perfection (= value with zero defects)**

The Origin of Industry 4.0

- The term "Industrie 4.0" originates from a project in the high-tech strategy of the German Government, which promotes the digitalization of manufacturing.

- The term "Industrie 4.0" was revived in 2011 at the Hannover Fair In October 2012 the Working Group on Industry 4.0 presented a set of Industry 4.0 implementation recommendations to the German federal government.

- The Industry 4.0 workgroup members are recognized as the founding fathers and driving force behind Industry 4.0.]

- On 8 April 2013 at the Hannover Fair, the final report of the Working Group Industry 4.0 was presented.

Car Industry is always the origin of successful manufacturing paradigms…

- Ford : Mass Production
- Toyota: lean production
- Car Industry features:
  - Volume
  - Variety
  - Product Complexity
  - Production Complexity
- Digitalization on car industry
  - Product Configuration
  - Manufacturing
  - Maintenance
- Digitalization of cars
  - …..
  - ……

Daimler Benz Strategy on Value Chain Digitalization

- Wilko Stark, Vice President of Strategy, Wilko Stark. "Our key business is still building, producing and developing cars.
- https://www.youtube.com/watch?v=brFtydqho00

Wikipedia: Industry 4.0

- **Industry 4.0** is a name for the current trend of automation and data exchange in manufacturing technologies.
- It includes cyber-physical systems, the Internet of things, cloud computing[1][2][3][4] and cognitive computing.
- Industry 4.0 creates what has been called a **"smart factory"**.
- Within the modular structured smart factories, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions.
- Over the Internet of Things, cyber-physical systems communicate and cooperate with each other and with humans in real time, and via the Internet of Services, both internal and cross-organizational services are offered and used by participants of the value chain

Industry 4.0: design principles focus on man-machine cooperation

- **Interoperability:** The ability of machines, devices, sensors, and people to connect and communicate with each other via the Internet of Things (IoT) or the Internet of People (IoP): Adding IoT will further automate the process to a large extent
- **Information transparency**: The ability of information systems to create a virtual copy of the physical world by enriching digital plant models with sensor data. This requires the aggregation of raw sensor data to higher-value context information.
- **Technical assistance**: First, the ability of assistance systems to support humans by aggregating and visualizing information comprehensibly for making informed decisions and solving urgent problems on short notice. Second, the ability of cyber physical systems to physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for their human co-workers.
- **Decentralized decisions**: The ability of cyber physical systems to make decisions on their own and to perform their tasks as autonomously as possible. Only in the case of exceptions, interferences, or conflicting goals, are tasks delegated to a higher level.

The evangelists of Industry 4.0

- Two evangelists: universities and business consultants.
- The focus of universities is the development of I 4.0 Model based on successful applications
- I 4.0 Model define the training contents, required skills and digital transformation features
- The focus of Business Consultants is the cost-benefit evaluation and the decision making process
- The cost benefit-evaluation is the support of decision making process on digital transformation
- In Germany, Business Consultants and Universities have worked together

German Universities: research and applications

- The **Fraunhofer Society** (*Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung:*Fraunhofer Society for the Advancement of Applied Research, pronounce is research organization with 69 institutes spread throughout Germany, each focusing on different fields of applied science (as opposed to the Max Plank Institute, which works primarily on basic science).

- It employs around 24,500 people, mainly scientist and engineers, with an annual research budget of about €2.1 billion.

- Some basic funding for the Fraunhofer Society is provided by the state (the German public, through the federal government together with the states or *Lander*, "owns" the Fraunhofer Society), but more than 70% of the funding is earned through contract work, either for government-sponsored projects or from industry.

- It is named after Joseph Von Fraunhofer who, as a scientist, an engineer, and an entrepreneur, is said to have superbly exemplified the goals of the society.

- The organization has seven centers in the United States, under the name "Fraunhofer USA", and three in Asia. In October 2010, Fraunhofer announced that it would open its first research center in South America. Fraunhofer UK Research Ltd was established along with the Fraunhofer Centre for Applied Photonics, in Glasgow, Scotland, in March 2012.

Fraunhofer and Industry 4.0

- Seven Fraunhofer Institutes have joined forces to set up the Fraunhofer Group for Production in order to conduct collaborative, production-oriented research and development and offer clients a one-stop shop for comprehensive, integrative solutions. Our aim is to pool the expertise and experience of the individual institutes to develop holistic and workable solutions, tailored to meeting the challenges of the future.

- **Business Areas**
  - Product development
  - Manufacturing technologies
  - Manufacturing systems
  - Production processes
  - Production organization
  - Logistics

- https://www.fraunhofer.de/en/research/fields-of-research/production-supply-of-services/industry-4-0.html

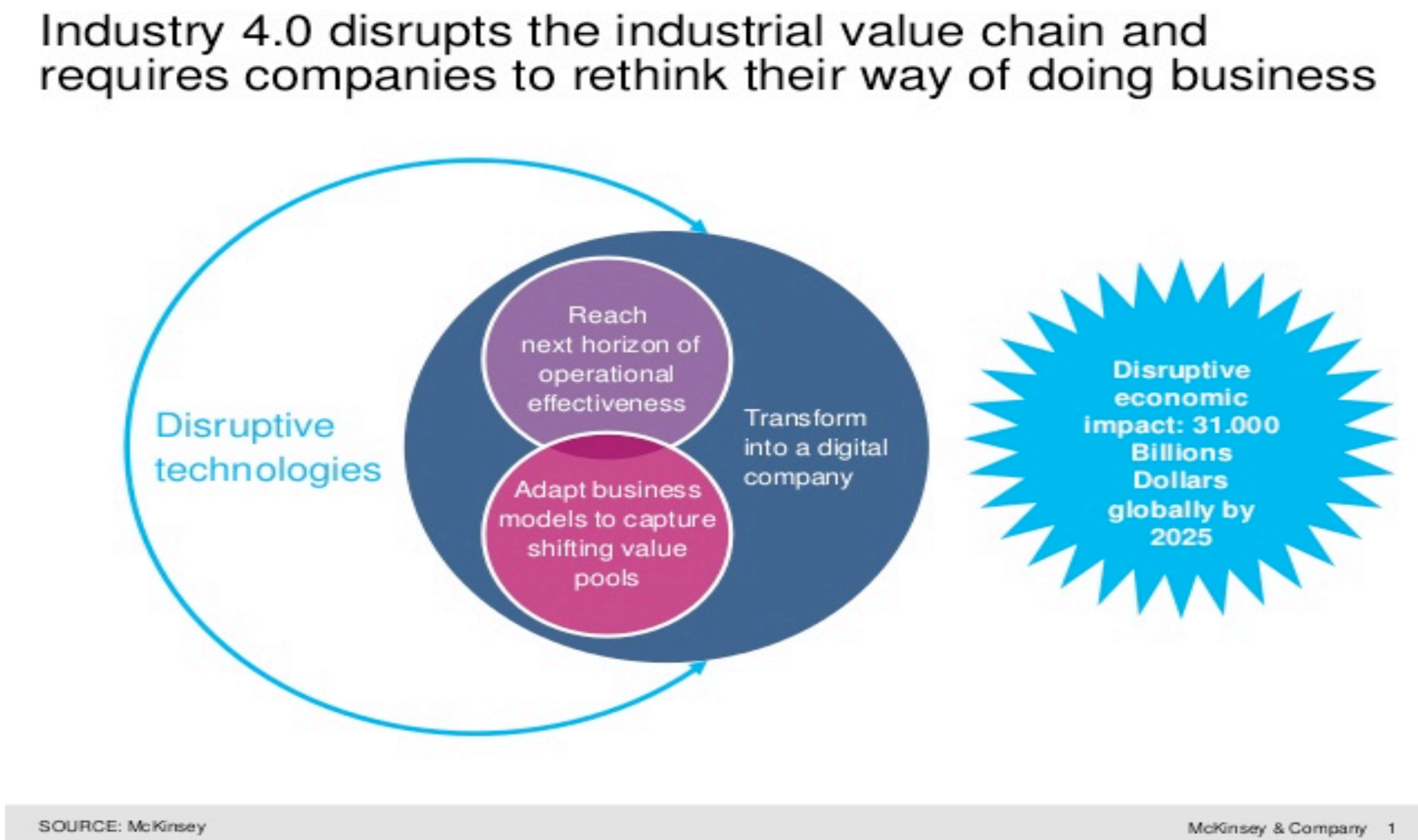
Business Consultants and Industry 4.0

- The German branches of major business consultants have already issued several reports on cost-benefits of Industry 4.0 applications

- Obviously the report focus is different because the Business Consultants expertise is different:
  - McKinsey focused on the value chain
  - Roland Berger focused on variety management
  - BCG focused on 9 technological pillars.
  - PWC focused on process impacts

- Anyway the result is the augmented competitive power of German companies.

Industry 4.0: McKinsey focus on value



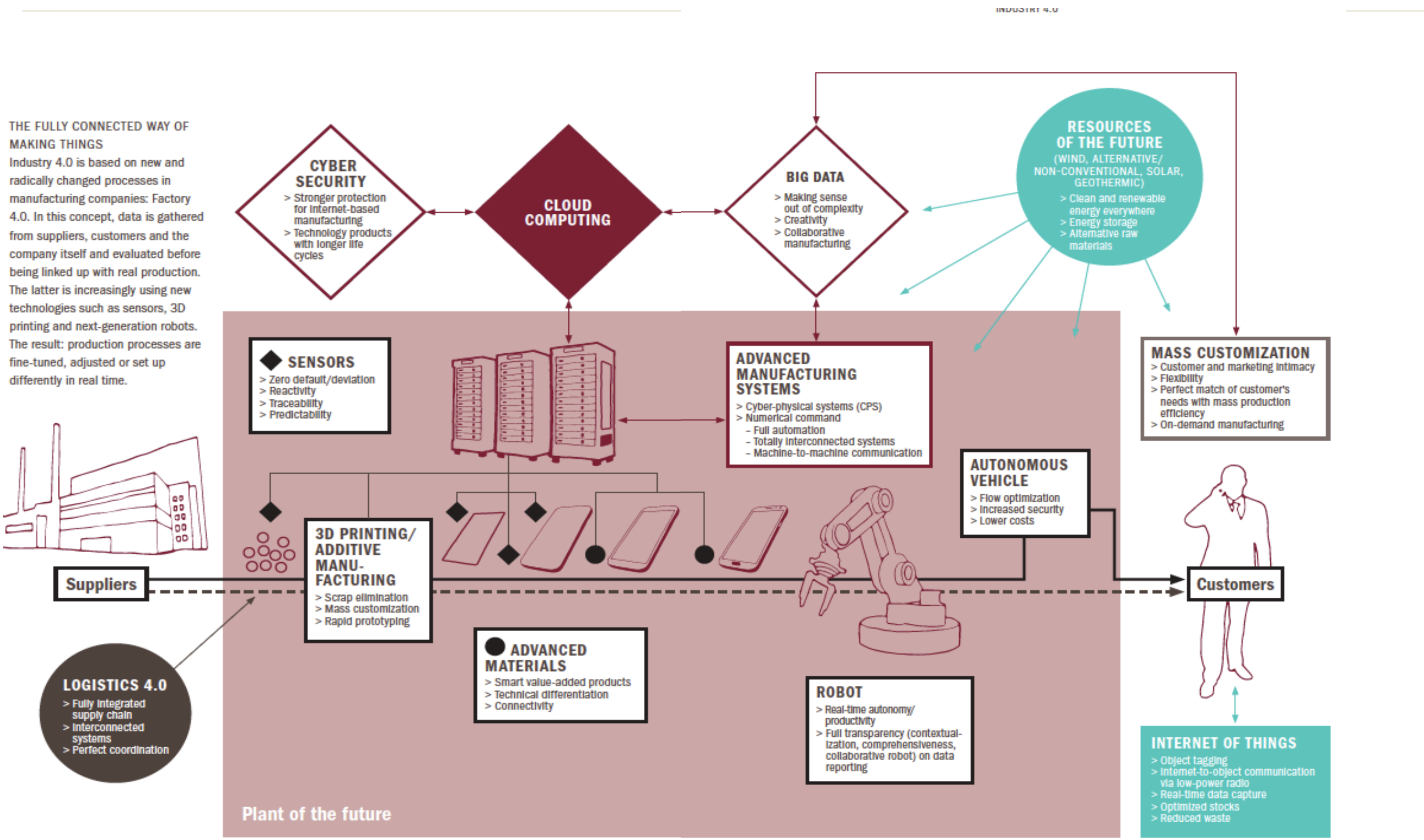
Industry 4.0: McKinsey focus on value

[1]Maintenance, repair, and operations.

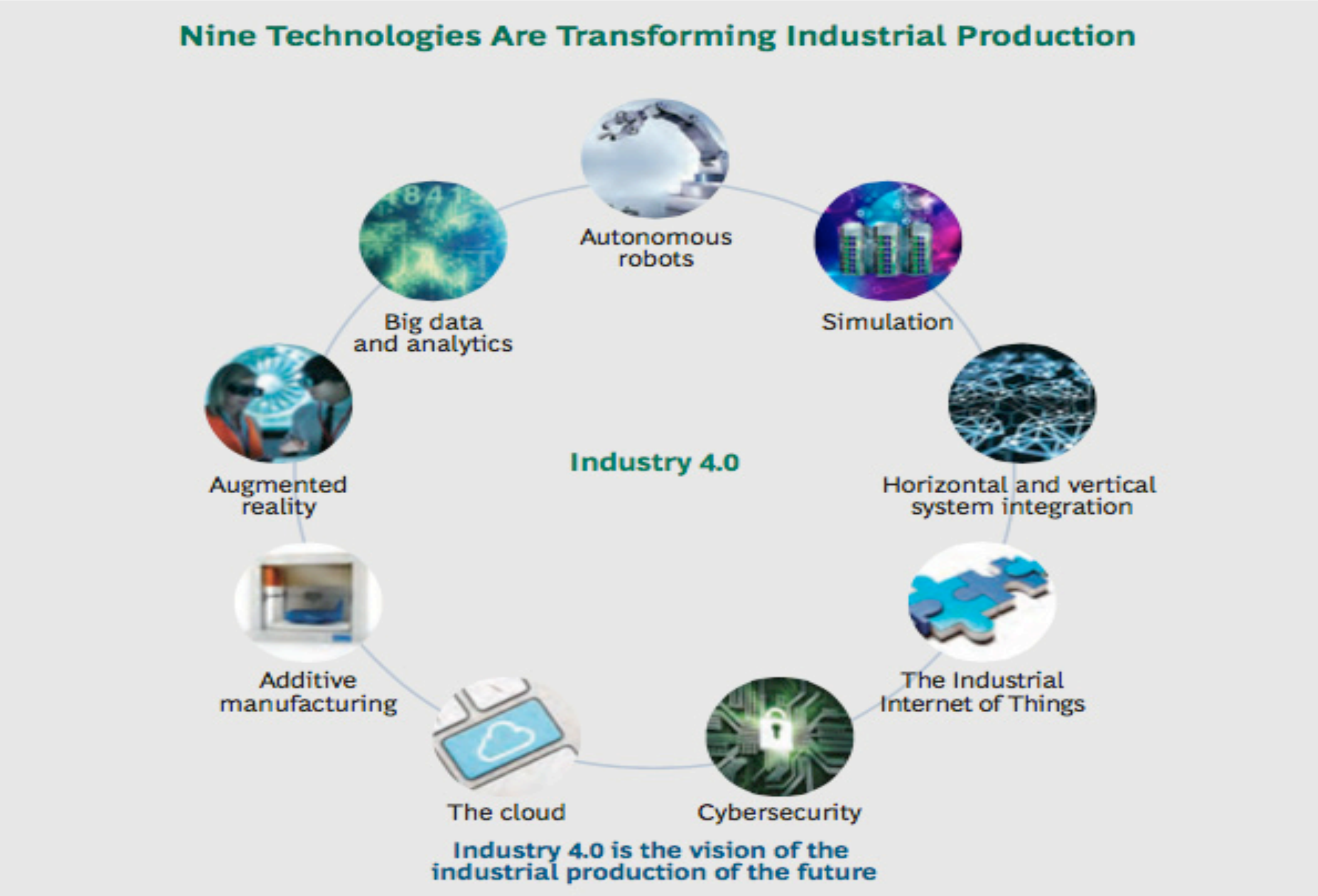
McKinsey&Company

LIUC Università Cattaneo

Roland Berger: impact on variety management



BCG: 9 pillars of technology



PWC: impacts on business processes

	1 Digital novice	2 Vertical integrator	3 Horizontal collaborator	4 Digital champion
Business models, product and service portfolio	First digital solutions and isolated applications	Digital product and service portfolio with software, network (machine-to-machine) and data as key differentiator	Integrated customer solutions across supply chain boundaries, collaboration with external partners	Development of new disruptive business models with innovative product and service portfolio, lot size of one, product and component identification
Market and customer access	Online presence is separated from offline channels, product focus instead of customer focus	Multi channel distribution with integrated use of online and offline channels; Data analytics deployed, eg, for personalisation	Individualised customer approach and interaction together with value chain partners	Integrated Customer Journey Management across all digital marketing and sales channels with customer empathy and customer relationship management
Value chains, processes and systems	Digitized and automated sub processes	Vertical digitization and integration of process and data flows within the company	Horizontal integration of processes and data flows with customers and external partners, intensive data use	Fully digitized, integrated partner ecosystem with selfoptimised, virtualised processes, focus on core competency, decentralised decision making & autonomy
Compliance, legal, risk, security and tax	Traditional structures, digitization not in focus	Digital challenges recognised but not comprehensively addressed	Legal risk consistently addressed with collaboration partners	Optimising the value chain network for legal, compliance, security and tax
Organisation and culture	Functional focus in "silos"	Cross functional collaboration but not structured and consistently performed	Collaboration across company boundaries, culture and encouragement of sharing	Collaboration as a key value driver

Industry 4.0, Smart manufacturing , Alliance industrie du futur…

- Industry 4.0 is the foundation of German Global Competition project (http://www.plattform-i40.de/I40/Navigation/EN/Home/home.html)
- Similar project of EC (https://ec.europa.eu/digital-single-market/en/policies/digitising-european-industry)
- In France: Alliance industrie du futur (http://allianceindustrie.wixsite.com/industrie-dufutur)
- Simar project in China and USA
- In Italy Carlo Calenda, Italian minister of economic development, presented in 2016 the national project Industria 4.0
- SME are the focus of Italian project Industria 4.0

Previous Models : the origins

- One paradigm: CIM (Computer Integrated Manufacturing).

The idea of "digital manufacturing" became prominent in the early 1970s, with the release of Dr. Joseph Harrington's book, Computer Integrated Manufacturing.

However, it was not until 1984 when computer-integrated manufacturing began to be developed and promoted by machine tool manufacturers and the Computer and Automated Systems Association and Society of Manufacturing Engineers).

"*CIM is the integration of total manufacturing enterprise by using integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency*

CIM: the dream was the **lights-out** manufacturing

- **Lights out** or **lights-out** manufacturing is a manufacturing methodology (or philosophy), rather than a specific process.

- Factories that run lights out are fully automated and require no human presence on-site.

- .As the technology necessary for lights-out production becomes increasingly available, many factories are beginning to utilize lights-out production between shifts (or as a separate shift) to meet increasing demand or to save money.

- An **automatic factory** is a place where raw materials enter and finished products leave with little or no human intervention

CIM : reality and limits

- FANUC, the Japanese robotics company, has been operating a "lights out" factory for robots since 2001.[
- Robots are building other robots at a rate of about 50 per 24-hour shift and can run unsupervised for as long as 30 days at a time. "Not only is it lights-out," says Fanuc vice president Gary Zywiol, "we turn off the air conditioning and heat too."
- In the Netherlands, Philips uses lights-out manufacturing to produce electric razors, with 128 robots from Adept Technology. The only humans are nine quality assurance workers at the end of the manufacturing process.
- But we have had several examples of ailed projects that did not work
- In Italy: Susegana plant, Cassino Plant etc.
- Why?

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The main reasons of failed projects

- The complexity of product and processes is and was the main reason
- The approach was: we can automate and solve any type of complexity
- **First Lesson** learnt: we must simplify before starting the automation
- **Second lesson** learnt: Human expert are more flexible than AI
- **Third lesson** learnt: if you have simple product and simple process, you can design and build an automatic and flexible system
- The examples of a.m. automatic and flexible system are the FMS (Flexible Manufacturing Systems).
- If you follow First and Second lesson, you modify the original CIM approach and you reach a new adaptive approach: Industry 4.0

FMS: MIRS (Modular Integrated Robotized System) is the first worldwide innovation in tyre manufacturing since 80 years

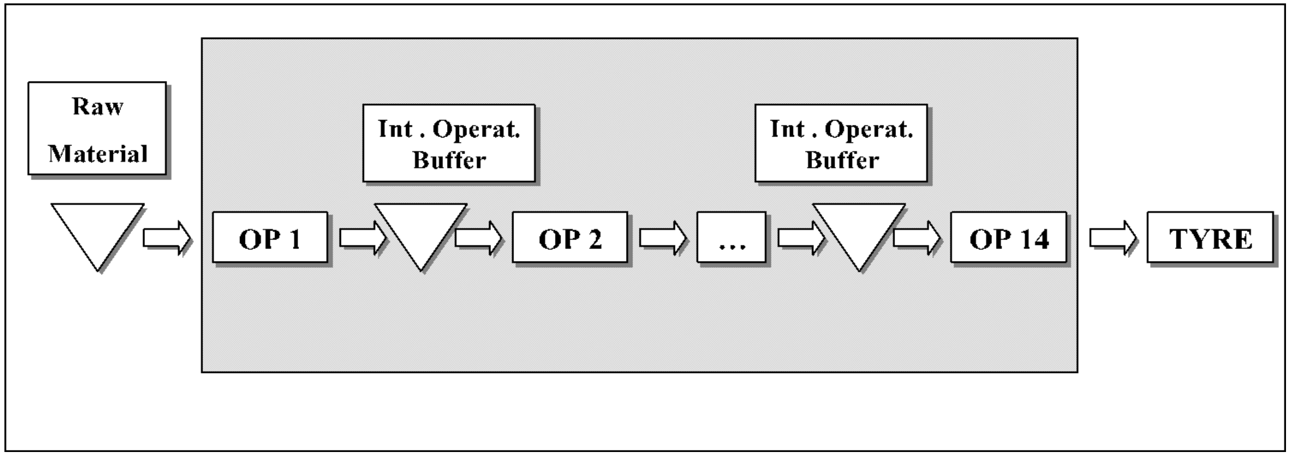
- Pirelli has successfully developed a new process to manufacture tyres with the innovative utilisation of Industrial Robots of Comau: MIRS (Modular Integrated Robotized System)

- Dramatic practical results have been achieved in terms of WIP and throughput-time reduction, higher flexibility level, logistics, product performance.

- Now MIRS is the worldwide best practice in tyre manufacturing. Following to successful implementation in June 2000 of first MIRS of Milano Bicocca (Italy), Pirelli has already implemented 18 new MIRS plants worldwide for manufacturing car and motorcycle tyres and is planning several new plants.

- This paper analyses the two most important features of MIRS Project that increased the competitive advantage of the firm.
  - Firstly the MIRS manufacturing impacts: the performances with main technical details of the application are described, including sound reference on quantitative results.
  - Second the MIRS organisational impacts: the focus is the Innovation management process. Here we present the approach that lead to industrialise an innovative application in a “mature” sector

The traditional tyre manufacturing process



- Typical performances of a. m. process are the followings:
  - Production rate: min. 25.000 / 30.000 tyres /day
  - Throughput-time: 3/ 6 days
  - Batch change: 3 days
  - 12% WIP in operation, 88% in stock
  - N. of manufacturing operations: 14

The MIRS manufacturing process improves flexibility and quality

- **High level of flexibility** smaller production units with low throughput-time and WIP, and **optimal logistic operations**.

- A single production cell is composed by 9 Comau Industrial Robots equipped with specific devices, programmed with dedicated software and calibrated with special procedures

- Tyres are built around a heated metallic drum, which is specific for a particular tyre model.

- The drum is **continuously rotated by robots** under an extruder, which dispenses the rubber on the surface

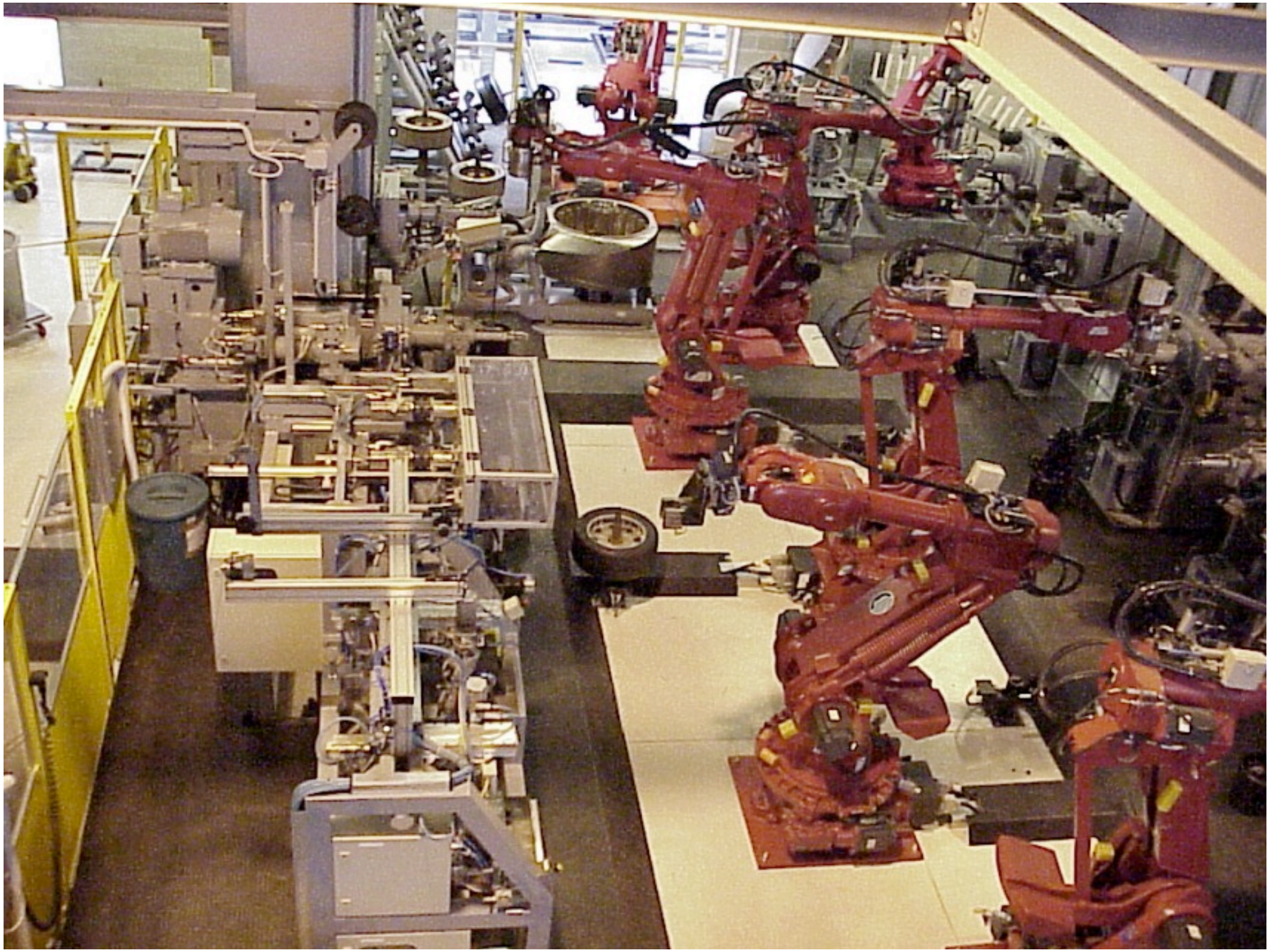
- . The rotations of the drum combined with the movements of robots under the extruders provide the distribution of the material to create the specific model.

The typical performances of the MIRS against the traditional plants

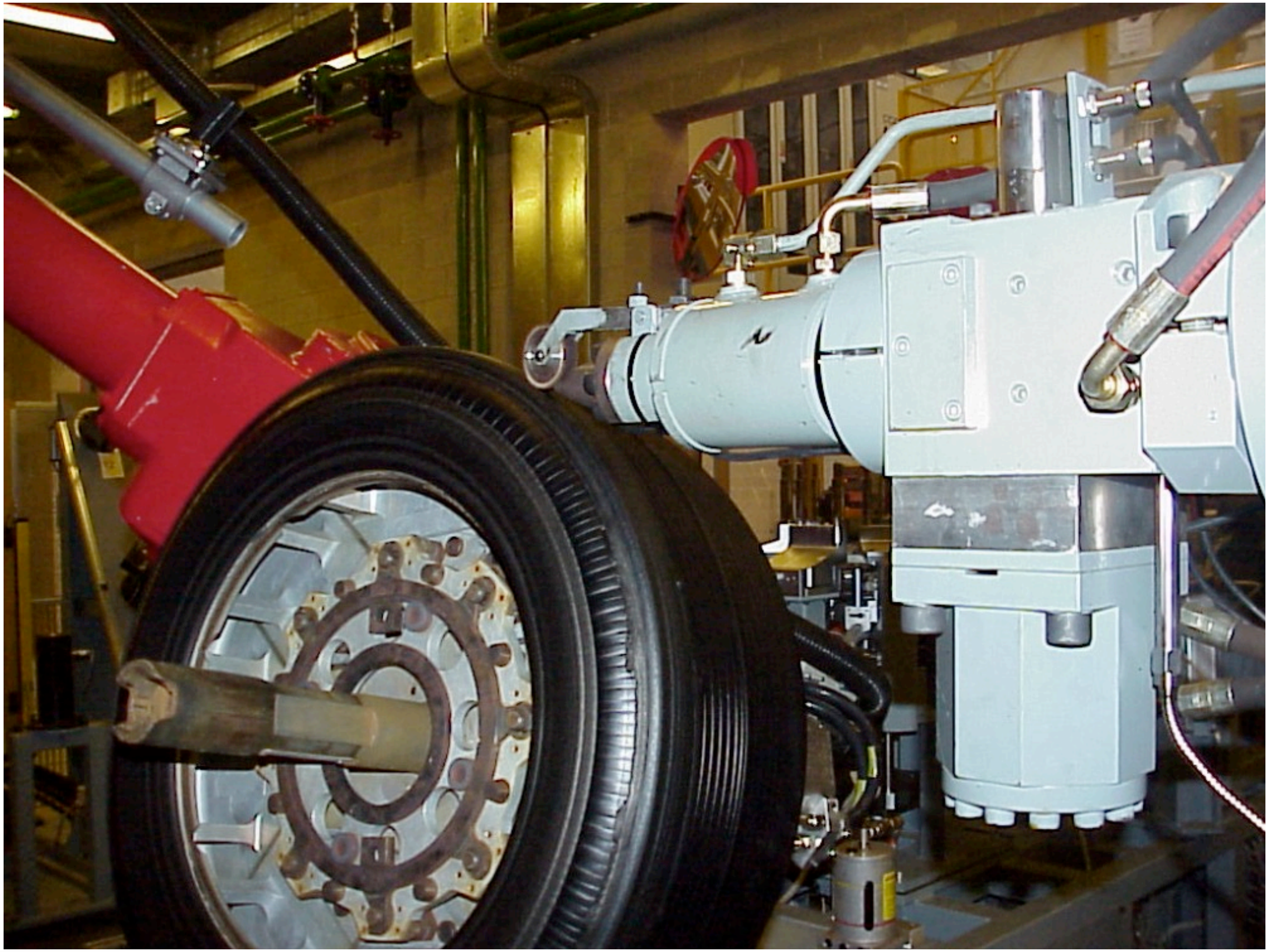
	Traditional Plant	Robotized Plant
Economical output (tyres/day)	30.000	350
Lead Time	6 days	72 minutes
Size Change Time	450 minutes	3,5 minutes
Lay out	120.000 m²	350 m²

- The flexibility of the cell is at maximum level and **no changeover time** is needed.
- The introduction of a new tyre model is straightforward since all the programming phase is performed off-line, similarly to CAD / CAM processes in machine tool industry.
- In case higher production capacity is needed the cell can be easily and fast cloned, with the advantages of incremental and certain investments.
- Throughput-time is 72 minutes with cycle time of 3 minutes/tyre.

MIRS Manufacturing Process



MIRS Technological Process

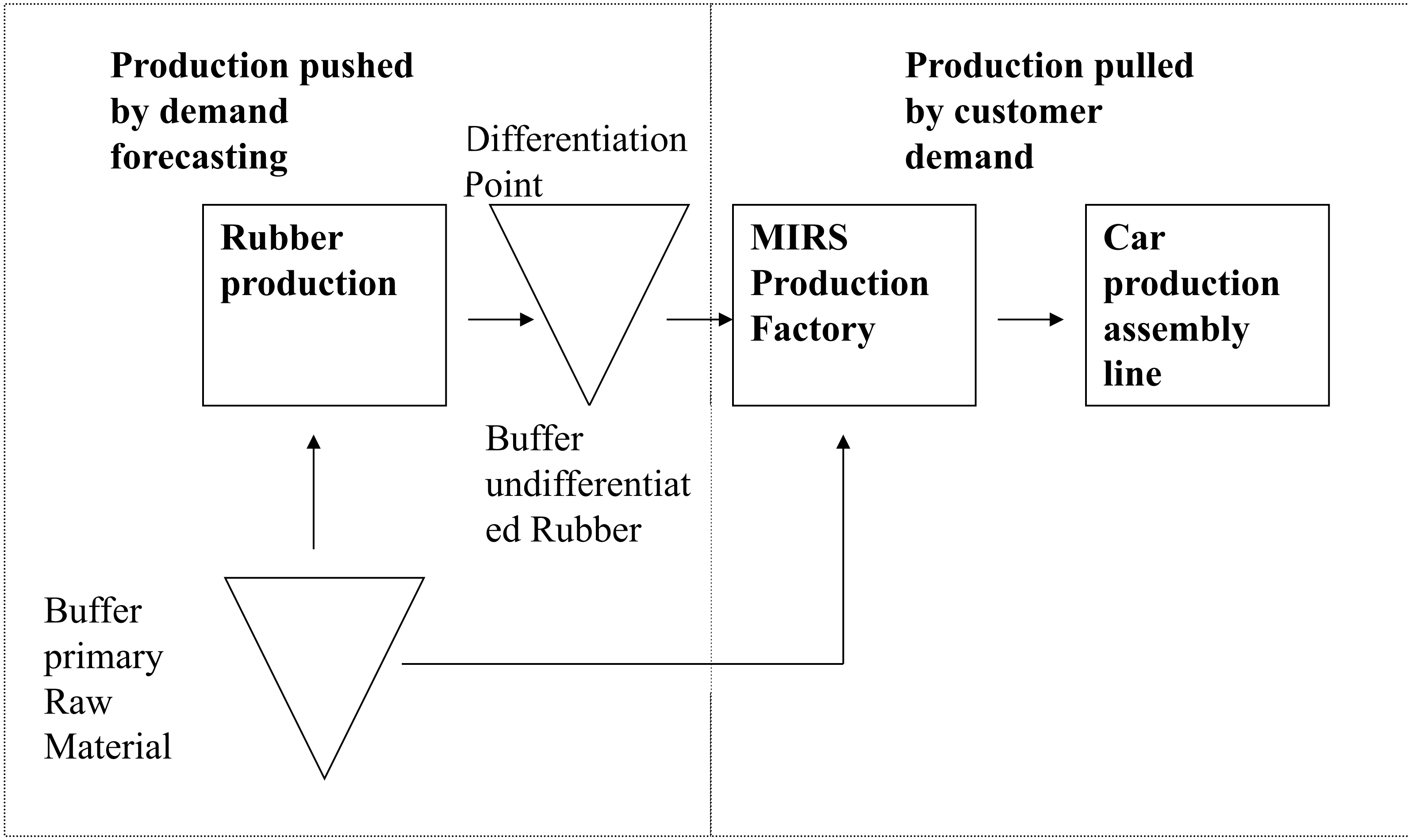


MIRS as an implementation of a real Manufacturing Postponement

- In fact the operational model implemented with the MIRS is characterised by two fundamental aspects, which modify tyre supply chain:
    - The possibility to manufacture tyres only after a customer order (Make to order), through marginal response time, practically JIT.
    - The possibility to reduce at minimum levels the logistical activities through the localisation of MIRS modules close to customer factories

- This is technically realisable and economically profitable since MIRS factory allows to reach competitive cost levels with minimal production batches and limited production capacities. Therefore we can have:
    - High number of different product models.
    - Production batches corresponding to product orders.
    - Total product costs very low
    - Delivery timing to customer correspondent to production timing

Manufacturing Postponement Model of MIRS



The evolution of Product Process Development

Vertical organisation	Transversal organisation	Outsourcing and Co-design
Years 60-70 Product Development in R/D function	Years 70-80 Product development with inter-functional internal teams and Project Managers	Years 80-00 Product Development with Internal External inter-functional teams and Project Manager

But the roots of successful experience of Pirelli and Comau are different

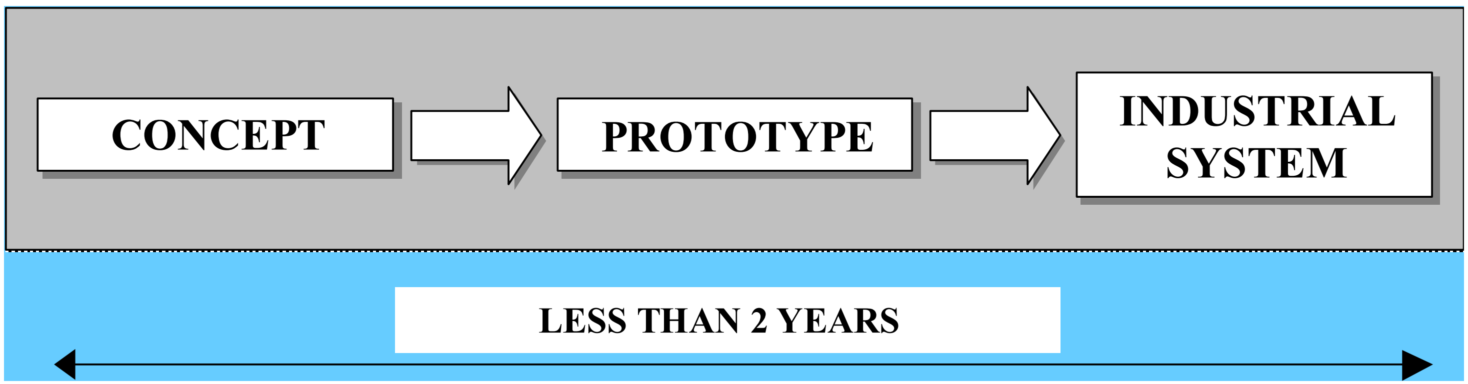
- Firstly the main prerequisite of a paradigm shift is based on the strategic vision of the Company management: without this basic starting point it is impossible to generate the sufficient impulse and momentum for a radical innovation.

- Radical innovations in operations that allow sustainable competitive advantages require putting together unique competences that cannot be bought on the market as a commodity, since they could be easily imitated.

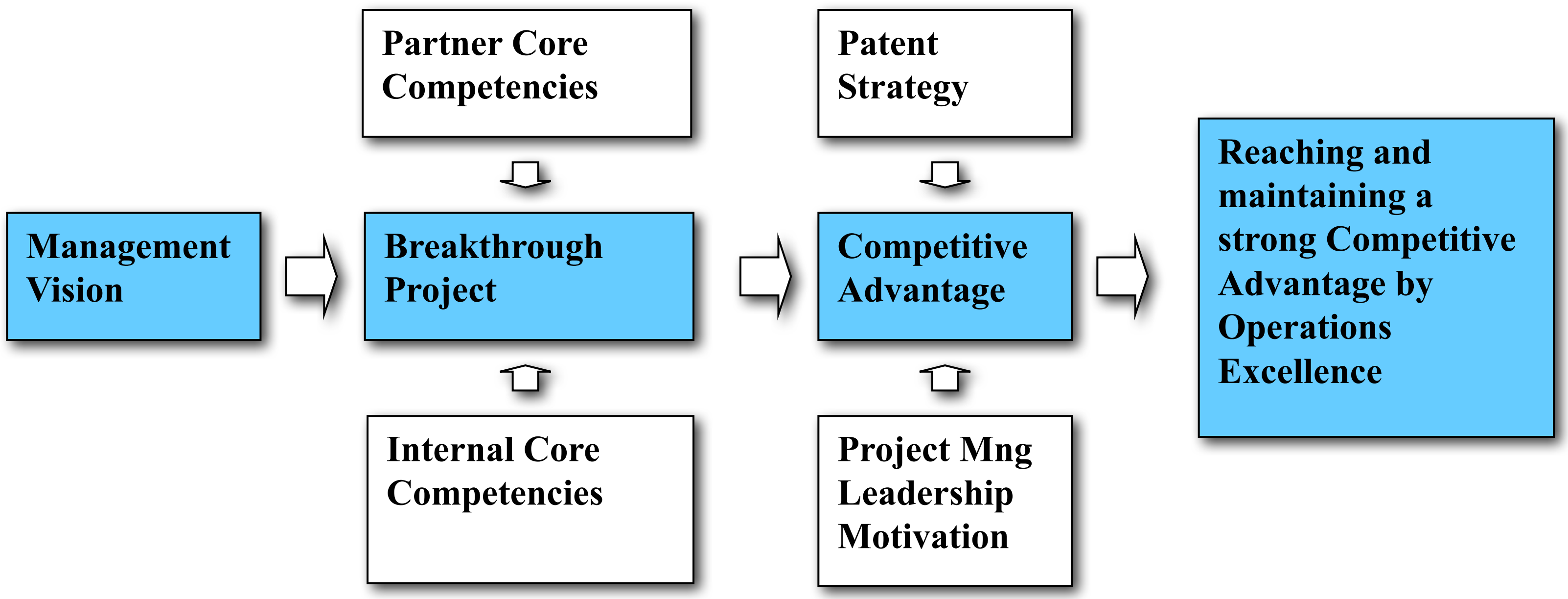
- The win-win approach with core suppliers must be managed in a peer-to-peer relationship.

- Strong project Management coupled with visionary leadership must be present to keep targets, efficiency and motivation in the inter-functional team.

And the MIRS Project experience is very effective



So we could generalise in a more ample model the MIRS experience of management of a radical innovation in Operations



Conclusions

- MIRS project was not only a revolution in manufacturing tyres, but also an outstanding model in the process to introduce an innovation in Operations.
- From the production point of view the principles of Manufacturing Postponement have been exemplary implemented by realizing a system that really operates on the demand side.
- From the organisational side MIRS is a perfect example of good management of risk and innovation in a mature sector.
- This outstanding experience should make reflect all the ones looking for a radical change in their Operations: bright results can be reached with the courage of a vision coupled with the capacity to manage technology, teams, partnership, with both efficiency and motivation.

Why is lean a prerequisite for industry 4.0?

- The lean production concept is the son of the Toyota production model that is based on two principles: focus on customer perceived value and waste elimination, or elimination of all assets or resources that do not add value to the customer.

- Many lean production experts believe that the simplicity and essence of a lean system means using only manual visual instruments such as kanban cards, "visual" boards, and hence there is a method contrast with the use of software and therefore of systems information.

- Somehow physical automation (robots, handling systems, etc) and logic (ERP systems, information systems etc) is associated with a mental representation of complexity that seems in sharp contrast to the perception of simplicity of the lean production concept.

Why is lean a prerequisite for industry 4.0?

- But this social belief is in clear contradiction with the same principles as Lean Production.

- Indeed, we must remember that process automation is a strategic goal of the lean approach, but this goal must be achieved following a precise methodological approach.

- Automation in the lean approach is not an objective itself but is the result of the application of a very strict methodology in which the replacement of human automation is not the first but is the last stage

What does it mean to automate?

- Automating means to realize physical or logical processes by means of automatic systems and servomechanisms.
- Information Systems are automated information management systems because they are able to acquire, use, and record data with or without minimal human intervention.
- In the same way, robotic systems have the ability to make movements, machining operations that are needed to produce products with or without minimal human intervention.
- But before writing a software program you can just try it with "paper and pen" to understand how processes are done and how they can improve.
- Undoubtedly, it is a very effective approach when you want to experience a new management process, but it becomes a "waste" as the process is developed and the activities become repetitive.

Automation in the lean approach

- In fact, automation in the lean approach is not an objective itself, but is the result of the application of a very strict methodology in which substitution of human automation is not the first but is the last phase of kaizen or improvement process:

- First, everything begins with "paper and pen" to analyze the processes to improve by following the Value Stream Ma

- Then you eliminate all the waste, that is, which does not add value to the customer, simplifying the processes themselves

- Then simplified processes are handled with manual management: in this way we can understand with experience everything that the rational analysis of the project failed to define

- And then the operational experience we can find the necessary steps to fine-tune the robustness of the new process

- At this point we are ready to automate the process without waste and no risk because we have already tested in the field possible risky situations and problems that might arise

The benefits of using Automation Systems in Lean Production

- The benefits are quantitative and qualitative.

- The most significant quantitative benefits relate to:

  - Save Administrative Activities
  - Reduction of crossing time
  - Eliminating errors
  - Reduce training time
  - Reduction of intervention time in case of anomalies

- The most important qualitative benefits relate to:

  - The ability to carry out a cost control based on the activity actually provide
  - Measuring individual performance and employee learning processes
  - Identification of the actual bottlenecks of the production process (the kanban wait times are measured ...)

The Toyota example is, as always the best

- Toyota is the most striking example of coherent application of Information Systems to the management of a complete production logistics system that has generated the Lean paradigm

- Toyota's integration with its dealers and suppliers is the most relevant example of the new Industry 4.0 paradigm but is also the secret of its success.

- Integration started with the physical kanban that was dematerialized into an electronic kanban just as the technological and cost conditions allowed it.

What does man-machine cooperation mean?

- The term man-machine cooperation can have many meanings that are dependent on two fundamental aspects: machine definition and man-machine interaction definition.

- For common sense, the concept o machine is analogously associated with predominantly mechanical systems such as a washing machine, a car, an aircraft.

- Most people do not feel that a software program is a machine also, but rather something related to electronics or something else. In fact, common sense classifies predominantly objects according to their physical structure and not according to their mode of operation.

- So what appears to be physical elements that I can touch and that is capable of moving itself or its parts is called a machine.

- But science has a different machine definition as an example when defining the concept of software program in a scientific way.

Machines and humans

- Humans interact with these machines and this interaction can provide humans with abilities that they normally do not have: more physical strength, more precision, more memory, more computing skills etc.

- On the other hand, humans have characteristics that machines do not have: the ability to dynamically modify their behavior as a function of the change that can take place: humans are able to adapt to the environment, to evolve.

- In other words, cooperation between men and machines can make a system where the characteristics of the sum go far beyond the characteristics of the individual components: the ability to dynamically adapt the actions to the essence of strategic goals.

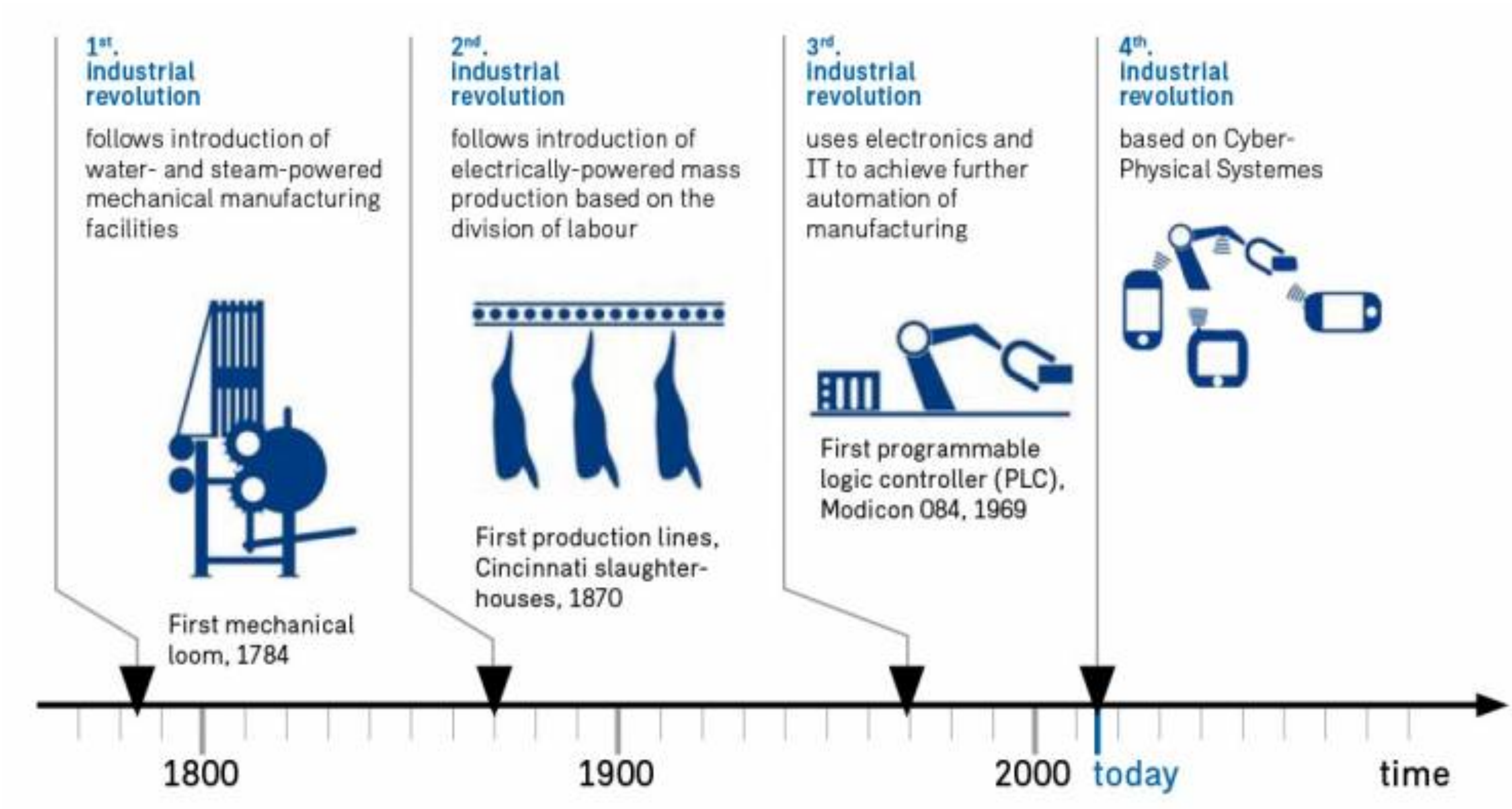
The peculiar characteristics of Industry 4.0

- Industry 4.0 is a paradigm born within the German automotive industry with the aim of radically transforming the structure of production systems to move from "interconnected but locally optimized production systems" to "integrated, automated and globally optimized production flows to high flexibility”

- Flexibility is necessary because you want to compete in markets where not only more and more customized products are needed, but also personalized products tailored to the specific needs of individual customers: Mass Customization.

- Industry 4.0 is seen as the fourth stage of an evolutionary path of production systems since the beginning of the industrial revolution to date.

The Fourth Industrial Revolution



The nine pillars of Industry 4.0

1. Big Data and Analytics: gathering and analyzing a large number of data from various sources to support decision making

2. Autonomous Robots: The new generation of robots will have a lower cost and greater capacity than those currently in use; will be able to interact with each other and with Humans and learn from these interactions.

3. Simulations: already in use in design processes, the use of simulation systems will be extended to all production processes. These systems will process real-time data in virtual simulation models in order to test and optimize machines, products and processes, and to anticipate problems before they occur in reality.

4. Horizontal and vertical integration of information systems: integrating data and systems throughout the value chain will ensure that all departments and business functions become part of a single integrated system.

5. Industrial Internet of Things: This is the set of technologies and sensors that will allow factory objects, both devices and finished products, to communicate and interact with each other and with people over the network.

The nine pillars of Industry 4.0

6. Cybersecurity: With increased connectivity between devices, it will increase the need, even at the factory, to protect production systems and the IT network from potential threats.

7. Cloud: Many companies already use cloud-based applications, but in Industry 4.0 there will be a need for more data sharing on the factory as well, and production control and management applications should therefore also be available in cloud.

8. Additive Manufacturing: 3D printing is currently only used to create prototypes or to produce specific components. In industry 4.0, these additive manufacturing technologies will be used more widely to produce small batches of highly customized products, and being achievable in multiple locations around the country, will reduce the distance for logistical transport of finished products.

9. Augmented Reality: These systems are systems that, by means of a mobile device such as a smartphone, or vision devices (eg projection screen on the retina), listening (earbuds) and manipulation (gloves), add multimedia information to reality already normally perceived by man.

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The nine pillars of Industry 4.0: what is really new

- Many of these technologies have long existed and are already in use in the manufacturing world.
- The real novelty of the Industry 4.0 paradigm is a new way of thinking about the factory and the relationships between suppliers, manufacturers and customers, and especially between man and machine.
- Industry 4.0 is a new industrial culture that like all cultures has fundamental characteristics that remain in time and other aspects that are the result of dynamics and therefore can vary over time.
- The fundamental feature of Industry 4.0 is cooperation between automated systems (robots, software etc) and Human.
- An example of co-operation is the direct relationship and contact between robots and operators working together instead of delimiting areas where only one or only others can operate and interfacing with component or semi-finished buffers.

Lean is an essential prerequisite of I4.0

- Prerequisite for applying industry paradigm 4.0 is the simplification of value-oriented processes for the customer: so it is necessary to implement the lean organization.
- Automating complex processes makes these unreliable and rigid; automating simple processes improves its robustness, flexibility and efficiency.
- The experiences of the past confirm the correctness of this approach.
- Many industrial engineers will remember the paradigm of the 1980s: CIM or Computer Integrated Manufacturing.
- The failure of these holistic models has been determined by automating the complexity of the processes rather than simplifying them and then automating them: without lean, it does not make industry 4.0.
- Not at all the origin of the paradigm is the German automotive industry that uses the lean philosophy on the example of Toyota

Industry 4.0 culture and digitization of life

- The impacts of Industry 4.0 culture can be assessed from an individual perspective and / or social relationships.

- In essence, we must try to understand whether and how manufacturing digitization impacts on the lives of people involved.

- Daily experience is that digitization of manufacturing is more a consequence of the actual digitization of everyday life than a cause: people are accustomed to technology and are less anxious about change.

- In fact, we are assisting and participating in the systematic and seamless use in the professional life and especially in the private life of digital technologies through the major electronic devices available on the market: computers, tablets, smart phones, tags etc

- The use of websites, blogs and participation in virtual communities pervades the whole world along with the increasing availability of more and more wireless connectivity to the Internet.

Digital natives and others

- Obviously, this phenomenon is different for anyone who can be called a "digital native" and who has instead approached digital technologies in a later part of his life and also the level of anxiety is different.

- The origin of the term Digital Native is attributed to the US writer Marc Prensky who used it for the first time in the article "Digital Natives, Digital Immigrants" of 2001 where Prensky attributes the Native Digitally Appearance to boys and girls born after 1985.

- The date was chosen by the writer as it is the year marking the crucial passage due to the mass spread of computers and especially the first systems that provided a graphical interaction with the computer.

- All people born before this date are called "digital immigrants", that is, people who have approached "digital language" only at a later stage of their lives.

- The Digital Native is therefore the mother tongue of this language

Digital technology and human skills

- Prensky believes that technology can improve our capabilities but at the same time we must keep in mind that it can not replace the ability of judgment or intuition itself but rather improve it by allowing us to gather more data than we could do without the use of these instruments.

- In fact, we could define the positive impact of digital technologies as enhancing the characteristics of the Humans, and this is really the foundation of the Industry 4.0 paradigm

- Indeed, technology allows us to enrich our cognitive capabilities, improve memory through storage, data acquisition and retrieval tools, so digital technology can help decisively by providing databases and algorithms capable of storing and analyzing large amount of data much more accurately than the human brain can do.

- Prensky calls this digitally-enhanced Humans "Homo Sapiens Digital" or the one who accepts the enhancement as an integral part of human experience

The impact of digital culture

- The very fact of accepting technology means that you do not have an attitude of fear towards the technology itself and therefore be available for technological change.

- Digital wisdom does not mean extreme skill in manipulating technology but the ability to make wiser decisions because they are enhanced by technology.

- In other words, the ability to use digital technology to improve one's life and that of others.

- Digitally-skilled people can be exceptional in manipulating digital tools (eg programmers, hackers, etc.) but if they do it in a wicked mode, pure and single-handedness does not help them become wiser.

- Industry 4.0 culture is simply extending to the professional activities of all those aspects of digital life that characterize not only digital natives but all.

- Obviously there are not only positive aspects, but also aspects that can be negative, such as the nature of social relationships that are mediated by digital instruments rather than direct physical contact

Conflicts between Lean culture and Industry 4.0

- Lean culture cold be defined by two different aspects: what to do and how to do it.
- The "what to do" is the lean approach goals: focus on customer needs, waste elimination, and continuous improvement.
- The "how to do" is to work in interdisciplinary teams, experimenting with solutions and in general best practice creations from shared experiences.
- All these dynamics of social relationships are developed with a physical sharing of space and time that is challenged by the typical virtual relationships of our digital life.
- Virtual relationships are not the same as physical relations, both in relationships one by one and in social relationships.

Conflicts between Lean culture and Industry 4.0

- The experience of lean projects allows people to develop effective behavioral skills especially in negotiating processes that are typical of teams and interdisciplinary projects.

- The virtuality of the relationship leads to a greater polarization of behaviors both in sharing and in refusing and thus in a radicalization of conflicts.

- In fact the reduction or even the lack of visual feedback to our behaviors is a disruptive element of the conflicting unconscious systems of conflict that in itself is necessary in negotiating processes.

- So the different "how to do" can be a barrier between lean and industry 4.0

The problem of social representation of Industry 4.0

- The Industry 4.0 phenomenon has begun to become a media phenomenon at the top of the list of priorities of political and industrial organizations.

- First of all, the complexity of new technologies is very difficult to understand their impact on operational processes for most decision-makers and even the majority of those who should be able to use it with great benefit.

- This difficulty is not due to the limited intelligence of people, but rather from the extraordinary heterogeneity of the industry's industry 4.0 paradigm technologies

- For example, Industrial Internet of Things, Big Data, Cooperative Robots are really very different technological environments and are usually proposed and implemented by technology specialists who do not understand the other.

- In addition, the car industry has been able to build Industry 4.0 with a process of almost thirty years that has seen highly capable technicians who have patiently accumulated the skills and experience they need.

The problem of social representation of Industry 4.0

- Second, we believe that the most important challenge is the one that requires the process of organizational change that can be generated by the possible implementation of Industry 4.0.

- If understanding the impact on processes is complex and difficult, understanding the impact on people is even more difficult and above all more important: not all are digital natives !!

- In fact, it is possible to understand the potential of the new paradigm and fail to actually implement it as has often been the case in recent years with the lean organization's industrial revolution.

- So we have the ambitious goal of trying to help those who are looking to evaluate this great change: on the one hand, recalling the importance of lean transformation as a prerequisite and on the other hand providing a set of useful tools for the next leap into the industry 4.0.

Conclusions and next steps

- After a first conceptual and historical framing of Industry 4.0 paradigm we have to see how the paradigm applies to businesses and what benefits they can give.

- To do this, we must first make an overview of digital technologies in order to understand their characteristics with the aim of subsequently understanding how they can impact on business processes.

- In fact, we would like to identify the most important business issues that can be solved by technology and not go in search of business issues that still justify the use of technology

- Finally, we will look at application examples of these new processes that help to understand the quantitative and qualitative impact of technologies in projects that are actually implemented.

The key issues of in the course

- Our approach will start from the architectural aspects of the digital information technology systems and their impact on planning and management projects
- Then we will deal with communication systems that allow systems to work at different levels and with different performance to understand the distinctive features of each data communication system and the limits
- At this point we can introduce systems that perform field operations sequences, acquire data and measurements, and systems that supervise them from a local optic or single machine to an overall system optic.
- But digitization requires product architectures and therefore tackles the theme of product modularity and order configuration that needs to be perfect
- At this point we will see how physically automates the production system as operators interfere with physical or logical machines and how this can become digital as an avatar of reality.
- We are ready to understand the impact on the supply chain and enterprise organization and change management processes
- Finally we will see how to set up a smart manufacturing project

Exam

- The assessment of the course provides an examination that can be supported by two methods:

  - Students attending the course will be able to support the examination with three parts that will include the final evaluation:
    - Project in small groups during the cours
    - Participation I-FA
    - Reduced examination of two questions
  - Students not attending the course will support the examination in two parts
    - Examination with 4 question
    - Oral (if the written examination is judged sufficient)