SUPPLIER ASSESSMENT OF AIRBUS: READINESS AND WILLINGNESS OF INDUSTRY 4.0

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Pasinee Phuangaprayong

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ABSTRACT

At present, all sectors are learning about Industry 4.0. The Federal Government of Germany has announced to be a driving force for Germany's production. The announcement that the 4th Industrial Revolution has begun. Moving forward to Industry 4.0, it is necessary to study to understand how to develop the concept. As Airbus would like their suppliers to apply industry 4.0 on the workflow in order to improve its performance. So, supplier assessment regarding the readiness and willingness of industry 4.0 is required by starting in the Supplier Development Department of Airbus. The objectives of study are to explore the existing supplier assessment tools available in the market based on the new era of industry 4.0, to assess suppliers at all tiers for Airbus by using the industry 4.0 framework, and to provide recommendations to Airbus suppliers based on their readiness and willingness of industry 4.0. There are many assessment tools available in the market. Those tools were helping the team to develop a brand new tools that suitable for Airbus. Assessing the suppliers by the readiness and willingness of industry 4.0 at all tier will help Airbus to prepare the system and move on to the implementation stage.

KEY WORDS: Industry 4.0/ Supplier Assessment / Readiness and Willingness of Industry 4.0

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CHAPTER I
INTRODUCTION

1.1 Background

The world manufacturing follows by new emerging technological innovations to reinforce sustainable and resilient growth of the world economy (World manufacturing forum, 2019). Many countries around the world are aware that the fourth industrial revolution has an essential role in improving communication and monitoring, along with self-diagnosis and new levels of analysis to provide a truly productive future (Moore, 2018). Many companies in Asian countries also take Industry 4.0 into account by slightly implement it. Samsung, the World leading mobile and electronic appliances company, is one of the Korean firms that adapt the smart factory concept using mobile devices as the platforms through plant management which allow workers to access cloud technologies with ease (Gibson, 2018).

Moreover, many large companies in European countries are leading the world's economy. The ideas of using the Internet of Things, automation and digitalization, called Industry 4.0, are widely spread throughout European countries. The Federal Government of Germany originated the concept Industry 4.0 or the fourth industrial revolution and started to apply Industry 4.0 to many large corporations in different industries, namely, Continental, Sanofi, BMW, Siemens and many more. (Moore, 2018). Using ultimately automation and advances in manufacturing technologies providing significant benefits to the corporation. Many companies are using Industry 4.0 to improve their business performance and reduce the amount of the workforce, for example, using robotics and Artificial Intelligence (AI) in the production line. Airbus, as one of the leaders in the aerospace and aircraft manufacturing industry, would like to apply and test Industry 4.0 on one of their departments, Supplier Development Department. This study will focus on how to use Industry 4.0 to effectively assess the suppliers on every tier by using the solutions and tools from Industry 4.0 already provided in the market.

There are some of the most notable aviation trends that may impact the aviation industry in 2019. The technological developments by using artificial intelligence will impact the growth of the industry. More airlines are continuing to focus on providing AI services to their customers (Grant, 2018). The aviation industry is considered as the growth sector. The performance of European aviation had exceed the growth predictions in 2018, and the trend appears likely to continue. Many airlines expand the aircraft orders (Silva, 2019).

Airbus Group is an aircraft manufacturer and assembly plant headquartered in Toulouse France. The company was established in 1970 from a joint venture from several private aviation companies in Europe hoping to be a competitor to the company which is a US aircraft manufacturing company like Boeing McDonnell Douglas. Airbus Group has three main sections; Airbus Commercial Aircraft, Airbus Helicopters, and Airbus Defence and Space. Many aircraft parts and components are produced from more than 16 sub-production bases in France, Germany, Spain, China, the United Kingdom, and the United States. The latest commercial aircraft model was A350 XWB Family of modern wide body family and the long-range of transportation as shown on figure 1.1. Airbus Supply is a single supply chain solution for direct procurement shared by the leading European aerospace companies within the BoostAeroSpace hub ("Be an Airbus supplier", 2019).

Figure 1.1 The commercial aircraft model A350-1000 from Airbus
Source: Airbus (2016)

Supplier Development department of Airbus is a department that developing the workflow between Airbus and its suppliers. The department was eager to learn and use Industry 4.0, since many industries in European countries had been active on the Industry 4.0. Airbus also has the vision to assess every tier of their suppliers effectively with the tools from the new era of digitalization in the Supplier Development Department. Airbus's suppliers are including both large and small corporations. The company of suppliers is mainly located on the European continent.

1.2 Problem Statement

For many decades, Airbus orders are customized, and creates many difficulties for ordering supply from the suppliers. Each time the number of order is varied, and generates complexity in term of the inventory, stock, and coordination to both Airbus's officer and suppliers. The reason why Airbus would like to study Industry 4.0 was because Airbus believe that Industry 4.0 would help the corporation to work smoother and more

effectively with their suppliers at all tiers by time-saving and cost-saving in the long term. Moreover Airbus noticed that many large corporations including the companies from aviation industry are applying Industry 4.0 to one or more of their departments and resulting in better performance. To implement a new way of working by using the Industry 4.0 framework, Airbus needs its suppliers to participate and invest in Industry 4.0 in order help the workflow between suppliers and Airbus smoother and more effective. Investing in a new way of working using Industry 4.0 as the tool to help smoothing the process may cost money and some of their suppliers may unwilling to participate especially small companies who believe that their way of working is already efficient. Suppliers who do not want to change the way of working toward Industry 4.0 may create a delay of supply delivery and unsmooth operations when Airbus using Industry 4.0 as a tool, but some of the suppliers are not.

1.3 Research Objectives

In this study, there were three objectives in order to understand the readiness and the willingness of airbus's suppliers. The objectives were followed.

1. To explore the existing supplier assessment tools available in the market based on the new era of Industry 4.0.
2. To assess suppliers at all tiers for Airbus by using the Industry 4.0 frameworks.
3. To provide recommendations to Airbus about suppliers based on their readiness and willingness of Industry 4.0.

1.4 Research Scope

This consulting internship project is a project of Toulouse School of Management cooperating with Airbus as a part of Master of International Management. The study took place in Toulouse, France which is the location of Airbus Headquarters. The supplier assessment with Industry 4.0 will be used in the Supplier Development Department to assess the suppliers for Airbus at all tier.

CHAPTER II
LITERATURE REVIEW

This chapter included two sections as followed.

1. Industry 4.0
- Autonomous Robots
- Simulation
- System Integration
- Internet of Things
- Cybersecurity
- Cloud Computing
- Additive manufacturing
- Augmented Reality (AR)
- Big data

2. Supplier Assessment

2.1 Industry 4.0

The Industry 4.0 or the fourth industrial revolution originates from a project in the high-tech strategy of the German government, which promotes the computerization of manufacturing. The concept of Industry 4.0 aims to enable German industry to be prepared for the future of production.(“Industrie 4.0 - BMBF”, 2016) The characteristics given by the German Government is a strong individualization of the products under the conditions of a highly flexible (high volume) production.

The original production system had done within the family, and the merchants were often capitalized by buying raw materials and distribute to each family produce goods. Then the merchants will receive the finished goods and sell it which the workers get paid in return. The original production of products was using human labor, animal labor, natural energy, and simple tools. Human started to use the machines to produce

general products to more complexity with higher production capacity until it created in the production by using the factory system. Then the production within the family was gradual decreases.

Going back to the beginning of the first industrial revolution in the late 18th century, the steam engine was more efficient and later used to build trains, reduce the distance of transportation (Hulse, 1999). It led to the creation of a machine called "the time of steam power." From that point, it was called "the 1st industrial revolution". James Watt did not invent a steam engine, but what he did was create several innovations that help increase the efficiency of textile production at least three times as ever. It can be said that he is the beginning of the arrival of a manufacturing plant that uses machinery to assist in the production of modern plants.

The second industrial revolution took place in the early 20th century, the production transforming from using steam machines to use electric power, resulting in the release of production power that had never happened before. Techniques for using the production belt have been published to other industries and resulting in increased production efficiency and lower production costs. This period is called the era of producing products like mass production has already happened.

Later, the 3rd industrial revolution was the result of the early era of computers that helped in the industrial job since 1970 resulting in the automated production lines, which added to the original production system with only a set of mechanisms. The use of automated machines or robots was using to produce the products instead of human labor and increase production efficiency to another level. Until today, almost every factory has to have an automated production system to help with production as well as the factory that uses advanced automation to produce very complex products. The purpose is to make the product at a low price that consumers can afford.

For the fourth industrial revolutions is bringing digital and internet technology to use in the production process. One of the essential advantages is that it can connect the needs of each consumer directly to the production process. Said, the 3.0 era factory can produce a lot of the same products in the blink of an eye. However, the 4.0 era factory will be able to produce a variety of different forms (according to the specific needs of each consumer) is a lot in a blink of an eye by using economic and efficient production processes with fully integrated digital technology like "Smart Factory." This

Industry 4.0 concept will be the integration of the production world with the network connection in the form of “The Internet of Things (IoT)” which is to make the production process connect with digital technology or even make the product itself connected with digital technology. The example of a technology using Industry 4.0 is followed. First, the company has an input system for the machine to produce items according to the order online from the consumer directly and then inserting the data transmitters in the electrical appliances to compile statistics for use and report (automatically) return to the factory when technical problems occur. Using tiny computers to consumer (The size of a medicine tablet) allows consumers to swallow into the body's health data. It can be seen that Industry 4.0 is still a very new concept. Many things are in the trial and development phase. However, it is a concept that has the potential to change every Industry from the general consumer product guidelines as well as medical treatment guidelines. Because Industry 4.0 technology is not a new thing. The attractive point is the combination of effective existing technology and the responsiveness to the needs of the market. For future development, there are nine elements as seen in figure 2.1 (S.W, 2016).

Figure 2.1 Nine elements of Industry 4.0

Source: https://buyukdonusum.com

2.1.1 Autonomous Robots

Autonomous robots are intelligent machines capable of operating tasks by themselves without human control. Autonomy refers to systems capable of operating in the real-world environment without any form of external control for extended periods (Müller, 2012). They are capable of adapting to environmental change but within limits. At present, the robot can sense, think, and act but most robots are not fully autonomous. Thus, a robot must have sensors, processing ability that emulates some aspects of cognition, and actuators (Bekey, 2005).

2.1.2 Simulation

Simulation typically uses statistical and computer modeling to stimulate the performance of a business process either for a new situation or to improve an existing set of processes (Barnett, 2003). By modeling different process scenarios and outcomes, companies have to face traditional risks associated with change management initiatives without having to make changes in a 'live' business environment where performance could adversely be affected (Harrington & Tumay, 2000). For an example of this technology is 3D printing.

2.1.3 System Integration

In broad terms, system integration is the process of connecting different sub-systems (components) into a single more extensive system that functions as one with regards to software solutions, system integration defined as the process of linking together various IT systems, services and software to enable all of them to work functionally together. Using system integration will improve the productivity and quality of the operations for that company (Lehtonen, 2018).

2.1.4 Internet Of Things

The Internet of Things, or “IoT” for short, is consist of various devices and things have linked to everything on the internet (Ranger, 2018). Enabling humans to control the use of various devices via internet network such as opening-closing electrical appliances (Ordering to turn on the power in the home by connecting the control devices such as

mobile phones via the internet) cars, mobile phones, communication devices, agricultural tools, houses, daily appliances through the internet network. (McClelland, 2019).

2.1.5 Cybersecurity

Cybersecurity is the practice of protecting systems, networks, and programs from digital attacks (Rouse, 2018). At present, the internet is considered an essential infrastructure that facilitates the daily lives of people in general. Private business operations as well as the work of the government making much information flowing online both general information, confidential information relating to national security. If this information leaked into the hands of a group of the adversary, it might cause damage that cannot be assessed (Lord, 2019). For example, the railroad or subway in many countries has prioritized the cybersecurity in order to prevent the cyber attack that could create a problem in the future (Melendez, 2019).

2.1.6 Cloud Computing

Cloud computing is the delivery of on-demand computing services (Ranger, 2018). It is services that cover the use of processing power storage unit and various online systems from service providers. Cloud computing is reducing the hassle of installing, maintaining the system, saving time and reduce the cost of building computer systems and networks themselves (Walker, 2018). Cloud computing is adaptable, secure, reliable, and scalable. Many businesses are using cloud computing with affordable prices that could match the apps they are needed .

2.1.7 Additive Manufacturing

Additive Manufacturing (AM) is a name to describe the technologies that build 3D objects by adding layer-upon-layer of material, and the material could be plastic, metal, concrete and many more (“What is Additive Manufacturing (AM)?”, n.d.). It uses a computer with 3D modeling software (Computer Aided Design or CAD), to help and sketch the object. Once a CAD sketch produced, the equipment will read in data from the CAD file and adds layers of liquid, powder, sheet material or other, in a layer-upon-layer to create a 3D object (“AM Basics | Additive Manufacturing (AM),” n.d.).

2.1.8 Augmented Reality (AR)

Augmented Reality is the technology that combines the real world with the virtual world through devices such as 3D TVs, game consoles. It creates a view of the physical, real-world environment with superimposed computer-generated images, thus changing the perception of reality by adding sounds, videos, and graphics to it ("The Difference Between Virtual Reality, Augmented Reality And Mixed Reality", 2018).

2.1.9 Big data

Big Data is enormous data so that standard software or hardware cannot be managed or analyzed effectively (Rouse, 2018). It is capturing data from many databases in the world as anyone can retrieve the data that they want with ease. It gives the users to take advantage across a wide range of areas, including business (Zikopoulos & Eaton, 2011).

2.2 Supplier Assessment

Supplier Assessment is the process of assessing potential and existing suppliers. The process can measure the performance, service levels, delivery times, problem-solving in case of an emergency and many more aspects. The ultimate result of this step is to give supplier recommendations. So the buyer must first identify current and potential suppliers, determine any information technology requirements and identify opportunities to leverage the commodity expenditures with similar commodities (Baily, 2008). The study will focus on the readiness to implement Industry 4.0 to supplier companies. One of the keys to apply Industry 4.0 more effectively is information sharing, and many companies are unwilling to share sensitive information (Kannan & Choon Tan, 2003). Many assessment tools measure the readiness level by using many aspects and factors before implementing Industry 4.0.

2.2.1 University of Warwick: An Industry 4 Readiness Assessment Tool

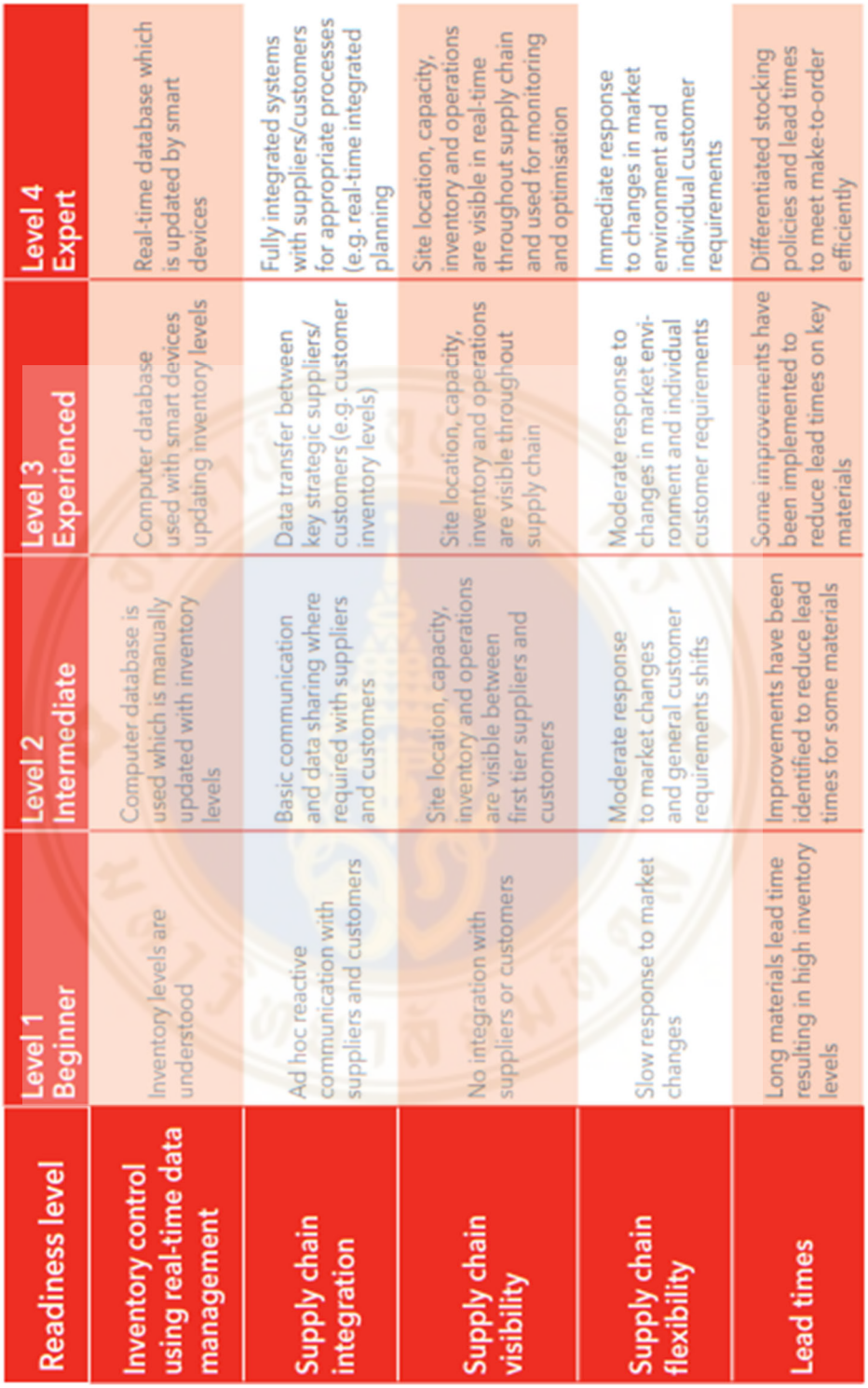
The University of Warwick together with Crimson & Co and Pinsent Masons, a consultancy and law firm, created the readiness assessment tools. The tool has been designed to enable the companies or suppliers to perform a self-assessment in terms of

the readiness of Industry 4.0. The tools constructed of six essential core dimensions, and there is a detailed breakdown of the relevant sub-dimensions and descriptions for the associated maturity levels (“Industry 4 readiness”, n.d.). The six core dimensions include;

- Products and Services
- Manufacturing and Operations
- Strategy and Organization
- Supply Chain
- Business Mode
- Legal Considerations.

There are more than 50 respondents from 20 countries in different sectors around the world who completed this self-assessment tool in the real business world. The assessment tools will show the level of readiness of Industry 4.0 in each aspect of the six dimensions.

Table 2.1 The Readiness of Supply Chain Integration



Readiness level	Level 1 Beginner	Level 2 Intermediate	Level 3 Experienced	Level 4 Expert
Inventory control using real-time data management	Inventory levels are understood	Computer database is used which is manually updated with inventory levels	Computer database used with smart devices updating inventory levels	Real-time database which is updated by smart devices
Supply chain integration	Ad hoc reactive communication with suppliers and customers	Basic communication and data sharing where required with suppliers and customers	Data transfer between key strategic suppliers/ customers (e.g. customer inventory levels)	Fully integrated systems with suppliers/customers for appropriate processes (e.g. real-time integrated planning
Supply chain visibility	No integration with suppliers or customers	Site location, capacity, inventory and operations are visible between first tier suppliers and customers	Site location, capacity, inventory and operations are visible throughout supply chain	Site location, capacity, inventory and operations are visible in real-time throughout supply chain and used for monitoring and optimisation
Supply chain flexibility	Slow response to market changes	Moderate response to market changes and general customer requirements shifts	Moderate response to changes in market environment and individual customer requirements	Immediate response to changes in market environment and individual customer requirements
Lead times	Long materials lead time resulting in high inventory levels	Improvements have been identified to reduce lead times for some materials	Some improvements have been implemented to reduce lead times on key materials	Differentiated stocking policies and lead times to meet make-to-order efficiently

The readiness of supply chain integration is one of the core dimensions related Supplier Development Department of Airbus. The table 2.1 shows the readiness of supply chain integration regarding Industry 4.0. There are four levels of readiness starting from 1 to 4. The suppliers will be able to complete the self-assessment without sharing sensitive information to an external party and will know the level of readiness right away.

2.2.2 PwC: Industry 4.0 Self Assessment

PwC's online self-assessment tool provides a better understanding of the suppliers' position in terms of Industry 4.0. The tool evaluates the actual level of the supplier's position against the target that the company would like to achieve along six dimensions as follows ("Industry 4.0 - Self Assessment", 2019).

- Business Models, Product & Service Portfolio
- Market & Customer Access
- Value Chains & Processes
- IT Architecture
- Compliance, Legal, Risk, Security & Tax
- Organization & Culture

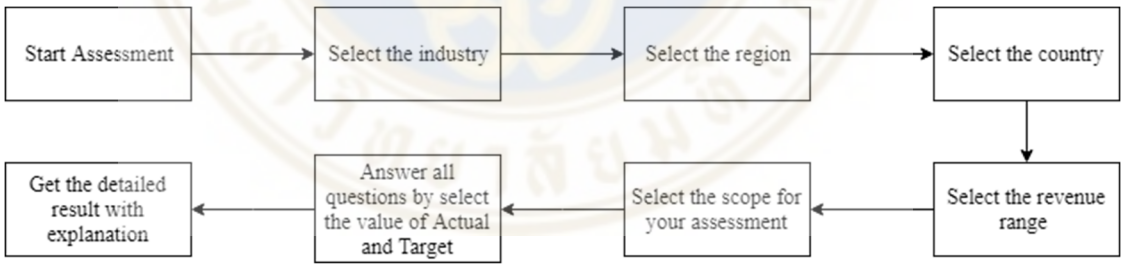


Figure 2.2 Steps of completing PwC's self-assessment

Source: Pasinee (2019)

According to Figure 2.2, I made the diagram to shows that the assessment tool is specific and analyzes the result by using the company's industry, region, country, and revenue. The company can assure that the tool will provide an accurate result. The result of the self-assessment tool will show the current maturity level of Industry 4.0, namely, Digital Novice, Vertical Integrator, Horizontal Collaborator and Digital Champion. Moreover, the company can also register to industry benchmarking with PwC after

received the result from the assessment, and gain valuable insights on how the suppliers positioned against competitors in the same industry.

Furthermore, I made a video and uploaded on Youtube show how to complete PwC: Industry 4.0 Self Assessment as Figure 2.3. The link of the video is the following. https://www.youtube.com/watch?v=fmAG1j11K2U

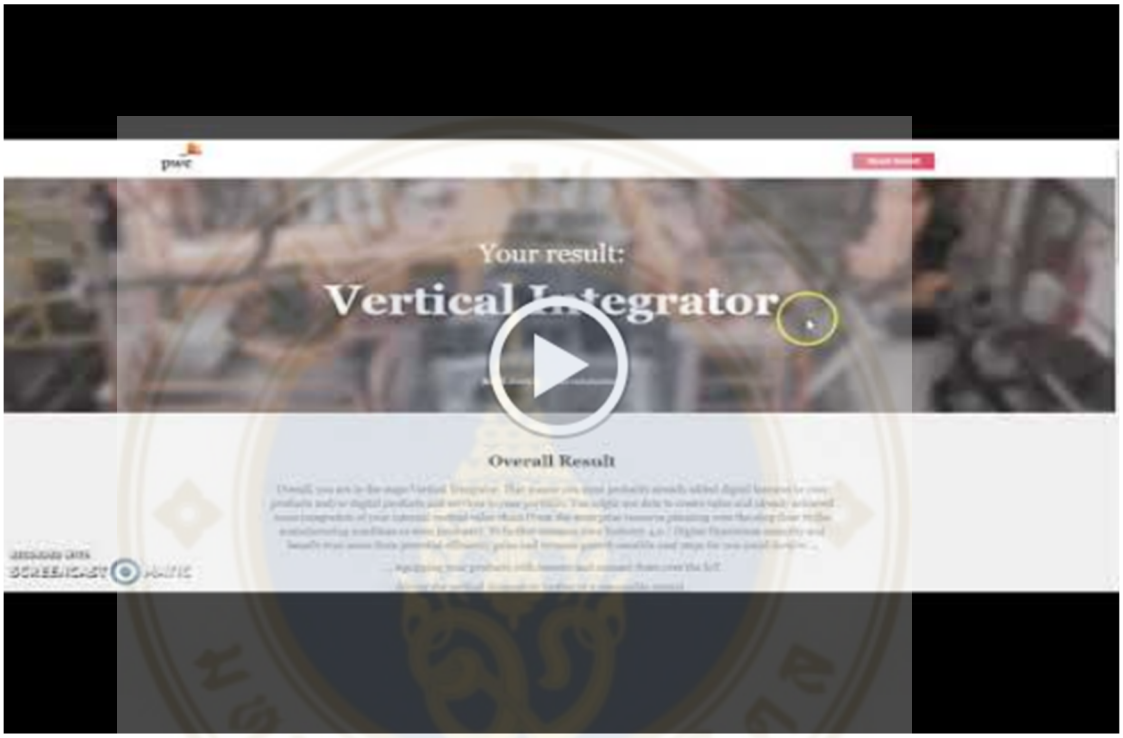


Figure 2.3 The screen capture of the Youtube video shows the step to complete the PwC's Industry 4.0 Self Assessment

CHAPTER III
RESEARCH METHODOLOGY

This chapter explain the research methodology and data collection used in this study. The research design is consists of five steps which are Problem Definition, Framework Development, Data Collection, Developing Tools, and Analysis.

3.1 Research Design

Toulouse School of Management (TSM) formed the multicultural team which consists of three members as shown in Figure 3.1. The first member on the left was Miss Camille Cros, a French. The second member in the middle was Miss Patricia Axen, a German. The last member on the right was Miss Pasinee Phuangprayong, a Thai. The Toulouse School of Management team or TSM team had a meeting together and discussed the concept of Industry 4.0 before starting to have a meeting with Airbus. The consulting internship with Airbus took two months in Toulouse, France. The TSM team had the meeting with Airbus weekly and every day meeting within the TSM team. The details and stages of this study as follows.

Figure 3.1 The photograph of the TSM team at Airbus

3.1.1 Problem Definition

In the first step, the TSM team received the topic, Industry 4.0, from the university, Toulouse School of Management, Toulouse, France. The school tutor briefed the problems that Airbus had and Airbus prefer to use the Industry 4.0 as a tool to solve their problems. The TSM team had a meeting with the Vice President of the Supplier Development Department in order to have more details at Airbus Headquarters. Airbus needs its suppliers to apply and invest in Industry 4.0. Airbus would like to assess the readiness of the suppliers toward Industry 4.0. Some of the suppliers may unwilling to participate especially the small companies who believe that their way of working is already efficient and may cost lots of money to implement the new way of working. Assessing the readiness and willingness of the suppliers will give Airbus guideline to plan their project toward Industry 4.0 in the future.

3.1.2 Framework Development

Since there are many elements in Industry 4.0, Airbus would like to use only some elements that could fit the Supplier Development Department. The framework should be suitable for their suppliers or supplier assessment. After many reviews and discussions, Airbus ignores the unrelated elements. The examples of the elements that had been removed by Airbus was autonomous robots which related to the manufacturing sector and cybersecurity which related to the Information Technology department. System integration and cloud computing were entirely related to the Supplier Development Department as the elements may help a coordination between Airbus and the suppliers proceed better.

3.1.3 Data Collection

The information mostly gathered from a secondary sources such as the internet and online articles. From several researches about Industry 4.0, Airbus decided to participate in fairs and conferences with the topic of Industry 4.0 in supply chain or smart supply chain which will hold in European countries in order to get insight knowledge from experts and solution providers (the list of fairs and conferences see Appendix A). Furthermore, Airbus and TSM team also contacted the universities that offer courses related to Industry 4.0 to have the insight knowledge from the one that familiar and

expert about the topic. Most of the professors and lecturers provide information as same as the university's website. Lastly, the TSM team was also tried to contact the companies that implement many elements of Industry 4.0, for example, Sanofi who invested a huge budget in Industry 4.0. Sanofi should have significant information that makes them succeed in the new era of revolution, but they were unwilling to share the sensitive company information ("The Fourth Industrial Revolution - Sanofi", 2018). The TSM team did not visit any suppliers.

3.1.4 Developing Tools

Airbus provided a list of the supplier as an example in order to develop a new tool to assess their suppliers. Many of their suppliers are small companies; thus the financial status is one factor that could be considered. The TSM team decided that the first tool is "the applications matrix' which including return on investment as one aspect to assess the existing solutions. The application matrix contains the solutions that already exist in the market (the list of companies applying Industry 4.0 see Appendix B) Afterwards, the TSM team developed the readiness and willingness supplier assessment tools based on several existing assessment tools. The TSM team selected an Industry 4 readiness assessment tool from University of Warwick as X-axis of the assessment tool because the Industry 4 readiness assessment tool from University of Warwick has supply chain integration which related to the Supplier Development Department. The TSM also developed willingness assessment table as Y-axis by creating willingness questions for the suppliers. The PwC self-assessment tool was chosen because Airbus can send the self-assessment link to the suppliers and let them complete the assessment by themselves.

3.1.5 Analysis

The TSM team had to analyze Airbus's supplier based on the information online because Airbus cannot disclose private or financial information to outsiders. Thus, the information that the TSM team could find were only the broad information from the suppliers website. The TSM team decided that the number of employees working in the company and the company reputation were two of the factors that determined the financial performance of the suppliers. After analyzed the suppliers, the TSM team

selected one supplier as an example to apply on the application matrix and selected one solution to presented to Airbus.

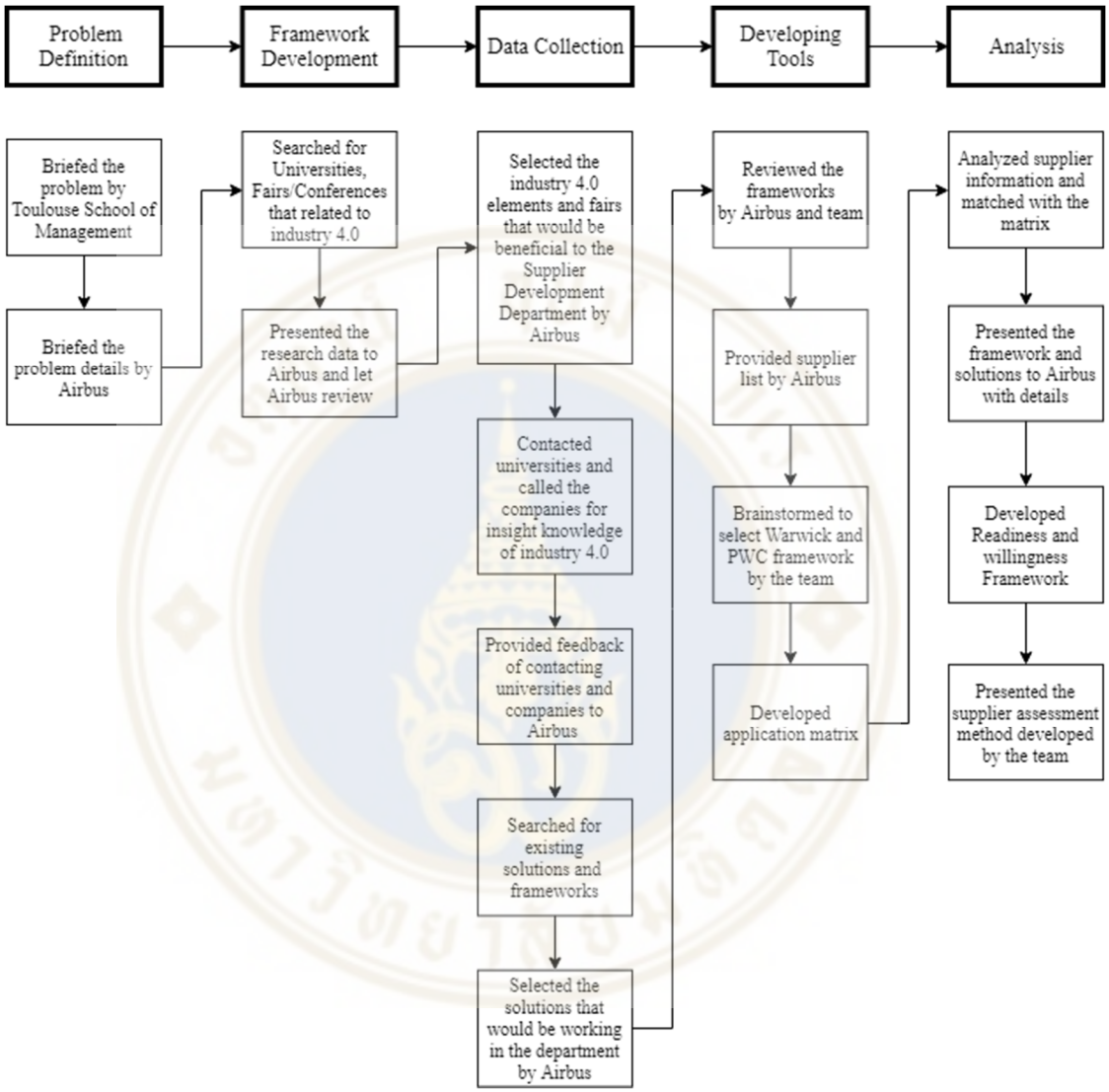


Figure 3.2 The workflow between Airbus and the TSM team from Toulouse School of Management

Souce: Pasinee (2019)

According to Figure 3.2, the flowchart diagram shows the overall workflow between Airbus and the TSM team from Toulouse School of Management. There were 5 differents stages; Problem Definition, Framework Development, Data Collection, Developing Tools and Analysis.

CHAPTER IV
FINDINGS AND ANALYSIS

This chapter, the study presents the results from the group brainstorming as followed.

1. Existing supplier assessment tools based on Industry 4.0: The Willingness Assessment Table
2. Suppliers Assessment of all tiers for Airbus using Industry 4.0 frameworks: Supplier Assessment Grid
3. Recommendations to Airbus about suppliers based on their readiness and willingness of Industry 4.0: Application Matrix

4.1 Existing supplier assessment tools based on Industry 4.0: The Willingness Assessment Table

The TSM team discovered 7 company assessment tools as shown in Appendix C. The TSM team selected two of the tools related to Supplier Development Department, the University of Warwick and PwC. The TSM team selected an Industry 4 readiness assessment tool from University of Warwick because the Industry 4 readiness assessment tool has supply chain integration which related to the Supplier Development Department. Moreover, the PwC self-assessment tool was chosen because Airbus can send the self-assessment link to the suppliers and let them complete the assessment by themselves. The TSM team developed the Supplier Assessment tools based on the concept of Industry 4.0. The willingness assessment table has a few questions asking the willingness in many aspects, for instances time and financial performance of the suppliers. The suppliers can complete self-evaluation by rating the company in 4 degrees of willingness from slightly willing to extremely willing as shown in Table 4.1. The suppliers have to sum the score and divide the score by 4 in order to get the average score. The score will be used by plotting in Y-axis in the company assessment grid. According to the willingness assessment

table, the respondents may have prejudices and favor themselves by answering the questions that make the company's overall picture look in the positive trend.

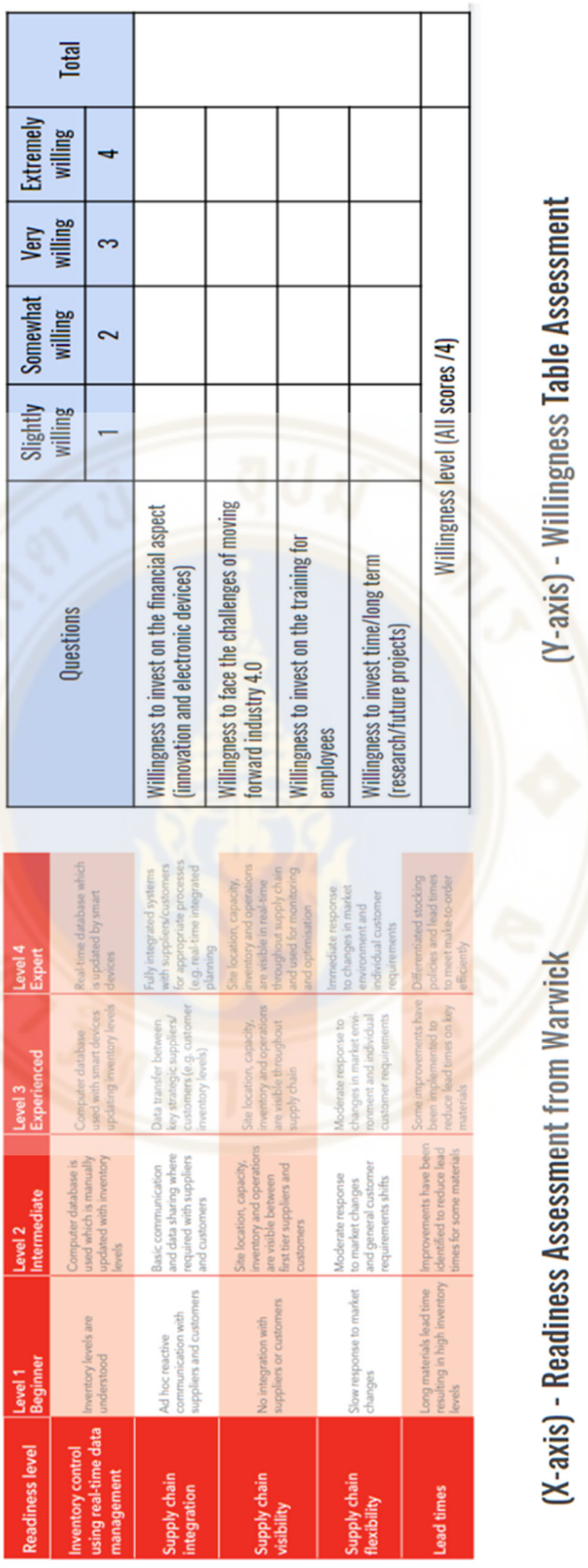
Table 4.1 The willingness assessment table for the suppliers

Questions	Slightly willing	Somewhat willing	Very willing	Extremely willing	Total
	1	2	3	4	
Willingness to invest in the financial aspect (innovation and electronic devices)					
Willingness to face the challenges of moving forward Industry 4.0					
Willingness to invest in the training for employees					
Willingness to invest in time/long term (research/future projects)					
Willingness level (All scores /4)					

Source: TSM team

4.2 Suppliers Assessment of all tiers for Airbus using Industry 4.0 frameworks: Supplier Assessment Grid

The TSM team decided to select an existing assessment tool that is available and related to Supplier Development Department which is the assessment tool from Warwick University. The Supplier Assessment Grid will combine the result from the University of Warwick: An Industry 4 Readiness Assessment on Supply Chain Integration as x-axis with the willingness table assessment as y-axis as shown in Figure 4.2. The suppliers have to complete both assessment, the Willingness Assessment Table and The Readiness Assessment, and use the score to plot on each axis as shown in Figure 4.1.



Readiness level	Level 1 Beginner	Level 2 Intermediate	Level 3 Experienced	Level 4 Expert
Inventory control using real-time data management	Inventory levels are understood	Computer database is used which is manually updated with inventory levels	Computer database used with smart devices updating inventory levels	Real-time database which is updated by smart devices
Supply chain integration	Ad hoc reactive communication with suppliers and customers	Basic communication and data sharing where required with suppliers and customers	Data transfer between key strategic suppliers/ customers (e.g. customer inventory levels)	Fully integrated systems with suppliers/customers for appropriate processes (e.g. real-time integrated planning
Supply chain visibility	No integration with suppliers or customers	Site location, capacity, inventory and operations are visible between first tier suppliers and customers	Site location, capacity, inventory and operations are visible throughout supply chain	Site location, capacity, inventory and operations are visible in real-time throughout supply chain and used for monitoring and optimisation
Supply chain flexibility	Slow response to market changes	Moderate response to market changes and general customer requirements shifts	Moderate response to changes in market environment and individual customer requirements	Immediate response to changes in market environment and individual customer requirements
Lead times	Long materials lead time resulting in high inventory levels	Improvements have been identified to reduce lead times for some materials	Some improvements have been implemented to reduce lead times on key materials	Differentiated stocking policies and lead times to meet make-to-order efficiently

Questions	Slightly willing	Somewhat willing	Very willing	Extremely willing	Total
	1	2	3	4	
Willingness to invest on the financial aspect (innovation and electronic devices)					
Willingness to face the challenges of moving forward industry 4.0					
Willingness to invest on the training for employees					
Willingness to invest time/long term (research/future projects)					
Willingness level (All scores /4)					

(X-axis) - Readiness Assessment from Warwick

(Y-axis) - Willingness Table Assessment

Figure 4.1 How to plot the Supplier Assessment Grid

The score from each assessment and the grid will show the position in which quadrant that the supplier will be positioned. The explanations of the quadrants are followed.

1. Innovative: The supplier is advanced in Industry 4.0; ready but not - yet - willing to invest

2. Advanced: The supplier is already advanced in Industry 4.0 technologies; ready and willing to invest further.

3. Hesitant: The supplier do not have enough knowledge on Industry 4.0 and not - yet - willing or hesitate to invest.

4. Beginner: The supplier do not have enough knowledge on Industry 4.0; not ready but willing to invest further.

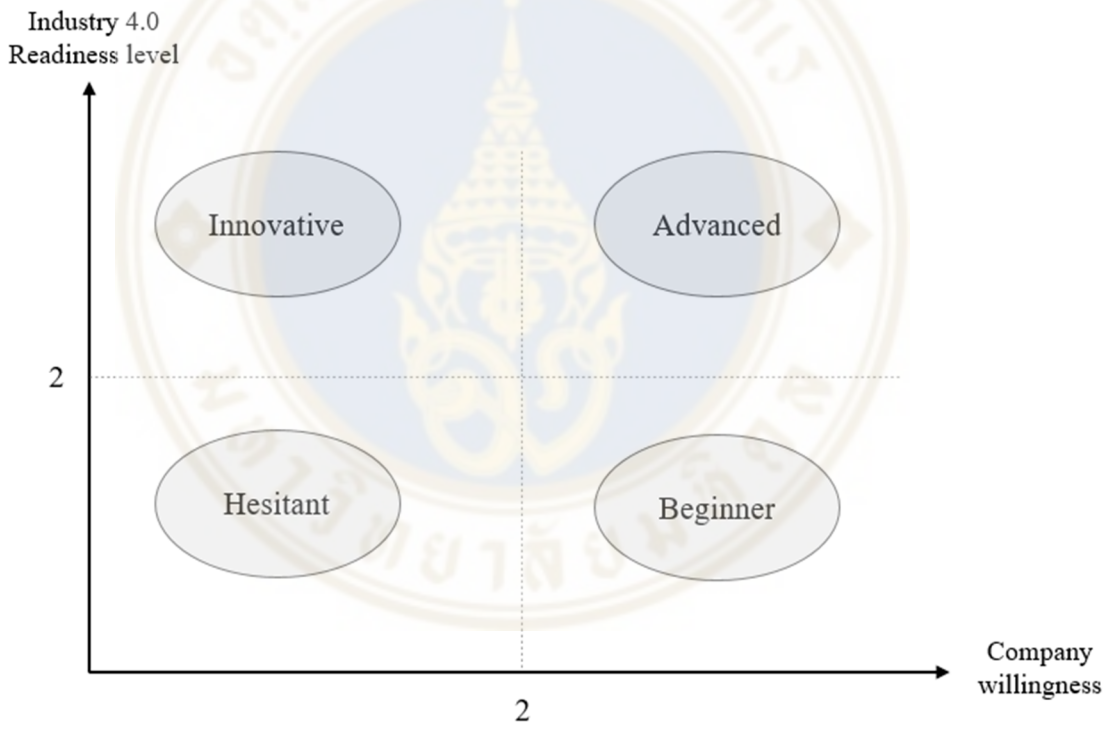


Figure 4.2 Supplier Assessment Grid shows the positioning of the company toward the willingness and readiness of implementing Industry 4.0

Source: The TSM team (2019)

4.3 Recommendations to Airbus about suppliers based on their readiness and willingness of Industry 4.0: Application Matrix

The application matrix is the matrix created to compare the existing solutions related to many elements of Industry 4.0 that available in the market and providing by solution providers. The TSM team researched existing solutions, and not all the solutions are plotted on the matrix as shown on Figure 4.3. The X-axis is the return on investment or ROI which will show the performance of the company since investing in Industry 4.0 will cost money. The Y-axis is the complexity of the solution or only the degree of difficulty using be employees of the solution. The different level of expertise may need in high complexity of the solutions. The circle sizes were indicating the cost of the solution, the bigger sizes are, the more expensive. This circle size indicator can be useful to the company who is worrying about the cost of investing in the Industry 4.0. The colors of the circle indicate the time to return on investment, red means taking quite a long time to achieve (more than three years), orange means taking some time to achieve (1-3 years to achieve) and green means taking less than a year to achieve the return on investment.

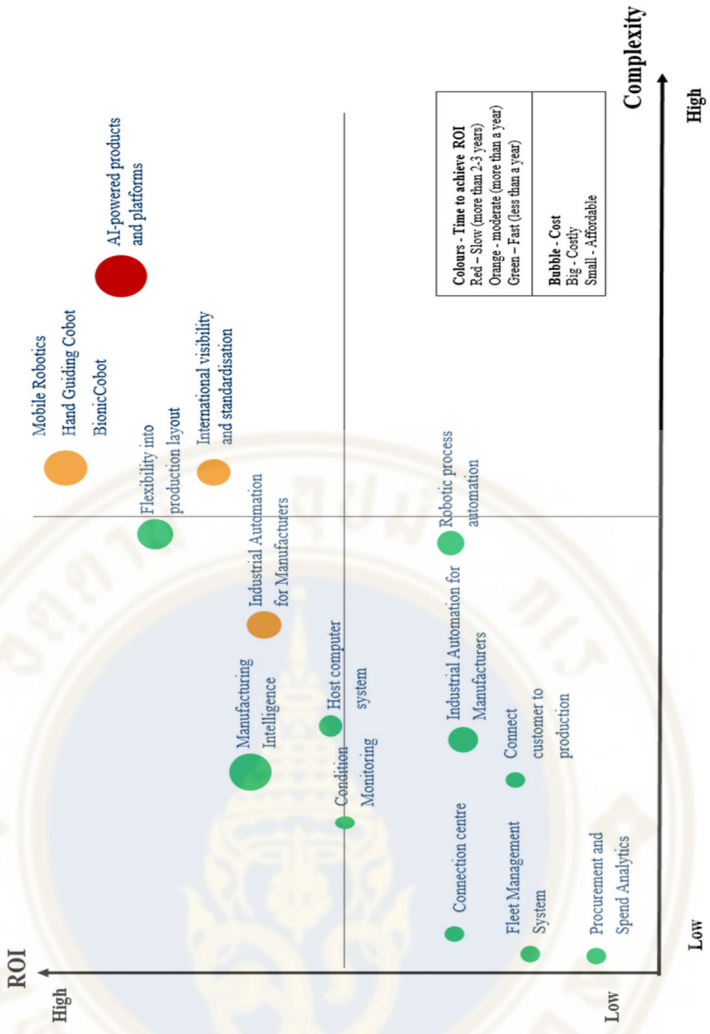


Figure 4.3 The Application Matrix comparing the existing solutions in the market using return on investment, time to achieve ROI, cost of the solutions and complexity as the indicators

Source: The TSM team (2019)

4.4 Case Examples of Supplier Assessment

4.4.1 Scenario 1: Suppliers with low budget

Many of Airbus's suppliers are small companies with a limit budget. In order to apply existing solutions, the solutions will create some cost, for example, employee training, device replacement, software installation, and maintenance fee. Some solutions

may need specialized knowledge and skills which will create more cost for the suppliers. The suppliers who are in the beginner and hesitant stage from the company assessment grid, are somewhat ready and willing to use Industry 4.0 as a tool to help the business run smoothly. The TSM team recommends using the solutions from the bottom-left quadrants since those solutions will not be costly compared to other quadrants as shown in Figure 4.4.

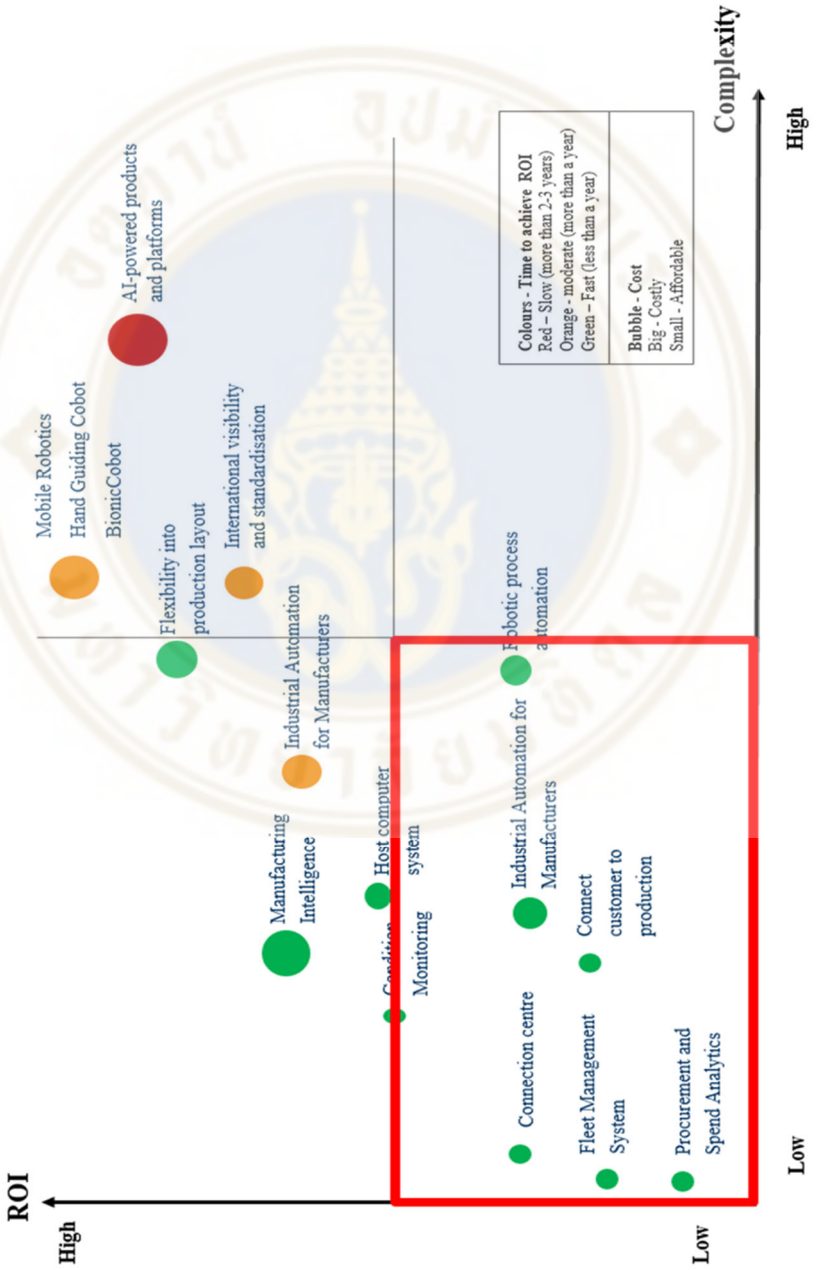


Figure 4.4 The bottom-left quadrant in the Application Matrix

Case example of Supplier A which has 25 employees working and it is in tier 3 of Airbus supplier, supplying the special screw in the aircraft. Since supplier A is a small screw manufacturing company and does not want to invest much in the fourth industrial revolution, the recommendation is to use “Connect the Customer to Production Software” from Innodox. The software helps automate the production of documents to communicate with customers effectively. The documents such invoices, orders, or proofs of delivery will be automated transactional documents, using the information from the systems. The cost of the software is low compared to the time saving that Company A will receive.

4.4.2 Scenario 2: Suppliers with requirement of less complexity

The complexity in applying the solution is another factor to be considered. Each supplier has different ways of working as well as company culture. The complexity of implementing Industry 4.0 may create a delay in the work process if the employees do not have knowledge to use the software or devices, the supplier may have to struggle with the way to using.

Case example of Supplier B, the company is in tier 1 supplying the main component to the commercial aircraft. The company is listed in stock market and has good financial performance. More than one thousand employees working at the company, so changing the complexity of the way of working will affect many departments. In this case, Manufacturing Intelligence Software located in the above-left quadrant from plex.com.The software will improve company workflow and performance as shown on the Figure 4.5. Manufacturing Intelligence Software will provide visible details for maintaining high performance and quality (See Appendix D).

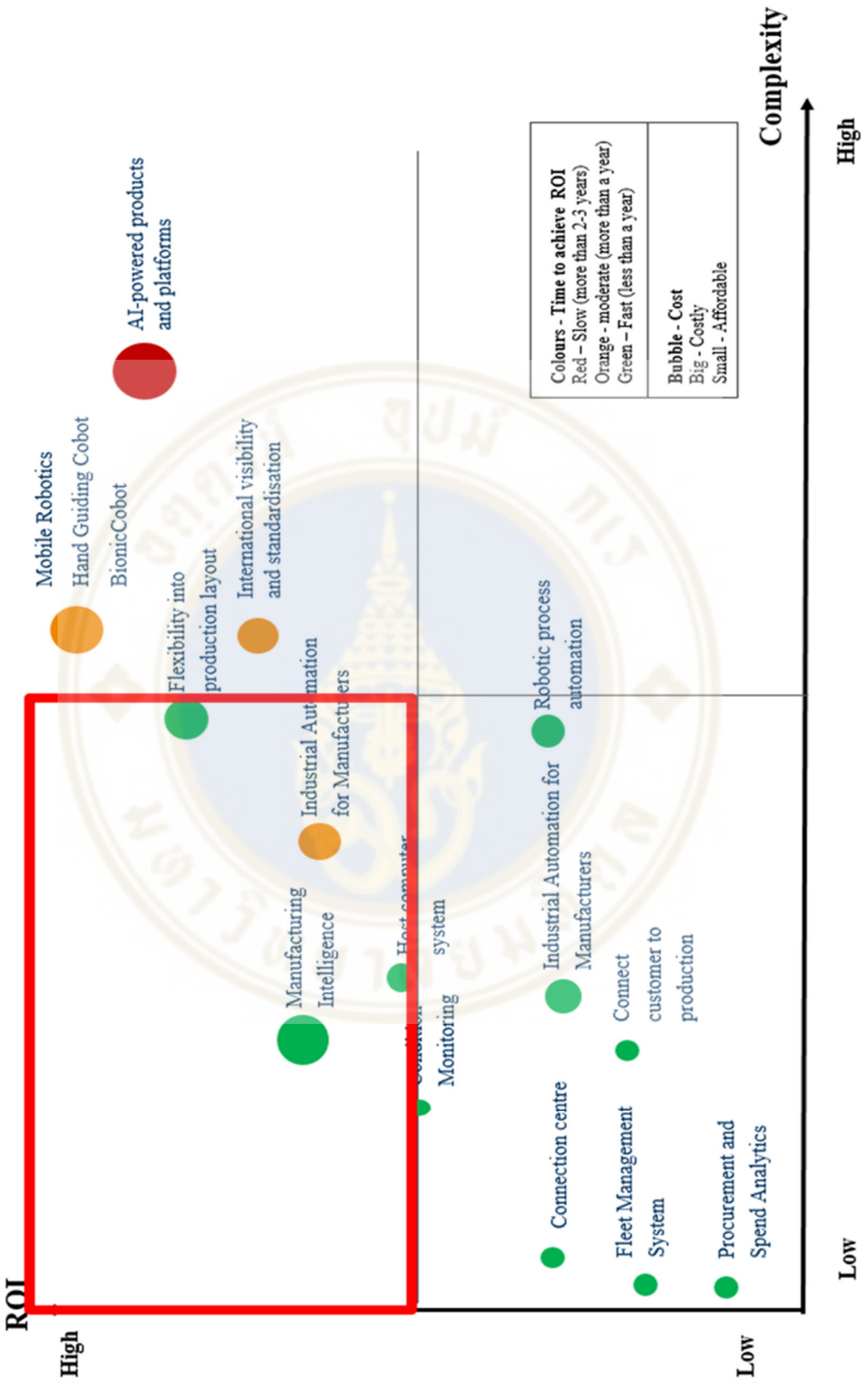


Figure 4.5 The above-left quadrant in the Application Matrix

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

This chapter presents conclusions and recommendations from this study. The purpose of this study is to explore the existing tools available in the market based on the new era of Industry 4.0, to assess suppliers at all tiers for Airbus by using the Industry 4.0 framework and to provide recommendations to Airbus suppliers based on their readiness and willingness of Industry 4.0.

5.1 Conclusions and Discussions

To achieve the research objectives, the TSM team explored the existing supplier assessment, assess Airbus' suppliers with the tools or framework regarding Industry 4.0, and provide recommendations to Airbus about suppliers.

Exploring the supplier assessment tools that are available in the market was new to the TSM team. Industry 4.0 carries a limitless opportunity for the company to improve its capabilities and standardization. There are many fundamental needs for assisting companies in the transition to Industry 4.0. Many assessment tools were focusing on only the manufacturing department. The TSM team discovered 7 company assessment tools and selected two of the tools related to Supplier Development Department, the University of Warwick and PwC. The supply chain integration is including in The University of Warwick assessment tools. According to the sensitive information of the supplier, Airbus can send the PwC self-assessment tools to the suppliers without intervene the internal information.

The TSM team developed the willingness assessment table and supplier assessment grid to assess the readiness and willingness of Industry 4.0 for Airbus suppliers. The willingness assessment table was one factor that important to supplier assessment for Industry 4.0. The willingness table was a part of developing the supplier assessment grid. Creating the grid was the combination of many tools and assessment method

which will suit Airbus's problem. Airbus will see which suppliers will be moving forward with good vision. A few of the small firms may need motivation or small help from Airbus.

For managerial implication, the TSM team provided the recommendations to Airbus' suppliers based on their readiness and willingness will help Airbus to prepare themselves for transition to Industry 4.0. Airbus could push suppliers that willing to invest in the new way of working based on the industry 4.0. Airbus could provide small help and pushing the Suppliers who are not ready to invest which finally create a good result for both sides. Many solution providers providing the software and tools that are suitable for the Supplier Development Department. Depending on the cost of investment, time to achieve the return on investment and the complexity of the software or tools, Airbus can select the best solution and software based on these criteria.

5.2 Limitations of This Study

Although the concept of Industry 4.0 was new to both Airbus and the TSM team, there are many people and companies who respond actively to the concept of Industry 4.0 in order to gain the advantages of the technology. There are many limitations found in this study and listed as follows.

1. The communication between Airbus and the TSM team was not clear. The concept of Industry 4.0 was new for the whole TSM team. Thus, the TSM team needed much time to find the correct direction.
2. Many universities and companies were not willing to provide information and their expertise through the phone interview.
3. Airbus is a huge company and cannot share suppliers' information to outsiders. The limited information created many difficulties for the TSM team when analyzing the supplier profiles.
4. Airbus did not inform the method or current way to assess its suppliers. When the TSM team developed new tools and proposed to Airbus, the TSM team will never know the result whether it is working or not.

5.3 Future work

Since there were limitations of this study, more actions should be taken in this particular topic as followed.

1. Airbus is huge corporation with no financial difficulties. The company should hire a consultancy company in order to provide a specific solution to specific sector. The existing solutions are valuable for other companies but may unfavorable for Supplier Development Department.

2. Airbus should arrange the training in the topic of Industry 4.0 in order to prepare their employee beforehand. Many of them, still misunderstood of the concept of Industry 4.0.

5.4 Recommendations

The practical recommendation for Airbus are divided into 2 ranges, short-run, 1-3 years and long-run, 3 years or more. For short-run, Airbus should focus on the Advanced and Innovative group on the Supplier Assessment Grid as shown in Figure 5.1. Firstly, the suppliers in the Advanced quadrant of Supplier Assessment Grid are ready and willing to apply the concept of Industry 4.0. Airbus can give full support on these suppliers, in order to improve the workflow instantaneously.

Secondly, Airbus should address the Innovative group, since, the suppliers in this quadrant is ready to apply the concept of Industry 4.0 but unwilling. Airbus shall motivate and push the suppliers until they starting to perceive the advantages of applying Industry 4.0. It is recommend Airbus to visit the suppliers and show the success stories and benefits of the previous suppliers applying Industry 4.0.

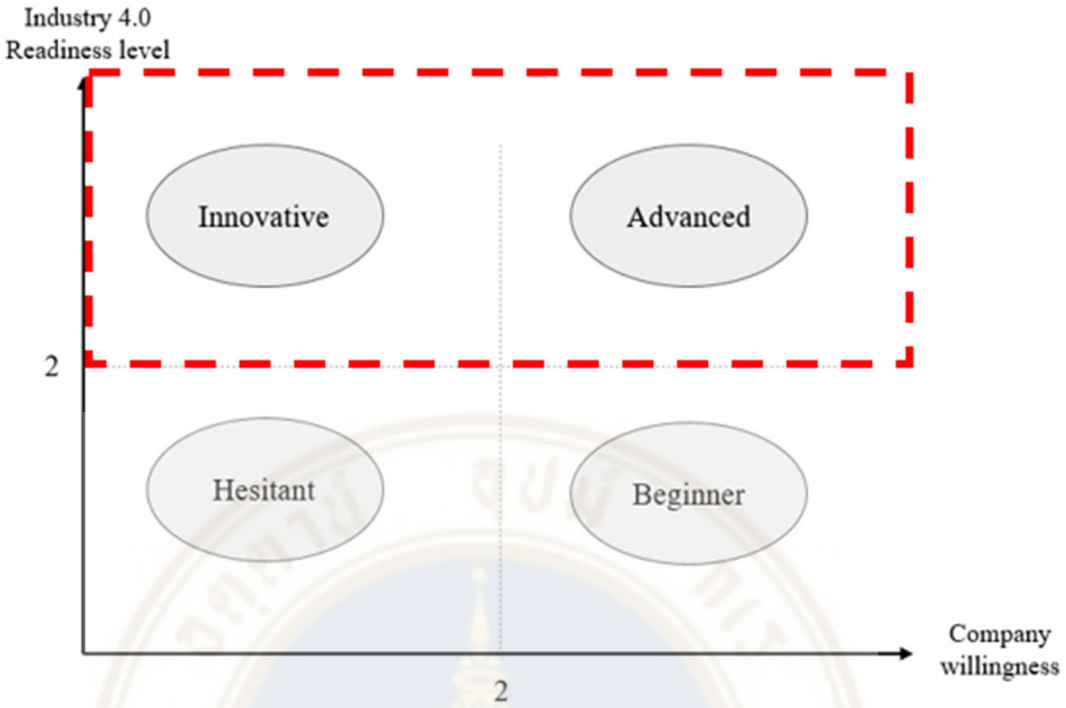


Figure 5.1 The suppliers that Airbus should focus on the short-run

In the long-run, Airbus will have to invest more effort on the Beginner and the Hesitant group as shown in Figure 5.2. The suppliers in the Beginner quadrant are not ready but willing to apply the Industry 4.0. Airbus may provide the trainings and courses in the topic of Industry 4.0 to prepare the supplier for the transition to Industry 4.0. The trainings and courses related to Industry 4.0 will enable the supplier and employees to understand about the concept and be able to incorporate Industry 4.0 to their workflow.

Lastly, Airbus will have to spend more time on the suppliers in the Hesitant quadrat. As the Hesitant are not ready and unwilling to apply the concept of Industry 4.0. Airbus should provide the trainings and courses not only to give the suppliers the insight knowledge of Industry 4.0, but also advise the advantages of applying Industry 4.0 to the workflow. Airbus may have to support the financial aspect to the suppliers especially the suppliers who have limit budget.

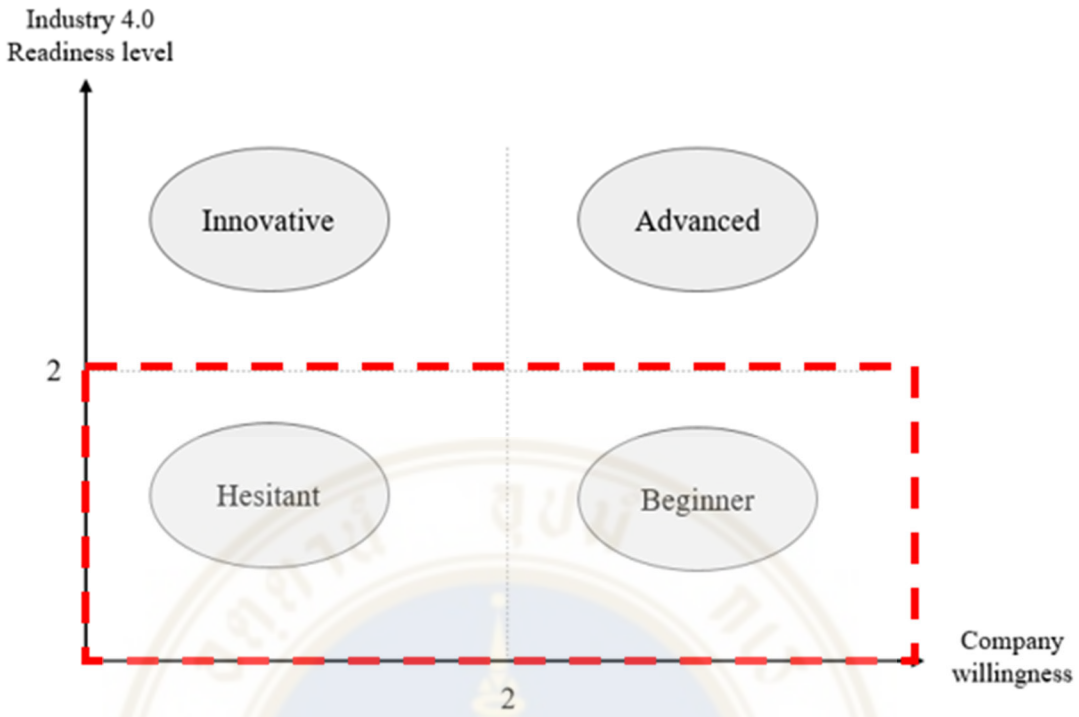


Figure 5.2 The suppliers that Airbus should focus on the long-run

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APPENDICES

Appendix A: List of Fairs and Conferences

Name of the Conference	Details	Country	Website	When
Get ready for the connected Industry 4.0	Intelligent, efficient, Industry 4.0 Small steps to the smart factory Security gaps Smart training	Hannover, Germany	https://www.reply.com/click-reply/en/topics/industry-4-0/homepage	01.04 - 05.04. 2019
GR-EX - Global Robot Expo - Logistics	Cobots Augmented Reality Big Data & Analysis Simulation, 3d Print, Drones, Accessories, Storage, Software (SGA) Collaborative Platform for Supply Chain Integration	Madrid, Spain	https://www.globalrobotexpo.com/	8.05-9,05. 2019
Industry 4.0 Summit and Expo	Topics: Made Smarter Industry 4.0 Insights Essential Strategies to get Started Making it Happen SME Forum	Manchester, UK	https://www.industry40summit.com/summit#	10.04 - 11.04.2019
Industry 4.0 and Artificial Intelligence Technologies	It address new trends and challenges, emerging technologies and progress in standards on topics relevant to today's fast-moving areas of Industry 4.0 and Artificial Intelligence Technologies.	Cambridge, UK	https://inait-conf.org/	19.08 - 20.08.2019
IoT Tech Expo Europe 2019	Exploring the latest innovations within the Internet of Things and covering the impact it has on many industries especially in Europe including Manufacturing, Transport, Supply Chain, Insurance, Logistics, Government, Energy and Automotive Industry 4.0 & 5.0	Amsterdam, Netherlands	https://www.iottechexpo.com/europe/	19.06- 20.06.2019

Appendix B: List of Companies applying Industry 4.0

Company	What they are doing	Country	City
Continental	- Technological innovations are the lubricating oil and fuel for making industrial companies competitive - Using smart sensors and is an expert in the fields of production and logistics, as well as the entire digital value chain which bring them their expertise in process automation, the smart factory, and the entire digital value chain - Target Robotics researches and develops robotic automation systems, replacing conventional and old technology machinery - Implemented Universal Robots with Robotiq's 2-Finger Grippers in their production line which reduce changeover time by 50%	Germany	Various
EXCENT	Helmet of augmented reality. Follow with customers the phases of product design and make sure that the future user can apprehend the new tool in a virtual environment.	France	Colomiers
Latécoère	New generation production plant Fully connected and digitized 6,000 m², labeled "Showcase Future Industry ". The group carried out a simulation of manufacturing flows with Dassault Systèmes and Ysiatis to design the factory	France	Various
Pierre Fabre	Using Veeva OpenData that enable them to target customers more effectively and deliver the right message at the right time	France	Various
Rockwell Collins	- Launch of a new manufacturing innovation program entitled ManuVation 4.0 - New IMS model based on working with local and regional economic development groups in addition to federal governments - Having international business innovation and research and development (R&D) program established to develop the next generation of manufacturing and processing technologies through multi-lateral collaboration - Offering workshops, project coaching services, Industry 4.0 guides, participation in regional World Manufacturing Forum events, and an international collaborative environment for a robust exchange of ideas and synergy creation.	USA	Various
Safran	- A 4.0 training center housed in the Faculté des Métiers de l'Essonne - Interacting with "smart" machines and robots, - Using digital tools, - Advancing lean management, - Working in more collaborative and empowering organizations, - Adapting to new training methods - Cobots and automatic trolleys	France	Various

Samsung	- Mobile devices are the gateway Industry 4.0, companies still working from legacy desktop computers or green screen terminals are reading the writing on the wall: move to mobile or risk irrelevance. - Fully embrace the promise of Industry 4.0. Enterprises are now have complete visibility into each and every aspect of the manufacturing process, from supply chain logistics, to enterprise asset management (EAM), to customer order fulfillment by using Mobile devices	South Korea	Various
Sanofi	- Use the AI to prevent machine stops (predictive maintenance) - Rationalize the Supply Chain - Establishment of a "Supply Chain Tower" - Need to be able to respond to real time to requests - Sanofi plans to invest 60 million euros on industry 4.0 by 2021 - Real-time data analysis	France and worldwide	Various
Siemens AG	- Financing model in the cloud - Deploy a multi-layered concept to protect industrial plants and always combining different measures such as encryption, protected access and so on - Defense in Depth, and it encompasses plant security, network security and system integrity. - Personalized production with the smart flexible pick system	Germany	Various
Thalès	- Cyber-factories set to transform production methods, make manufacturers more agile and boost demand for innovative services - A complete range of solutions and services to support the secure end-to-end digital transformation of production systems as Cybersecurity - They supplies custom-tailored augmented reality solutions that help improve industrial processes by making operations faster and more efficient, providing context-sensitive support as well as real-time traceability, delivering new services, and optimizing travel costs - Cobotics- robots which can learn and interact with human manufacturing technicians and provide new levels of agility and production precision.	France	Various

Appendix C: The 7 tools of Industry 4.0 assessment tools

Name	Description	Analyzed areas
Industry 4.0 Maturity Index **Acatech Study**	Helps determine which stage a company is currently at into leaning, agile company. There are 6 levels **Industry 3.0:** Computerization; connectivity **Towards industry 4.0:** Visibility; Transparency; Predictability; Adaptability.	- Companies current situation and goals - Technological, organizational and cultural perspective. Most important: - Companies current situation - Strategic decisions
The connected enterprise maturity Model **Rockwell Automation**	Rockwell Automation developed a five-stage process to become a connected enterprise. 1- Assessment 2- Secure and upgrade 3- Working data capital 4- Analytics 5- Optimize and collaborate	Evaluates all facets of an organization's IOT /IT network. - Information infrastructure - Controls and devices that feed and receive data - Networks that move all information - Security policies
A maturity model for Industry 4.0 Readiness **Elsevier**	Analysis the maturity of a company by using 62 maturity items grouped into nine dimensions. Each item undergoes five maturity levels. The maturity of each dimension results from calculating an average.	- Strategy - Leadership - Customers - Products - Operations - Culture - People - Governance - Technology

Industry 4.0 Readiness model **Warwick**	They propose a template for self-assessment. For all the 6 dimensions you identify your current level of readiness (1,2,3,4).	- Products and services - Manufacturing and operations - Strategy and organization - Supply Chain - Business model - Legal considerations
Industry 4.0 self-assessment **PwC**	Online self-assessment with 6 dimensions.	- Business models - Products and Services; - Market and customer access; - Value chains and Processes, - IT - Compliance, Legal… - Organization and culture
Industry 4.0 Readiness model **Impuls**	This model assesses the maturity level and grants levels (0 to 5) for industry 4.0 readiness. It is built on a questionnaire based on the 6 different departments the most concerned about industry 4.0	-
Country classification along I4.0 readiness **Roland Berger**	Macro level industry 4.0 readiness index.	- How sophisticated the production processes - Degree of automatization - Innovativeness of workforce - Attitude towards innovation - GDP of the country

Appendix D: Manufacturing Intelligence Software

Name of the Software	Manufacturing Intelligence Software
Website	https://www.plex.com/industries-and-solutions/manufacturing-business-intelligence-software.html
Types of analysis	1. In-Process Analysis – Real-time inline reporting keyed to specific roles, for example, enable the shop floor manager to make quick decisions based on production volume, machine performance or quality levels. 2. Operational Analysis – Intra-day analysis to help business managers evaluate the business to optimize inventory levels, shipments, accounts payable and more. 3. Enterprise Analysis – Daily, weekly or monthly reporting and dashboards to analyze more complex data across business metrics over time such as inventory turns, cash flow or Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA).
Capabilities	1. Quickly find and navigate through data based on visual representations of table relationships 2. Visually track plant floor machine performance to identify inefficiencies, and improve performance 3. View rich visualizations that help identify trends or anomalies far more easily than pouring through tables or spreadsheets 4. Analyze historic time-series data to more easily identify trends 5. Rely on pre-packaged analytic applications that give you detailed performance through visual, intuitive dashboards
Number of Users	Everyone in the company