POLITECNICO DI TORINO

Department of Mechanical & Aerospace Engineering

Master's Degree Program
in Automotive Engineering

Thesis of Master’s Degree

Industry 4.0 in Logistics

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Abstract

This thesis is about the logistics application of Industry 4.0.

In order to link the Industry 4.0 with Logistics applications, the background to the technologies used in Industry 4.0 will be briefly outlined. The first part of the thesis shows introduction of World Class Manufacturing (WCM) and Industry 4.0 and the identical goal of WCM and Industry 4.0. The second part of this thesis considers the several technologies (advanced manufacturing solution, collaborative robot, augmented reality, simulation, Internet of Things, Big data analytics, Cloud Computing and Cyber-security) among all the nine technologies in Industry 4.0 which is applicable to Logistics. And their current application and the future in Logistics area. The final level of the analysis consists of a project developed by Mopar (MOtor PARts, parts and service division of FCA) Master Distribution Center (Master DC) of Volvera to implement Industry 4.0 technology in warehouse management. The process within the Master DC of Volvera is discussed and the motivation for innovation is analyzed. A comparison between the solution consists Radio Frequency Identification (RFID) System to locate the items and the solution consists a Real Time Location System (RTLS) is presented. Finally the future of the RTLS technology used in warehouse management is introduced.

Acknowledgment

I would like to thank Prof. Marco Gobetto, for giving me the chance to work with the excellent team from FCA WCM Training & Consulting.

I would like to acknowledge Claudio Vacca, who is the tutor while I was working as an intern in the FCA, for his expert advice and encouragement throughout my stage period.

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1 Introduction to WCM

The concept of World Class Manufacturing (WCM) was introduced in the 80s by J.R. Schonberger. He collected several cases and experiences of companies that were undertaking the Japanese philosophy of continuous "Kaizen" improvement, and defined WCM to embrace techniques and technologies designed to enable companies to match its best competitors; however, the meaning has inevitably evolved considerably.

WCM has its roots in Toyota Production System. TPS, designed and developed after Second World War, applies lean production principles to attack all losses and wastes hidden inside production process and increase efficiency and productivity of manufacturing and logistics systems. This means to produce more and better products with less resources and less costs, without reducing the value for the Customer but even increasing it in product quality and service level.

WCM program at Fiat Group Automobiles has been developed together with Prof. Hajime Yamashina from Kyoto University from 2005. It has first designed and then implemented to its own production system, inspiring at TPS principles. The system was initially called FAPS (Fiat Auto Production System) and later renamed WCM (World Class Manufacturing) and extended to all Group divisions. The implementation level of WCM program is measured according to the methods applied and the performance achieved by best-in-class companies worldwide.

WCM overall logic is modeled as the TQM (Total Quality Management) is on the top and represents the excellence in all management processes as concerns Safety, Product Quality, Service level and Cost.

WCM model is therefore deployed into 4 operating systems.

- Total Industrial Engineering (TIE): It works inside manual manufacturing processes and has the target to maximize manpower productivity through reduction of non-ergonomic activities and non-value-added activities (e.g. waiting times, useless movements, walking, checking, etc.). TIE main aim is to maximize manpower efforts on transformation activities, as they are the only ones creating value for the Customer.

- Total Quality Control (TQC): It works with the target of attacking scraps and reworks, by moving from product control to process control with prevention logic and implementation of «poka-yoke» (error proof) systems
- Total Productive Maintenance (TPM): It works inside automatic manufacturing processes and has the target to maximize equipment efficiency through reduction of machine breakdowns, speed losses, microstoppages, and optimization of setup times, production change, startup/shutdown losses, etc.
- Just In Time (JIT): It works to optimize logistic processes and production lines feeding, minimizing inventories and Work in Process stocks. Logistic system is also working to increase overall service level (internal and external).

WCM model is based on 10 Technical Pillars representing all Production System components managed by dedicated teams and 10 Managerial Pillars representing Management responsibilities and tasks in WCM program governance.

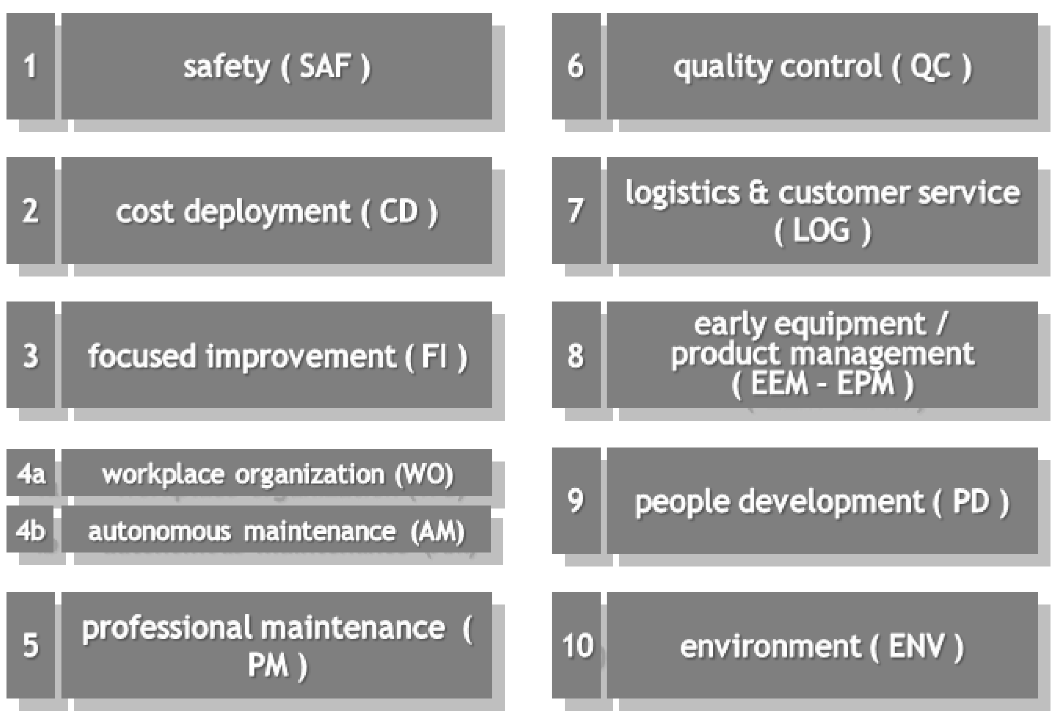

Figure 1: Ten technical pillars in WCM -- source FCA

Ten technical pillars are developed with 7 step logic; steps represent pillar development path from the beginning (step 1) up to total implementation in terms of both expansion in the

Plant and advanced use of pillar tools (step 7).

Figure 2: Ten managerial pillars in WCM -- source FCA

WCM is focused on 3 aspects. The first one is to involve all the employees, the second one is to attack on all the wastes and losses that exists, the last one is to identify the standards and methods used through all level of organization.

WCM has a standardized audit system, aimed to assess in the most objective way the program implementation level achieved by the plants.

Assessment is made for all Technical and Managerial Pillars following specific criteria, taking into account both the rigor in WCM methods, tools application and the improvement of plant KPIs (key performance indicators).

2 Introduction to Industry 4.0

The phenomenon of Industry 4.0 was first mentioned in 2011, in Germany, as a proposal for the development of a new concept of German economic policy based on high-tech strategies (Mosconi, 2015). The concept has launched the fourth technological revolution, which is based on the concepts and technologies that include cyber-physical systems, the Internet of things (IoT), and the Internet of services (Lasi, 2014) (Ning, 2015), based on perpetual communication via Internet that allows a continuous interaction and exchange of information not only between humans (C2C) and human and machine (C2M) but also between the machines themselves (Cooper, 2009).

2.1 Industry 4.0 VS the 4th Industry Revolution

Although it is called Industry 4.0, it shouldn't be confused with the 4th industry revolution.

To have an overall picture about these classis industrial revolutions, for the differentiation of the concept of Industry 4.0, here it presents:

- **The first industrial revolution**, due to the introduction of water-powered and steam-powered mechanical manufacturing facilities, which really was a revolution, would led to the industrial transformation of trains, mechanized manufacturing and massive smog into society.
- **The second industrial revolution** is typically regarded as the period when electricity and related new manufacturing inventions which electricity enabled, such as the assembly line, led to large-scale production.
- **The third industrial revolution** had everything related to the invention of computers, computer networks (such as Wide Area Network, Local Area Network, Metropolitan Area Network), the use of robotics in manufacturing process, connectivity provided by the birth of the Internet which is the most important game changer in the ways of handling and sharing information and the evolutions to build anything a e-version of previously environments, with much more automation.
- **In the Industry 4.0,** which is not really a revolution, the separated idea of the Internet and the client-server model is merged to expand a ubiquitous mobility, the connection

of digital and physical systems (which will be explained in following chapter as Cyber-physical System in manufacturing), the convergence of Information Technology and Operational Technology, and all the technologies (which will be discussed in the following chapters) such as IoT (Internet of Things), big data and cloud computing, with several additional catalyzers such as advanced robotics (AGV and Collaborative robots) and Artificial Intelligence which change Industry 4.0 in entirely new ways to provide automation and optimization that lead to huge opportunities to innovate and a revolution may enable the fully automate and bring the industry to the next level.

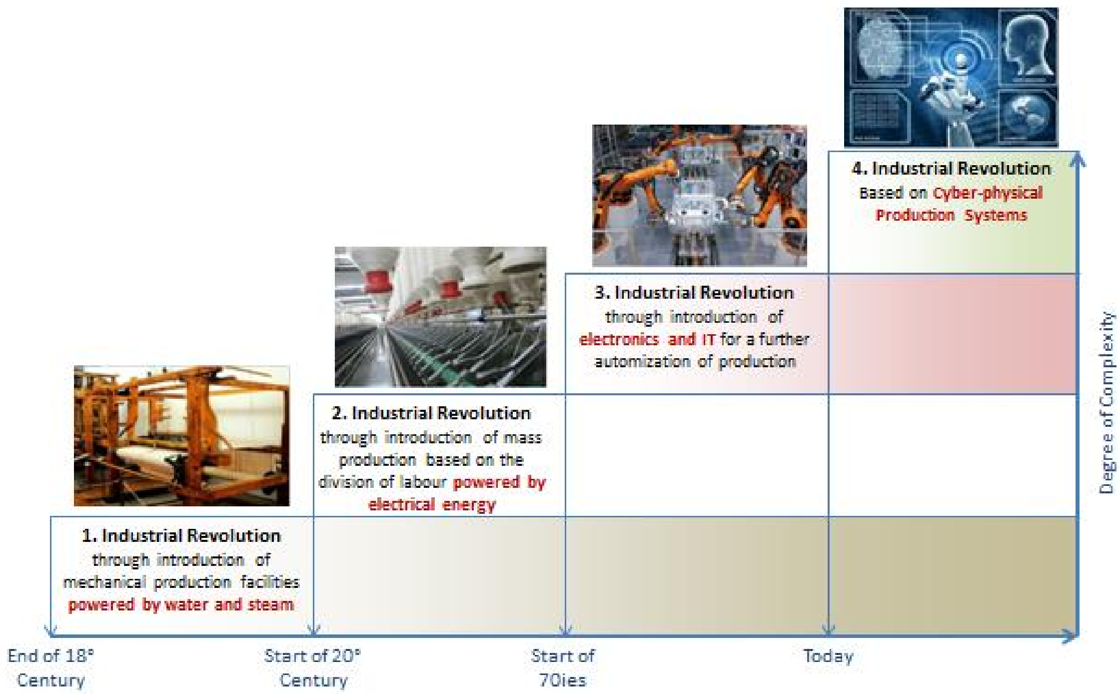

Figure 3: The four stages of the Industrial revolution

The name of 4th industry revolution does not exist due to the absence of revolution, what is changing the industry is the integration of different technologies and innovations.

2.2 Industry 4.0 definition

A shorter definition of Industry 4.0: the information-intensive transformation of manufacturing in a connected environment of data, people, processes, services, systems and production assets with the generation, leverage and utilization of actionable information as a way and means to realize the smart factory and new manufacturing ecosystems. (Industry 4.0: the fourth industrial revolution – guide to Industrie 4.0)

For now, Industry 4.0 is definitely a hot word in the world of manufacturing, money and time are invested to develop Industry 4.0. But, how far have we gone in Industry 4.0? Are manufacturing companies ready to jump from 3 industry revolution to Industry 4.0?

According to (Justin Rose, 2016) companies are implementing Industry 4.0, but in rather ad-hoc and isolated ways. This is typical in any industry when a transformation is happening. It is the first step for organizations to move from obvious goals to true innovation. The benefits below are the ones manufacturing companies are expecting as obvious goals.

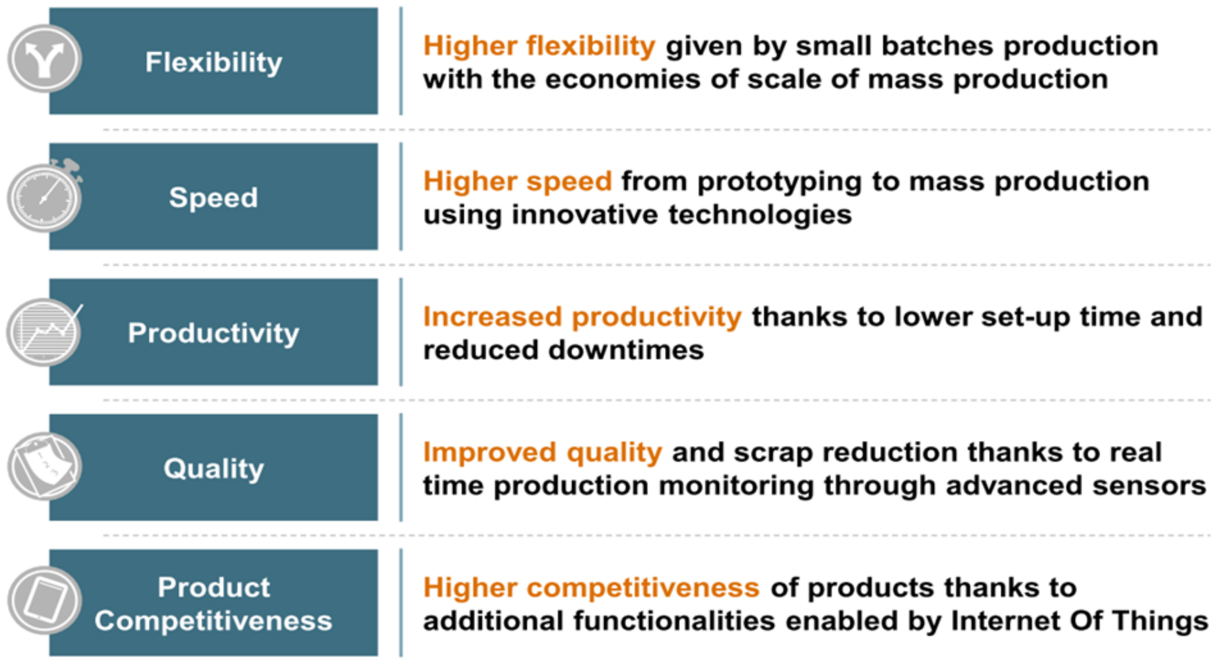

Figure 4: Benefits expected from Industry 4.0

2.3 Industry 4.0 in 2017: the first stages of maturity

Most manufacturing and industrial companies are still in a phase of change with isolated efforts, but often without a broader picture or broader strategy, or as the Boston Consulting Group calls it in the Industry 4.0 context ‘a comprehensive program’. This is still the first stage of real maturity and there is also a focus on the optimization and automation goals and benefits mentioned, which are perfectly normal, but it should not stop there.

To have a more detailed view, Industry 4.0 refers to the convergence and application of 9 digital industrial technologies:

1) advanced robotics
2) additive manufacturing
3) augmented reality
4) simulation
5) horizontal/vertical integration
6) Industrial Internet
7) the cloud
8) cybersecurity
9) Big Data and Analytics.

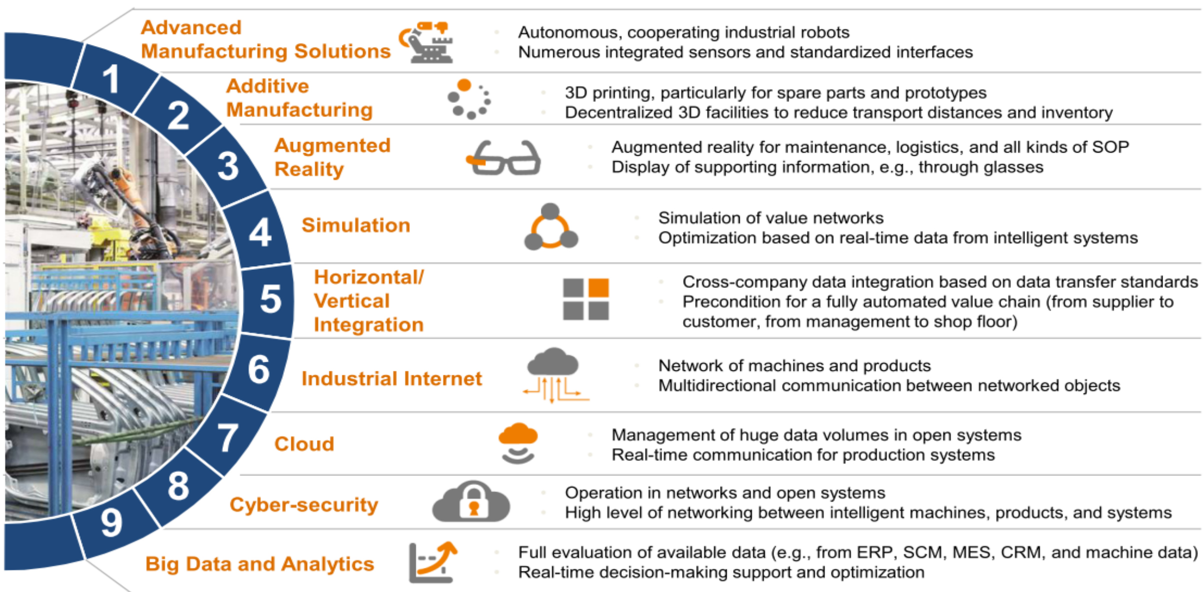

Figure 5: Nine technologies in Industry 4.0 -- source Boston Consulting Group (Philipp Gerbert, 2015)

2.4 Industry 4.0 and WCM

The objective of WCM as a value engineering tool is to estimate non-value-added activities from manufacturing process. One key aspect is to identify all the wastes and losses and eliminates them. A loss is defined as the cost associated to the use of any resource (i.e. materials, manpower, energy, production equipment), which does not generate customer-perceived value. Waste is defined as an excessive input to achieve the same output, which means more resources are used in input process than those strictly necessary to produce the required output. From the definition of efficiency and effectiveness, the variation of wastes and losses are shown.

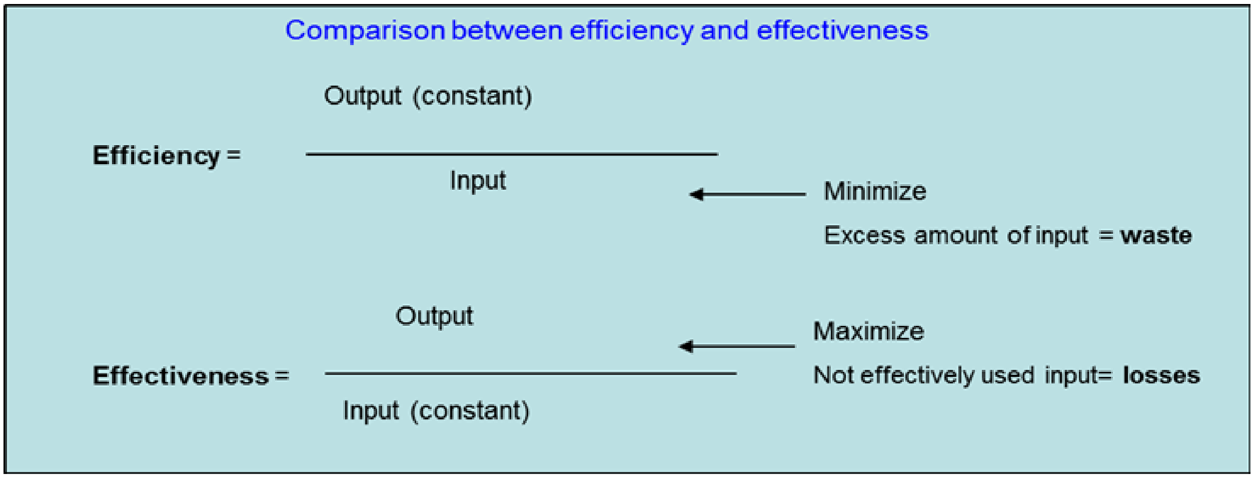

Figure 6: Comparison between efficiency and effectiveness

Industry 4.0 is usually regarded as the automatization of the industry production process. Although it is not the whole picture of the Industry 4.0 but it is the aspect closely related to the lean product that WCM is pursuing, which means reduce wastes and losses by means of transfer to highly capital intensive manufacturing process.

Industry 4.0 is not only a technical improvement, it is more like an overall concept and tool that should be understood and implemented throughout all the employees. During the progress of evolution to Industry 4.0, all standards and methods set by WCM are still applicable.

3 Logistics in Industry 4.0

Logistics has many definitions and it is categorized into different types, it can be the organization of material storages, planning of material flows and management of things complex, like the logistics of setting up an activity, moreover it can be the activities involves many moving parts and processes.

Logistics is defined in an easiest way as the basic activities consisted with multiple intermediary steps to getting right things within right times to right destinations, which also covers the organization of the components of the supply chain. Logistics activities can be categorized in following aspects:

- Supply chain Logistics
- Inbound Logistics
- Warehouse Management
- Intralogistics/ Line feeding
- Outbound Logistics
- Logistics Routing

When logistics is considered in Industry 4.0 to the realize the intelligent and effective movement in all these different aspects, it can be seen clearly which kind of applications is developing: from smart warehousing and smart supply chain, to the AGV and auto-store system to the information connection within all logistical environment.

From the technological perception, the level of Industry 4.0 can be related to the number of 9 technologies of Industry 4.0 is used in logistics.

Area of logistics	Level of Industry 4.0	Applications	Number of technologies in Industry 4.0 are used
Supply Chain Logistics	Intermediate	Complete Global Resource Planning/Controlling	Horizontal/Vertical Integration and Simulation
	Industry 4.0	Open and Flexible Operations Footprint	Intergration of nine technologies, information-intensive process
Inbound Logistics	Intermediate	Autonomous Inventory management	Advanced Manufacturing Solutions, Horizontal/Vertical Integration and Simulation
	Industry 4.0	Predictive inbound Logistics Management	Intergration of nine technologies, information-intensive process
Warehouse Management	Intermediate	Supply Chain Warehouse Network	Advanced Manufacturing Solutions, Horizontal/Vertical Integration, Simulation and IIoT
	Industry 4.0	No warehouse in Supply Chain	Intergration of nine technologies, information-intensive process
Intralogistics/Line Feeding	Intermediate	Autonomous FTS on open area	Advanced Manufacturing Solutions, Additive Manufacturing, Simulation and IIoT
	Industry 4.0	Autonomous FTS on open area steered by production machine	Intergration of nine technologies, information-intensive process
Outbound Logistics	Intermediate	Automatic Delivery Management	Advanced Manufacturing Solutions, Horizontal/Vertical Integration and Simulation
	Industry 4.0	Predictive Delivery Management	Intergration of nine technologies, information-intensive process
Logistics Routing	Intermediate	Real-Time Routin and Connected Navigation	Horizontal/Vertical Integration, Simulation and Industrial Internet
	Industry 4.0	Autonomous Transportation Vehicle/Equipment	Intergration of nine technologies, information-intensive process

Figure 7: Relationship between Logistics and technologies in Industry 4.0

In this thesis, the nine digital industrial technologies are discussed separately to understanding how logistics are affected by Industry 4.0.

3.1 Advanced manufacturing solution

Advanced manufacturing is defined as the application of innovative technologies to improve products or manufacturing processes. Compare to the traditional manufacturing which is defined as the act of converting raw materials into finished products by using manual or mechanized transformational techniques (Thareja, 2005), the advanced manufacturing adds the use of autonomous solution. Such as implementing the autonomous, cooperating robots and numerous integrated sensor and standardized interfaces. The use of Automated Guided Vehicle, Autonomous Mobile Robot and Collaborative Robot can be included in Advanced manufacturing solution of Industry 4.0.

3.1.1 Automated Guided Vehicle (AGV)

The first implemented automatization solution are AGVs. An automated or automatic guided vehicle (AGV) is defined as a mobile robot that follows markers or wires in the floor, or uses vision, magnets, or lasers for navigation. (Automated guided vehicle)

Figure 8: An AGV

AGVs are used for both internal and external transport of materials. But in the past, AGVs were mostly used alongside with the manufacturing line internally, to provide the material needed during the production process. Nowadays, AGVs have extend the application area to repeating transportation tasks outside of production line, such as container terminals, warehouses and external transportation systems. So, AGV utilization is no more limited to plants and manufacturing process.

AGVs can be sorted by their navigation system, whether it is Fixed path or Open path.

- A fixed path AGV are obliged to follow the reference systems located along the route, typically is represented by buried wires or tapes.
- An open path AGV has no reference systems along the route, instead they are stored in the on-board memory of the vehicle. It can be driven by laser, inertial, natural features, vision guidance or geo-guidance.

AGVs can transport simultaneously one or more unit loads. A unit load is defined as a series of items that can be handled like a single object. Inside the warehouse or distribution center a unit load can be a pallet or a container. There are 2 kinds of transportation type depends on the number of unit loads are transported:

- Batch production/ batch transportation: multiple unit loads are transported in one time. This kind of transportation type increases the lead time, while reduces the transportation costs.
- One piece flow: one unit load is transported in one time. This kind of transportation type decreases the lead time, while increases the transportation costs.

The process of transportation of AGVs have the option of one-load-carrying consist of the following steps.

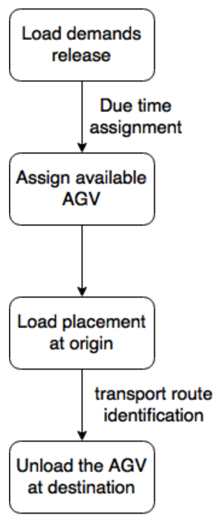

Figure 9: Process of AGV transportation

During the transportation process, many decisions have to be determined for each steps. Hence, a robustly AGV control system which is responsible for scheduling and dispatching the AGVs and avoiding traffic issue is essential for an efficient transportation system.

3.1.2 Autonomous Mobile Robot (AMR)

Autonomous Mobile Robot (AMR) is a portable robot that is able to performs tasks with a high degree of autonomy.

An mobile robot with high degree of autonomy contains 4 characteristics:

1) Self-maintenance: Evaluate the health status of itself, so that to work for an extended period without any intervention from human. It is the basic requirement for high degree of physical autonomy. It is the ability to sense the health status and take care of

itself. Nowadays, a lot of robots that is already on the market which are powered by the battery can find their charging stations and connect to them by themselves.

2) Sensing the environment: Get information about the environment. The next requirement is sensing things about the environment. AMR must have a large amount of sensors to gain information about the environment in order to perform their tasks without messing around with the environment.
3) Task performance: Avoid situations that are harmful to surroundings such as people, property, or even itself unless those are part of its design programs. The next requirement for AMR is to perform a task without cause any trouble that is not designed. A new market that shows business prospects is home robots. The autonomous task performance at the next level requires the robot to perform the task that is conditional.
4) Autonomous navigation: Move all or part of itself by internal power throughout its demanding operating environment without any human assistance.

3.1.3 AGV & AMR

Compare to the AGVs, AMRs has a lot of advantages, in following aspects

- Navigation system: Whether an AGV is fixed path or it is open path, it requires certain kind of "track". AGVs require the detailed information of environment and controlled by the surrounding marks. AMRs are equipped with trackless navigation system.
- Flexibility: Due to the infrastructure of AGVs, they are difficult to re-map, and an AMR can be easily re-mapped.
- Expandability: To expand the utilization of an AGV system needs extra investment into the infrastructure, while AMRs can expand their utilization area by simply scanning the new area at the beginning of operation.
- Obstacle intervention: AGVs have the command of stopping when an obstacle is presented. But AMRs go around obstacles which is relied on their sensors and control system.
- Others: AGVs do not deliver to user but AMRs do, AGVs travel in dedicated areas but AMRs travel around people.

In conclusion, AMRs have considerable advantages in flexibility, compatibility and control. While consider the robot itself, AMRs are always more expensive than AGVs.

3.1.3.1 AMR Application to logistics: Omron mobile robot

Figure 10: Omron mobile robot

This is one of the latest product of Omron, defined as autonomous intelligent vehicles.

It is equipped with all the feature that an AMR needs to have. (Autonomous intelligent vehicles LD Mobile Robots, 2018)

- Robust navigation with acuity (Which is patented). It provides an additional method of "localization" to the onboard laser, helping the robot adjust to frequently changing environments. It identifies overhead lights and overlays the "light map" with the "floor map". It also allows the robots to move easily across wide-open areas in large warehouses.
- Fully safety compliant. They use an onboard laser and other sensors to detect obstacles in their path and, based on speed of travel, trigger an E-stop to prevent vehicle collision.
  Sensors:
  · Safety Rated Main Laser
  · Lower Laser
  · Side Lasers (Patented)
  · Front Bumper
  · Rear Sonar
  · Rear Laser

Figure 11: An example of AMR sensors -- source Omron

- Enterprise Manager is a network appliance that provides coordination of mobile robots while providing traceability, job allocation and traffic control across the entire fleet. With the feature of Transport Request (Job) Allocation, Traffic Control, Communications and Mobile-Planner.

Based on these characteristics, the AMR can be used to transport between workstations or logistic centers. The benefit from implementing an AMR like this is the increase of flexibility and controllability during the intralogistics. The process can be defined as a lean process under following several conditions:

- The delivery between workstations must be in high pace which means high number of robots or limited distance.
- Operated in a local environment.
- Low quantities for each transport

Although the AMR shows a higher saturation and higher efficiency than manpower, it still has limitations:

- The battery of the AMR is not large enough to support a robot arm on the AMR, so the AMR is not able to perform picking or packing activities while transportation.
- The load of the AMR is limited, which means batch transportation is not possible.

3.1.3.2 AGV Application to logistics: Amazon KIVA

Warehouse has always been thought as the feature as it always was, a large, column by column, fixed storage space. The workers inside the warehouse need to drive a forklift or a cart to pick up the goods on the shelf. But, now KIVA changed it all.

Figure 12: Amazon warehouse with Kiva system

Kiva is the AGV that Amazon uses for their distribution centers. The Kiva Mobile-robotic Fulfillment System uses large amount of AGVs as the shelf and a specially designed control software. The system change the definition of traditional warehouse layout and construction into a high surface utilization, easy to operate and highly flexible building which can implemented anywhere over the world.

Kiva Mobile-robotic Fulfillment System is consisted with following components:

- The orange ottoman-shaped robots are the body of AMRs. A central computer gives instructions to them to go and get inventory pods (which are regarded as movable shelves). The instruction includes to bring forward the pods to different work stations, such as picking stations, packing stations and restocking stations.
- Pods are presented as the mechanical shape of shelves, which are used for storing. The pods are identified with the id, locations and the priority. According to the priority sequence the AMRs will transfer the pods to their destination within the floor grid. There are two kind of destination, one is to change the location where the pods were to provide a better stock layout, another is to move to the picking and packing work stations for the que.
- Work stations are the working area where the operators stand or sit to perform activities such as picking, packing or replenishment. It is designed to be ergonomic friendly.

- The key to use the full potential of the Kiva Mobile-robotic Fulfillment System is the sophisticated control software to handle the material. It manages the Kiva AMRs and the flow of material in an efficient way.

An example of KIVA system layout is shown:

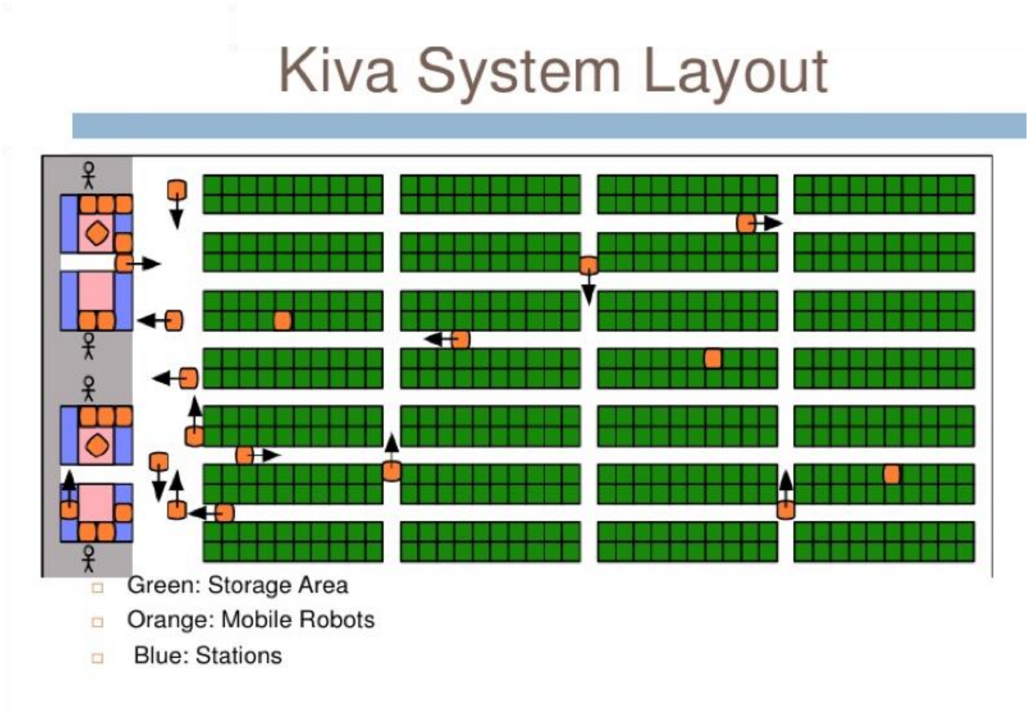

Figure 13: Kiva system layout

The key idea of KIVA system is to build a “goods to person” system other than the traditional “person to goods” system. The following advantage can be expected while implements the KIVA system:

- High order picking productivity
- Increasing order accuracy
- Flexibility
- Reduce training time for new labor
- Reduce the direct labor demands for receiving, shipping and picking activities
- Ergonomic considered

The design of the work station and the pods are ergonomically considered, but not the best solution for ergonomic. As it shows in the following figures, the left one is what kiva system is and the right one is the definition of the best ergonomic zone for material handling. The height of pod is limited to maximum 180 cm to avoid the very poor zone for ergonomic, but during the picking activity, access to poor area of ergonomic is not avoidable.

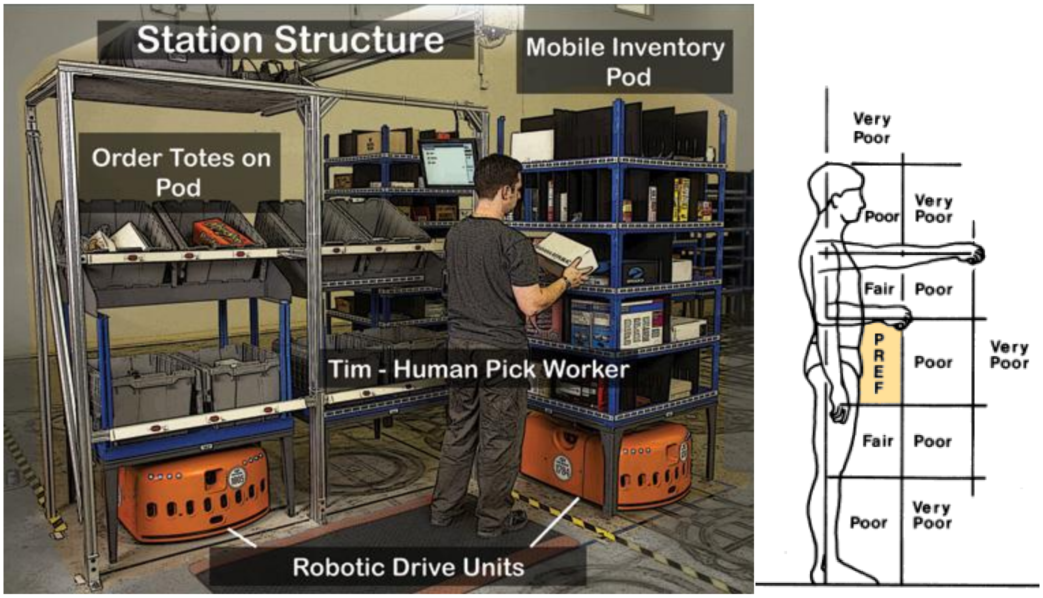

Figure 14: Kiva work station compare to ergonomic golden zone

It is for the ergonomic reason, the volume utilization of Kiva system is low. The upper space of the warehouse is empty and not used, which is a waste of space. A possible solution to increase the volume utilization is to build a multistory warehouse with height of each floor is limited no more than 2 meters.

Until 2014, Amazon's continuing using of AMRs and AGVs allowed it to store 50% more material in their warehouses and save 50% of time to pick items. But Amazon is not the only warehouse operator using the new automation solutions, plenty of suppliers of warehouse are implementing the automation transformation.

While Amazon acquired Kiva Systems for $775 million in 2012 and recently renamed it Amazon Robotics. It is now a wholly owned subsidiary of Amazon. This left a big gap in the marketplace for robotic innovation in distribution and fulfillment centers because Kiva’s goods-to-man technology was taken in house by Amazon. (Tobe, 2015). To fill the gap, other robotic startups are entering the market, such as Fetch Robotics, GreyOrange and Harvest Automation. Old companies like Grenzebach Group are also not going to lose the opportunity to earn more market share.

3.1.3.3 AGV Application to logistics: Autostore

Figure 15: Aurostore overview

Autostore is another game changer for small part storage. It is an automatic warehouse built to enhance the good-to-person concept and to maximize the space utilization density. It redefines the operation area of AGV, the Autostore's AGVs operate on top of the grid. (AutoStore)

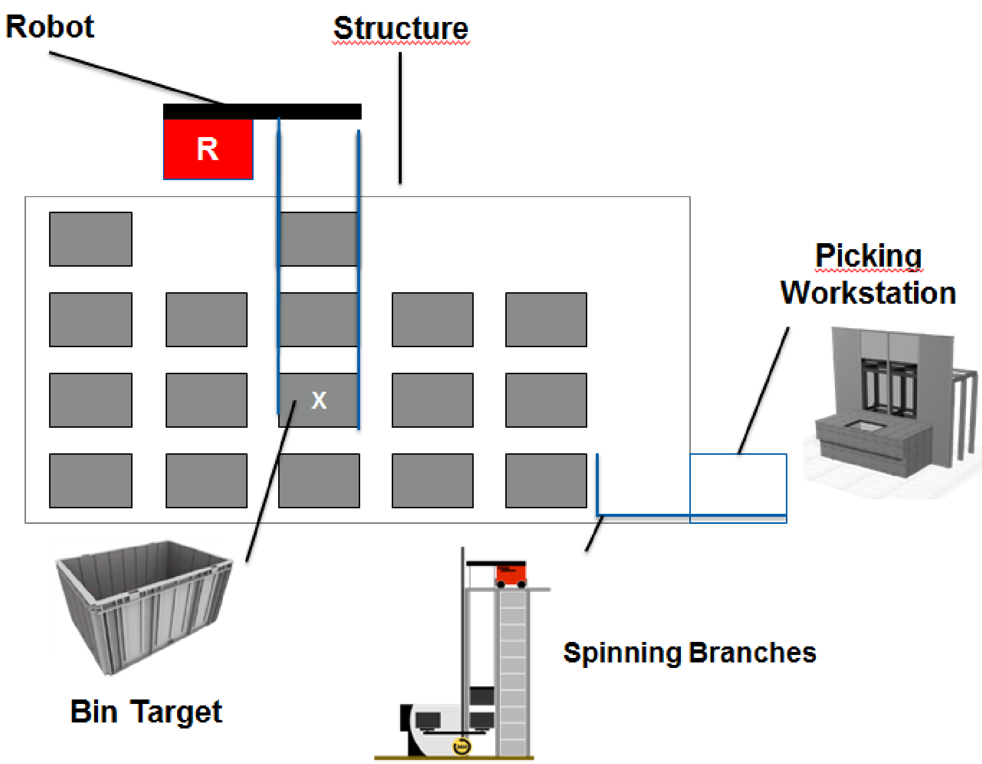

Figure 16: Section view of Autostore

The AGVs is receive orders through wireless connection from the control system, telling them which bin to fetch. They move the empty bin or target bin to the port at the work station to perform the storing or picking activities. The work station is ergonomically designed, so that the operators can work at their golden zone. The most important component of the overall solution is the control system or the algorithm behind the mechanical system. The item stored inside the Autostore is identified with the id and priority, the system will arrange the location of the items according to the priority and the time item stays in the system. For example, a slow moving item may not occupy the location in the above level. The process of a picking activity is showed in following figure.

Figure 17: Picking process of Autostore AGV

Autostore contains several main characteristics:

- Picking Route optimization(driving loss elimination)
- Picking activity optimization (motion loss reduction)
- Space & volume optimization
- High flexibility thanks to module concept
- Redundancy system: robot failure is not blocking the system
- Green system: very low energy consumption
- Ergonomics considered

So far, the implementation of this new Autostore system is moving with favorable development. But it still has some problems:

- Although with the redundancy system the robot failure is not a breakdown of the system, the infrastructure fatigue is not considered. The mechanism of the structure may cause a large scale of breakdown.
- The control system is reliable in certain level, but what if the program behind operation system is hacked or has some default, it may cause a completely shutdown of the system.
- The Autostore is limited with both the size of the item and the weight of the item. The utilization area is narrow.

Lufthansa Technik Logistik Services GmbH (LTLS) has commissioned the innovative, automatic storage rack system AutoStore for small parts in Hamburg. At LTLS, a total of 19 robots travel on an aluminum base frame, retrieving items from stock and transporting them to seven picking stations. 75 stock inputs and up to 200 stock outputs are possible per hour.

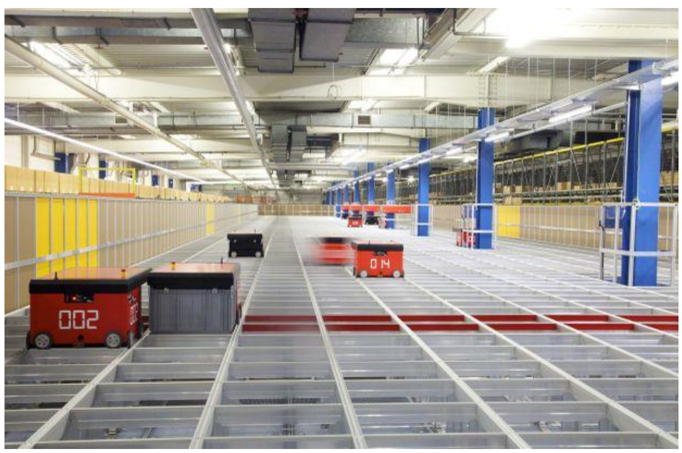

Figure 18: LTLS´s automatic storage rack system AutoStore

The compact storage concept delivers space savings of more than 50 percent compared with the legacy system. The area covered by the automated storage system extends to 700 square meters, with 24,000 containers accommodating 215,000 batches. (Hamburg: Investment in Lufthansa Technik Group site logistics, 2015)

3.1.4 Collaborative robot: COBOT

Collaborative robot (Cobot) is a robot designed to operating with humans in a shared workspace and to have the possibility with physically interaction.

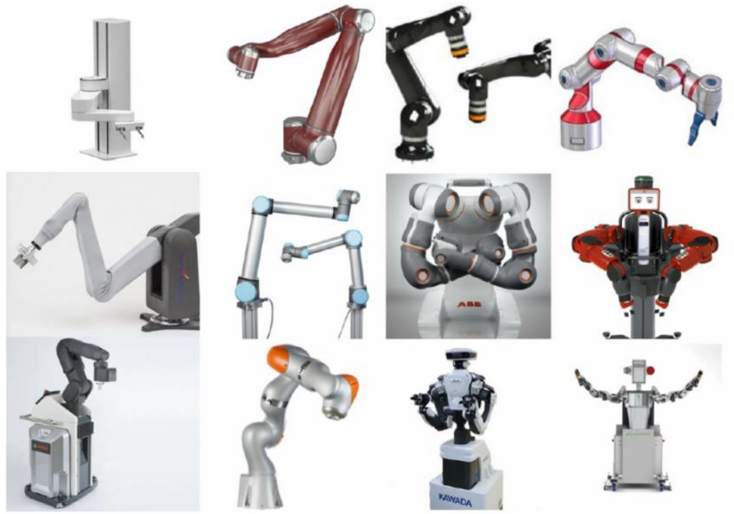

Figure 19: Example of Cobots

Traditional robots is fended in a specific area for operation due to the possibility of dangerous and potentially unpredictability. For safety reason, workers are restrict to the specific area while robots are operating even it is idle, the access to the area is only allow when the robots are off. In recent years, a new kind of robot which is called Cobot have got out of the cages to work side by side with human.

As all the technologies, cobots are designed not only to work with humans but also to improve the productivity and efficiency. There are five characteristics a cobot should has:

1) Safety: The first essential characteristic is to be safe around human. It is realized by the collaborative features according to the standards which will be discussed later.
2) Light weight: The second one is to be relatively light weight, so that they can be portable. In such a way that one cobot is suitable for multi tasks.
3) Simplicity: The third one is to be simple, which means operators do not need and background knowledge about programming to teach and work with them. Anyone, especially blue collar can easily work with a cobot.
4) Low expenses: The fourth one is to be cheaper for both acquirement of the cobot and the cost of maintenance and management than the traditional robots.
5) Flexibility: Last one is to be dexterous and flexible, with the innovation of new technologies, it allows cobot to have up to 7 dof, one more than what was strictly necessary. It is this plus one dof provides better configuration.

According to the international standards ISO 10218, which defines the safety requirements for industrial robots, there are four types of collaborative features a robot can collaborate with human. The standards specify that a robot working in collaboration with a human need to meet at least one of these four features. The 4 kind of collaborative features are (Bélanger-Barrette, 2015) :

1) Safety Monitored Stop: This kind of collaborative feature is used when a robot is mostly working on its own, but occasionally a human might need to enter its workspace. As soon as the human enters the pre-determined restricted area, the robot would stop all its movement. It needs to be pay attention that the robot is not shut down, but it is stopped due to the brakes are on. For example, the case when the item be performed on is in the restricted robot space. The robot took the heavy item, and when the operator enters the restricted area the robot stops. The operator can perform the secondary operation on it while the robot is still holding the item.

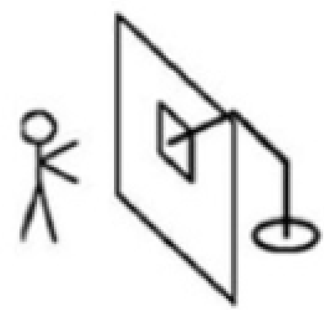

Figure 20: Safety Monitored Stop sketch

2) Hand Guiding: This type of collaborative application is used for hand guiding or path teaching. With this kind of collaborative feature, the robot can be taught the path for picking or placing quickly and store the operation path inside the memory. Any regular industrial robots can equipped with this type of feature with a device to sense the force at the end of the arm.
3) Speed and Separation Monitoring: This type of collaborative, the environment around the robot is monitored by a vision system or lasers equipped on the robot that identify the exist or position of the workers. The robot will move within the functional area of a pre-designed safe zone. If the person is in a safe area, the robot will respond at the specified speed (usually slow) and stop when the worker approaches. Therefore, as the worker approaches the robot, it slows down and when the worker approaches, the robot slows down even more until stop.
4) Power and Force Limiting: This type of collaborative feature sense the abnormal forces during its operation. When the force it senses is overload, it is programmed to stop.

This collaborative feature is not able to use on a regular industrial robots, it is specific designed for certain robots. These robots usually have rounded cover to avoid the impact from a large force and the motors are covered.

Table 1: Comparison of different collaborative feature

	Safety Monitored Stop	Hand Guiding	Speed and Separation Monitoring	Power and Force Limiting
Used on regular industrial robots	YES	YES	YES	NO
Sensor device	A safety device that detect employee at proximity	An end of arm device to detect applied forces	It needs vision system to detect the proximity of the worker	It has force limited features; It does not require additional safety devices
Use case	It is used for sparse cooperative operations	It is used for hand guiding and path teaching	It is used for operations that require frequent worker presence	In most cases, still requires a risk assessment
Collaborative level	The robot basically stops when the safety zone is violated	It does not make robot collaborative in other functions/modes	Medium collaborative level	It is used for direct collaboration with the worker for various task

But when cobots are talked about in Industry 4.0, only the last type of collaborative feature is referred. The power and force limiting feature has the highest collaborative level since it can work side by side with humans without additional safety devices to detect the human movement.

According to the latest market study released by Technavio (Global Collaborative Robots Market 2017-2021, 2017), the global collaborative robots market is expected to grow at a CAGR (Compound Annual Growth Rate) of more than 60% during the period 2017-2021.

The market size of collaborative robots is expected to reach USD 2,1 billion by 2021, with APAC (Asia-Pacific region) responsible for generating the highest revenue and maximum incremental growth through the period of 2017-2021.

The increased incorporation of collaborative robots by Small and Medium-sized Enterprises (SMEs) will be a major driver of the market through the period 2017-2021. With rising labor costs, collaborative robots come across as a very attractive alternative for SMEs to stay competitive in the market. Offerings like Racer 3 from Comau, targeted especially for SMEs will lead to the wide-scale adoption of these collaborative robots.

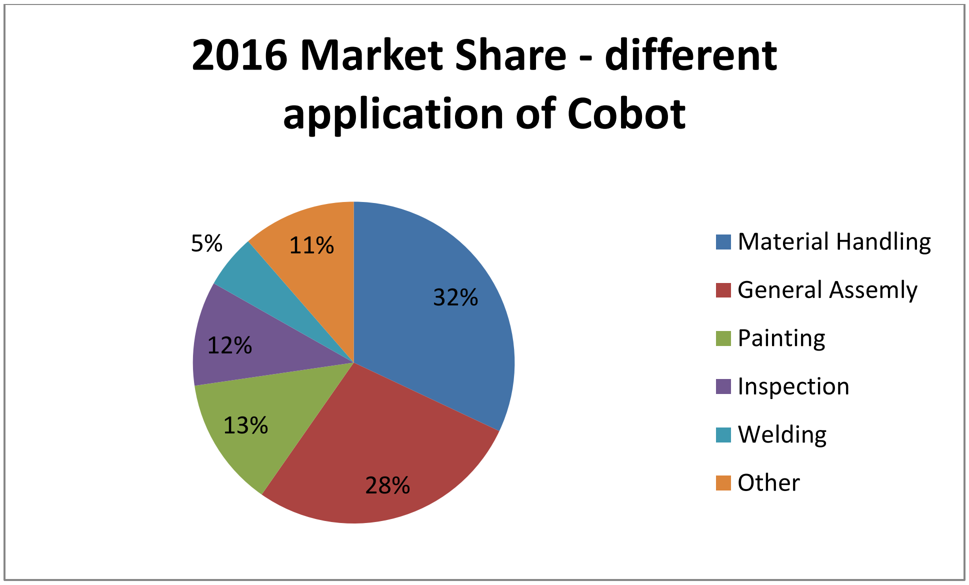

Figure 21: Market share of different application of Cobot in 2016

Based on application, the global collaborative robots market is categorized into the following segments

- Material handling
- General assembly
- Painting
- Inspection
- Welding
- Others

The top one revenue-generating application segments in the global collaborative robots market is material handling, because collaborate robots represent a balance of flexibility and technical skill, which facilitates material handling and takes complete advantage of human expertise and skills.

Material handling collaborative robots can perform a wide range of operations such as machine feeding, loading and unloading, packing, palletizing, and disengaging to name a few. They are witnessing swift market penetration, especially from the automotive industry. The maximum demand for these robots is expected to be from countries like China, USA, Germany, Japan, and South Korea where there are many prominent manufacturing industries.

3.1.4.1 Cobot Application to logistics: Comau Aura

Advanced Use Robotic Arm (AURA) is the collaborative robotic product presented by Comau's innovation. It defines zero spaces between manpower and high payload robots. This new product cover the blank area of high payload robots that means much more industrial areas can be operated under a safety implementation of robots during the manufacturing processes.

Figure 22: Comau Aura

Thanks to the Comau's innovation of collaborative technologies, the Aura is fully safety to co-work with human. The Aura is equipped with contact sensor under the special foam skin. The management of sensitivity is a unique feature of Comau solutions; for the very first time, AURA combines the simultaneous perception of the proximity of a person – or of any other component of the automation – as well as contacts and their intensity. The combined use of these technologies, employing laser scanners to identify the positions of persons dynamically makes it possible to ramp down the motion of the robot to a complete stop only when it is very close to or actually in contact with the worker.

In addition, the Aura is covered with special foam skin, when it is touched, it acts like a button, to perform the demands of physical interaction with human such as stop or moving long the force. It is thanks to the contact sensor integrated in the skin.

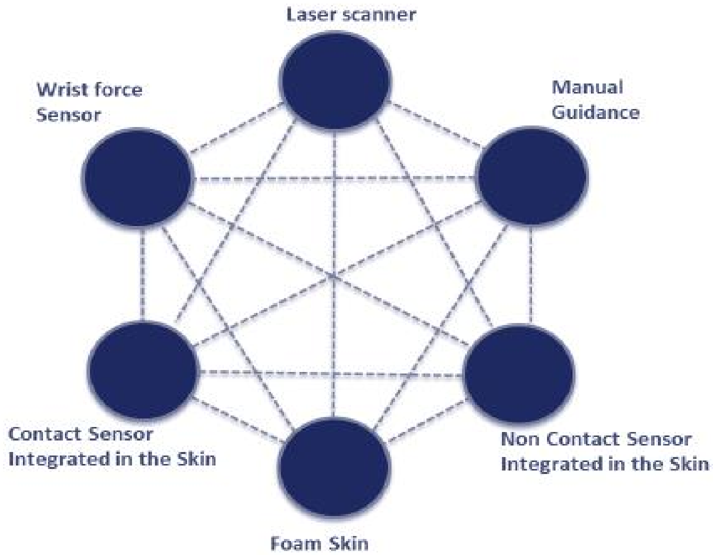

Figure 23: 6 technologies to become collaborative for Aura

When an AURA is implemented for material handling, many advantages can be expected:

- Reduce safeties "yellow components", i.e. fences, light barriers.
- Reduce labor costs.
- Reduce floor space.
- WCM enabler, i.e. reduce NVAA, improve Ergonomics and spaghetti chart.
- Increase flexibility and re-configurability. Easily reprogrammable and task repurposing.
- Reduce process complexity.
- Increase quality and efficiency.

3.2 Augmented reality

Augmented reality is a live direct or indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data. (Augmented reality)

Virtual reality and augmented reality are widely used and spread, from the consumer market to industrial applications. However, the great value of augmented reality can provide is in the industrial manufacturing, along with some other technologies.

It is usually confused the concept of augmented reality and virtual reality. The concept of virtual reality is the first definition within the public's mind to access the technology like this, because several well-known product of VR headset are already launched in the market. Virtual reality replaces the real environment around the user with a simulated one. If someone is wearing a VR headset, it means that person is totally blind to the real world.

But on the other hand, Augmented reality does not replace the whole environment of the user , it just enhances user's current perception of reality. Augmented reality cannot bring someone to another environment, it adds digital items into the current reality that in one's sight.

AR is enabled by performing four basic tasks individually and orderly, then combining the output to present the demanding activities.

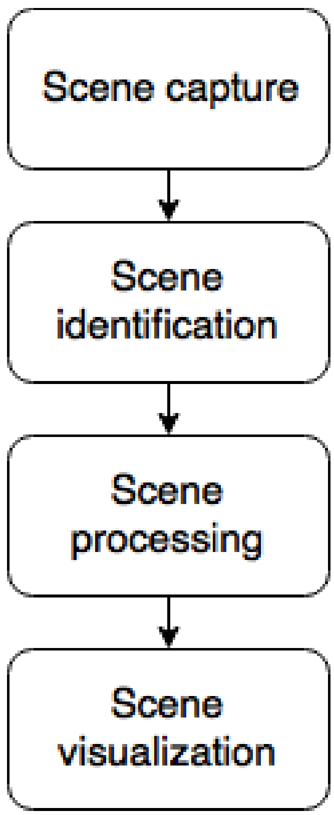

Figure 24: Four basic tasks of AR

1) The first basic task is to capture the reality which needed to be augmented, by using a camera or a video-capture device, or a head-mounted display like glasses so that the world is seen-through.
2) The second basic task is to identify the possible position where the virtual matter should be placed. It is marked or tracked after scanning the captured reality.

3) The third basic task is to generate the demanding virtual matters, based on the internet or required database.
4) The final basic task is to combine the real world with the virtual matters and visualize it using the AR system.

Hardware components for augmented reality are: processor, display, sensors and input devices. Modern mobile computing devices like smartphones and tablet computers contain these elements which often include a camera and MEMS (Microelectromechanical Systems) sensors such as accelerometer, GPS, and solid state compass, making them suitable AR platforms. (Augmented reality)

3.2.1 Augmented reality application in logistics

AR is still in its early stage to the maturity considering industrial application, especially in logistics, but there are huge benefits can be developed from it. For example, information is one key driver for any logistics provider, it is the guarantee to an accurate anticipation and operation. AR enables a quicker acquirement of the desired information anywhere and anytime. It can lead to a higher level of customer service.

3.2.1.1 Warehousing operations

AR has definitely shows its value in warehouse operations for logistics.

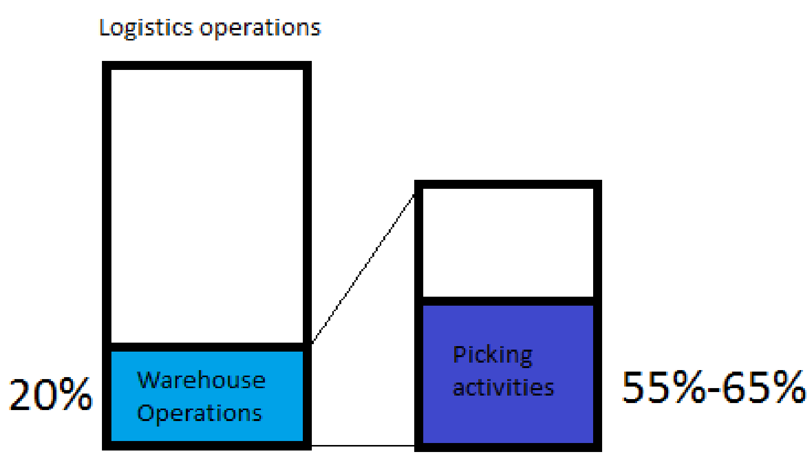

Figure 25: Costs of logistics operations

Among all the cost of logistics operations, the costs of warehouse operations stands for 20%. And among that, the picking activities account for about 55% to 65%. This statistic data shows how important the picking activities is to a logistics supplier, which also shows the great potential of reduction that AR can provide. An AR device can be also used during the training session of the warehouse labor management.

The most typical application is Pick-by-Vision, which consists of mobile AR systems such as smart glasses, cameras and a wearable PC. The vision picking software enables indoor navigation, real-time item recognition, barcode reading, and integration with the Warehouse Management System (WMS). A key benefit of Pick-by-Vision is to free the operators' hands during the picking activities.

The digital picking list is presented in the line of sight of each worker and along with the best route to pick the item, due to the exist of the indoor navigation system. The time that workers travel through the warehouse is reduced.

Field tests that DHL made in their warehouse for these AR systems have proved that they improve significantly productivity in warehousing operations. The errors are decreased by 40% through constant picking validation. The picking error today is very low, but the costs for fixing an error is huge, so any possible approach to reduce the error till zero is deserve.

3.2.1.2 Transportation Optimization

In the last ten years, the efficiency and reliability of the transportation operations are largely improved by the implementation of advance information innovation. AR is the next innovation provide a further optimization of cargo transportation. It can be used to verify the completeness, to navigate the driver and to facilitate the cargo loading and unloading.

AR can support application such as:

- Verify the completeness: AR provides an option to pick-up more effectively. The operator who is equipped by AR can verify the completeness in a simple glance. Nowadays, the verification process is done by manually counting and check the paper list, or by scanning the barcode one by one which costs a lot of time. In the future, an AR device is used for this process by scanners and sensors to detect the number of items and compare it to the predefined values, and the result will be show in the operator's view.

- Dynamic traffic support: the device to navigate the driver. It can be a glass that driver wears or the display embedded in windshield. It is able to display the real time information of the transportation route or the traffic. AR is better than the navigation app on the phone or external device is due to that the driver's sight can be concentrate on the road in the front of him.
- Cargo loading and unloading: As well as AR is used for warehouse picking activities, it provide the same advantages in cargo loading and unloading. Different from the traditional paper list, the AR system can update the real-time information, so that when the loading and unloading is occurring, any order change is considered without any delay. Other than that, AR device can show the instructions to help the operator to easily identify the item needs to be handled.

3.2.1.3 Last-mile Delivery

Another possible AR application is during the last-mile delivery. Last-mile delivery have never experience such a challenge with the rapid growing using of e-commerce. Last-mile delivery is the last task in the logistics chain and the important one due to the high expense. Although last-mile delivery is benefit from the AMRs and AGVs, it can add more profit by using AR devices.

AR can support application such as: Parcel loading and unloading, navigation of Last-mile delivery and AR-secured Delivery.

3.2.1.4 Enhanced Customer Services

AR improves not only the logistics process, but also the customer service level, by changing the way that after sale is now, giving the customer initiative. The VolksWagon is developing a system called MARTA (Mobile Augmented Reality Technical Assistance), which uses augmented reality that display the instruction through you line of sight to guide you step-by-step to repair the problem.

3.3 Simulation

Simulation is a behavior of simulating the process or the existed system in the real world with the passage of time.

The premise of simulating the process of something is to establish a model whose function is to characterize the key features, behaviors and functions of the physical or abstract behavior as well as system. Among them, the model can be understood as a system, and simulation refers to the behavior of the system in the time dimension.

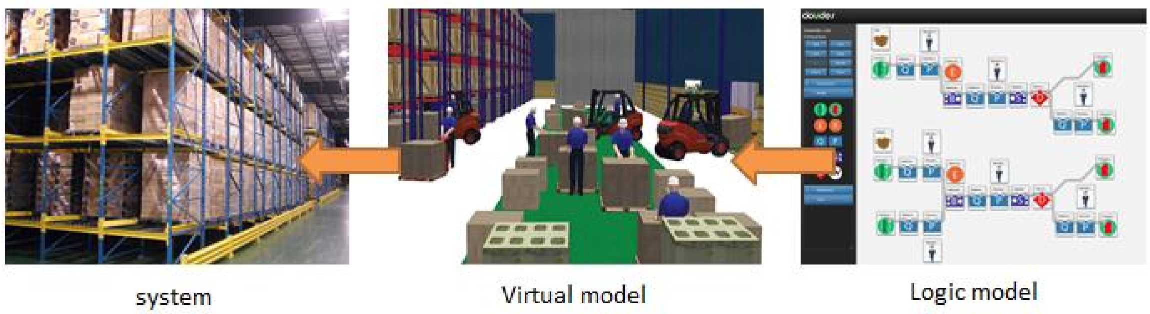

Figure 26: Simulation Process

In the meanwhile, the 3-D simulation technology for materials, products and manufacturing processes has been well applied in the production process. It is foreseeable that the application scope and depth of simulation technology in the factory production will be more extensive.

The process of traditional simulation in manufacturing often consists of:

- Build a logic model for the system, which represents the sequence and logic through the activities of the system. The output of different input is tested and simulated with the logic model.
- Based on the logic model, and virtual model is built to provide a more tangible view on the system behavior.
- The system is set by the verified input to generate a desired output.

3.3.1 Simulation in future

The future of simulation is closely related to the rise of using digital twins.

Digital twins are the dynamic replicas of physical assets, products, and machine by digital and software code. From the original concept, digital twins have been well used in real production at present, thanking to modern information and data management and analysis technologies, as well as technologies that support digitization and so on. However, the technology now has more to do with IoT (Internet of Things) and with the cost savings that can drive IoT and digital twin. IoT and sensors power digital twins.

The features of digital twins is connecting to the ontology in the real world whose function is to reflect the behavior and reactivity of the things or systems in the real world, to optimize operations and to improve quality. In the process of using, digital twins are basically used initially, after which they are continuously optimized to improve the accuracy and visualization of the data collected, to analyze and use the rules reasonably, and to respond quickly and effectively to business goals. On the basis of the development of time, the digital content of every aspect of the digital twins will be dynamically connected in real time with the corresponding parts of its real ontology, and will be learned and evolved based on the AI (Artificial Intelligence) technology. Finally, the simulation, operation and analysis functions will be continuously improved.

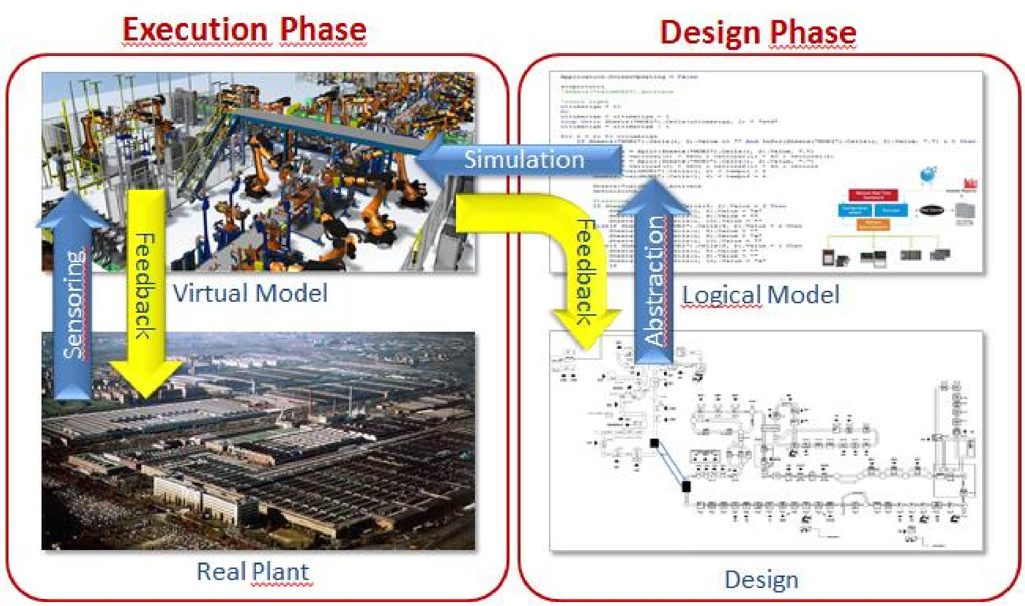

Figure 27 : Simulation process in future

The simulation techniques based on the digital twin of system evaluate the performance on real-time data. The advantage of doing this is that the machine test and optimization process for the next production in the virtual model can be achieved before the physical structure changing, resulting in saving time to machine setup and improving quality.

The basic process it similar to the one of traditional simulation, but in additional, the process of future simulation is a close loop which takes the real-time data as the input of simulation. The detailed processes are:

- The design of system is made according to the requirement.
- The logical model (or digital twin) is built for simulating the system activities
- The simulation is processed with the logical model and represented on the virtual model, using the history or hypothesis data as input.
- Based on the output of simulation, the real system (such as plant or warehouse) is built and operated.
- Real-time data is collected from the real system by sensors.
- These data is transmitted to the virtual model and logical model, as the input data of simulation, to get a real-time simulation output.
- The design of system may needs modification according to the real-time output.
- Once the design of system is fixed, the simulation loop restrict between execution phase.

3.3.2 application for logistics

In the latest years FCA has developed many simulation projects using Plant Simulation by Siemens, whose function is building a digital model based on Discrete Event Simulation (DES) for real systems, just like production. On this basis, the features of the system are studied and the performance of the system is improved.

Discrete event simulation (DES) is the process of modeling the behavior of a system as well-defined discrete events in sequence. Based on this, each event marks a change in the system's state and occurs at a particular point in time. Because of the events are discrete, between two consecutive events, there is no change in the system's state may occur. The simulation of the system consists of simulating events in order of time.

Discrete event simulation (DES) is a tool that helps to achieve "world class" levels of productivity performance.

Table 2 : DES application

DES can be used to:	Field of use
Verify different alternatives of production system in terms of throughput, time, saturation	Green or Brown fields (Design of new plant or Improvement of exist plant)
Identify bottlenecks/ optimize buffer dimension between different processes	From Body In White to Paint
Define the optimal number of tuggers used	Deliver body parts to the BIW
Design or optimize body painting warehouse structure (such as dimensions or layout)	Sequencing after Paint
Define the optimal number of hangers	Assembly
Simulate and analyzing material flows and operators movements	Production areas

For the logistic applications, simulations can be used for testing and developing logistics path and warehouse designs, guaranteeing the right level of saturation for corridors and locations as well as lowest distance to allocate and collect materials.

There are several similar software for the different company to simulate these process, such as:

- Flexsim
- Class(warehouse simulation)
- Simul8

Another common application during the everyday life is what most people used for navigation – google map. With the function like real-time traffic conditions and route planning for travelling by multi options, google map helps the consumer to simulate different way to get to the destination. The google map present the street map and all the characteristics need to be defined, the route is simulated based on the specific algorithm using the real-time information like traffic, position of consumer and timetable or real-time location of public transportation. The map, the route and the little arrow which represent the consumer position and direction are all the digital twins of the real world.

3.4 Cyber-physical systems

A Cyber-Physical System (CPS) takes the computer algorithm as the control center, and its structure is tightly integrated by the Internet and its users. In this system, the physical structure and software system are closely integrated, and its operation is carried out on different spatial and temporal scales, its behavior patterns are also diverse. The mutual communication ways between cyber world and physical world change with context.

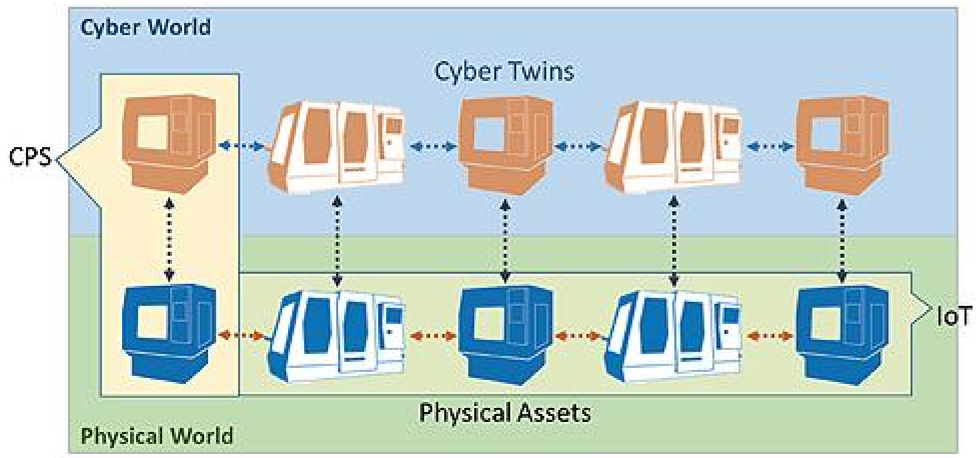

Figure 28: Cyber-physical system, relation with Internet of Things

CPS is usually confused with the concept of IoT (Internet of Things), due to the similar definition of containing the use of network, internet and sensors in IoT and CPS. But they are different. The basic construction of IoT is linking physical assets and digital twins, in whom the data can transfer. The connections are made possible by the secure implementation of computer networks, internet and communication protocols. Figure 28 above clearly shows that cyber-physical system is a vertical concept that combines the physical world with the cyber world, and the IoT is a horizontal concept that connect all the physical assets together and enable the communication between each other.

The Internet of Things and CPS have a very big impact on industrial development. So far, many companies have used IoT and CPS-related technologies, most of which do more than embed sensors in RFID-tagged production equipment or labeling products. A relatively simple analysis of the data from these devices is only the most basic step. The deeper role of the above technologies and equipment is to analyze these data through the information system and make more informed judgments and decisions based on the analysis results.

For manufacturing CPS systems, (Lee J, 2015) provide a 5C architecture. The system is pyramidal in structure, which corresponds to the higher level of data, its magnitude is smaller, but the greater the amount of information it contains. The sense of the pyramid shape is that lower levels collect data that is analyzed and condensed at each upper level. So information fed to each higher level is more valuable than information coming into the level below. The 5C architecture breaks out this way:

5). Connection: The data obtained at this level comes from interconnected machines, tools and products, which are then sent to the substructure

4). Conversion: At this level, the data obtained is analyzed and converted into information by the algorithmic program. Take the raw vibration data of the machine tool in the production line as an example. The raw data cannot tell the status of the system, but after the relevant characteristics are extracted from the data through the health assessment algorithm, the system running status and other information can be obtained.

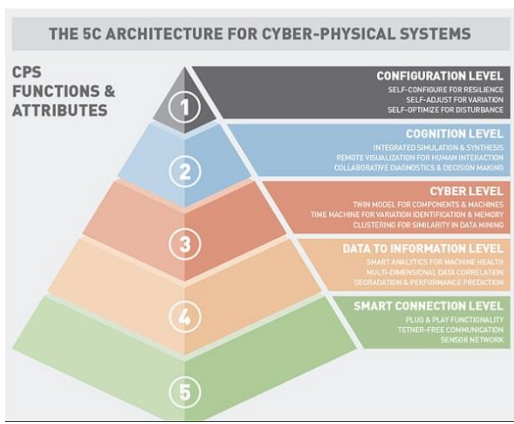

Figure 29: The 5C architecture for CPS

3). Cyber: This level receives the processed information sent from the lower layer, and then creates additional value based on this. This layer can be seen as a message center, but it also enables more sophisticated analysis. For example, fleet or near assets in a group can be compared (eg, a particular type of production facility in a system) by using sophisticated fleet-based analysis methods. It uses deep learning algorithms to identify common patterns in large amounts of data. A recommendation system is a special algorithm that is used to predict the "rating" or "preference" of a single item, which can be a good predictor of each individual asset.

The above two levels seem to function the same. The main difference is that the scope of the input information and the object of the algorithm are different. Conversion level is more focused on the analysis of personal assets, while the network level is more inclined to infer additional information based on the entire system of data. That is to say, using a single sensor node allows for conversion-level data analysis, but network-level methods are only available through a central computing center like the cloud.

2). Cognition: The purpose of this layer is to translate machine signals into health information and to compare health information from different samples. At the cognitive level, the system itself should be able to diagnose its own potential failures using online monitoring methods and be aware of any potential performance degradation before any obvious signs of failure occur. Based on the adaptive learning approach of historical health assessment, the system can use a suitable prediction algorithm to anticipate potential failures and estimate the timing of a particular failure.

1). Configuration: By recording their own health, the machine can predict the occurrence of the failure and send health monitoring information to the operational layer. The above information is the basis of the business management system to achieve the basic functions. Based on this, operators and plant managers can make more scientific, rational and informed decisions. In addition, based on this can also adjust the machine's workload or operating schedule, in order to reduce the time caused by the failure of the machine. In short, according to the above technique, a flexible system is perishable so as to avoid interruption of operation. The system can adjust the operation plan and predict the occurrence of the fault to deal with the system fault and prevent the system operation from being interrupted.

The 5C architecture can apply to different levels of an industrial concern including:

- Component level
- Machine Level
- Fleet Level
- Enterprise Level

The most suitable method for each level is to extract useful information from the raw data. Generally speaking, the superstructure gets the data from the lower layer, and then uses a specific algorithm to analyze it, and finally sends the analysis results obtained to the higher layer structure.

3.4.1 Internet of things (IoT)

The Internet of Things is the interconnected sphere of physical devices with the Internet and other networks through uniquely identifiable IP addresses. The basic devices for data collection and transmission are sensors, electronic devices, and software systems.

The Internet of Things can be viewed as another level containing information, exchange, event and operation, connected to the network through appropriate equipment, and had the functions of data collection, analysis and translation through Internet technologies. The IoT deepened the relationship between digital and physical facilities, promoting information-driven automation and raising the standard of living in business, society and people.

In a more common way, an embedded system, such as RFID technology, provides the identify function, such as gave the thing an unique IP addresses and the sensor gather the data, and some actuators to act on the thing, with the wireless internet technology gave the possibility to connect things together, consisted the Internet of Things.

Actually the original of the IoT can be traced back to the development of RFID (Radio Frequency Identification). RFID had the function of identifying and tracking the labels stuck to some devices automatically with electromagnetic fields technique. The role of the label is to save the electronic information, including passive tags and active tags, of which the former using the power contained in the ask radio waves from the nearby RFID reader, while the latter itself has a power supply, which has the advantage of sensing distance, you can Up to several hundred meters.

This technology is used for decades but not yet shown its fully potential. RFID is used in product identification and management, in the field that the product outflow is relevantly low due to the high price of single RFID tag, such as library management and pet identification system.

The identification system is a critical aspect in IoT, due to the essential of the IP address along with the sensor to provide the data.

Sensor is usually an electronic component, module, or subsystem which has the function of detecting the signals of the close thing or situation and sending the information to other equipment, for example an embedding system. It can be various type depends on the way of categorize, such as distance sensor, accelerate sensor, temperature sensor etc. Sensors collect the data and transport it to the data center by several possible means. The data center analyze the data then give the command to the actuator. It is a close loop action when data center is local.

With the wireless data transportation, the data center can be remotely and the data analysis can be sufficient with additional information from other terminals.

The technology is not very new or trending at this moment, but the integration of these technologies provides the possibility to manage the industry or non-industry things over a bigger picture. The Internet of Things is a holistic concept that can be divided into Consumer Internet of Things (CIoT) and Industrial Internet of Things (IIoT).

There are many common features in the definition of IoT. The common elements are the 7 characteristics that IoT contains:

1) Internet of Things Connectivity: Network usually refers as including physical devices, sensors, or lines. It can be said that the dimension of network and connectivity or hyper-connectivity is an indispensable concept in a reasonable IoT system. The question then changes to whether it is 'just' about some networks including the Internet. The answer is obvious, you know the answer. Also note that in the context of connectivity, the dimensions of automation are key in many IoT applications.

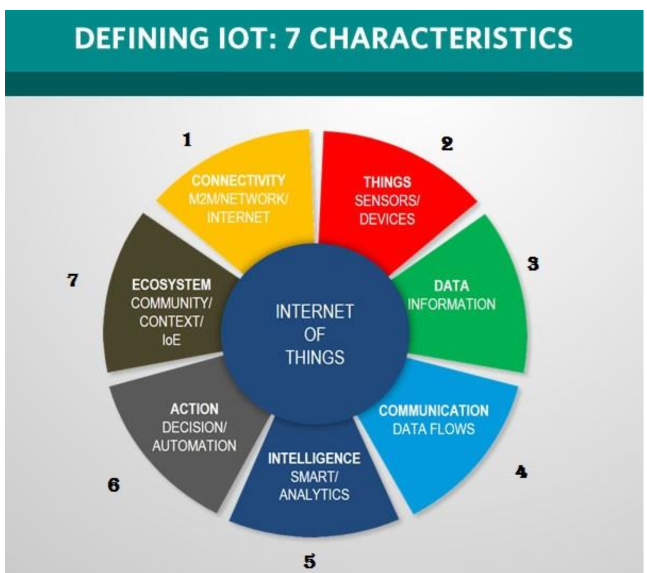

Figure 30: Seven characteristics of IoT

2) The Things in the Internet of Things: The world, equipment, hardware systems, sensors and terminals. All of these represent an essential part of the reality that forms the network. Some of these parts have developed clever and intelligent properties. We can

imagine that if technology evolves so that they can "do something": detecting water, detecting air humidity, tracking specific objects, collecting exercise information, or collecting any other data that can be detected.

3) The Internet of Things and Data: This concept is about intelligence, however, it can also reducing the distance of human beings and the nature. It can be regarded simply as listing all the features of the IoT ("what's this?"), provided that it accurately captures its purpose ("why"). Among them, the data is very important, this is only the first step due to the lack of data volume, but this does not need to worry because the existence of the Internet of Things is bound to have a lot of data.

4) Communication in the Internet of Things: Data cannot be said to be worthless, but data is meaningful only if it is used to achieve a certain purpose, at which point data is transformed into a variety of forms, such as meaning, insight, intelligence and action. The DIKW model (from Data to Information to Knowledge to Wisdom and action) is excellent at this point, and at this point the data collected from the Internet of Things needs to be communicated to further translate into understandable and accessible Information, even worse is knowledge, insight, intelligence or action.

5) Internet of Things, Intelligence and action: However, in most cases, the concept of intelligence appears in network systems and / or in some physical devices. Admittedly, while in many cases technologies such as "smart networking technologies" are essential and some devices also have the capability of acting, the true intelligence and action should come from intelligently on the basis of the analysis of the data The application of these data has been to solve the problem, to achieve automated operations, thereby increasing the competitive advantage. In general, IoT solutions should solve any possible problem. Just as the Internet of Things (IoT) cannot do without (large) data, a useful IoT cannot be without meaning, intelligence, (big) data analytics, cognitive and AI and so on..

6) Automation: The concept of automation is essential, and there is no need to consider the scope of the project or the style which the IoT utilizing. The reality is that most IoT applications are developed for automated implementations and this is also about cost and benefit. Industrial Automation, Business Process Automation, or Automatic Software Updates: Depending on the situation, it all works. As the saying goes:

software to eat the world. Automation technology has a huge role in promoting Tesla Motors and future autopilot technologies. Maintenance and upgrades are all about automation and software, based on data driven from sensors and devices.

7) Ecosystem: When it is thought about the meaning of the Internet of Things, meaning and hyper-connectivity are usually ignored. It is common to focus more on how to describe, focus more on technology, while ignoring purpose and smart technology. At this point, what is discussed is not a mere IoT in the strict sense but a comprehensive description of the IoT or the ecosystem of the IoT or other aspects, but in other words, the point does not refer to move the IoT confused with the concept of many devices related to certain applications. Because while these are applications that most people are talking about, which is the majority of IoT applications, they are far from the essential implication of the IoT.

3.4.1.1 IoT in logistics

Information is the key aspect to logistics. As a logistics supplier, the degree of information intensive mostly affect its competitiveness. IoT shows its great potential to improve the logistics by taking the full advantage of information through the logistics processes. Applications can be:

- Accurate tracking of vehicles: Logistics and operators have to deal with a number of fleet comprising of trucks and other commercial vehicles. Based on type of shipment, the same cargo may need to undergo flight, on road and ship based transport. When advanced GPS sensors and tracking devices are used in such cargo vehicles, the logistics companies can track their movements at each moment. They can get information on whether the vehicles are adhering to the recommended route or not. This in turn helps them better to answer client queries regarding delay in delivering cargo, no matter where it is. If a vehicle of the fleet gets stuck on a route, its driver can alert others on the same route using IoT services as well.
- Delay elimination: The biggest customer grudge any logistics and courier company is weary of is delay in product delivery. Cargo can get delayed by a number of reasons and delay can lead to many other issues apart from an irate customer. Delay in transit can often lead to perishable products getting damaged which can have further implications. It can lead to negative publicity of the company. Transit delays caused by factors like

inclement weather and traffic woes can largely be evaded by using IoT in the APT (Automatic Picture Transmission, a weather satellite system) way. When both the major cargo hub and recipient centers are connected by IoT enabled devices, real time sharing of weather information and traffic details becomes easier. The vehicles can change usual routes if the news of a traffic snarl is available.

- Cost reduction: Using IoT in logistics and transport also results in cost cutting for the companies involved. First of all, the data obtained on traffic situation can help cargo carrying vehicles avoid traffic snarl affected routes. This will help in fuel cost reduction to an extent. When logistics service providers do not end up with product perished in transit owing to delay caused by such factors, the compensation related cost can also be reduced largely.
- Cargo quality damage reduction: Sometimes, cargo can get damaged in transit owing to a number of factors. Perishable cargo, including vegetable and food grains may get damaged owing to unexpected rise in temperature, humidity or failure of temperature controlled cargo containers, etc. With IoT enabled cargo vehicles, maintaining surveillance over cargo container interior becomes easier. The company can be informed at all stages about the deterioration of cargo and preventive measures can be adopted faster.
- Monitoring inventory: Despite implementation of technology in warehouses, logistics and courier companies depends a lot on manpower and human observation till date to stay updated on inventory stock. With 24×7 digital and accurate surveillance made possible by the usage of RFID and CCTV cameras connected by IoT enable devices, inventory management becomes improved. Companies can be updated at all times on position of inventory at warehouses. This helps them meet fluctuating customer demands in a more efficient way. Before a product gets exhausted in warehouse, the company can gather additional stocks and keep equilibrium between customer demand and supply.
- Monitoring the phases in transport: Sometimes, the logistics service providers need to send cargo through their various centers before it can reach the customer address. At any of these centers delay can happen. This happens when the process is operated mostly manually. Human errors and unforeseen situations cannot be predicted! However,

with cargo processing controlled by machines that are monitored by advanced sensors such errors are largely minimized.

- Reduction in equipment errors: Sometimes, machinery errors in large and small equipment at various stages of cargo shipment can take place and that can make logistics companies worried. For example, equipment like conveyor belts at airports, yard tractors and cranes at warehouses may develop snags and that can lead to cargo mishandling. When IoT enabled sensors are used to monitor cargo handling at such areas, risk of cargo mishandling is largely reduced. When an error occurs, the company is immediately alerted and remedial measures can be taken.
- Delivery hassles reduction: With the deployment of IoT in logistics operations, delivery related hassles can become a thing of the past. Instead of relying on documents for customer verification, digital IDs supported by IoT can be used. In the near future, features like NFC will make inroads into all mobile devices. Using such advanced digital features, making payments will become smoother for customers too.

3.4.2 Big data and Analytics

Big data and analytics refers to the process of finding hidden patterns, unobvious links, trends, user preferences, and other useful information from a multitude of large data sets (big data) that can help users make more wise business decision. Big data is not only about collecting but also about analysis.

The concept of "big data" first refers to the increase in the amount of data in the last ten years of the 20th century. In 2001, Doug Laney, major in consulting firm Meta Group Inc., extended the Big Data concept to include the proliferation of data generated by organizations and the speed at which data is created and updated. These three factors - capacity, speed, and breed - are known as 3V for big data. According to (Hilbert, 2015), recently it is increased to 5V characteristics.

Big data can be described by the following characteristics:

- Volume: The quantity of generated and stored data. The size of the data can influence the value and potential insight, and more importantly, it determines whether it can be called big data.

- Variety: The type and nature of the data. This helps people who analyze it to effectively use the resulting insight.
- Velocity: In this context, the speed at which the data is generated and processed to meet the demands and challenges that lie in the path of growth and development.
- Variability: Inconsistency of the data set can hamper processes to handle and manage it.
- Veracity: The data quality of captured data can vary greatly, affecting the accurate analysis.

There is no IoT without big data. IoT is a trending word, when new innovation and application is talked about. But behind the intelligence, is that the large amount of the data is produced and collected. With big data and analytics, it is possible to dramatically improve the management and use of rapidly expanding databases that are built by collecting and consolidating information from multiple sources.

The advent of big data analytics applications has dramatically increased the complexity and speed with which structured transaction data is analyzed by professionals in data scientists, forecasting modelers, statisticians, and other analytics. It also enables traditional business intelligence (BI) and analytics In the easily overlooked data types of analysis possible. The style of the data could be semi-structured or unstructured, such as web server logs, text from customer emails, mobile phone call detail records and the data collected by the sensor system.

One tool used to realize big data analytics is Hadoop. It is an open-source software framework used for distributed storage and processing of datasets of big data using the MapReduce programming model.

The Hadoop distributed processing framework is a framework released by Apache in 2006 for clustered platform application services built on commodity hardware and developed for big data analytics. With the rapid emergence and development of big data analysis technologies such as Hadoop, by 2011, big data analysis has drawn wide attention from various departments and the general public.

With the development of big data and analytics, thousands of big data tools are presented on the market, which are designed for different progress phase of dig data analytics.

- For data cleaning phase, OpenRefine or DataCleaner can be used.
- For data mining phase, RapidMiner, IBM SPSS Modeler or Kaggle can be used.
- For data analysis phase, Qubole, BigML or Statwing can be used.

- For data visualization phase, Tableau, Silk, CartoDB or Chartio can be used.
- For data integration phase, Blockspring or Pentahu can be used.

The choice of tool depends on different aspects such as area of use, storage and data language.

3.4.2.1 Big data in logistics

The logistics industry can be said to benefit most from the advances in big data technologies and methods. In this area, data mastery has always been a very important concept, and in ancient Greece the roots of logistics mean "practical arithmetic". At present, the logistics providers hold a bulk of goods flows and thus also get a wealth of data, including The origin, destination, size, weight, content and use of all shipments are recorded on the Global Delivery Network. However, it is questionable whether such data tracking can fully develop the value contained in the data.

There may still be a lot of room to grow in terms of operational efficiency improvement, customer experience and generating the right management model. For instance, if the logistic data of multiple logistics suppliers can be integrated and analyzed together, the organic integration of the market may be realized and a new type of logistics operation system that is more rational and efficient may be generated.

Many providers have come to realize that big data will be a key factor affecting the direction of the logistics industry. The data show that 60% of respondents looking at supply chain trends have said they have plans to get in big data analytics over the next few years. Big data will not change the pattern of the logistics industry much in the future.

The discussion of how big data is used can start with creating and consuming information. The big data analysis contained in the logistics industry can affect its development from five aspects, and ultimately improve their competitiveness. Through the analysis of these five aspects can be seen as how the big data affect the logistics industry, the most prominent situation. (Martin Jeske, 2013)

1) Optimization to the core
    - All along, the characteristics of service such as how to ensure the transport time-consuming, improve resource utilization and actual space utilization are all problems of the logistics industry.

- The large-scale nature of logistics data sets high demands on the efficiency of data processing. From this point of view, to improve the timeliness and accuracy of information is conducive to improving the performance of optimization.
- Using reasonable methods to improve forecast accuracy and real-time performance can be helpful in furthering the quality of capacity forecasting and resource control

2) Tangible goods, tangible customers
   - The delivery of the actual form of the goods requires the provider to interact directly with the customer
   - Globally, there are a large number of logistics points every day, which is a very good environment for market intelligence gathering, product feedback and demographics
   - A variety of analytical methods are included in the big data related system to enable efficient and valuable analysis of customer satisfaction and product information feedback
3) In sync with customer business
   - Modern logistics solutions seamlessly integrate into production and distribution processes in various industries
   - Closer links with customer business help to provide logistics providers with more realistic market conditions, including individual businesses, market developments and geographic differences
   - Introducing analytical methodologies to big data analytics is very helpful in predicting supply chain risks and improving system robustness
4) A network of information
   - The transport and delivery network is a high-resolution data source
   - Not only can data be used to train and optimize networks, but it can also be used to discover deeper levels of useful knowledge about trends in global commercial products
   - The power and diversity of big data analytics has moved the perspective of analysis to the micro level
5) Global coverage, local presence
   - Local presence and decentralized operations is a necessity for logistics services

- Through the logistics and transport lines, we can easily collect the real situation in different regions along the way
- Through the analysis of data from the large-scale logistics chain, we can discover a certain degree of the knowledge of population, environmental and transport status

3.4.3 Cloud

Cloud can be known as cloud computing, refer to achieving the purpose of computing on the demand of a customer utilizing the computer resource connected to the Internet.

The concept of cloud computing was first proposed by computer experts. It can also be understood as computational utility, and at this point, cloud computing has a unique meaning of "pay for what you use".

Today's computing is experiencing an era of users from using their own computers to computers that users do not own, with the latter being calculated mainly through computing hardware and software systems provided by service providers. This process mainly involves the user running computing resources built on the "cloud" and then pays for the computing resources and time spent. In other words, computing providers function just like utilities or telephone companies, and computing services will become more generic.

Depending on the privacy degree of the resources and service delivery mechanisms, several types of cloud deployment or cloud deployment models have been defined. The cloud delivery and cloud deployment models usually are divided into four main types.

1) Public cloud (owned and operated by a third-party provider and can be used by anyone, think Microsoft Azure, Google’s cloud, Amazon Web Services and so forth, publicly accessible and thus no distinct private resource pools),
2) Private cloud (can be used in several ways but as the name says used by the organization alone with cloud computing technology and virtualization, a distinct cloud where privacy is the key trait) and
3) Hybrid cloud (the answer to the multi-cloud reality of most organizations and de facto the main delivery model and strategic model).
4) Community cloud (simply a cloud that is used by a community of people for a common shared purpose and/or with shared/common profiles; an example: the BT Radianz cloud for the company’s financial customers).

In reality many companies use several cloud deployment models for various cloud services and processes at the same time.

Depending on the types of services and resources the customer subscribes to, various types of cloud services have been defined. The classic main three types are Software as a Service (SaaS), Platform as a service (PaaS) and Infrastructure as a service (IaaS).

1) SaaS (Software as a Service): The capacity of running software applications in the cloud and de facto also used for (vendors of) applications in the cloud and sourced from the cloud as a service with a gradual increase of less typical applications than in the earlier days (CRM and ERM still account for the majority of spending though, with other early stage Saas applications such as web servers, collaborative applications, email and social apps to name a few) and increasingly including more mission-critical applications.
2) PaaS (Platform as a service): The cloud application platform, giving its user the capabilities to do virtually everything related to applications: from application development and testing to application management and beyond. You could call PaaS the cloud service model for developers of software, web applications and so forth.
3) IaaS (Infrastructure as a service): Anything related to sourcing infrastructure-related resources and the hardware and other infrastructure as well as key infrastructural resources with regards to for instance computing power and connectivity. The hardware is typically managed and ranges from servers and storage to anything you find in a data center (and cloud data centers as such). Operating systems and several infrastructure-driven resources such as bandwidth also fall under the IaaS cloud service model. Infrastructure, the scalable way you need it.

However, there are far more types of services and resources that can be obtained via cloud computing: from disaster recovery and back-up to computing capacity, bandwidth and security, everything indeed ‘what-as-a-service’.

Among the more traditional cloud solutions we find Desktop as a Service, Backup as a Service, Business Process as a Service and Disaster Recovery as a Service; among the newer ones (although new is relative) we find, for example Security as a Service (and, indeed security offered IN the cloud), IoT Data as a Service and many more.

The early big data systems were built using local devices, mostly in large organizations that collect, organize, and analyze large amounts of data. With the use of cloud technologies such as Amazon Web Services (AWS) and Microsoft helped drive the development and management of Hadoop clusters in the cloud. For example, Cloudera and Hortonworks have already supported their big data calculation system built on AWS and the Microsoft Azure cloud. When used, users simply start the cluster in the cloud, do operation according to the demands, then quit the cloud framework after use, and their charges are based on usage, thus avoiding the need for a continuous software license.

Cloud computing is one of the essential enablers of Industry 4.0, has been shaping the software and business applications market for over a decade and has an important place in the development of the Internet of Things or IoT.

3.5 Cyber-security

Although the emergence of the Internet of things has promoted the organic combination of the real world and the computer control system, it also brings new risks. In particular, the rapid development and popularity of the Internet of Things has increased the risk of cyberattacks, making it closer to the real world (rather than confined to the online world).

As industry 4.0 continue to evolve, more business and social field will use IoT technologies while more real devices will be linked to tighter connectivity. This adds considerable difficulty to cybersecurity, data protection, and regulation establishment. For example, the purpose of the proposed GDPR (General Data Protection Regulation) is to ensure that organizations effectively address them.

Cybersecurity cannot be treated by traditional security methods which has limitation with the complex characteristics big data contains. It has become highest priority when an information transformation is occurring in the company. But the current status of cybersecurity is not as mature as it was thought.

Completed by more than 1,700 qualified professional designers of embedded systems, the (Embedded Systems Safety & Security Survey, 2018) assesses the state of product development practices of engineers from around the world. It has revealed the following statistics:

- 43% don’t do regular code reviews

- 41% don't perform regression testing
- 38% don't comply with any safety standard
- 33% don't use a static analysis tool
- 17% don't follow any coding standard

It can be observed that cybersecurity is involved in Industry 4.0 too late, or in some case not yet. But it is not the only reason, why the great gap exists. Other reasons are presented:

- Security Requires Tactics and Priorities: The implementation of security is somehow difficult and its starting point is not about the addition of security control to everything, but rather by risk assessment which start from identifying the most critical process or system and the potential sources of attack or loopholes. As is known, the risk of loopholes in the field of Internet of Things has been increasing. From this point of view, security needs a strategy, which is not only solved by using some firewalls.
- Business Case for Cyber Security Challenges: For example, it is more difficult to create a safe business case for digital transformation projects in terms of digital workplaces, collaboration or customer experiences. When adding the current cost is rising, when you are unable to keep what you need to protect in terms of security, a more effective strategy is to measure the loss. But the key issue right now is when you know it, it's happened, the business has been interrupted, the data has been stolen, the compliance requirements have been compromised, or the reputation has dropped.
- Specific Security Skills Group Challenges: Skills are another concern. In fact, lots of large enterprises find it very difficult to choose the right security expert for a given application, and in the context of digital transformation typically involves large amounts of data and new and emerging technologies.
- The key, but undervalued, role for data and information in transition: Data and information are the foundations for business fulfillment and the foundation for generating profits and building new business models. The basic of economy is three things: people, purpose and controllable information. Unfortunately, the level of network security maturity in many organizations and the neglect of these three elements in their compliance and/or governance practices. An analysis of the Ponemon Institute's cybercrime cost information map for 2016 shows that information loss accounts for 40% of the damage from cybercrime, and that when a company develops an advanced

information governance program, its loss is reduced by 10% annually One hundred million U.S. dollars.

Although in this article several technologies enabler of Industry 4.0 is discussed separately, but it is only for the reason of giving an easier understanding of the innovation technologies. The reality is that all the technologies are connected to each other and integrated together to enable a transformation from Industry 3.0 to Industry 4.0.

4 Application of Industry 4.0 in logistics – Auto Identification project in Mopar

Auto Identification project is a implementation of Industry 4.0 in Logistics under the consideration from not only technology innovation but also performance improvement. It is focused on offering a new version of warehouse management, especially in the inbound and outbound area.

4.1 Mopar and Word Class Logistics (WCL)

Mopar – a combination of MOtor and PARts – which is established in 1937, has gone through 80 years of significant evolution. Transformed from the trademark of antifreeze products to the partner who provides the official service, parts and customer care globally for FCA brand vehicles.

Mopar offers authentic parts and accessories that are engineered together with the same teams that develop the factory-authorized specifications for FCA vehicles, offering a direct connection that no other aftermarket parts company can provide. With its global reach, nowadays the Mopar brand distributes more than 500,000 parts and accessories in over 150 markets around the world and holds an unparalleled position in its segment, in terms of famous, level of service and worldwide customers. (Mopar Brand: evlolution over 80 years, 2017)

Over the past decade, Mopar has continued to contribute in the technology innovations with many solutions, including the first smartphone vehicle information apps, in-vehicle wireless charging and factory-connected tablet technology at service centers via Mopar wiADVISOR.

Since 2010 FCA extended WCM methodology to Logistics processes, such as warehouse management in Mopar, with the objective to implement a World Class approach on business and logistics operations.

WCL is based on same principles and pillars of WCM (see Introduction to WCM). Mopar transferred World Class approach into 10 principles:

1) The basic principle is safety first. To ensure zero accidence and to build a Warehouse where all employees work in absolute safety and without risk for the health.
2) Widespread adoption of standards for measuring performance, defining objectives and regulating production processes. To set a common language of understanding in all management level and labor level.
3) Customer Voice perceptible in the warehouse through visual systems.
4) Goal tension towards the concept of zero waste and losses.
5) Development of activities mainly in the field and not in offices. To really design and plan the actions for implementation, not only on paper.
6) Spread of best practices and their sharing among the establishment.
7) Rigorous and standardized use of tools for improvement
8) Total involvement of people in the program
9) Best practices to be the reference
10) Energy in crisis

WCL is aimed at reducing wastes and losses in the logistics process, which are different from those in manufacturing process. However, the concept and the method are the same.

Recently, the central distribution centers of None and Volvera in the Turin area, have reached the prestigious Silver level of the World Class Logistic (WCL).

The WCL Silver, is the synthesis of the work done by the approximately 650 people employed at the central Parts Distribution Center (PDC) who have given four priorities in the search for continuous improvement: Safety at work, Quality of service, Process productivity and respect for the environment.

4.2 Mopar process

In the Europe, Mopar manage their distribution network aiming to guarantee the service level expected by the customer and optimizing supply chain cost by two working flows:

1) Inbound Flows: Materials from supplier are sent to Master Distribution Center (Master DC) and Source Distribution Center (Source DC).

Figure 31: Inbound flows of distribution network

2) Outbound Flows: Materials in the Master DC and Source DC are distributed to Importers or Reginal Distribution Center (RDC), and further to the customer or to Local Distribution Center (LDC) if a RDC is not capable to cover the special area, such as LDC of Sicily.

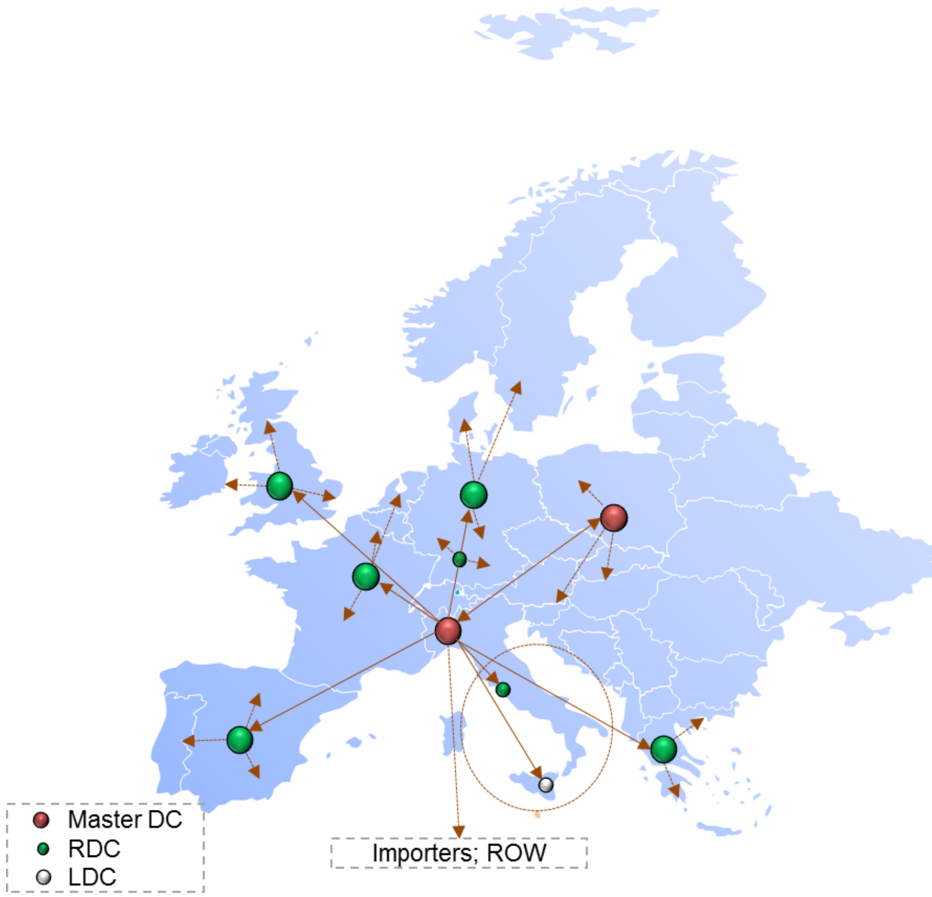

Figure 32: Inbound flows of distribution network

The PDC of Volvera is a Master DC, which handles almost 300,000 item numbers. Every year from Master DC of Volvera, materials from 800 suppliers are procured and 7 million orders from customers and RDCs are processed (i.e. the additional 19 distribution centers located in the main EMEA countries).

In Master DC of Volvera, the operations are separated into two parts: inbound operations and outbound operations.

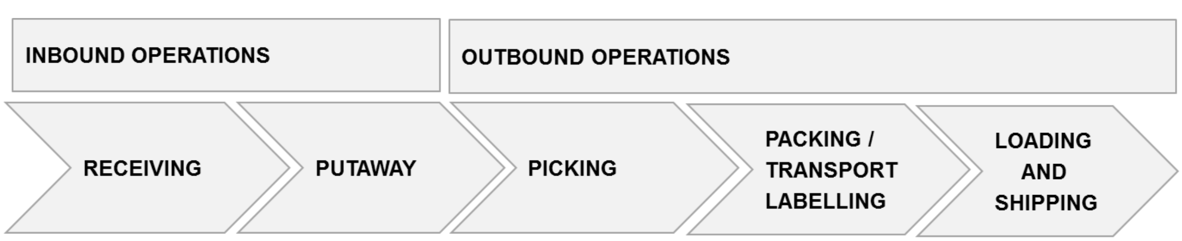

Figure 33: Operations of Master DC of Volvera

All the operations is processed by the warehouse management system (WMS). It is a software system, which is designed to optimize and support warehouse management or distribution center management. The WMS enable all the activities involved in the warehouse management such as daily planning of the warehouse, labor location and management, resource utilization and controlling, material flow management inside the warehouse and during the inbound and outbound area, in the meantime providing a solid support to the labors in daily activity completeness. In Mopar, the WMS called Click is used. It is the overall software run behind the physical world.

4.2.1 Inbound process

The inbound processes can be divided into 2 phases: receiving and put-away.

In **receiving phase**, material arrives in the warehouse by the truck is received through several steps:

- Material is unloaded from the truck.
- Material is checked by WMS if it's aligned with the expected ones or if it needs a random quality check. A put-away label is printed when a material is first scanned by WMS. The material doesn't aligned with the expected ones by WMS will have the "Manca dati" (lack of data) sign on the label and the material needs quality check will have the "Qua" sign. If the quality check is not approval, the material will be send back to the supplier. The materials passed the quality check are scanned again to generate a new put-away ticket.
- A put-away label generated by WMS contains the information that needed to move the material such as: priority, warehouse storage location, date of entry, date of put-away, quantity of item, type of container and so on. The item priority is determined by stock level and outbound volumes. The higher priority means the shorter time before the material goes on the shelf. The latest type of label with the thermal technic can shows the priority by different color on the top of ticket clearly.

- The material that is not in the storage container needs an additional activity to move to the storage container. The empty metal container from this activity and from the shelf is send back to supplier for the next delivery. All the materials in the storage containers that can be handled by material handling equipment, like forklift, are called UDC (unità di carico/unit load). Activities to move a UDC from a position to another are called moving UDC. The UDC is located by scanning the I/O barcode (In and Out barcode) that near the unload area.

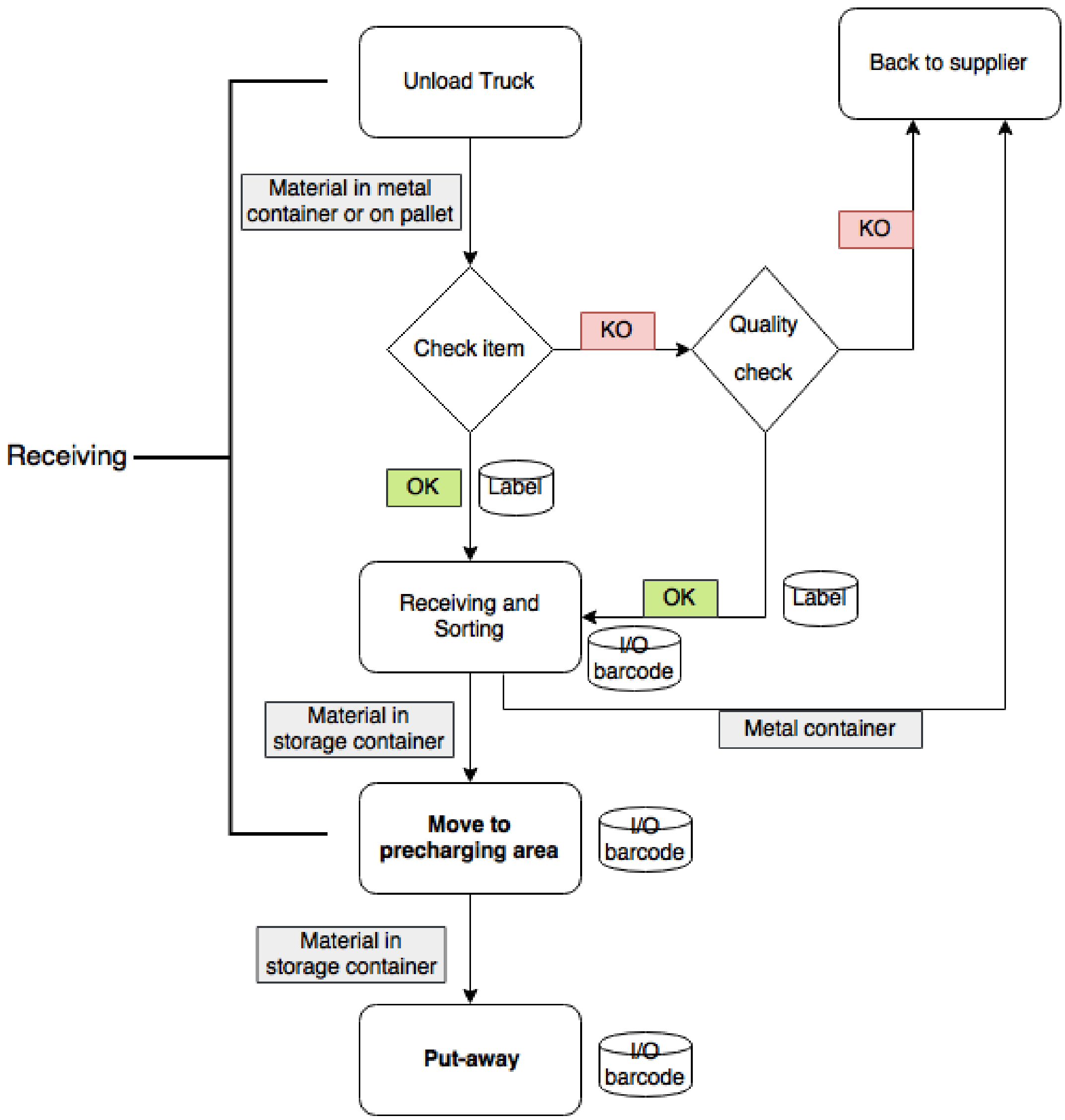

Figure 34: Inbound process in Master DC of Volvera

- The UDCs are sorted and moved to the precharging area determined by storage area. The precharging area is divided into 2 kinds, one is a dedicated area for each shelf, and another is the small area near the shelf which exists due to the technology difference between moving UDC and put-away. UDC is located by scanning the specific I/O barcode near the precharging area, when it is moved to that area.

In **put-away phase**, the UDC is put on the shelf according to the destination that generated by WMS. It is finished by scanning the I/O barcode of the shelf and the UDC barcode.

4.2.2 Outbound process

The outbound process is divided into 3 phases: picking, transport labeling and delivery.

The **picking phase** can be realized by 2 kind of picking methods: Pick & Pack or Geographic Picking.

- Pick & Pack: It is the picking method that one forklift driver picks the items by one customer or multiple customers. Pick & Pack starts by picking the right container that the customer or customers need, and picking the items according to the Pick &Pack picking list which indicates the items, the customer that orders the items, and the destination of customer. Items are picked and putted into the customers' containers. The packing activity is naturally done during the process. In this method, the extra activity to packing is eliminated, but the picking efficiency is low.
- Geographic Picking: It is the picking method that one or multiple forklift driver pick items by destination area. Forklift drivers pick items according to the Geographic Picking list which consist of only items and their destination. After the picking activities, the items are sorted and packed for different customers with suitable containers. In this method, the picking efficiency is improved, but a extra activity to packing and sorting is needed.

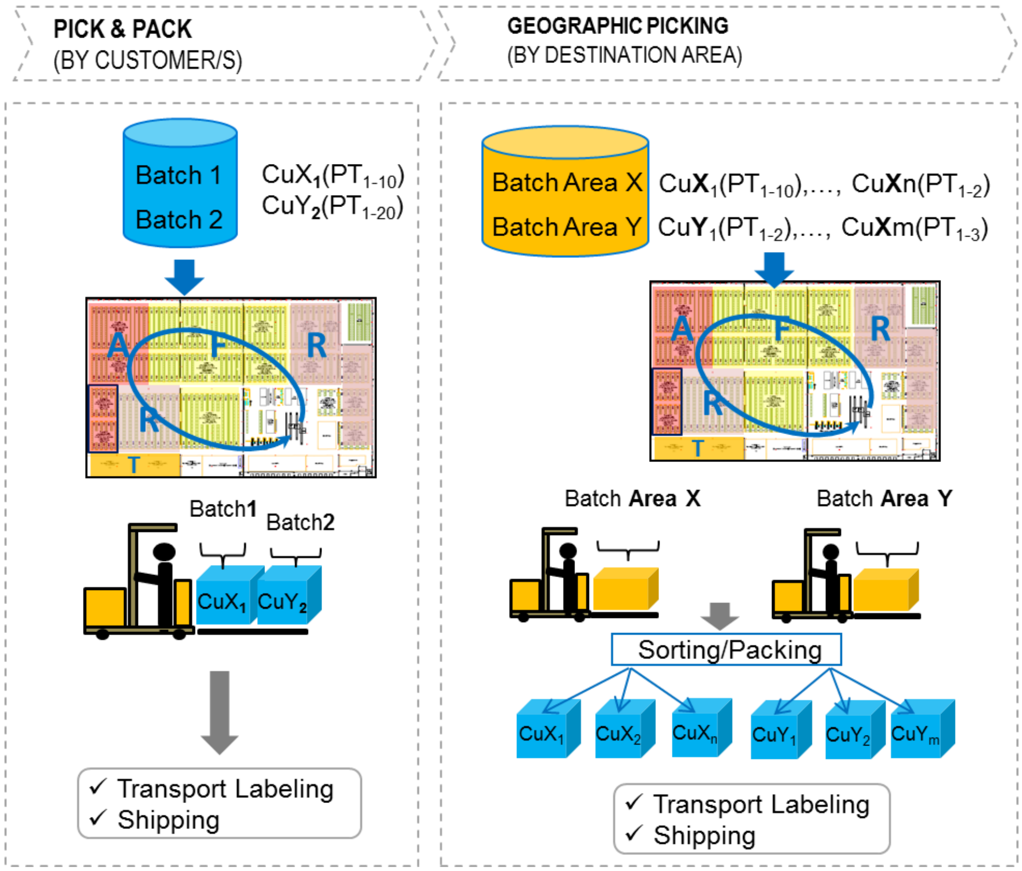

Figure 35: Pick & Pack and Geographic Picking

After, is the **transport labeling phase**, the containers are moved to the transport labeling station. The transport labeling station is equipped with the trolley which can sense the container's weight to check the item with the picking list. The transport labeling process provides the information about where and when will the container be send.

Finally, it is the **delivery phase**. The containers are moved to the preload area near the outbound dock, and it is loaded on the truck when the truck arrives. In the meantime, the I/O barcode is scanned to locate the container whenever the container is moved.

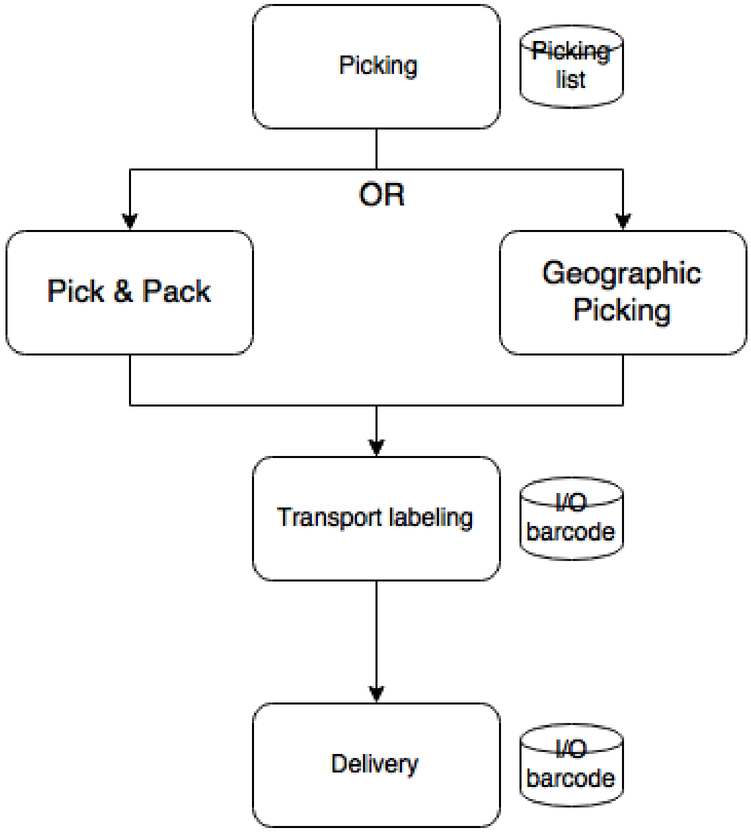

Figure 36: Outbound process in Master DC of Volvera

4.3 Motivation for Auto Identification Project

With the globalization and the new technology development, do nothing means to be left behind. To continue maintain the competitiveness, implementation of new technologies under the desired demand is needed. The obsession of quality and productivity is the key driver to survive in the automotive industry.

The Industry 4.0 is wide spread, it changes logistics in production and transforms the demands regarding logistics organizations. Higher degree of Industry 4.0 means higher efficiency and higher quality which leads to competitiveness.

With WCL as an engineering tool for increasing the competitiveness of company, new innovation to create higher efficiency and productivity is urgently needed.

A WCL procedure is used to implement the Auto Identification Project to realize Industry 4.0.

4.3.1 Wastes & Losses Reduction

Based on WCL main focus, the main motivation is the wastes and losses reduction. From the analysis of monthly report, wastes and losses can be defined as:

- Non-Value Added Activities (NVAA) of scanning UDC
- NVAA of looking for UDC
- Rework due to scanning errors
- Operational wastes and losses
- Non used shelf space

And the root causes for these wastes and losses are identified.

4.3.1.1 Non-Value Added Activities (NVAA) of scanning UDC

The wastes and losses due to NVAA of scanning UDC consists of:

- the time that forklift driver needed to get off the forklift.
- the time that forklift driver needed to scan the container.
- the time that forklift driver needed to walk to the I/O barcode tag nearby the destination and scan.
- the time that forklift driver needed to get back in the forklift.

It is evaluated in a quantitative way according to the monthly report from cost deployment department, by following 4 steps:

1) Calculate the time needed for a complete activity of scanning UDC according to the MTM-UAS (which is method to evaluate the standard time needed to complete the task).
2) Evaluate the total number of activities of scanning UDC is needed for each shelf each day, according to the data of number of UDC is handled, number of moving UDC process occurred and number of UDC can be handled by one forklift.
3) Multiply the time needed for a activity of scanning UDC and the total number of activities of scanning UDC, the total time of NVAA of scanning UDC is calculated.
4) According to the hourly rate of direct labor who drives forklift and the working days per year, the wastes and losses due to NVAA of scanning UDC is calculated in term of costs.

The root cause of the NVAA of scanning UDC is the exist of scanning activity to update the UDC position.

4.3.1.2 NVAA of looking for UDC

Another kind of waste and loss is the NVAA of looking for UDC, this can be categorized into two kinds:

1) The activity of looking for UDC within a large area. For example, when precharging area is relevantly large, WMS can only shows that the UDC is in this area but not exact position. The operator has to find it by visual check.
2) The activity of looking for UDC that has no updated information in WMS, due to the missing of scanning activity. Sometime due to lack of attention, the operator can forget to scan the UDC, especially when several UDCs are stacked and to be moved together.

The NVAA of looking for UDC is evaluated by identify the abnormal working time, which is usually much longer than the reference standard time. Sum them up and allocated the time to costs by an allocation criteria.

The root cause of NVAA of looking for UDC is the lack of UDC detailed position, and the exist of scanning activity.

4.3.1.3 Rework due to scanning errors

Another kind of waste and loss is the rework due to scanning errors. With lack of attention, the operator may scan the wrong item, and assign it to the current location area. This mistake leads to a rework.

The root cause of rework is the exist of scanning activity.

4.3.1.4 Operational wastes and losses

There are 2 kinds of wastes and losses related to operational problem:

1) Variation in put-away process. Because during the moving UDC activities, it is the operator not the WMS system chooses the UDC to move, there is variation in put-away process.

2) Not 100% FIFO (First In, First Out). Due to the same reason above, the warehouse operation is not 100% FIFO. 100% FIFO is the necessary step to the goal of zero inventory.

The root cause of operational wastes and losses is the current push system of warehouse management. The operator chooses the UDC to move and push the warehouse operation.

4.3.1.5 Non used shelf space

Another waste and loss is that there are some shelf spaces are not used. It leads to a decrease of space utilization, and is a waste of warehouse space.

For example, the second level of last row of shelf is kept empty, in order to provide a better vision for the forklift drivers at the corner.

The root cause of this waste and loss is the safety concern, which lead to another important motivation of Auto Identification Project, safety.

4.3.2 Safety

The safety concern is another important motivation for Auto Identification Project.

The most concerned accident in the warehouse for transportation is the forklift truck accidents. There are two kind of forklift truck accidents:

1) Collision between forklift to forklift
2) Collision between forklift to human

The current solution in Mopar is the Red Spot Technology. Red Spot Technology is consisted by an LED spotlight projects a red dot 5 meters way from the forklift on the ground, which provides visual warning for the pedestrians or the forklifts. It can be on the same side with the travel direction or the opposite, which is depends on if it is installed on the front of the forklift or the rear. This is a signal in advance to announce the presence of a forklift, which is useful to reduce the forklift truck accident.

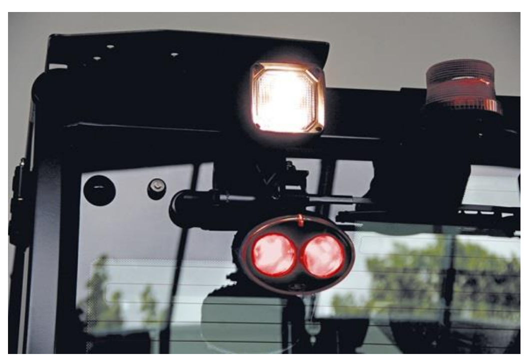

Figure 37: Red Spot LED

But this solution still has limitation, which is that if the pedestrian or other forklift driver lacks visual attention on the floor, the exist of light is useless.

The root cause of the forklift truck accidents are the lack of detection between forklifts or between forklift and human.

4.4 Auto Identification technologies

The root cause of wastes and losses and safety concern are:

- The exist of scanning activity
- Lack of UDC position
- Push system in warehouse operation
- Lack of detection between forklift and forklift/human

Based on these root cause, different technologies to implement the Auto Identification Project is presented. During the research process, suppliers are involved to integrate the new technology with the exist WMS software, in order to make sure the new project's applicability. There are two technologies are proposed:

1) **Radio-Frequency IDentification** (RFID) technology
2) **Real-Time Locating System** (RTLS) technology

4.4.1 RFID technology

Radio-Frequency IDentification (RFID) technology is the first possible solution can be thought about, as it is designed for identify the items. The application of the solution must base on the current material flow and integration with the WMS.

The hardware of a RFID solution consists in 2 parts: the RFID tag or transponder and the RFID reader.

The RFID tag or transponder consists of:

- a microchip that contains information in a memory (including a unique identification number)
- an antenna or an anchor (signal transmission circuit)
- a physical support that holds together the chip and the antenna called "substrate" and that can be in Mylar, plastic film (PET, PVC, etc.), paper or other materials.

- a battery (optional)

Depending on the application, transponders can be: circular or rectangular; rigid or flexible; coated glass, paper or plastic, small or medium-sized; resistant to water or temperature, etc ...

The RFID reader emits an electromagnetic/electric field which generates in the antenna of the tag a current that feeds the chip by the induction process. The chip been fed communicates all its information which is irradiated through the antenna towards the reader. In addition, the reader can also write data on the tag. (D'Angelo, 2015)

Figure 38: RFID Tags

The software of RFID solution consists of WMS and the logistics interface provided by the supplier. The logistics interface is a proprietary software application that allows the different field technology solutions to be easily integrated on the forklifts with a WMS from a third-party supplier.

The “moving UDC” activity can be divided into 3 phases: identify the UDC when pick-up, identify the UDC when move to the precharging area, identify the UDC when put-away.

1) Identify the UDC when pick-up: The RFID transponders can be positioned on the UDC or directly on the load. The RFID reader is installed on the base of the forklift’s mast. When the operator makes the withdraw, the transponder is activated and read, and the information is transferred via the logistic interface to the WMS.

Figure 39: RFID hardware

2) Identify the UDC when move to the precharging area: A RFID reader as gate is set through the moving pass. Another solution is possible is to use RFID transponder installed underground all around the specific area of precharging area. When the forklift enter the area, the RFID transponder underground is sensed and the activity is registered.
3) Identify the UDC when put-away: Each column of the shelf is labeled with specific RFID tags (on metal). The warehouse control module supplies the correct height of the forks. By combining these two information, the logistics interpolation calculates the location and transfers the information to the WMS that verifies that the data matches the assigned mission.

Figure 40: RFID tags on shelf and on forklift

The RFID system has several advantages:

- Important time-saving: Because the location or the UDC is automatically read from the cart during the deposit/withdraw operations and the operator's manual operations are reduced to minimum.
- High process accuracy: Because of the reduction of errors during picking (possible errors are detected automatically), the put-away phase (incorrect locations are automatically detected) and loading of goods on vehicles (any errors are detected automatically)
- Inventory in real time: Because the WMS is constantly informed about all the movements that take place in the warehouse

The RFID system presents anyway some disadvantages:

- High investment for infrastructure: The installation of the RFID tag underground to identify the precharging area needs time and money.
- High cost for tags on the container: The cost of tags is related to total number of containers in Master DC Volvera. Some of them are recyclable, some of them like carton boxes on pallets are not reusable.
- Possible interferences while using RFID with metal container: RFID system is disturbed by metal containers managed in warehouse.
- Low flexibility and difficult for modification: The labeled precharging area is not easy to modify.

4.4.2 RTLS technology

Real-Time Locating Systems (RTLS) is an accurate positioning system that enable the user to trace and track the item which can be all kinds of objects such as tools, assets, containers, equipment, as well as provide in real time these positioning information by means of constant communication between the system and the object being tracked. In other words, an RTLS system provides the company with real time information on precisely where something is and/or has been.

The current used method in the PDC Volvera is called the asset tracking. It can tell that an UDC is in a certain area, but not the exact location. The difference between asset tracking system and RTLS is that RTLS can tell the exact location of an item and not only the area where you can find it.

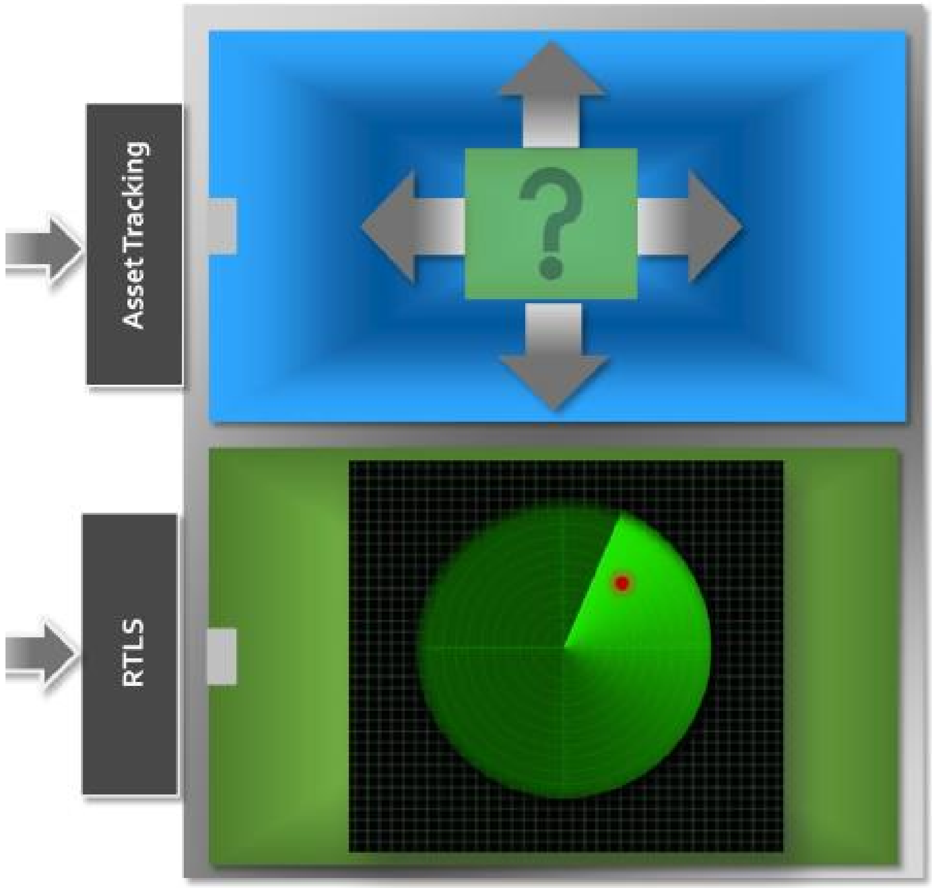

Figure 41: Asset tracking vs RTLS

The hardware for a RTLS system is consisted with the infrastructure and the transmitter installed or fixed on the object. The transmitter affixed to the object can be a location aware device and upload its location to the infrastructure such as GPS devices. As well as the RFID technology, the tag or the location aware device is identified by unique identification number or name, and contains additional data about the object such as location information, object's owner. The data are transmitted to connected system to present a visual information such as on the map or GUI (Graphical User Interface). Those data can be also integrated with the exist management system like WMS in warehouse management, to provide a better data base for planning and scheduling decision.

There are different type of location technologies and communication technologies between transmitter and infrastructure for RTLS system. According to (Michael Liard) primary communication technologies used in RTLS solutions include, but are not limited to:

- Active RFID location tracking solution: determines location via communication with a battery supported radio frequency-based transponder capable of transmitting and/or receiving information independent of the reader (e.g. ISO 24730, UWB)
- Passive RFID-based location tracking solution (i.e. EPC UHF): determines location by receiving power from and array of RF power transmitters that energize passive RFID tags, (e.g. EPC Gen2, ISO 18000-6) within an area of coverage and allow locating by using sectored antennas to determine Angle of Arrival (AoA).
- GPS (Global Positon System) location tracking solution: determines location via communication of a GPS device and GPS satellites.
- Assisted-GPS (A-GPS) location tracking solution: determines location via reading from both GPS satellites and cellular base stations/towers and is supported by a location server. Typically more accurate that GPS only system.
- Wi-Fi-based location tracking solution: determines location via correlation from interactions with mapped Wi-Fi access points and GPS.
- Out-of-Band (OoB) proprietary RF/sensor-based location tracking solution: determines location leveraging proprietary solutions and technologies such as ultra-wide band (UWB/IEEE 802.15.4f), infrared and ultrasound.

The choice of technologies is a comprehensive consideration about the environment, user's demand, installation possibility and other aspects. The GPS which works perfectly in the outside environment is not suitable for the application inside the building. Usually, the technologies exists is also an important concern, in order to minimize the investment and the effort of innovation.

4.4.3 Compare RFID based project to RTLS based project

4.4.3.1 Motivation realization analysis

Consider the realization of the motivations that discussed in the previous chapter, the comparison between RFID based Auto Identification project and RTLS based Auto Identification project is shown in following chart:

Table 3: Compare between RFID and RTLS

	RFID	RTLS
NVAA of scanning UDC reduction	√	√
NVAA of looking for UDC reduction	√	√
Rework due to errors reduction	√	√
Operational losses improvement		Possible in future
Non used shelf space utilization		Possible improvement in human restricted area
Collision between forklift and forklift reduction		√
Collision between forklift and human reduction		

The RTLS based Auto Identification project can fulfill more motivations of the project, and it shows more potential of improvement in future.

In additional, from technical point of view, the RFID technology is disturbed by metal items managed in warehouse.

4.4.3.2 Cost analysis

From economy point of view, the cost of RFID based Auto Identification project and RTLS based Auto Identification project is compared by ratio. It is shown in following chart:

Table 4: Cost variation between RFID and RTLS

Cost Variation	RTLS/RFID
Start-up project and feasibility study	1.8
Middleware + License SW	1.74
Modify Infrastructure	0.23
Tag / Anchors	0.13
Hardware + lane	0.15
Forklifts	0.48
Interface with Click	1
Running	0
TOT	0.29

The cost of implementation of RTLS based Auto Identification project is around 30% of the cost of RFID.

In conclusion, the RTLS technology is chosen for the Auto Identification project.

4.5 Auto Identification project using RTLS technology

To maximized the possibility of implementation, the project is developed with the current forklift suppliers and several potential suppliers.

The RTLS solution that the current supplier provides is a hardware and software system that allows real-time tracking of the location of objects in a defined space with the aim of increasing the productivity and safety of an environment.

The warehouse area covered by the project is covered by an Ultra-Wide Band (UWB) network infrastructure capable of detecting the precise position of the handling movements.

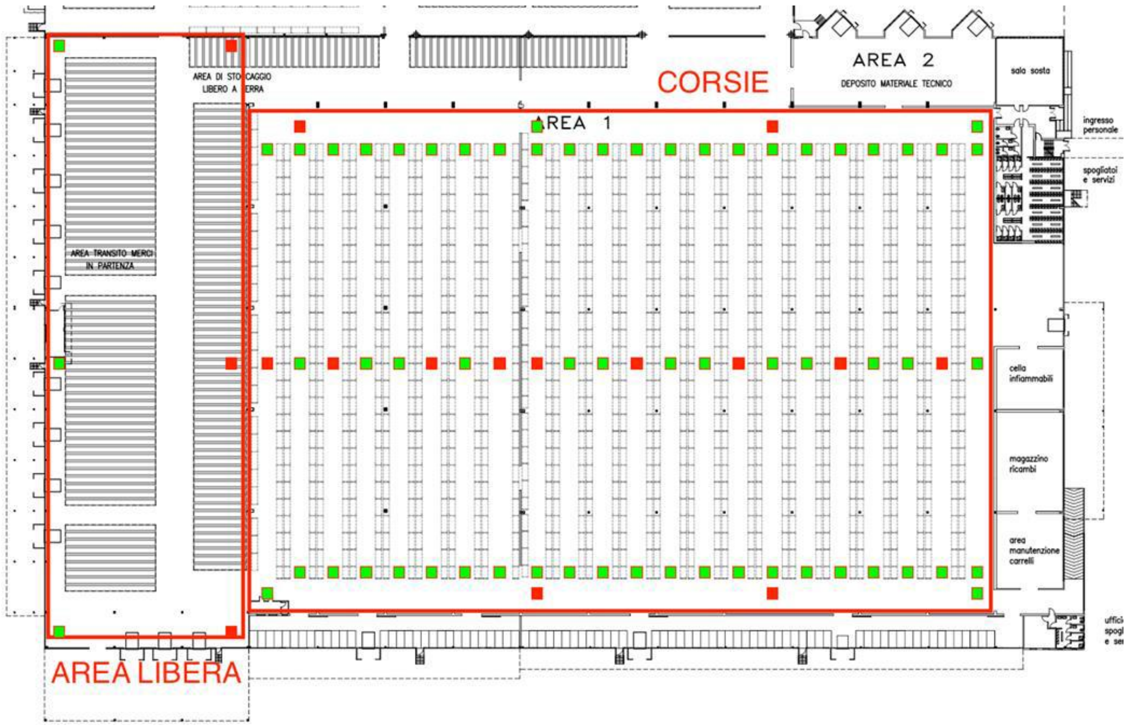

Figure 42: Warehouse overview

The technology used is the Ultra-Wide Band (UWB, IEEE 802.15.4a), characterized by a low power radio transmission that, thanks to the very high frequencies used (from 3 to 10 Ghz), is very robust to noise and interference with the other radio systems of the warehouse (i.e. WiFi, RFID).

The calculation of the position is triangulation, similar to the common GPS systems, using instead of the satellites but the radio devices installed on the ceiling, called "anchors".

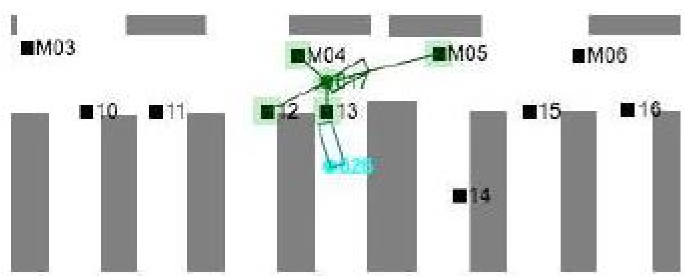

Figure 43: RTLS system display

The anchors of the localization system are placed at a distance of 20 to 40 meters from each other. An advanced roaming algorithm selects at all times the most "convenient" anchors, taking into account the obstacles and the geometry of the warehouse. In this way it is possible to trace not only forklifts that are in the free area, but also forklifts that are in the lane.

Every four anchors, one master and three slaver anchors, provides the XYZ coordinates of a transmitter. (max 4 transmitters that can be located correctly within the area of four anchors at the same time).

The forklift is equipped with following components of system to realize the location and safety function:

1) UWB network transmitter
2) visual / acoustic alert
3) D-GPS (optional)
4) sensors (load presence and fork height)

Figure 44: RTLS hardware on forklift

There is a centralized software system through a central server allows monitoring the actual positions of UDCs in real time with the following function:

- data acquisition
- data processing
- communication with the field elements and with the Host system (WMS)

The centralized software system is equipped with intelligent algorithm, which has the main function of knowing the movement of UDCs and record them on WMS, by allocating the position of UDC with the encrypted position of forklift. Not only the current position but also the trajectories, the velocities and the direction of the movement are tracked. Whenever the signal is missing, the transmitter on the forklift record the data, in the meantime the system simulates the path according to the history data, and refresh the data when the signal is back online.

The first positon of UDC is red with special device equipped with UWB network transmitter, that assign the right location (XYZ coordinates). When the forklift move the UDC, the WMS system update coordinates through a fork sensor and the forklift transmitter.

With another supplier Linde, an option to optimize the paths of the handling vehicles become possible. The Forklift NAV system is presented. Forklift NAV introduces the concept of "Assisted Driving" for forklifts in modern warehouse logistics, allows the automatic tracking in real time of pallets and forklifts, in internal and external areas, in immediate adjacencies of the shed, as seen during the inspection.

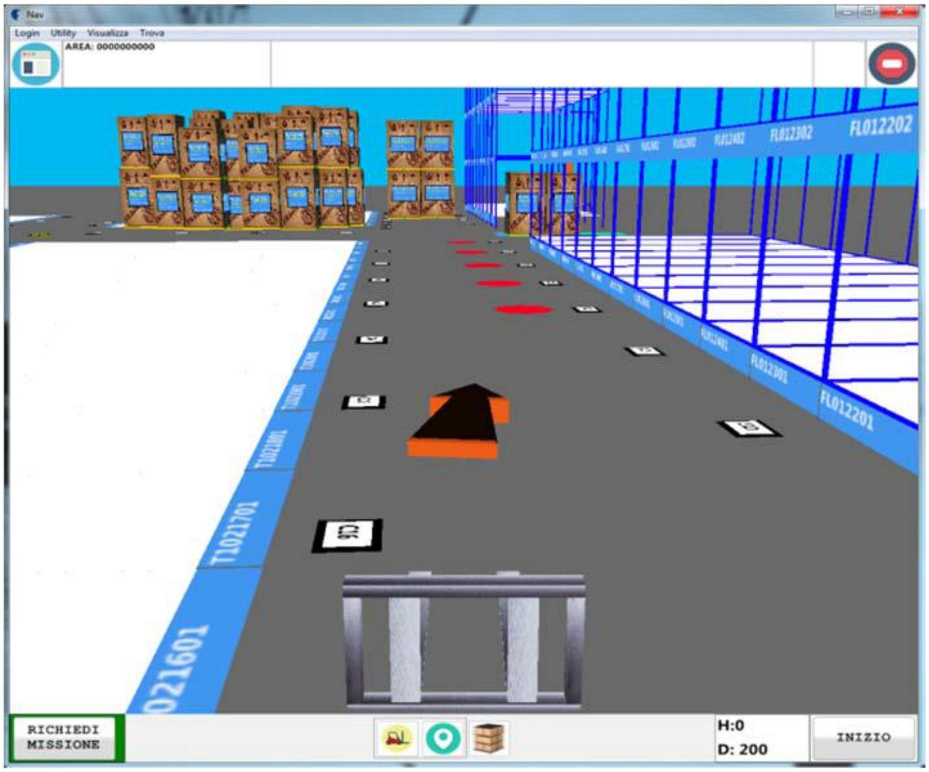

Figure 45: Forklift NAV example

- Navigation in warehouse: Forklift, through the 3D graphic interface, shows the operator on the forklift the path to follow, the names of the holds, the composition of the piles of pallets around the forklift, the codes of identification of pallets. Through simple commands on the touch screen monitor the operator can change the display of the pallets and the surrounding reality, with zoom and virtual camera rotation. The always active 3D graphic representation allows the operator to constantly check of the correspondence between graphics and reality, this prevents mistakes and is valuable in debugging in the field.
- Warning in the event of an error: If the forklift driver puts on a pallet or if he enters a hold other than those indicated by the mission in course, the system sends a warning message on the monitor.
- Automatic mission distribution: Forklift can, through a configuration parameter, report to WMS which forklift it must a mission is sent according to the position. The distribution of the mission can be done by WMS or Forklift.
- Mission manager: Forklift NAV, through the Mission Manager module, allows the operator to ask what the next mission, Forklift Mission manager will analyze the list of

missions to be carried out and will send the optimal mission according to the priorities, positions and characteristics of the forklifts.

- Traffic viewer: It is the supervision of warehouse, which reproduces all warehouses and areas mapped on the system, and shows all moving carts, stored pallets and ongoing missions.

These technology gave the possibility to transfer from push inter-logistics system to pull inter-logistics system, yet needs a grand jump of technology.

4.5.1 Sample Project of Inbound process with RTLS technology

Mopar uses their Logistics Training Area to simulate the RTLS performance during the inbound process with a sample project.

The sample area is covered with seven anchors to locate the UDC. 3 rows of traditional rack is built as a small version of warehouse shelfs. In the figure 47, the area marked with P presents the parking area such as: unloading area and precharging area of the UDC. And area marked with S presents the safety area that used for safety tests.

Figure 46: Logistics Training Area for Auto Identification project

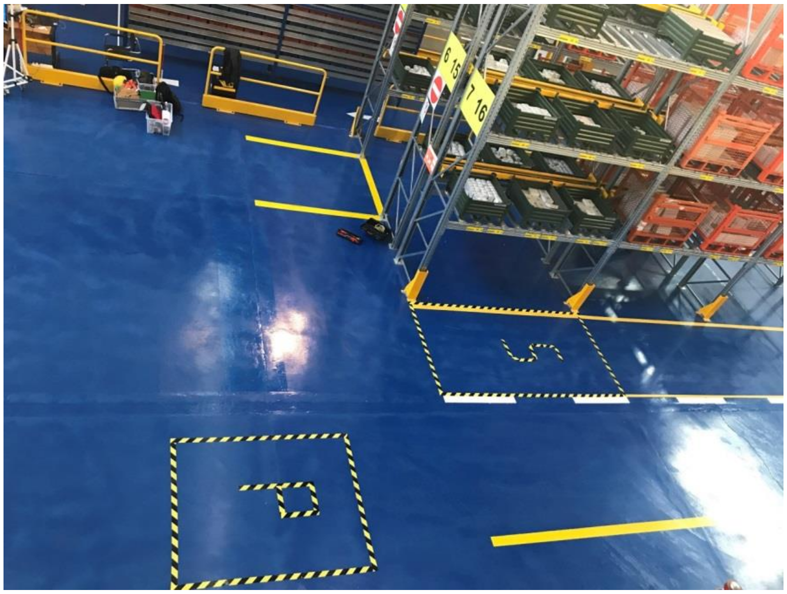

Figure 47: Logistics Training Area for Auto Identification project

Two main function is tested:

- Tracking UDC
- Safety assist (Alert Collision)

4.5.1.1 Tracking UDC

A forklift equipped with UWB transmitter and acoustic alert is used for testing. Due to the lack of sensors on the forklift, the height of fork is unknown and the loading and unloading of UDC is not automatically registered in the system. Hence, the tracking of Z coordinate of UDC is not tested in this sample project and the loading and unloading of UDC is registered by manually click a button in the operation program of the system. During the sample project, only the XY coordinate of UDC is located. The test UDC is the orange metal container in the figure 47. The test of tracking UDC is separated in 2 phases:

1) Verify the loading process: The UDC is positioned on the P area and a XY coordination is manually generated in the system. As soon as the forklift with the transmitter enter the sample area, the forklift is presented as a rectangular at real time on the screen. Once the forklift arrives near the position of the UDC, the system should identify the UDC. After the identification, the UDC is registered as loaded on the forklift by manually operation. The forklift with a UDC loaded is represented as a

colored rectangular. So, the position of UDC is tracked through the transmitter equipped on the forklift and recorded in WMS.

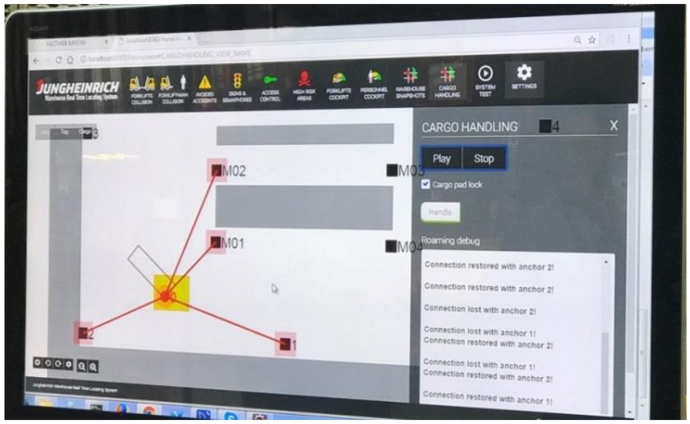

Figure 48: Forklift on display

2) Verify the unloading process: P area is defined in the system and on the screen. Once the forklift with a UDC loaded arrives near the P area, the system identify the presence of UDC near the area. The UDC is registered as unloaded by manually operation, and recorded in WMS.

Because the transmitter is installed in front of the forklift, when forklift moves backward the representation of forklift in the system changes its position in opposite direction. Sometime, it causes the failure of the identification of UDC or P area. But this is a setting problem, it can be fixed during the implementation.

The test of tracking UDC is verified.

4.5.1.2 Safety assist (Alert Collision)

The safety assist (Alert Collision) is categorized by two kinds:

- Forklift to forklift: One forklift parked in left of the rack and another one is driving in the aisle nearby from right to left. When the moving forklift approach the end of the rack, the system detects the possible collision between two forklift by the driving direction. The acoustic alert on the forklift makes continuous sounds until the safety distance is reached or the direction of the forklift is changed.
- Forklift in the safety area: When the forklift drives into the predetermined safety area, the acoustic alert on the forklift makes continuous sounds.

Both of them are realized by defining the safety region around the forklift transmitter and compare the current coordination of forklift with the target area. If the target area is overlapped with the safety region the alert on the forklift will be activated by means of visual or acoustic.

4.5.2 Benefit from Auto Identification project using RTLS technology

4.5.2.1 Wastes and Losses Reduction

The first benefit of the project is the wastes and losses reduction. The Auto Identification project using RTLS technology can eliminate or reduce some of above mentioned wastes and losses:

- NVAA of scanning UDC: The scanning activity during the "moving UDC" activity is canceled, so the NVAA is eliminated.
- NVAA of looking for UDC: The Auto Identification project provide a real time positioning of UDC, this kind of NVAA is reduced.
- Rework due to scanning errors: The scanning activity during the "moving UDC" activity is canceled, but the possible unreliability of Auto Identification project exists. So the rework is reduced but not eliminated.
- Non used shelf space: The empty shelf space for safety concern can be eliminated, in the area where human is restricted to go inside during the work shift, because of the Alert Collision function in Auto Identification project.

4.5.2.2 Organization Optimizing

Another key function can be used for improving the productivity is route tracking. Real-time tracking of the routes made by the forklift with the aim of optimizing the organization and the warehouse flows by:

- travel statistics (table)
- "spaghetti chart" (map)
- traffic analysis (graph and map)

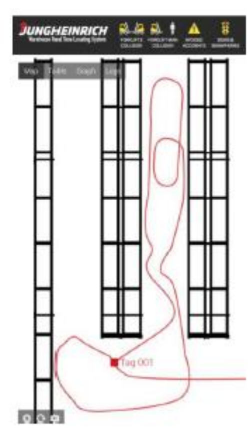

Figure 49: Spaghetti chart

4.5.2.3 Safety

The RTLS technology gives new solution to the safety issue. To identify the control zone which is mentioned in the sample project as safety area, and the collision warning system.

The control zone is used to identify areas of high collision or to discriminate areas based on the speed allowed (standard speed vs. reduced speed, see areas in light gray in the image on the right). In the control zone, all the safety assist are available, due to the real time data from RTLS

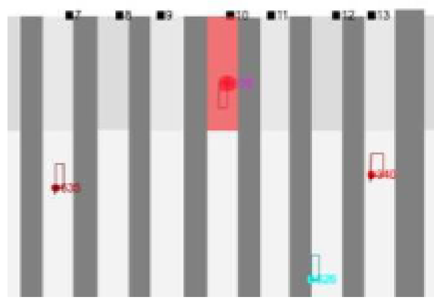

Figure 50: Control zone

system, the safety assist can realize its high accuracy and configurability of the system.

The safety assist activated additional by the Auto Identification project using RTLS technology are the following:

- Forced slowdown (with speed ramp and minimum speed settable up to 2 km/h)
- Acoustic alert (continuous or pulse with configurable duration)
- Steering vibration (continuous or pulsed with configurable duration)

As for the collision warning system, thanks to the tracking of the forklift in real time that provides the actual position of the vehicle in space, it can be managed multiple situations of possible tickling in an extremely timely manner.

The anti-collision algorithms calculate and foresee the trajectories of the vehicles, generating and activating the warnings only when strictly necessary, preserving productivity.

Beside the safety assist, one additional function can be realized by the same algorithms is

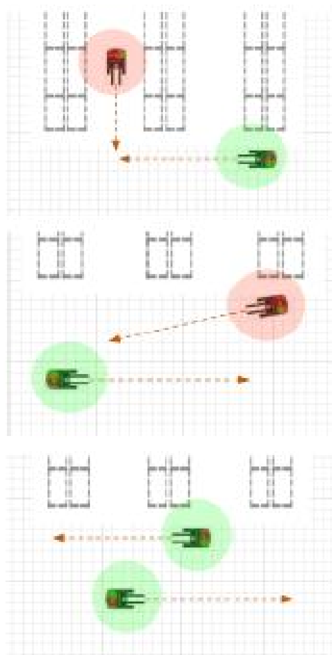

Figure 51: Collision warning system

access control which is not used in this case. Rely on the real time information of the forklift position the opening and closing of the gate is controllable, and the automatic management of pedestrian traffic lights is possible.

4.6 Economic analysis of Auto Identification project using RTLS technology

To analyze the economics of Auto Identification project using RTLS technology, two indicators are evaluated by Mopar, B/C (Benefit and Cost) ratio and Payback period.

The cost of the project consists of following components:

- Feasibility study and a start-up project: After the research and planning process, it is needed to verify the feasibility from both technical point of view and the degree of implementation.

- Middleware and license of software: This cost is majorly depends on the software supplier and the current system supplier.
- Modification of Infrastructure: It is the cost to modify the current infrastructure.
- Transmitter/Anchors.
- Hardware and lane.
- Forklifts.
- Interference with WMS.

The benefit of the project consists of following components:

- The eliminated cost of NVAA of scanning UDC.
- The reduced cost of NVAA of looking for UDC.
- The reduced cost of rework.
- The benefit from location recovery.

The B/C (Benefit and Cost) ratio is calculated through dividing benefits by costs. The B/C ratio under 1 is not acceptable. For this project, it is equal to 2.5.

The payback period indicates the time needed to close the gap between the project investments and the project savings. It is calculated through dividing initial investment by cash inflow per year. It is equal to 1.4 years.

Table 5: Economics indicator of Auto Identification project using RTLS technology

	RTLS
B/C	2,5
PayBack period	1,4 years

4.7 RTLS in future: Industry 4.0

The objective of the project is to provide a new solution to reduce the wastes and losses, it also contains a bigger ambition to implements the new technology into the current warehouse management system and to be the market leader in the field to reach Industry 4.0.

In the future, the management system logic could be used to evolve from a push system where the operator decide which UDC to be moved to a pull system where the WMS tell the operator which UDC to be moved.

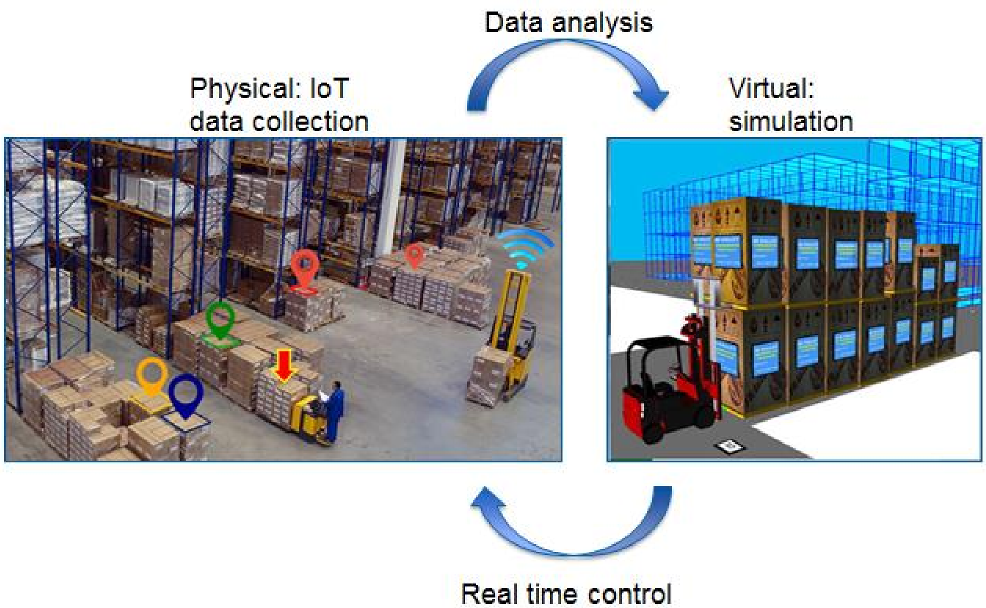

Figure 52 : RTLS in future

To realize the pull system, a solid infrastructure and reliable software are essential. A **cyber-physical system** is built between the forklift, the UDC and the WMS which is realized by the RTLS system. Moreover, to establish an **Internet of Things** all the forklifts are connected through the RTLS system, by its positioning on the visual map. The transmitter equipped on the forklift should possess the function to sensor the "health status" of the forklift including the operator information, the working hour etc. The RTLS may generate large amount of data, which are the forklift history route, the forklift current location, the overall warehouse traffic and etc. Along with the WMS information about shelf utilization and UDC movement, all the data is valuable. The **big data analysis** includes operating activities, productivity index for forklift and area, times for the execution of missions, error indices, storage density, traffic density by area, organization of stored materials etc. These data can be considered by the **simulation** system, so that the trend of future activities can be forecasted. The WMS is able to identify which UDC and where is the best position in advance, and give these information to operators.

Industry 4.0 of warehouse management is reached by an integration of the new technologies with existed ones.

5 Conclusion

With the rapid spreading of e-commerce, the logistics industry has changed from the base. The market leader company: Amazon is always the pioneer in developing the potential of new technologies. Since the takeover of Kiva, Amazon has shown their ambition to be the first one to reach Logistics 4.0. Following that, Amazon has built their own data base, the infrastructure for cloud computing, using them for internal applications and providing them as service to sell.

As well as the level of Industry 4.0 has achieved in the warehouse management, the Logistic Industry 4.0 is in intermediate status to the fully innovation.

Separated technologies are implemented and developed by logistics supplier. The innovation is focused on either the connection of physical world or on the collection and analysis of internet data, while the cyber-physical system and other technology as a whole innovation is neglected.

Consider other companies, most of other companies are at the stage of early maturity, that either the use of innovation is limited to several technology, or the implementation of the Industry 4.0 is restricted to single plant or single warehouse but not among the whole supply chain.

Logistics is evolving with the industrial market, manufacturer not following the step of the innovation will be left behind the new industrial market, as well as the logistics part. On the other hand, company only pays attention on increasing the productivity of the manufacturing process, but not also on the logistics aspect will find out helpless in the late part of innovation.

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