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Launch Management Process in Automotive. A tool for managing the modern complexity of the Project Development in the phase close to Start of Production.

Theoretical base and application to a real case study

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Introduction

The needs of the modern Automotive market require to be ready for production in almost half of the time in comparison to 10 years ago. This is the reason why project phases are squeezing in time and are overlapping more and more in the Automotive industry nowadays. Besides, concurrent reduction in budget and resources has brought to the frenetic situation in which the Automotive business is at the present.

In particular, the critical phase of an Automotive project is the Launch phase. During this phase, production starts with ramp up towards full production rates. Therefore, the product design should be stable, as well as the manufacturing line. However, the Development phase suffers from reduction in time, budget and resources. This phase precedes the Launch phase and ensures product and process ability to produce at production rates while meeting specifications. Consequently, at the Launch phase, product and process have not achieved full maturity yet. This is the reason why Development and Launch phases are overlapping more and more.

The core work of this paper is oriented to identify the major indicators in order to effectively guide the Project Team to a flawless Launch. This work is illustrated in Chapter 4, which is the most important Chapter of the paper. Here the development of the tool is illustrated, as well as its application to a real case study. The case study is about the Production Launch of a new product on a new manufacturing line. The already complex Production Launch is challenged by the fact that the Product Development Team, the Customers, and the Suppliers were Asian, whereas Production took place in Italy.

However, before developing this system of indicators, the existing company approach that supports Production Launch management has been analyzed in order to:

- Be aligned with company requirements and support the existing approach;
- Identify what is missing from the existing approach and what the tool has to provide.

This analysis is provided in Chapter 3, in which is illustrated Program Management and Launch Management within the organization. A general theoretical excursus on Program Management and Launch Management is provided in Chapter 2 instead, in order to introduce the case study.

However, the paper starts with an overview on the Company of the Case Study.

1 The Company of the Case Study

This first chapter provides key information about the company and the plant of the case study. This overview has the aim of providing a better understanding of the core work of this paper, which is deeply illustrated in Chapter 4. The name of the company is omitted, in order to be compliant with the privacy policy of the company.

1.1 The Company

The company is an Asian supplier of automotive thermal and energy management solutions worldwide. Born in the late '80s, it is now a multinational organization with more than 50 factories and 20 engineering centers in more than 20 countries across Asia, Europe and America. The company has about 22,000 employees.

1.1.1 Corporate Direction

The company's vision consists in being a global leader in innovative thermal and energy management solutions in the automotive sector. Its strategy is grounded on three fundamental pillars:

- Accelerate technological innovation, in particular to meet legislative requirements as regards fuel economy and emissions;
- Strive for excellence;
- Power growth.

The company is now taking advantage of the industry transition towards eco-friendly vehicles and is focusing on solutions for electrified vehicles.

1.1.2 Products

Its products are eco-friendly and high-efficient thermal and energy management solutions. The main product lines are the followings:

- HVAC (Heating, Ventilation, and Air Conditioning) Products;

- Compressor;
- Fluid Transport;
- Powertrain Cooling Solutions;
- Thermal and Emissions Solutions;
- Hybrid and Electric Vehicle Thermal Solutions;
- Fuel Cell Vehicle Technologies.

1.1.3 Costumers

The company has a strong global sales, equal to nearly KRW 6 Trillion in 2018. Its customers are automotive manufacturers all over the world.

1.1.4 Competitors

Entry and exit barriers to the automotive climate control systems industry are high because of the amount of capital and the type of technology required. Besides, this is a highly-competitive industry characterized by high speed.

1.2 The Plant

The plant of the case study is located in Northern Italy and has more than 600 employees. The main products manufactured in this plant are:

- The electric Water Pumps (eWP), represented in Figure 1.1;
- The electronic Cooling Fans (eCF), represented in Figure 1.2 instead. In particular, the case study regards the Production Launch of a new eCF.

Figure 1.1: electric Water Pumps (eWP)

Figure 1.2: *electronic Cooling Fans (eCF)*

These products reinforces the company's eco-friendly product offerings.

The technology used consists in assembling electronic control units and brushless DC-drives into integrated smart actuators. However, this topic will be further illustrated in Chapter 4.

In 2019, the plant production volumes were nearly 3.5 million for eCFs and more than 1 million for e-WPs.

2 Project Management and Launch Management

This chapter is a theoretical overview of project management with a focus on launch management. The aim of this chapter is to provide a basis for what is the heart of this paper, that is the case study of the production launch of a new automotive product on a new production line. For this purpose, examples from the case study in question will already be included within this chapter.

2.1 History

Project management has been consolidated in the past forty years, and is expected to confirm its presence even more in the next decades, especially in multinational companies (Kerzner, 2013, p.47). Here follows a brief excursus of the development of project management from the creation of the standard techniques to its consolidation.

Project management has always existed, since the construction of the pyramids. However, the modern approach to project management was developed in the fifties and the sixties in the USA. Project management techniques were elaborated after the Second World War when in the USA the development of armaments required complex projects and the involvement of thousands of suppliers (Bove, 2008, p.5). Shortly after, also NASA (National Aeronautics and Space Administration) started to apply project management concepts on all its space programs. Project management took off in the sixties when also the construction sector began to adopt this discipline, especially in the case of big and complex governative projects. Instead, at the beginning, the private sector was not interested in deploying project management techniques as these were seen as tools with no added value for companies; the management of a project was left to the single functional managers.

In the seventies and the eighties, also businesses started to recognize the importance of project management and to adopt its standardized methodologies. This was mainly due to the advancement of technologies, especially information technologies, which required more focus on the different organizations.

Finally, in the nineties project management started to be considered a need for organizations, and no more a choice. Nowadays, this discipline is adopted by any sector and industry, becoming more and more the key for survival or for growth for any kind of organization.

2.2 Basics of Project Management

What is project management? Why project management is becoming a need for ensuring the success of a project? The definition of project management and the reasons why it is even more important these days are discussed below in this paragraph, starting with the definition of what a project is.

2.2.1 Definition of Project

According to the Project Management Institute (2019), a project is "a *temporary* endeavor undertaken to create a *unique* product, service or result". In particular, two are the main elements that characterize the definition of a project: *temporary* and *unique.* A project is *temporary* because it is limited in time by an established start and end date, and as such it has specified scope and resources. Instead, a project is *unique* because it is not a regular activity, but a defined set of activities with a singular objective. In the case of a manufacturing company, an example of a project is the development of a new product, as opposed to ordinary activities such as issuing invoices.

2.2.2 What is Project Management and Why is Important

Project management is a *discipline* that organizes resources, such as people, in order to ensure that a project is executed according to its scope, quality, time and cost constraints (Bove, 2008, p.6). Project management is not only about creating a programme and a budget. It also consists in putting together a team of experts to solve problems or take advantage of opportunities through a methodology that guides the decision making process and the subsequent creation and implementation of an action plan. In conclusion, project management permits to execute a project in a more efficient way and to successfully manage eventual changes.

As a consequence, in a world in which businesses prosper and struggle to meet market needs, project management is becoming more and more a standard way of doing business. The main reasons for the need for good project management across all industries are reported in Figure 2.1 and are argued below.

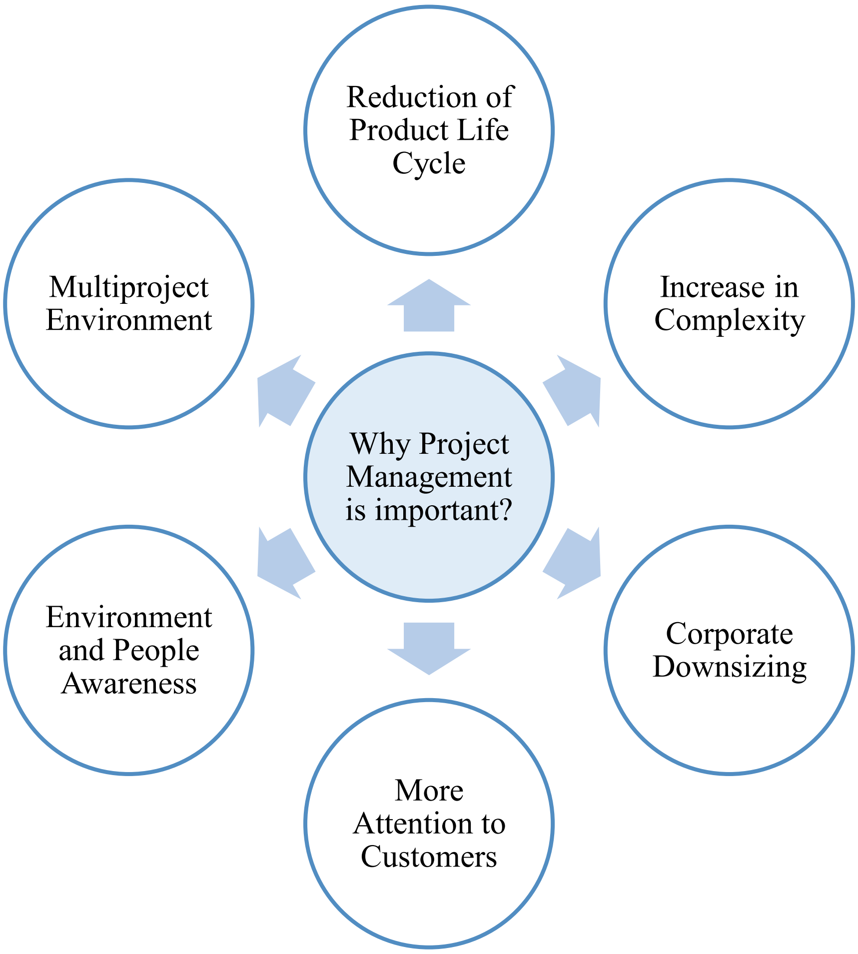


***Figure 2.1**: Main reasons why project management has becomed a need for businesses*

Reduction of product life cycle. A new product or service that has a short life cycle requires a very quick time to market, that becomes an important competitive advantage for a company. This is particularly true for the high-tech industry, in which a postponement in the project of about 6 months may cause a 33 percent loss in revenue, as the product life cycle usually lasts from 1 to 3 years (Larson and Gray, 2011, p.11).

Increase in complexity. Projects are becoming more and more complex because of materials, specifications, codes, aesthetics, equipment, and required specialists (Larson and Gray, 2011, p.11). This has raised the necessity to incorporate divergent technologies. Project management provides the method for dealing with this issue.

Corporate downsizing. In the last decade, a lot of companies have been forced to downsize for survival and, as a consequence, project management is taking the place of middle management as overseer of activities (Larson and Gray, 2011, p.11).

More attention to customers. Companies are more focused on satisfying customer needs that have become more and more demanding because of the significant increment of competition. This implies a much closer relationship between the provider and the customer, which is now responsibility of the project manager (Larson and Gray, 2011, p.11).

Environment and people awareness. Environmental concerns, in particular as regards global warming, are rising in today's society. As a consequence, companies are focusing on adopting sustainable business practices, and are no more focused only on making profit with no care in the effects on the environment and communities (Larson and Gray, 2011, p.11). All this has introduced changes in the objectives and techniques employed in projects; these changes are effectively managed by good project management.

Multiproject environment. Increasing competition has imposed a high rate of change and hence the simulaneous implementation of a lot of projects, especially small projects (Larson and Gray, 2011, p.12). For example, this means sharing and prioritizing resources among projects, for which project management plays a key role.

2.3 Project Manager and Team Work

The project manager is a key figure for achieving the objectives of a project and hence its success. The project manager has a transversal role within a project. On one hand, the project manager is an expert on deploying planning tools and models. On the other hand, the job of the project manager is to coordinate team members with different professional backgrounds and different objectives. In particular, the project manager has the important role of developing cooperative relationships within the project team. However, the success or failure of a project is not only determined by the performance of the project team, but also by the involvement of top management, functional managers, customers and all the other stakeholders, which is also responsibility of the project manager (Larson and Gray, 2011, p.339).

As a consequence, the role of the project manager requires peculiar characteristics. The project manager has to be *analitic* in order to split the project into working units. The project manager has also to be a *negotiator* able to manage limited resources and time in order to reach the project scope. This professional figure has to instill *confidence* and demonstrate his capability of giving stability to the project. Finally, the project manager has to aim at future milestones in compliance with time and cost constraints (Bove, 2008, p.25).

2.3.1 Management vs Leadership

Ideally, the project manager's job would be to execute the project plan by realizing a schedule, forming the team, monitoring the performance, and taking decisions accordingly. However, all of this is not as simple as it may seem. For example, technical problems may emerge, activities may last longer than planned, and team members may get irritated and become less cooperative. Consequently, the project manager has the core task to get the project back on track for example by accelerating activities, decreasing tensions within the team group and taking decisions by considering project's scope, time and cost constraints (Larson and Gray, 2011, p.339).

Furthermore, the project manager has to cultivate innovation and significantly adapt what has been planned to the constantly evolving circumstances. This is the case of the automotive industry in which the development phase and the production launch phase are soo squeezed in time that crucial design changes may be required even in later stages. For example, when the production of a new automotive product is tested on a new manufacturing line, mass production may require substantial changes of the product and/or the manufacturing process, even towards the end of the project.

In conclusion, the project manager's job consists in pushing the project ahead, while adapting it to necessary changes. Here comes the difference between *management*, which corresponds to dealing with complexity, and *leadership*, which instead corresponds to dealing with changes (Larson and Gray, 2011, p.339). Not all projects need a solid leadership in order to be successful. The more project variables are uncertain, the more leadership is needed for the project success, as in the case of the automotive industry.

2.3.2 Reinforce Team Work

As already mentioned, one of the main tasks of the project manager is to cultivate commitment and confidence within the project team. This is reached through positive and constructive team reinforcement based on feedback on the team acitivites and obtained results, avoiding any kind of intimidation (Bove, 2008, p.109). In this regards, the aim of the work described later in this paper is developing and implementing a tool for monitoring the activities of the implementation phase of a project. This monitor is able to measure the project performance and determine the distance between results and targets. This tool is used to guide weekly team meetings and provide feedbacks on the work done. As a consequence, positive feedbacks encourage the team, whereas negative feedbacks are the base for corrective actions and improvement. Furthermore, this monitor allows to provide to the team members a clear vision of the project with its targets and the direction to take to reach them.

2.3.3 International Teams

The task of managing team work becomes particularly difficult for the project manager in the case of international teams, which are nowadays the most frequent. In fact, projects may be of different types:

- Domestic projects, performed in its native country for a native company;
- Overseas projects, executed in a foreign country for a native company;
- Foreign projects, performed in a foreign country for a foreign company;
- Global projects, which have teams made up of professionals spread in different countries all over the world, as in the case of multinational companies (Larson and Gray, 2011, p.533).

The management of international projects has the additional challenge of having to deal with different environmental backgrounds within the same team. The environmental factors that influence project execution and team work are briefly described below:

- Legal/Political, in terms of political stability and local laws; for example, typical local laws that influence international projects are the ones that protect local workers, suppliers, and environment (Larson and Gray, 2011, p.534);

- Security, such as terrorism, crime, and the ease of commerce across borders (Larson and Gray, 2011, p.535);
- Geography. Special geographical conditions in terms of climate, seasons, altitude, and natural geographical obstacles have to be taken into consideration by managers as they could become a major obstacle to the success of the project (Larson and Gray, 2011, p.536);
- Economic, in terms of GDP (Gross Domestic Product), which indicates the level of development of a country, balance of payments, currency fluctuations, hyperinflation, market size etc.
- Infrastructure, such as communication, transportation, power, technology, and education systems (Larson and Gray, 2011, p.538);
- Culture, in terms of customs, values, techniques, and language.

The case study reported in this paper is an example of a global project, as the design phase of the automotive product was carried out in Asia, the production phase was executed in Italy, and the customers as well the suppliers were also Asian. The most critical environmental factor to this project was culture and as such it is further analyzed in the following paragraph.

2.3.3.1 Cultural issue

As in the case study described as well as in general in international projects, one of the major challenges for the project success is overcoming differences in culture. Such differences may be found in the techniques used (e.g. CPM, risk analysis, trade-off analysis as regards project management techniques) and in the way in which activities are carried out. For example, in the case study in question, many hurdles have been encountered in overcoming a design problem observed during the production test. First of all, it took one hour before the Italian team made the Asian team understand the technical problem. Moreover, the Italian team wanted to tackle the problem on the base of a root cause analysis, while instead the Asian team did not consider this tool the best one to be used on that kind of issues resolution; in fact, the interim solution was a primary concern in comparison with the root cause analisys.

Another critical element when working in a multicultural environment is the language. First of all, when translating something is lost. Furthermore, English cannot always be used as the operating language, especially if a part of the team is in East Asia. In the case study described in this paper, only some Asian team members were able to speak English and this was a major obstacle to communication within the team. Moreover, none of the suppliers was an English speaker and, as a consequence, intermediaries such as managers were necessary, and this slowed things down. Furthermore, in case of need, translation services may also not be available. For example, to overcome this language problem, a dedicated workshop was organised in the Italian plant to which took part the Asian Product Design Team and suppliers representatives. Additional translation services were sought in the region where is located the Italian plant in order to make the workshop more efficient, but no translators specialized in the specific industry sector were found.

During the project in question, the terrific support from intermediaries has been fundamental in order to:

- Focus on the partnership as the key factor for the development success;
- Smooth cultural differences within the international team and establish a common decision making process.

Intermediaries had to be located in the two different locations, in order to follow the centre of gravity of the project.

In conclusion, the role of the project manager in facilitating and encouraging communication and collaboration within an international team is fundamental for international projects success. For instance, with respect to the case study just described, the Italian project manager leads a weekly call of about one hour in which the Italian team and the Asian team communicate major issues to each other and try to find a solution together. The first calls were very inefficient because of cultural problems, with only one or two problems faced each time. However, after a while, with effort and commitment of the two teams and thanks to the coordination and encouragement of the project manager, communication has improved a lot and these calls, which are essential for the project progress, have become very efficient.

2.4 Project Phases and Milestones

A project is structured in four different phases, according to the project life cycle (Figure 2.2), for which a project is limited in duration and the level of effort changes in a foreseeable way during the project existence. The stages of a project, described with more detailed shortly after, are:

- *Definition*. This phase includes definition of project specifications and objectives. The team is put together with the allocation of major responsibilities (Larson and Gray, 2011, p.7).
- *Planning*. The project plan is defined by considering what activities involve, the time constraints, the required level of quality, and the established budget (Larson and Gray, 2011, p.7).
- *Execution*. The project is implemented and is monitored according to specifications, time and cost constraints (Larson and Gray, 2011, p.8). Countermeasures may be implemented if what is monitored does not equal what was planned.
- *Closure*. This phase includes the delivery of the output to the customer; a customer training or documentation release may be provided at this stage. Team members are reallocated to other projects, as well as equipment and other resources. In conclusion, final considerations permit to evaluate performance and reflect on the lessons learned to apply in future projects (Larson and Gray, 2011, p.9).

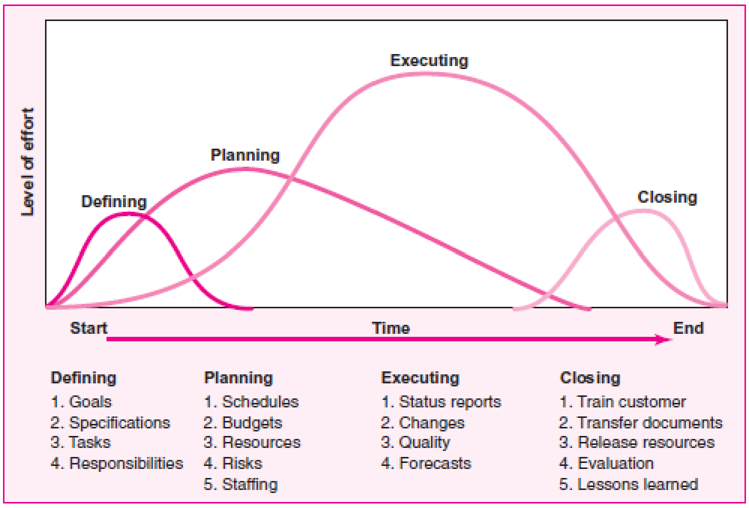


***Figure 2.2**: Generic Project Life Cycle (Larson and Gray, 2011, p.7)*

A project is also divided according to milestones. A milestone is an established moment of the project in which a specific goal has to be reached. Milestones allow to visualize the path of a project and to compare actual results with established targets and hence monitor project progress.

2.4.1 The First Stage: Definition

The defining phase lays the project foundations and involves two main activties. The first activity consists in the transition from the project idea to the structure for its implementation (Bove, 2008, p.35). The project scope, that is what has to be done, is defined and an initial analysis of resources and time constraints is performed. The second activity of the defining stage regards the initial implementation with the first actions taking place (Bove, 2008, p.35). People to involve are choosen, in particular who will be in charge of the leadership and who will be the stakeholders.

The defining phase permits to clarify key elements such as determining if there is an added value and if the project is in line with company strategies. On the basis of this first project management exercise, the feasibility of the project is evaluated, determining the subsequent rejection or acceptance of the project. Three main conditions have to be satisfied in order to launch the project:

1 Obtaining the approval from stakeholders on project objectives;
2 Obtaining the support of management/sponsor;
3 Being able to control the project scope.

Once these three elements have been determined, the framework of the project management is settled.

Within a document called charter, the defining phase output is reported; here scope, objectives, deliverables, resources, and schedules of the project are clearly stated (Bove, 2008, p.38). This document has the aim to inform all stakeholders about the contents of the project. It is also the basis for the next phase of the project life cycle, that is the planning phase.

However, in modern times, the scope phase has been extended by including a wider Engineering feasibility study. In this way, the execution phase can start in advance and with a more robust basis.

2.4.2 The Second Stage: Planning

The output of the planning phase is a map to follow for the execution of all project activites. It is obtained by performing the following analysis:

- List of all tasks and sub-tasks, which are represented within the WBS (Work Breakdown Structure);
- Identification of team members and creation of the project team;
- Development of time;
- Development of budget;
- Risk analysis and subsequent creation of risk management system (discussed in detail in paragraph 2.6);
- Definition of the communication plan addressed to all the stakeholders;
- Project launch meant as the final presentation to all stakeholders, with a guiding document that includes all defining and planning contents for final approval from client/sponsor.

There is not a rule that establishes how much time must be spent on performing the project planning. Usually the planning phase corresponds to 10%-50% of the project life cycle (Bove, 2008, p.38). A well done project planning allows to significally decrease the execution time. Surveys of the last decade have found out that for each hour spent on planning, execution time decreases from 20 to 100 hours (Bove, 2008, p.39).

2.4.3 The Third Stage: Execution

The execution phase of the project life cycle is the phase in which the project plan is implemented. In this phase it is also controlled that activities are in line with the project plan, allowing to make adjustments if necessary (Bove, 2008, p.41). As already mentioned, the heart of this paper concerns the monitor activity of the production launch of an automotive product, which is examined more in depth in paragraph 2.5.

The execution phase is the longest phase of the project life cycle and ends with the achievement of the final objective of the project, the completion of the product or service.

The main activities of this phase are the following:

- Management of the technical part of the project, by monitoring results with respect to specifications and level of progress;

- Communication to all stakeholders of results achieved and project status, according to the communication plan that has been defined in the earlier phase and that states who, what and when communicate project progress;
- Management of costs and time, which are monitored in order to measure performance;
- Monitor and authorization for project changes;
- Risk management, according to the system defined in the planning phase that guides the implementation of focused and controlled actions;
- Management of team performance, by clarifying both team and individual objectives and by measuring relative performance.
- Management of relationship with client/sponsor, with the aim of maintaining reciprocate confidence and sharing deliverables resullts.

2.4.4 The Forth Stage: Closure

The closing phase is the last one of the project life cycle. This stage includes the delivery of the final output with the full acceptation from the client/sponsor (Bove, 2008, p.42).

In this phase are also made considerations on how to improve project management processes towards next projects, the so-called lessons learned. This is also an important part of the case study described in this paper, as it allows to improve the monitor tool that has been developed and to establish it as standard tool within all the organization.

Finally, this phase includes the communication to all stakeholders of obtained results, with direct recognition to the team of the achieved success.

In modern times, the duration of the project phases just described is more fluid than in the past. In fact, the need to reduce the timing, while keeping the required quality of the deliverables, lead to an intense overlap of the phases. This means that a new phase is starting when the previous one is not completely concluded. Therefore, grey zones have to be managed with new processes and tools in order to mitigate risks and reduce the increase of activity loops; Risk Management is the most important tool in this respect.

2.5 Production Readiness: Launch Management

As already anticipated, the heart of this paper is the development and use of a tool that allows to monitor the production launch of an automotive product. As a consequence, this paragraph has the aim to introduce the topic of the measurement and the monitor of results in the execution phase of a project, which is the focus of this work.

Monitoring the performance in the launch phase as well as in all the execution phase is really important in order to ensure that the final deliverable respects quality, time and cost requirements. If the monitor is performed on a regular basis, every warning allows to act in a timely manner in order to bring the project back on track (Bove, 2008, p.221). In particular, by monitoring the performance it is possible to provide a forecast of project's next happenings. The collection of information (e.g. testing data, ramp up data, and KPIs) is now directed to indicate the trends, rather than the project status. The identified trends allow to build new possible scenarios and create road maps both in the medium and long term before the issues arises.

The monitor activity must be focused on six areas in order to measure project progress: *risks*, *scope*, *quality*, *team performance*, *time*, and *budget* (Fig. 2.3). Scope and risks are the areas that usually generate the most frequent changes, which have an impact also on the other areas (Bove, 2008, p.221). For this reason, risk management is analysed in paragraph 2.6.

As regards keeping under control the *duration* of a project, the fundamental approach is monitoring the progress of project tasks and sub-tasks over time. A task is a working unit and has a start and end date; as such, monitoring the duration of a task permits to control the project progress. Besides, splitting a task in sub-levels allows to determine more easily the source of delay and act to speed the task in the right direction. Also milestones helps monitoring the performance relative to time as they are core project moments wih specific numerical objectives to reach.

Instead, as concerns monitoring project *costs*, measuring costs is a particularly critical activity because it involves the measurement of project productivity (Bove, 2008, p225). As a consequence, time and its influence on costs have to be taken into account; for example, costs may increase in the case a project is anticipated in time.

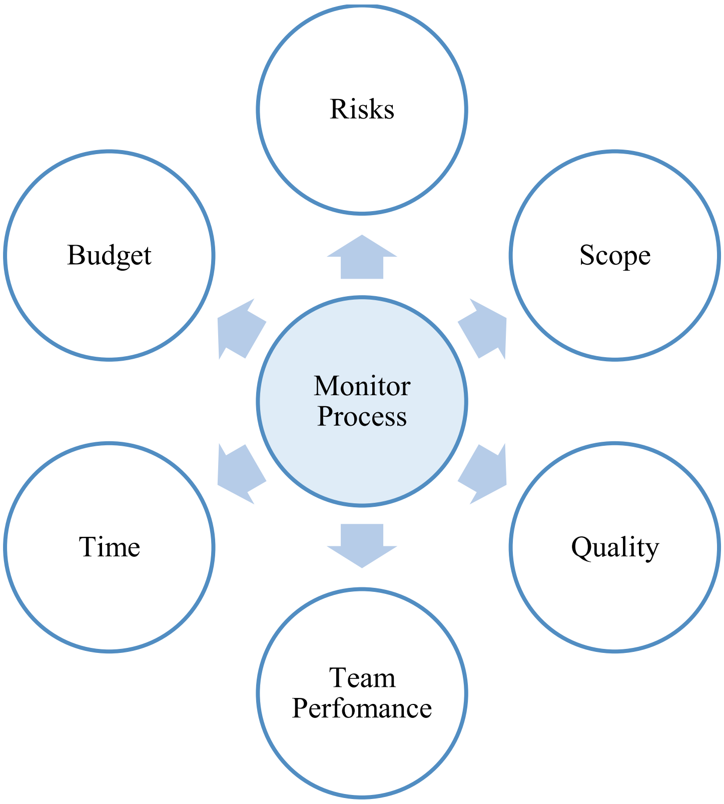


Figure 2.3: Areas for Monitoring Project Progress

2.5.1 Launch Readiness Team Meetings

Team meetings allow to continually measure project progress in order to ensure that it is in line with the target.

The frequency of team meetings depends on the complexity of the project. The project described in this paper had a high level of complexity because a new automotive product was launched in production on a new manufacturing line. In this case, Launch Readiness team meetings of approximately half an hour took place three times per week. In general, it is better to avoid that team meetings last more than half an hour, otherwise working hours of a lot of people are blocked. In the case an issue requires more time to deal with, a dedicated meeting with only directly interested team members is suggested.

Team meetings are joined by team members as well as whoever has been individuated for particular project needs (e.g. an external technician). It is preferable that participants are no more than six people to avoid caotic and endless meetings. The meeting has to be coordinated by the project leader or launch leader; it depends on the organizational structure of the company.

In the case study in this paper, a launch leader collaborated with the project manager in leading the project. The launch leader job was to coordinate the production launch activities of the operative team specifically, whereas the project manager job was more focused on taking care of the relationship with the customer and top management and on coordinating the completion of the tasks that were not completely executed in the previous phase, as above mentioned.

At every meeting, tasks progress must be updated depending on priority. For each task, the progress of the following elements must be tracked:

- Scope,
- Risks,
- Duration,
- Budget,
- Change requests,
- Issues to solve with the creation of an action plan.

A set agenda helps guiding the meeting and avoiding that participants get lost in debates not inherent to the aim of the team meeting. For example, in the case study described in this thesis, the agenda of the Tuesday meeting was to analyse the KPIs of the previous week production. In particular, the meeting was focused on the analysis of the scraps Pareto and the machine downtime Pareto. The Pareto diagram, which is deeply discussed in section 4.3.1.1, indicates the most serious causes of process problems. For each serious cause, the corrective action, the responsible for the action, and the date by which the action has to be performed were established. By continually updating the progress of the activities, the tasks as well as the process problems were monitored.

2.5.2 Status report

The status report is the written document that summarizes the status of advancement of the project (Bove, 2008, p.231). This is of essential importance in the case of complex projects, as for the case study in question.

Having a written document, instead of just oral communication, allows to provide a more precise and syntethic tool that remains, even if requires time to be drawn up. This document has to be simple, so that can be quickly read and understood by all stakeholders, without generating misunderstanding. Further specific documentations, such as on risk management, can be attached for more insights.

In the project described in this work, a weekly report relative to previous week production results was forwarded to all team members and top management. This report included a monitor on KPIs together with appropriate syntetic analysis. These were mainly in graphic format, collected within a powerpoint document. Short and focused comments were added to each slide of the presentation, in order to facilitate the interpretation of graphs.

2.6 Risk Management

As already anticipated, risk management is one of the most important tools in the whole phase of product development and in particular in the production launch. It is the tool that allows to manage the impacts from the many changes that are still introduced during the project implementation and from old issues not solved yet.

Risks are intrinsic to projects. By definition, a risk is an uncertain event that, if occurs, has a positive or negative effect on project goals by impacting cost, time, and quality (Larson and Gray, 2011, p.211). Risk management is particularly important because the cost of a risk event increases rapidly when it occurs in the last phases of the project instead of at the beginning.

Risk management is a proactive method that tries to identify and manage both potential and unexpected (negative) events that may occur during the life of the project. The risk management process, represented in Figure 2.3, is organized in four steps; at each step new risks could appear, bringing the process back to the beginning.

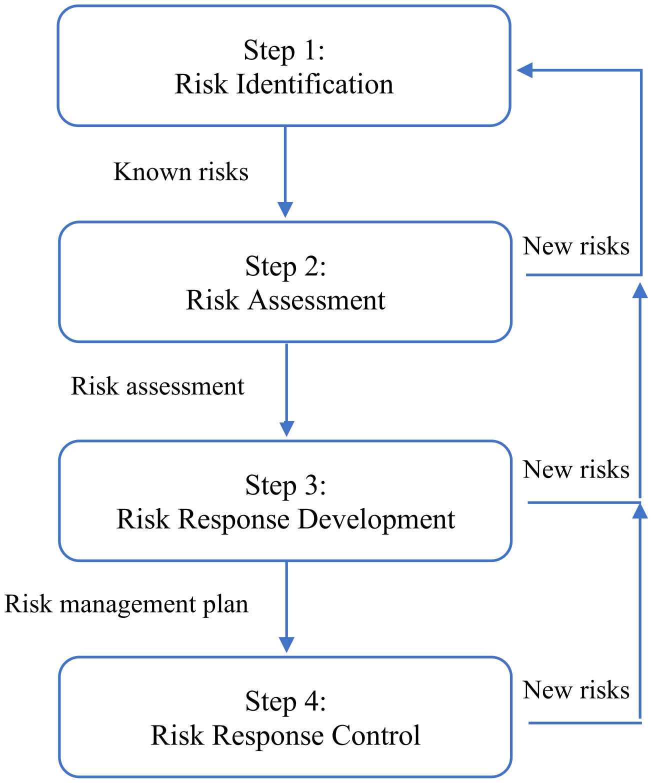


Figure 2.3: *Risk Management Process*

2.6.1 Step 1: Risk Identification

The first step of the risk management process consists in analysing the project and identifying as many risks as possible. In order to carry out this activity, the project manager gathers core team members and other key stakeholders, which through brainstorming and other techniques try to identify potential issues to the project success (Larson and Gray, 2011, p.213). In particular, by involving other key stakeholders such as customers and suppliers, not only an additional perspective on project risks is acquired, but they will be more committed to achieve project objectives.

One common tool used in performing this activity is the risk breakdown structure (RBS), employed in combination with the work breakdown structure (WBS). A generic example of a risk breakdown structure is represented in Figure 2.4, in which risks are grouped in four main categories: *technical*, *external*, *organizational*, and *project management*. In the first place, the team should identify only the risks associated to the project as a whole. It is recommended to focus on specific sections of the project only after having identified macro risks.

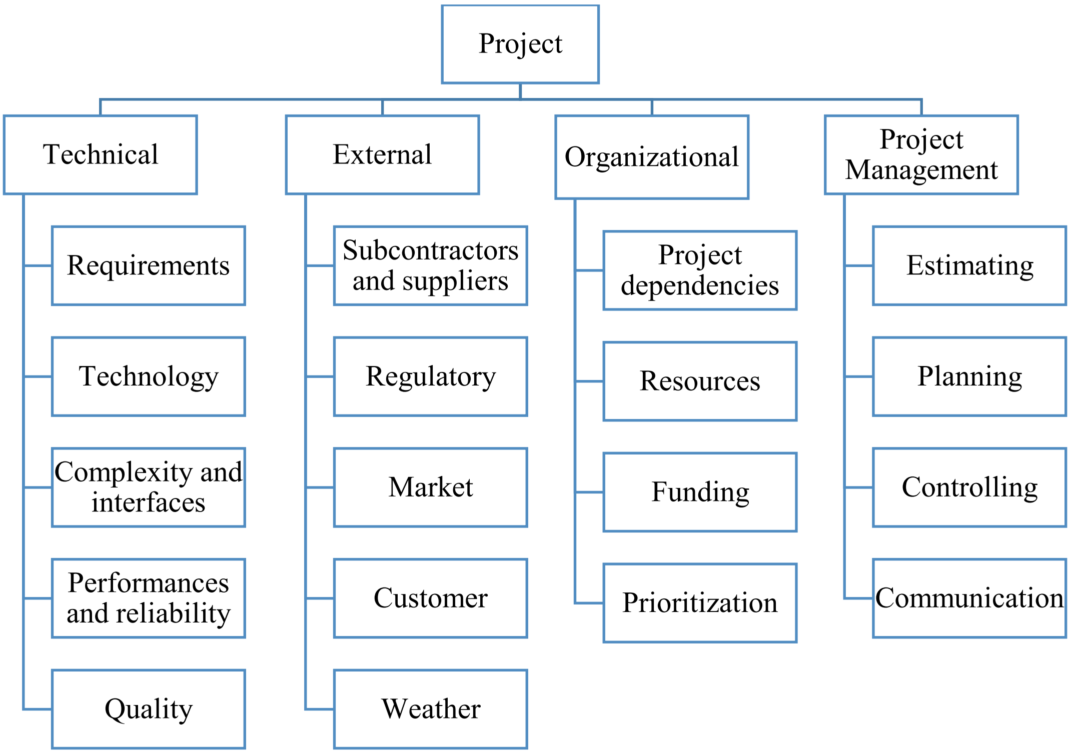


Figure 2.4*: Risk Breakdown Structure (RBS)*

Project managers should urge the risk management team to think critically as the objective of this activity is to take into consideration all potential issues before they occur. This is the attitude necessary to succeed in carrying out this first phase of the risk management process.

2.6.2 Step 2: Risk Assessment

Once all potential risks have been identified, the project manager should guide the risk management team in determining which ones deserve more attention. As a consequence, the second step of the risk management process, called also the scenario analysis, consists in assessing each risk by considering:

- *Severity of impact;*
- *Likelihood of occurrence;*
- *Controllability.*

The project manager has to determine the scale of severity of impact, likelihood and controllability of a risk event on the basis of the type of project and its needs. For example, the scale of *likelihood of occurrence* may be qualitative, ranging from "very unlikely" to "almost certainly", or quantitative, using instead probabilities (e.g. 0.1, 0.5…). More complicated is the definition of *impact* scales as risks events could have different effects on the project objectives in terms of cost, time and quality. As a result, it is important to first set a priority among these three critical project variables. Impact scales may be as well qualitative, ranging from "very low" to "very high", or quantitative, using numeric weights (e.g. from 1 to 10). The last variable taken into consideration when assessing risks is *controllability*, which is the ease in detecting the occurrence of the risk event. The scales used have to be clearly defined so that all the risk management team is aligned in assessing risks events in the same way.

For example, in the case of the project described in this paper, the risk of not meeting customer demand was identified. This because the manufacturing line would not have been ready at 100% at start of production, with the risk of having a too long cycle time. As a consequence, the *probability* of not meeting customer demand was very high as it was tied to the occurence of a longer machine downtime or a higher scrap rate, which had a very high probability to arise at that critical stage of the project. The *impact* of this risk was also very high, as it would have affect time, which was considered the most important of the project variables. Finally, the difficulty in *detecting* the risk occurence was medium, because, even if cycle time would have been quite variable due to changes for manufacturing line improvement, it was quite easy to monitor cycle time according to the following formula:

$$Cycle\ Time\ [s/parts] = \frac{Net\ Available\ Time\ [s]}{N°\ Parts\ OK}$$

$$Net\ Available\ Time = Available\ Time - Planned\ Downtime$$

$$N°\ Parts\ OK = Total\ Parts\ Run - Scrap$$

Figure 2.5 represents a typical risk assessment form of the example just described.

RISK EVENT	**LIKELIHOOD** (from 1 = "very low" to 5 = "very high")	**IMPACT** (from 1= "very low" to 5 = "very high")	**CONTROLLABILITY** (from 1= "lots of time to react" to 5 = "no warning")
Not meeting demand.	5	5	3

Figure 2.5: *Scenario Analysis*

Another common tool used by organizations is the risk assessment matrix (Figure 2.6), which allows to prioritize risks. By combining the *likelihood of occurrence* and the *impact* of risks, this matrix organizes the assessed risks in three different areas:

- Green area, which includes minor risks, with low likelihood and low impact, and hence risks that can be ignored;
- Yellow area, which includes moderate risks, with medium likelihood and medium impact, and hence medium priority;
- Red area, which includes major risks, with high impact and high likelihood, and hence high priority.

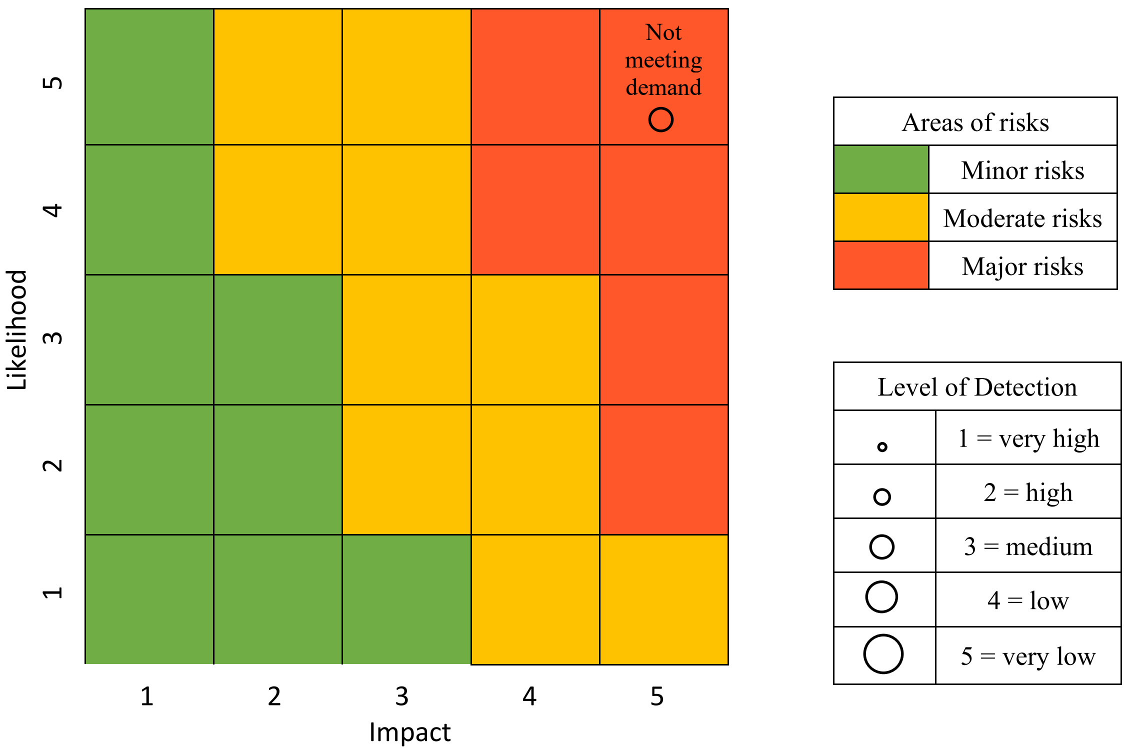


Figure 2.6: *Risk Assessment Matrix (FMEA)*

The risk assessment matrix can be integrated by taking into consideration also the level of *detection* of the risk, as done by the FMEA (Failure Mode and Effects Analysis). In Figure 2.6, the level of detection is represented by a circle, which becomes bigger as the ease of detection decreases, according to the legend.

2.6.3 Step 3: Risk Response Development

The third step of the risk management process consists in determining the most suitable response to the specific risk event that has just been assessed. Risk responses can be of four different types: *mitigating*, *avoiding*, *transferring*, or *retaining* (Larson and Gray, 2011, p.219).

- *Mitigating* risk is usually the first type of response addressed. A risk can be reduced in two ways: or by reducing the probability of the event to occur either reducing the event effect. It is preferable to apply the first strategy as it is usually less expensive. In the case of the project of this report, the first mitigating response would have been focusing on cycle time reduction, the root cause of the risk event.
- Another type of response could be *avoiding* risk by modifying the project plan, which in the reported example could have been doing two shifts per day instead of just one.
- *Transferring* risks to another party is also a common strategy. However, this type of response does not change risk and usually causes a premium to pay.
- Finally, a *retaining* response may be adopted, for which the risk occurence is just accepted for example because the probability of occurence is very very low.

As a consequence, a contingency plan is developed so that can be executed in the case of risk occurence. Thanks to this structured approach, it is possible to better control the project without big surprises.

2.6.4 Step 4: Risk Response Control

The forth step of the risk management process, that is the risk response control, involves the following three activities:

- Implementation of the risk strategy;
- Monitor and adaptation of the plan for new risks;
- Change management to handle such events that need formal alteration of the scope, budget, and schedule of the project (Larson and Gray, 2011, p.229).

It is essential that the team members are active participants in the process of monitoring the risk strategy implementation and the rise of new risks. The project manager should urge the team to express their concerns without the fear of being blamed. To this end, the project manager should establish an environment in which mistakes are accpted, whereas covering mistakes is not. The project manager should also have a positive attitude towards facing risks and transmit it to the team.

2.7 Agile Project Management

At the threshold of the new millennium, Agile Project Management (Agile PM) was introduced because of the need of more flexibility and ability to manage changes. Agile PM is based on incremental and iterative development cycles to accomplish projects and is adopted by those projects in which the product evolves over time, such in the case of the automotive industry (Larson and Gray, 2011, p.583).

In this paragraph the principles of Agile PM are explained and contrasted with traditional project management. Then the most popular Agile method, Scrum, is described.

2.7.1 Traditional vs Agile Project Management

Traditional project management methods are based on a solid planning. This approach demands a high level of predictability in order to be effective (Larson and Gray, 2011, p.584). However, not all project benefits of a high degree of certainty, particularly in the case in which project *scope* and/or *technology* are not well established during the life of the project. This led to the introduction of Agile methods.

For example, software development projects usually have many customers with different requirements. Customers needs are likely to be undefined and vary during the life of the project. As a result, developing a list of *scope requirements* before the execution phase of the project would be pointless.

Also *technology* can be a critical element for project planning if the technology to be used is not well established. For example, in the case of a product development project, such as the one described in this paper, it can be very difficult to plan a reliable schedule when technological challenges have to be undertaken.

The table in Figure 2.6 summarizes the main differences between traditional and Agile Project Management.

Traditional	Agile
High predictability	Low predictability
Defined scope	Undefined scope
Deliverables	Requirements
Fixed design	Evolving design
Avoid change	Deal with change
Distant customer relationship	Close costumer relationship
Conventional teams	Self-organized teams

***Figure 2.6**: Main Differences between Traditional and Agile Project Management (Larson and Gray, 2011, p.585)*

2.7.2 Agile PM

As already mentioned, Agile PM is based on iterative and incremenental product development. Iterations are short periods of time that usually last from one to four weeks (Larson and Gray, 2011, p.585). The output of each iteration, which is an expanded and improved version of the product, is compared with customer requirements and organizational objectives. Adjustments are made on the basis of shareholders and customers review, with the beginning of a new iteration.

The principles of Agile PM are the following:

- Focus on customer value by giving priority to customer requirements;
- Iterative and incremental delivery to customer;
- Experimentation and adaptation based on customer feedback;
- Self-organized team;
- Continuous improvement, through team reflection, lesson learned and adaptation to change.

In particular, the self-organized team is able to identify among themselves which activities need to be done and who is the responsible for its execution. There are not appointed roles, and team members assume different responsibilities as required by the project. As a consequence, the Project Manager is no more the leader of the team. The Project Manager supports the project management process, removes obstacles for the project successful execution and is the bridge between the team and outside interference (Larson and Gray, 2011, p.590).

Agile PM includes different methods for facing unpredictable projects. Among the most popular methods there is Scrum, which is explained below.

2.7.3 Scrum

According to Scrum method, the project management process starts with a broad definition of the scope and an approximate estimation of time and budget (Larson and Gray, 2011, p.588). Deliverables are set by product features, meant as functional elements of a product, rather than by product WBS. The project team together with the product owner, who represents customers interests, prioritize the features and focus first on the features with the highest value and greatest feasibility. At the beginning of each iteration, priorities are re-established according to results.

Each iteration is carried out according to four distinct stages:

- Analysis of functional requirements to realize the feature;
- Development of a design that satisfies requirements;
- Build the feature;
- Test of the feature functionality.

At the end of each iteration, features are demonstrated to customers and stakeholders.

2.7.3.1 Scrum Meetings

Meetings are considered key moments in order to manage project activities. These are of different types: *sprint planning, scrum, sprint review,* and *sprint retrospective.*

At the beginning of each iteration, the product owner and the team agree on the features to accomplish in the current iteration. This meeting is called *sprint planning*. The feature must have an estimated execution time of maximum four weeks, as it has to be accomplished within the iteration (Larson and Gray, 2011, p.590). If this is not possible, then the feature is divided into sub-elements. A product backlog gathers together all committed features. Activities to be done and responsibles are determined by the team on the basis of the product backlog and are recorded in a sprint backlog. Once the meeting is ended, the established objectives cannot be modified anymore.

Daily meetings, called *Scrum*, are fundamental in order to monitor the advancement of an Agile project. Scrum takes place every day at the same hour and location. Scrum consists in team members answering in turn to the following important questions:

- Which activities have you performed since the last Scrum?
- Which activities are you going to perform before the next Scrum?
- Are there obstacles that prevent you from working effectively? If yes, which are they?

The Scrum should last 15 minutes and should take place in front of a board, where tasks as well as blocks are registered and updated. In this way the team is quickly informed about the project advancement. In the case the three questions above arise issues, these are treated in dedicated meetings were only interested team members participates.

At the end of each iteration, a *sprint review* takes place, during which the output of the iteration is presented to key stakeholders. A dialogue between team members and key stakeholders is an opportunity to evolve the product concept and redefine requirements (Larson and Gray, 2011, p.591).

Finally, the *sprint retrospective*, which is supported by the scrum master (the project manager), has the aim of identifying improvement actions to apply on the next project iteration in order to work more effectively.

3 Project Management and Launch Management applied to the Case Study

After a general excursus about Project Management, an application to a real case study is provided in this Chapter. The first paragraph illustrates the Product Development and Delivery System in the organization of the case study. This establishes phases and tasks for Forward Models' projects. Secondly, the tool that supports Project Management within all the organization, which is enterProj, is illustrated. In particular, it is provided an overview of the organizational standard approach for dealing with Risks, Issues and Opportunities (RIO), fundamental during Production Launches. Follows a focus on the section of enterProj dedicated to Launch Readiness Review. In this regard, considerations are made in order to develop a complementary tool for supporting Launch Readiness Review. This is the core work of this paper and is described in Chapter 4.

3.1 Product Development and Delivery System in the Case Study

In the case study, the Product Development and Delivery System regulates projects as regards Forward Models. Other systems are in place for Current Models.

According to the Product Development and Delivery System, the project is divided into eight main phases:

1. *Business Planning.* This phase is based on corporate strategy. Its main activities are business plan set-up and business development.
2. *Customer Quote.* This phase starts with the receipt of a Customer Request For Quote (CRQ) or Request For Information (RIF). Follows the Approval to Pursue Quote, which is considered as *Gate 0*. *Gate 1* consists in the Executive Quote Approval. The phase ends with the Quote Response to Customer. This includes all negotiations about changes to product, manufacturing and other requirements.
3. *Award and Planning.* This phase is based on the Customer Purchase Order (PO) or Commitment of Business. It ends with Executive Funding Approval, which constitutes *Gate 2*. In this phase, project team kick-off takes place. Besides, the team reviews all

further changes introduced, project timing plan, investment and resources required to support the project.

4. *Sample Delivery.* This phase consists in the sotware development process to guarantee quality for products that have internally developed embedded systems. In particular, this phase is articulated in the following activities: planning sample delivery, defining product requirements and architecture, development of software, mechanical, and hardware, BOM definition, procurement and prototypes, validation, and, in the end, release and delivery.
5. *Development*. This phase consists in the development of product design as well as of the production manufacturing process. The Launch Readiness Review (LRR) process plan is established. The Development phase ends with a phase review, which constitutes *Gate 3*.
6. *Pilot.* In this phase, the development of product design as well as the manufacturing process is completed and validated to ensure ability to produce at production rates while meeting specifications. Production Part Approval Process (PPAP) is completed. The team prepares plans for activities to support launch. Towards the end of this phase, the Executive Pilot Phase Review consitutes *Gate 4*.
7. *Launch.* This phase is intended to ensure readiness for full production. The full compliment of tooling and equipment is in place and validated. The product design should be stable, except for changes due to PV test issues or Customer request. Production starts with ramp up towards full production rates. *Site Launch Readiness Review* is carried out together with Run at Rate. The Launch phase ends with *Gate 5* Phase Rewiew.
8. *Post Launch.* This is a transitional phase for the project from Forward Model to Current Model. It ends with the Executive Post-Launch Review *(Gate 6)* and transfer of project to Current Model within enterProj.

Each phase is then organized in tasks according to the Product Development and Delivery System. An example of a task is the *Site Launch Readiness Review*, which is the core activity of this work and, as already mentioned, is described in Chapter 4. The *Site Launch Readiness Review* is a process to evaluate the manufacturing location's level of preparation to Customer Launch event. This task is carried out by the *Launch Leader*, who is responsible for doing weekly reviews on the project status, producing reports, addressing risks/issues etc. Depending on the needs, the *Launch Leader* may be the Program Manager or a dedicated staff resource. This assessment is done at several points close to Start of Production (SOP). It is recommended to do three different assessments during three different phases: Development, Pilot and Launch. The inputs and the outputs of the task at each phase are different, as illustrated in the table in Figure 3.1.

Site Launch Readiness Review		
Phases	Inputs	Outputs
Development	Design FMEA Manufacturing Assumptions Manufacturing Feasibility Process FMEA Process Flow Project Timing Plan Test/Validate	Launch Champions identified LRR sections (10) assigned responsibility in enterProj LRR checkpoints dates Launch Readiness Review Plant tab Customer Launch Readiness Review
Pilot	Manufacturing Feasibility Manufacturing Process Audit Process FMEA Process Flow Project Timing Plan Run at Rate Test/Validate	Launch Readiness Review Plant tab Customer Launch Readiness Review
Launch	Manufacturing Feasibility Process FMEA Process Flow Project Timing Plan Run at Rate	Launch Readiness Review Plant tab Customer Launch Readiness Review

Figure 3.1: *Inputs and Outputs of Site Launch Readiness Review in Development, Pilot and Launch phases*

Enterproj is the tool that supports the execution of tasks within a project phase. In particular, in the case of *Site Launch Readiness Review*, a Checklist is included within enterProj in order to ensure a flawless launch. The next section provides an overview of the enterProj tool; afterwards, a paragraph is dedicated to the *Launch Readiness Checklist*.

3.2 Enterproj tool

EnterProj is a cloud based enterprise business management system (NGS, 2019a). It allows to integrate cross functional capabilities that are usually managed in separate tools. Besides, it enables to share key information and ensure performance transparency. Consequently, enterProj facilitates global collaboration within the organization and, therefore, improves speed to market (NGS, 2019b). In particular, enterProj is fully integrated with Enterprise Financial Management, allowing real time understanfing of business. The different modules that are included within enterProj are represented in Figure 3.2.

Figure 3.2: *Modules of enterProj (NGS, 2019b)*

Project Portfolio Management is the most important module of enterProj. This module includes all key information on all company's projects (NGS, 2019b). Consequently, it favorites team collaboration and management of timing, issues, documents, equipment etc. In particular, through gateway reviews, the module allows to instant executive review of all crucial project information.

The most important elements of the *Project Portfolio Management* are illustrated in the sections below. Special reference is done to those elements that supports the management of Launch Readiness Review.

3.2.1 Project Portfolio Management: Dashboard

Within the *Project Portofolio Management* module, a Dashboard summarizes document approvals and assignments for the specific user. The Dashboard provides real time status about tasks, action items, Risks/Issues/Opportunities (RIOs), documents and reports, giving quick access to work items. Besides, notifications and alerts allow to keep the specific team member on track.

For example, on the Dashboard is present the box shown in Figure 3.3. This indicates to the specific team member how many tasks she/he has to do, how many of these tasks are on time, how many are due today, and how many are overdue. The box provides links to get direct access to the tasks.

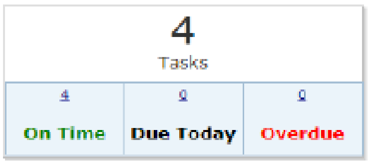


Figure 3.3: *Tasks Box within enterProj Dashboard*

3.2.2 Project Portfolio Management: Project Tab

Within the *Project Portofolio Management* module, the specific team member can have access to key information about the projects to whom she/he belongs to. Project information is organized into different tabs.

The first and introductive tab is the *Project* tab. This provides general information about the project such as project title, project description, project leader, SOE (Start Of Engineering), SOP (Start Of Production), EOP (End of Production) etc.

In particular, the *Project* tab shows the *Measurables* of the project. These are subjective evaluations of critical project attributes that are updated by the Project Leader. The measurables considered are the following ones:

- *Overall*, which defines the Project health as a whole;
- *Financials*, which assesses Project Financial health;
- *Prototype Design*, which evaluates Prototype Design completion and success;
- *SW and Requirements ,* which assesses software requirements completion and success;
- *DV Testing*, which defines DV test level of completion and success;
- *Production Design*, which regards the assessment of production part design completion and success;
- *PV Testing*, which is the assessment of PV test completion and success;
- *Manufacturing Readiness,* which evaluate manufacturing equipment, tooling and Launch Readiness;
- *Supplier Readiness,* which assesses supplier status to requirements completion and Launch Readiness;
- *Quality*, which is the assessment of prototype, pre-launch, and production product performance.

The evaluation of each measurable is represented by an arrow according to the legend in Figure 3.4. In particular, the color of the arrow indicates the status of the critical project attribute, whereas the direction of the arrow indicates the trend of the status.

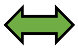
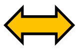
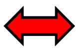
Type of Arrow	Description
	Objectives are being met, risk is minimal to none.
	Objectives are not being met, mitigation plans are in place with confidence of success. Risk is minimal to moderate. Performance is improving.
	Objectives are not being met, mitigation plans are in place with confidence of success. Risk is minimal to moderate. Performance is stable.
	Objectives are not being met, mitigation plans are in place with confidence of success. Risk is minimal to moderate. Performance is deteriorating.
	Objectives are not being met, mitigation plans may not exist or there is little confidence of success. Risk is moderate to high.

Figure 3.4: *Legend to Evaluate Project Measurables Using Arrows*

Measurables allow to acquire the actual status of the project at the first glance. In particular, attention is drawn on those measurables that are more at risk, thanks to the red colour. For each measurable, further notes are added by the Project Leader in order to provide more insight on the evaluation.

Here considerations are made concerning the core work of this paper. This is the development of a system of KPIs to analyze project status during Production Launch, with the purpose of effectively guide activities day after day. In this case, measurables could be no more than the output of this work, in other words its final summary.

3.2.3 Project Portfolio Management: Task Timing Tab

Within the *Task Timing* Tab, enterProj allows to build a costumer/product- specific project plan. Consequently, enterProj provides a flexible tool for timing planning.

Once a phase has been built, the *Project Leader* can select the tasks from a standard list on the basis of project requirements. For each task, the *Project Leader* establishes the due date, the duration, and the responsible team member.

Within the *Task Timing* Tab, the *Phase* View shows the project by phases, as represented in Figure 3.5. Here sensible information are omitted in order to be compliant with the privacy policy of the company. A generic example is provided instead.

Project | Team | Task Timing | R I O | Plants | Parts | F & T | Suppliers | Docs | TGR/TGW | PIC Log | eFIN

Dashboard | Phase View | Timing View | GANTT View | Tasks View | Structured View | Quick Edit | Calendar View | Report | Print GANTT

Deleted Phase(s) HPDS 1.0 HMG **Active** Phases for Project » [redacted]

Seq	Template Phase	Phase Desc	Start Date	Planned End Date	Forecast End Date	Actual End Date	% Complete (Actual / Planned)	Progress	Tasks
	Development	Gate-3, Development Phase	2019/05/21	2019/06/26	2019/11/29		92 / 98		50
	Pilot	[redacted] Pilot		2020/02/25	2020/03/17		0 / 0		42
	Launch	[redacted] Launch		2020/04/28	2020/05/05		0 / 0		25

Figure 3.5: *Generic Example of a Phase View Within Enterproj*

In particular, the *Phase* View allows to quickly get the level of progress of a specific phase, such as the Development phase. For example, in Figure 3.5, the Development phase has 92 tasks completed against 98 tasks planned.

Figure 3.5 shows that other phases have been planned, besides the Development phase, which are the Pilot and Launch phases Stricly monitoring the progress of these three phases is fundamental in order to ensure a flawless launch. Another important view within the *Task Timing* Tab is the *Tasks* View, which shows the tasks associated with the project such as the *Site Launch Readiness Review*. Again, a generic example is provided in Figure 3.6, where sensible information has been omitted in order to be compliant with the privacy policy of the organization.

Task	Parent	Responsible	Start Date	End Date	Duration	Estimated Completion Date	Actual Completion Date	Status	Actions (Closed / Total)	Docs (Attach / Links)
Design Freeze		[redacted]	2019/05/21	2019/06/12	23	2019/07/31			0/1	0/0
EDI Orders and Set-up			2019/05/21	2019/06/12	23		2019/05/31		3/3	0/0
Engineering Resources			2019/05/21	2019/06/12	23	2019/06/25	2019/06/12		1/1	2/0
Environmental Health and Safety Sign Off			2019/05/21	2019/06/12	23		2019/06/26		1/1	3/0

Figure 3.6: *Generic Example of a Tasks View Within Enterproj*

In particular, in order to quickly get the task status, thisis represented graphically by an indicator. The level of completeness of the task is determined by the task responsible, according to the legend in Figure 3.7.

Type of Circle	Description
	0% work done
	25% work done
	50% work done
	100% work done
	Task completed

Figure 3.7: *Indicators of Level of Completeness of Tasks*

Instead, the color of the indicators represents whether the task is carried out on time or not, as illustrated in Figure 3.8.

Indicator color	Description
Green	Task is projected to be completed by due date.
Yellow	Task is projected to be completed on delay. Estimated completion date is later than due date.
Red	Task will be completed late. Current date is later than due date.

Figure 3.8: *Level of Colors of Task Indicators.*

In the end, in the case a conflict between dates arises, the Critical Path warning icon (Figure 3.9) will alert team members.

Figure 3.9: *Critical Path Warning Icon.*

With reference to the case study, here the Project Manager can quickly get the progress of the tasks that are key to a flawless launch, starting from *Site Launch Readiness Review*.

3.2.4 Project Portofolio Management: Risks, Issues, and Opportunities (RIO)

Another important area of Program Management and Launch Management is the management of Risks, Issues and Opportunities (RIO). Here is provided a general overview of its application within the organization of the case study

Within the Project Portofolio Management module in enterProj, the *RIO* tab is a section in which whatever team member can open, update and close a Risk, an Issue or an Opportunity. These differ from tasks because they are unplanned items. Through the *RIO* tab within enterProj, RIO items are shared with all team members in a dedicated section. For example, in the *List* view within the RIO tab, Risks, Issues and Opportunities are listed as represented in Figure 3.10. Here sensible information are omitted in order to be compliant with the privacy policy of the company.

Type	#	Title	Responsible	Group	Opened Date	Due Date	Magnitude	Status	Actions (Closed / Total)	Docs (Attach / Links)
R	1	[redacted]	[redacted]		2019/11/19	2020/01/17	Medium		1/1	1/0
R	2	[redacted]	[redacted]		2019/11/19	2020/01/24	High		1/1	0/0

Figure 3.10*: List view within the RIO tab within enterProj.*

The item is described in a few words in the “Title” column. The responsible team member is indicated as well in the apposite column. The date in which the item was opened is reported, together with the due date for the resolution of the Risk, the Issue or the Opportunity.

In particular, the item responsible establishes the magnitude of the RIO through the Magnitude Assessment Matrix represented in Figure 3.11. According to this matrix, for example, if an item has a high impact rating, but a low probability of occurrence, then the magnitude of the item is medium. This matrix is similar to the Risk Assessment Matrix already illustrated in Figure 2.6 within the paragraph about Risk Management.

Impact Rating

High	Medium	High	High
Medium	Medium	Medium	High
Low	Low	Low	Medium
	Low	Medium	High

Probability of Occurence

Figure 3.11: *Magnitude Assessment Matrix*

EnterProj allows to develop for each RIO multiple action plans in order to assign to the appropriate team members the actions needed to close the specific item.

In conclusion, the List view of the RIO tab within enterProj provides all the key information about the opened RIOs of a project, besides giving easy access to edit information. It is a user-friendly tool in order to share RIOs and action plans to solve Risks and Issues and take advantage of Opportunities.

EnterProj has the functionality of producing reports that can be customized according to the specific stakeholder. For example, in the case study a review with the Management Board takes place on a monthly basis. During these reviews, all programs of the plant are reviewed in one hour. The focus are on those programs that are in the Launch phase. In this case, a report showing RIOs with the following characteristics could be very useful in order to focus the attention only on the most important topics of a specific program:

- Only open items;
- Only items with red status;
- Only items with high magnitude;
- Only items with high priority.

However, the tool that specifically supports the Launch Readiness Review within Enterproj is included in the *Plant* tab. This tool is called the Launch Readiness Checklist, and is deeply illustrated in the next paragraph.

3.3 Production Readiness: Launch Readiness Checklist

Launch Readiness consists in effectively planning and implementing the introduction of a product or a process into a plant. It ensures satisfaction of all Customer delivery milestones, quality requirements, and internal financial objectives.

Four main steps ensure Launch Readiness:

- *Plan*, which consists in preparing the site and the team for events to effectively perform launch activities;
- *Do,* which consists in managing and performing all required activities to ensure effective plant performance;
- *Check,* which consists in assessing level of site readiness to Production Launch. This activity is the core work of this paper and is deeply illustrated in Chapter 4.
- *Adjust,* which consists in putting in place quick countermeasures in the case problems arise.

3.3.1 Launch Readiness Checklist's categories

As already mentioned in paragraph 3.1, the *Product Development and Delivery System*, within the *Site Launch Readiness* task, defines the activities to carry out to ensure a flawless Product or Process Launch. In particular, Launch Readiness is assessed by following a standard *Checklist* process based on ten macro areas, which are called *Categories or Elements*. Through the completion of all questions within the Checklist, it is ensured that all fundamental items are taken into consideration and monitored for Launch Readiness. These ten Categories are briefly described below:

1. *Product Maturity*. Proves design readiness, current release level, identifies pending changes or feasibility issues, manages corrective actions, quality concerns, validates service BOM is released.
2. *Tooling, Facilities and Equipment Readiness*. Proves tools are complete and meet design requirements, facilities are ready to receive equipment, and equipment meets design and capability targets.

3. *Production Process Readiness.* Proves all process elements are ready to produce the product, such as process feasibility, lot control, PFMEA, non-conforming material control at station etc.
4. *Production Capacity Confirmation.* Proves all machine loads satisfactory to meet production requirements. Manages structured OEE maturation to program targets. Confirmed ability to meet delivery and ramp requirements.
5. *Measurement, Testing and Inspection*. Proves all online and offline gages are in place. All equipment is verified capable, calibrated and operators instructed.
6. *Materials and Supply Readiness.* Proves quality and quantities of suppliers' components, material delivery requirements into Plant are understood and met for pre-production and ramp. Verifies completion of all material validations and approval of part packaging.
7. *MP&L, Logistics and IT Readiness.* Proves efficient and lean material flow, FIFO maintained, part protection in process, end-item packaging, inventory targets set and met, future capacity plan established, shipping/receiving logistics defined, and IT/EDI requirements satisfied by implemented system.
8. *Personnel and Training Readiness.* Proves all manpower are hired and trained, in particular ensures that special launch support is in place.
9. *Quality System Readiness.* Proves Plant Quality Operating System is in place and product area is integrated.
10. *PSW Readiness.* Proves all customer approvals and documentation are in place.

3.3.2 How the Project Team is involvedin Launch Readiness

Regular assessments allow to monitor the status of activities and hence identify potential issues to Launch Readiness. Launch Readiness Checklist is usually filled three times during the life of the project, near crucial meetings and milestones. This is at the discretion of the Project Leader. However, it is recommended to perform the Launch Readiness assessment during the Development, the Pilot, and the Launch phases.Launch Readiness Checklist is filled internally by team members. To facilitate the completion of the Checklist, this is included within enterProj. EnterProj also allows to easily share the content of the Checklist among all team members. The *Launch Leader* has to assign to each Launch Readiness Category a team member responsible for its completion, who becomes the *Element Champion*. The Element Champion is the functional leader that oversees his/her element to ensure a flawless launch. In particular, the Element Champion has the task to assign each question of its element to the appropriate team member. The main members of a Launch team are illustrated in the table in Figure 3.12. Here it is illustrated how the Launch Leader has assigned the Element Champions in the case study.

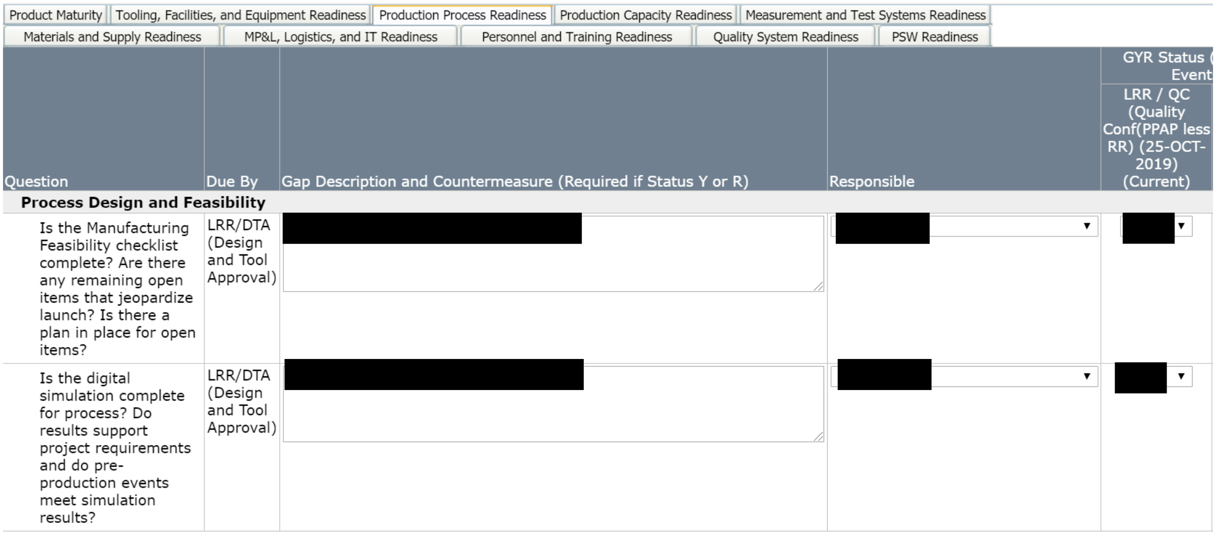
Launch Team Member	**Responsibilities**	**Checklist Category**
Project Leader	Identifies Site Launch Leader and ensures Site LRR execution.	x
Site Launch Leader	Manages Site Launch Readiness Review completion. Identifies RIOs and countermeasures generated from LRR.	x
Manufacturing Engineer	Proves manufacturing readiness, process capability and ongoing product and process performance.	Production Process Readiness
		Production Capacity Readiness
		Tooling, Facilities and Equipment Readiness
PD Engineer	Proves product design testing completion and controls upcoming design changes.	Product Maturity
Purchasing	Deals with critical suppliers and supply chain readiness.	x
SQE (Supplier Quality Engineer)	Proves supply chain Launch Readiness, completion of suppliers PPAPs etc.	Materials and Supply Readiness
EDI Leader	Proves ERP system readiness.	x
MP&L	Deals with material flow, incoming material, handling, FIFO labeling, packaging and inventory readiness.	MP&L, Logistics and IT Readiness
Quality	Deals with Quality System, gauging, testing, measurement, non-conforming material control etc.	Quality System Readiness
		PSW Readiness
		Measurement and Test System Readiness
HR	Proves manpower plannin, hiring and training readiness.	Personnel and Training Readiness

Figure 3.12: *Launch Team Members assigned to the appropriate LRR Checklist Category*

For example, in the case study, the Launch Leader identified the Element Champion of the category "Production Process Readiness" into the Manufacturing Engineer. In turn, the Manufacturing Engineer identified for each item of the category "Production Process Readiness" the responsible team member. Sometimes the question owner was himself, other times it was another team member.

3.3.3 How Launch Readiness is established

To explain how the Launch Readiness Checklist is completed in enterProj, a screenshot is provided in Figure 3.13. In this case, sensitive information is omitted in order to be compliant with the privacy policy of the company.



Product Maturity | Tooling, Facilities, and Equipment Readiness | Production Process Readiness | Production Capacity Readiness | Measurement and Test Systems Readiness
Materials and Supply Readiness | MP&L, Logistics, and IT Readiness | Personnel and Training Readiness | Quality System Readiness | PSW Readiness

Question	Due By	Gap Description and Countermeasure (Required if Status Y or R)	Responsible	GYR Status (Event LRR / QC (Quality Conf(PPAP less RR) (25-OCT-2019) (Current)
Process Design and Feasibility				
Is the Manufacturing Feasibility checklist complete? Are there any remaining open items that jeopardize launch? Is there a plan in place for open items?	LRR/DTA (Design and Tool Approval)	[redacted]	[redacted]	[redacted]
Is the digital simulation complete for process? Do results support project requirements and do pre-production events meet simulation results?	LRR/DTA (Design and Tool Approval)	[redacted]	[redacted]	[redacted]

Figure 3.13: *Screenshot of the Launch Readiness Checklist in Enterproj*

First, questions are standard. An example of question, shown in Figure 3.13, is "Is the Manufacturing Feasibility checklist complete? Are there any remaining open items that jeopardize launch? Is there a plan in place for open items?"

Besides, questions are grouped according to the LR Checklist Categories. In Figure 3.11 the category shown is the "Production Process Readiness".

For each question, it is indicated by when it is due, according to the key generic milestones for Launch illustrated just below:

- *PT,* which corresponds to the first event with Production level Tooling;

- *DTA*, Design and Tool Approval;
- *PP,* which consists in first trial of Production Process equipment;
- *QC,* which corresponds to the Qualification of the process, which is PSW/PPAP less RR;
- *RR,* Run-at-Rate event to prove the ability to meet capacity;
- *SOP,* Start Of mass Production;
- *SOP+90,* which corresponds to an assessment 90 days after mass production begins.

The team member responsible for the completion of the specific item is indicated as well, as established by the Element Champion. The question owner has to evaluate the applicability of the activity and, in the case it is applicable, its status. In the column called GYR (Green, Yellow and Red) status, the question owner has to assess the status of the item according to the following guidelines:

- *Green*, in the case the activity is on schedule and has low risk;
- *Yellow*, in the case the activity is behind schedule, but a concurred recovery plan is in place. Risk is medium;
- *Red*, in the case the activity is behind schedule, and no recovery plan is in place. Risk is high;
- *Blue*, when the activity is complete.

For each question, a box allows for further comments on the status of the item. In particular, in the case of a red or a yellow status, the question owner has to describe the gap and the countermeasure to close the gap.

3.3.3.1 GYR Score as indicator of Launch Readiness

An *overall assessment score*, also called *GYR score*, represents the status of Launch Readiness. It is based on the last completion of the Checklist and is the result of each single item status. It is expressed in percentage and is calculated according to the following formula:

$$GYR\ Score = \frac{\#Blue + \#Green}{\#Blue + \#Green + \#Yellow + \#Red}$$

GYR score is an aggregated numerical information, and, as such, is a very useful indicator in order to:

- Determine the current Launch Readiness status,
- Establish a target for next Launch Readiness Review,
- Compare GYR scores between two different Launch Readiness Reviews.

However, it is the output of the completion of the Launch Readiness Checklist, which is usually performed only three times during Development, Pilot and Launch phases. The Launch Leader has no limits in the number of Launch Readiness Checklist to perform. However, completing the Checklist is time consuming, and, as such, it could not be completed on a weekly basis for example. Consequently, the need to develop a system of KPIs to constantly monitor key elements for Production Launch Readiness arose. This would allow to effectively guide activities during this critical phase of the life of a project. As already mentioned, this is the core work of this paper, and is deeply illustrated in Chapter 4.

3.3.4 Launch Readiness Checklist Reports

Through enterProj, different types of reports can be generated from the Launch Readiness Checklist. In this way, information is provided in the more appropriate form and content according to the specific stakeholder. Below are illustrated only two types of reports, which are the most relevant towards the work described in Chapter 4.

A first type of report is called the *Launch Readiness Summary Report* and is shown in Figure 3.14. Here sensitive information has been omitted in order to be compliant with the privacy policy of the company. All ten Categories are included in this report, together with their Champions. In particular, for each Category it is indicated its overall status, which is based on the status of its single items. In this way, the attention is immediately drawn on those categories with a red status. A blank status means that category's questions have not been answered yet. In this case, the Launch Leader has to urge the Element Champion to evaluate the readiness of its category.

Seq	Category	Champion	Notes	Proj Team Status	Checklist Status
10	Product Maturity	[redacted]			
20	Tooling, Facilities, and Equipment Readiness				Y
30	Production Process Readiness				Y
40	Production Capacity Readiness				Y
50	Measurement and Test Systems Readiness				
60	Materials and Supply Readiness				R
70	MP&L, Logistics, and IT Readiness				Y
80	Personnel and Training Readiness				
90	Quality System Readiness				
100	PSW Readiness				

Figure 3.14: *Example of Launch Readiness Summary Report*

Another relevant report is the *Launch Readiness Detail Report*. This allows to filter Checklist questions according to GYR status, Checklist completion date, and Category. For example, it could be useful to filter Checklist questions to produce a report of all red questions at last Checklist completion.

3.3.5 Launch Readiness Reviews

Launch Readiness Reviews follows every Checklist completion. Reviews are headed by the Plant Manager, Program Manager, and Launch Leader and involve critical team members. During these Reviews, the Launch Leader presents Launch Readiness results, for example by using the two reports described in the previous section. In case of questions with yellow or red status, the Review Team focuses on the gap and the countermeasure to fix issues.

The identified gaps are then tracked in enterProj RIO (Risks, Issues, and Opportunities) for example, which is a tool explained in the next paragraph.

4 Case study: new eCF application for an Asian OEM

The heart of this paper is the discussion of a case study that regards the Production Launch of a new engine Cooling Fan (eCF) on a new manufacturing line. In particular, the case study is a complex project for the following elements:

- It is a new motor project, not similar to the existing motor projects from the Company past experiences;
- It is a new concept of production line, not similar to the existing assembly lines;
- The Program is based on Engineering development in Asia, supply chain worldwide and Mass production in Italy; consequently, it requires a multicountry and multicultural approach.

Because of the complexity of this project, the monitor of the Production Launch through *KPIs (Key Performance Indicators)* is particularly important in order to efficiently guide the activities of the team members and ensure a flawless launch.

Another important aim of this work is to develop a *standard approach* for efficiently monitoring Production Launches within all the plant. Consequently, this paper stands as a guide for the monitor of future Production Launches.

4.1 Product and application

The product in question is an *engine Cooling Fan* (eCF), which is a smart actuator. The technology used for the eCF consists in assembling an Electronic Control Unit (ECU) and a Brushless DC-Drive into an integrated smart actuator, as represented in Figure 4.1.

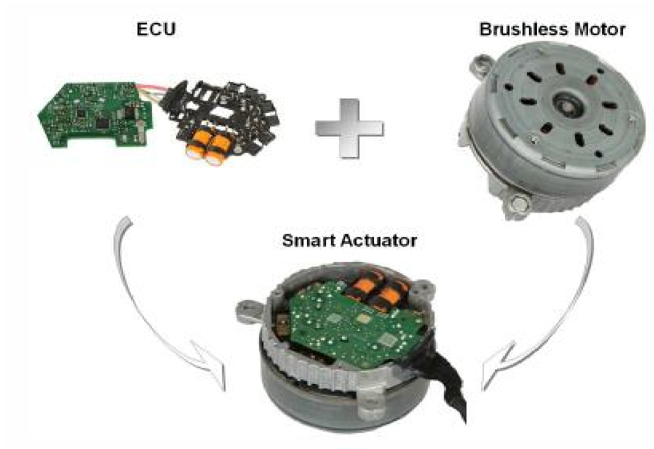


Figure 4.1: *eCF (engine Cooling Fan) assembly components*

A *Brushless DC Motor* (BLDC motor) is also known as an Electronically Commutated Motor (ECM). It does not have brushes on the rotor and commutation is realized electronically at specific positions of the rotor (Farnell, 2019).

A Brushless DC Motor stands out in particular by a rotor with permanent magnets and a stator with windings. In comparison with a Brushed DC Motor, there are no more brushes and commutator; instead, the windings are connected to the Control Electronics. Control Electronics act in place of the commutator and energize the right winding. Windings are energized in a pattern that rotates around the stator. The energized winding of the stator guides the magnet of the rotor and commutes in the moment in which the rotor is aligned with the stator (Farnell, 2019). The process just described is represented graphically in Figure 4.2.

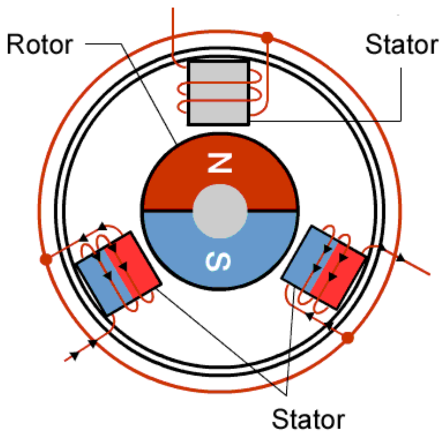


Figure 4.2: *Operating Mode of a Brushless DC Motor (Renesas, n.d.).*

The BLDC motor is the solution for those applications that need high reliability, high efficiency and a high power-to-volume ratio (Farnell, 2019).

In the case study, the application of the Brushless DC Motor is completed by assembling the fan, as shown in Figure 4.3.

Figure 4.3: *eCF (engine Cooling Fan)*

4.2 Production Process

The production process is totally developed by the Company. It mainly consists in the assembly of components that are all bought from suppliers, which are "built to print" suppliers as the Company developed the components as well.

The operations of the production process can be grouped into three different areas: stator, rotor and motor. Main operations are shown in Figure 4.4.

Machine #	Process Step
Stator	Winding
	Phase Ring Welding
	Electrical Testing
Rotor	Magnets Gluing
	Magnetization
	Rotor Balancing
Motor	HV Isolation Test
	Plasma Treatment
	Fluid Dispensing
	Phase Welding
	Pin Soldering
	AOI Screening
	EOL Testing
	Gap Filler Dispensing
	Wacker Resin Dispensing

Figure 4.4: *Main Process Steps*

The new manufacturing line is represented in Figure 4.5. The manufacturing line consists of a fixed sequence of machines. It is semi-automatic and needs four operators to run. The shape of the line is elliptical in order to facilitate communication and change of position of operators.

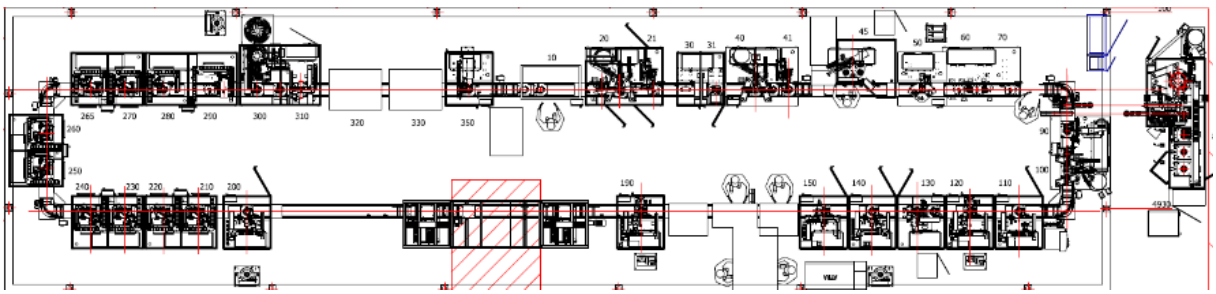


Figure 4.5: *The New Manufacturing Line*

After production, outside the manufacturing line, further tests and controls of the parts produced are perfomed by an additional operator. In particular, visual controls are typical of the Production Launch of a new product, because reinforced controls are necessary in order to:

- Ensure the quality of the parts delivered to the Customer;
- Get fresh data to analyze and quickly react in case production parameters adjustments are required.

At last, the assembly of the product is completed with the addition of the fan to the motor. However, this last step is performed by another Company plant, which is located overseas and close to the final Customer.

Production is of pull type, which means that it is determined by customer requests, and not by warehouse needs. This because during a Production Launch is not possible to stock materials mainly for the following reasons:

- The production process is not ready at 100% yet, for which there are still capacity problems;
- The product design is not frozen yet, for which product versions follow one another . Therefore, components as well as the final product risk to become obsolete in the short term.

Serial production is alternated with batch production for client events. In fact, the manufacturing line produces also eCFs that have not already been launched in serial production. These eCFs are variants of the one in serial production.

4.3 KPIs (Key Performance Indicators)

The Production Launch of a new product on a new manufacturing line is particularly complex especially in the automotive sector. This because in this industry project phases have been dramatically reduced in time and hence are overlapping more and more. Consequently, the need to systematically monitor the launch performance has arised in order to guide team activities in an efficient way.

The *Launch Readiness Checklist*, illustrated in section 3.3, is a tool that provides a picture of the project performance in key moments of the Production Launch. However, it does not allow to constantly track the evolution of key elements of the Launch Readiness and, therefore, to constantly monitor them. Besides, it does not provide a forecast of future results, thus preventing from determining risks and opportunities. For these reasons, there was the need to develop a tool to monitor specific *KPIs (Key Performance Indicators)* for the Production Launch performance in the automotive industry. In conclusion, the Launch Readiness Checklist stands as a static monitor, whereas KPIs stand as a dynamic monitor.

What are KPIs? In general, KPIs are a group of measures of those elements of project performance that are the most critical for the current and future success of the project. KPIs have the following principal characteristics:

- KPIs are nonfinancial measures and hence are not expressed in monetary units (e.g. in euros). Indeed, financial measures are result indicators and not performance indicators (Parmenter, 2010, p.6).
- KPIs are measured on a daily or weekly basis, because they reflect current and future performance and not past performance (Parmenter, 2010, p.6). In the case study, they are measured on a weekly basis. They are not measured on a daily basis because information would not have been sufficiently significant to provide a direction for project activities.
- KPIs are brought to the attention of the senior management team (Parmenter, 2010, p.6). In the case study, they are forwarded to the senior management board on a weekly basis. In particular, on Tuesday it is released the Launch Readiness Review of the previous week.
- KPIs point out to team members the appropriate actions to do in order to fix issues (Parmenter, 2010, p.6).
- KPIs tie responsibility down to team members (Parmenter, 2010, p.6).
- KPIs have a crucial influence on project success as they affect project goals in all directions (Parmenter, 2010, p.6).

KPIs are fundamental to guide team activities during the phase of Production Launch because they help estabilishing priorities among tasks and foresee future issues.

The KPIs used to monitor the Production Launch of the project in question have been extrapolated from the Launch Readiness Checklist in order to be in line with company requirements. Figure 4.6 in the next page shows how each KPI corresponds to a specific category of the Launch Readiness Checklist. Some KPIs can be applied to whatever sector, such as OEE (Overall Equipment Effectiveness); instead, other KPIs are more specific to the automotive industry, such as the PPAP (Production Part Approval Process) Glidepath.

As shown in Figure 4.6, KPIs are complemented by *Analysis Tools* for further understanding of issues and for the development of effective action plans. Therefore, Analysis Tools are fundamental for the team in order to perform activities more efficiently. However, as regards the top management level, KPIs are of most interest with respect to the Analysis Tools. This because KPIs allow to quickly get a lot of information and, at the same time, to immediately focus only on the most important issues.

As can be noticed in Figure 4.6, not all the sections of the Launch Readiness Checklist are monitored by a KPI. It has been preferred to focus only on the most important elements that ensure Production Launch Readiness. The other sections are still monitored through the recurrent completion of the Launch Readiness Checklist by team members.

The development and the application of the KPIs as well as of the corresponding Analysis Tools are discussed in the sections below. This is done according to the following outline. The reason for the specific KPI is explained. Follows an excursus on the element monitored by the KPI. The KPI is then illustrated and applied to the case study, as well as the corresponding Analysis Tool. However, in the case of sensitive information about the company, a template of the KPI is provided, together with the application of generic examples. In explaining the tool developed, KPIs follow one another according to the order shown in Figure 4.6.

Category of Launch Readiness Checklist	**KPI**	**Analysis Tool**
Product Maturity	ECR (Engineering Change Request) Glidepath	ECR Analysis Tool
	Customer Claims Glidepath	Customer Claims Analysis Tool
Tooling, Facilities and Equipment Readiness	x	x
Production Process Readiness	Cycle Time Evolution	Bottleneck Workstation Analysis
Production Capacity Readiness	OEE (Overall Equipment Effectiveness)	Refer to Availability, Performance and FTQ
	Availability	Ishikawa diagram + Downtime Pareto
	Performance	Ishikawa diagram + Microstops Pareto
	FTQ (First Time Quality)	Ishikawa diagram + Scrap Pareto
Measurement and Test System Readiness	x	x
Materials and Supply Readiness	PPAP (Production Part Approval Process) Glidepath	PPAP Analysis Tool
MP&L, Logistics and IT Readiness	Delivery Performance	Delivery Plan Simulation Tool
Personnel and Training Readiness	Training Timetable	
Quality System Readiness	x	x
PSW Readiness	Motor PPAP Checklist	

Figure 4.6: *KPIs and Analysis Tools developed according to the Launch Readiness Checklist.*

4.3.1 ECR (Engineering Change Request) Glidepath

Within the section of the *Launch Readiness Review* that regards *Product Maturity*, it is very important to monitor the implementation of *Design Changes*. In fact, during a Production Launch, Product Design is not frozen yet, due to the overall short development timing in modern automotive. Therefore, Design Changes could be submitted after the product has been frozen for mass production. When the Design Change has been officially opened, this becomes an *Engineering Change Request* (*ECR*). Usually the specific design characteristic goes into "deviation", which means that is temporary approved until the change has been implemented. The interim approval of the Design Change is based on a validation through dedicated tests.

In particular, Design Changes can be of two types:

1. Design Changes requested by the Customer, to adjust an issue of the car that impacts the BLDC;
2. Design Changes requested by internal Company functions, to adjust an issue occurred to the BLDC itself.

Monitoring the implementation of Design Changes is particularly important because they may have many important consequences on Launch Readiness. For example, a Design Change may influence the version of the components to be bought, which need a lead-time also of several months. A Design Change could reduce capacity issues, such as reduce the number of scraps. Therefore, it is very important to constantly monitor the progress of ECRs and act templestively in the case in which major obstacles delay activities.

Furthermore, managing these changes has been particularly complex in the case study for different reasons. First, the product was new and was developed by an Asian team in their native country. Secondly, the manufacturing line was new as well and was installed by an Italian team in their native country. This means that every time the Italian team decided that a Design Change was necessary for mass production requirements, this change had to be explained and discussed with the Asian team. As illustrated in Chapter 2 in the section dedicated to International Teams, this activity required a lot of effort by the two teams because of cultural differences and communication difficulties. Consequently, all this was an additional obstacle to the already challenging activity of implementing Design Changes during a Production Launch.

The KPI developed to monitor the implementation of Design Changes is shown in Figure 4.7. In this case, sensitive information is omitted in order to be compliant with the privacy policy of the company. Instead, Figure 4.7 provides a template of the KPI. Follows also examples of the application of the KPI.

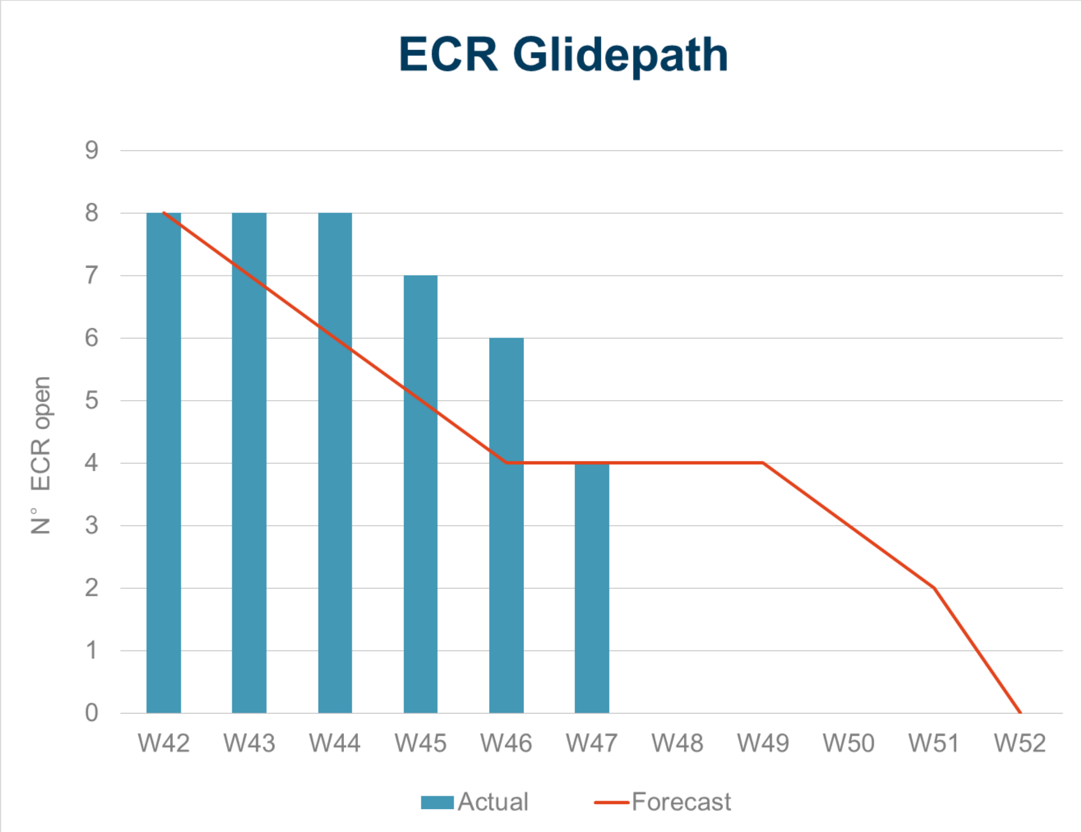


Figura 4.7: *Template of ECR (Engineering Change Request) Glidepath.*

On the horizontal axis of the graph are represented the weeks of production launch, whereas on the vertical axis are represented the number of ECRs (Engineering Change Requests) that have not been implemented yet. The red line indicates the forecast of when Design Changes are expected to be implemented. This can be considered as a target. For example, it is expected that in week 46 there will be only four Design Changes still to be implemented. One of the purposes of the graph is to indicate when all Design Changes will be closed, which in Figure 4.7 corresponds to week 52; here comes the graph's name "glidepath", which means aircraft's landing path. Instead, the blue columns indicate actual results, which are the changes that have not been implemented yet in the specific week.

For example, in week 46 there are still six changes to be implemented, against a forecast of four changes. Consequently, the graph also allows to determine if there is a gap between actual and target results and to monitor the gap week after week. In the case of a gap, this has to be investigated in order to put in place corrective actions and speed up activities.

Sometimes a new forecast of ECRs implementation is required. This may be due to the introduction of a new ECR or because of major obstacles that cause irreducible delays in activities. In this case, the new forecast is represented on the graph as well, as shown in the example in Figure 4.8. However, the previous forecast is still indicated on the graph, because it is also important to track the delay in ECRs implementation.

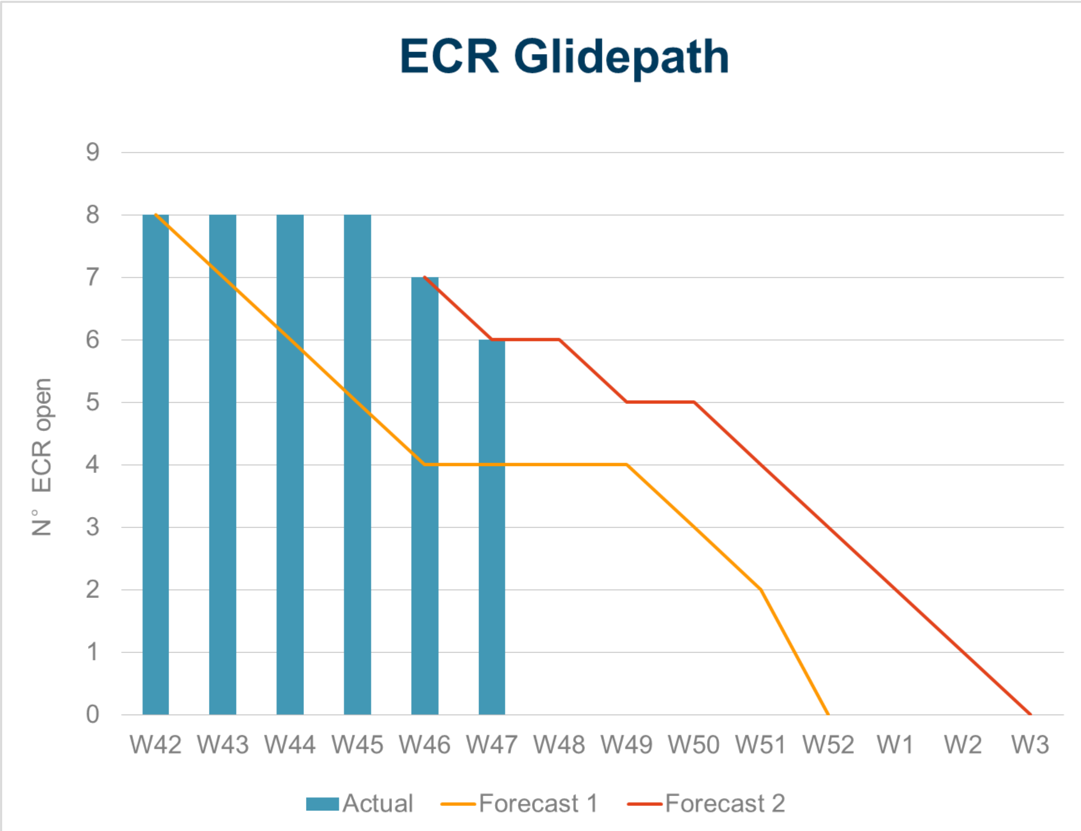


Figure 4.8: *Another Template of ECR (Engineering Change Request) Implementation*

In the example shown in Figure 4.8, a new forecast has been done in week 46 in front of irremediable delays in activities in the previous three weeks. With the new forecast, the implementation of all ECRs is expected in week 3, instead of in week 52.

In particular, the new forecast is represented by a red line, because is the one on which the attention must be focused. Instead, the initial forecast is in yellow. The use of colors is particularly important when communicating with top management. In fact, top managers do not have time to acquire all details, and their attention is usually get by the color red.

For further insight on activities about ECRs implementation, the analysis tool shown in Figure 4.9 is provided.

ECR description					*Road Map*			
#	Component	Description	Who	Impact	Opened (Y/N)	Actions	Due Date	Actual Due Date
1		Purpose: Reason: Change:		Timing: Y/N Quality: Y/N Cost: Y/N				
2		Purpose: Reason: Change:		Timing: Y/N Quality: Y/N Cost: Y/N				

***Figura 4.9**: Template of ECR Analysis Tool*

The analysis tool clearly indicates for each ECR the components involved. The ECR is then described by explaining its purpose, the reason for it and what the change consists in. The person who submitted the Design Change is indicated for reference. Whether the ECR impacts timing, quality and cost variables is indicated as well. This section of the analysis tool regards the description of the ECR. It is important that this part is short and concise and that provides only key information for all stakeholders.

The analysis tool includes also a road map for monitoring the activities required to implement the changes. It is indicated whether the Design Change has already been officially opened, what actions are required for its implementation, and the due date. Actual due date is also indicated in case of delay in actions execution. The first forecast is based on the due dates of the ECRs, whereas an eventual subsequent forecast is based on actual due dates.

In particular, this analysis tool is used during weekly meetings between the R&D and the Manufacturing teams in order to discuss ECR issues in a more structured way. In fact, especially ECR implementation needs the collaboration of all members of the International team.

An ECR may be opened by the Manufacturing Engineer, the R&D engineer, the Product Design Engineer, and the Quality Engineer. As such, ECR progress is one of the key topics of the weekly meetings that take place between the two teams.

4.3.2 Customer Claims Glidepath

Within the *Launch Readiness Review*, another fundamental element of *Product Maturity* is the resolution activity in reaction to *Customer Claims*. A Customer Claim is an official declaration of a product issue that has been found out by the Customer. Once a Customer Claim has been done to the supplier, the supplier has to put in place corrective actions in order to solve the product issue and ensure to the Customer that this is not going to show again. Therefore, Customer Claims are a quite delicate matter that directly influences the relationship with the customer. As such, it requires a strict monitor of the progress of the resolution activities that have been put in place in order to prevent that the product issue shows up again. These activities are in charge of the Quality department, but could involve whatever department. For example, the case of a product that arrives to the Customer with a broken component could involve the Logistic department for a packaging issue.

The tool developed to monitor this activity is represented in Figure 4.10. Also in this case, sensitive information is omitted in order to be compliant with the privacy policy of the company. A template of the tool is provided instead.

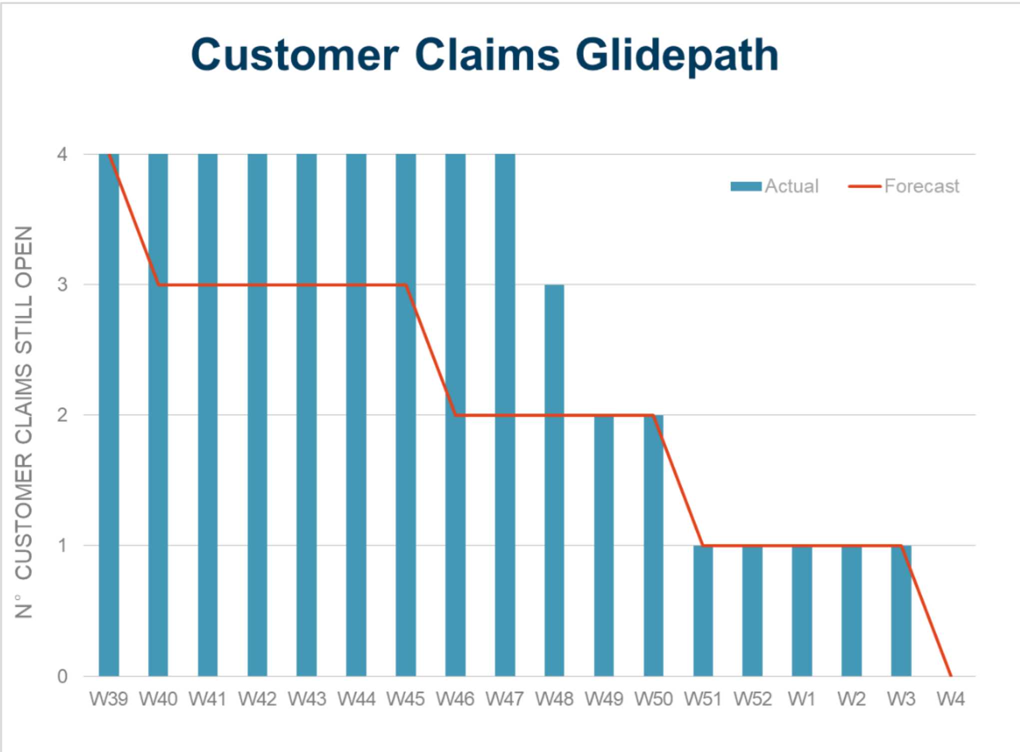


Figura 4.10: *Template of Customer Claims Glidepath*

On the horizontal axis of the graph are indicated the weeks of Production Launch, whereas on the vertical axis are indicated the number of Customer Claims that have not been solved yet. Through the graph, it is possible to track the progress of their resolution.

First of all, the red line indicates the forecast of when Customer Claims are expected to be closed with a permanent solution in place. The forecast is set as a target. For example, in week 51 it is expected to have only one Customer Claim still to be solved. One of the purposes of the tool is to clearly indicate when all Customer Claims will be closed, for example in week 4 in Figure 4.10. Again, a new forecast may be required in the case of a new Customer Claim or irremediable delays in activities. This new forecast will be indicated together with the previous one, as for the ECR glidepath.

Instead, the blue columns indicate how many Customer Claims are actually still open in the specific week. For example, in week 51 there is still one customer claim to be addressed, as was expected by the forecast. Consequently, the graph also allows to determine if there is a gap between actual and target results. In the case of a gap, this has to be investigated in order to speed up activities.

An analysis tool is provided in order to give further insight on the matter. A template is shown in Figure 4.11. In general, the analysis tools provided in this paper are a summary of more developed analysis tools. The first ones have the purpose of sharing key information to all stakeholders and are the means through which the project manager is able to monitor the timing of activities. Instead, the second type of analysis tools are more detailed and as such are used by the specific team member to develop action plans.

Customer Claim Description			*Road Map*					
#	Customer Claim	Date	Action	Responsible	ICA	PCA	Due Date	Actual Due Date
1								
2								

Figura 4.11: *Template of the Customer Claims' Analysis Tool*

Within the Analysis Tool, each Customer Claim is briefly described and the date in which it has been officially opened by the Customer is indicated in the apposite column.

The road map is then briefly illustrated into the table. Activities required to solve the product issue are indicated, together with the team member responsible for their execution and the due date. Actual due date is also indicated in case of delay of activities. In particular, the following two elements are clearly stated:

- ICA (Interim Containment Action), which is the temporary solution to secure the product and has to be in place in maximum 24 hours;
- PCA (Permanent Correct Action), which is the final, validated and robust solution to definitively close the issue.

4.3.3 OEE (Overall Equipment Effectiveness)

Within the *Launch Readiness Review*, *Production Capacity Readiness* requires special attention because it determines the ability to meet Customer delivery and ramp requirements. *OEE (Overall Equipment Effectiveness)* is the leading measure of both productivity and efficiency (Stamatis, 2010, p.21). As such, it is one of the KPIs used in order to determine Production Capacity Readiness.

OEE comprehends a set of measurements in order to determine the efficiency of the use of a manufacturing facility. OEE is obtained by multiplying the following three measurements, which are deeply explained in the sections below:

$$OEE = Availability * Performance * Quality$$

However, through semplifications, OEE can also be calculated as follows:

$$OEE = \frac{Total\ Parts\ Run - Total\ Defects}{N^\circ\ \ Planned\ Parts} * 100$$

$$Total\ Parts\ Run = Good + Bad$$

$$Total\ Defects = Scrap + Rework$$

$$N^\circ\ \ Planned\ Parts = \frac{Net\ Available\ Time}{Ideal\ Cycle\ Time}$$

$$Net\ Available\ Time = Available\ Time - Planned\ Downtime$$

Good values of OEE are deemed to be equal or above 85% (Stamatis, 2010, p.22).

In the case study, OEE has been calculated on weekly data in order to provide a more reliable measurement. This because the process as well the product are not yet the definitive ones during the Production Launch, especially in the modern automotive industry as already explained. Consequently, OEE may significantly vary from one day to another. Instead, data aggregated on a weekly basis are able to give information that is more significant in order to prioritize activities.

For example, OEE in week 50 was obtained by doing the following considerations and calculations. In order to get the Net Available Time, it was considered that Available Time is determined by the fact that there is only one shift of 8,5 hours per day. Instead, Planned Downtime includes the lunch break of 30 minutes and two physiological breaks of 10 minutes every day, besides technical Planned Downtime equal to 151 minutes for all week 50. The manufacturing line runs five day per week. Consequently, Net Available Time in week 50 has been calculated as follows:

$$Net\ Available\ Time\ in\ Week\ 50 = 510\ min * 5 - (50\ min * 5 + 151\ min) = 2149\ min$$

In particular, line warm-up is considered a Planned Downtime as long as it lasts less than one hour. In the case it lasts longer, the extra time is considered Unplanned Downtime. This decision has been made together with the Manufacturing Engineer and the Leader of the operators, by considering what happens in the rest of the plant. In fact, on the other manufacturing lines, where there are three shifts per day, line warm-up is done only at the beginning of the week; an operator arrives one hour earlier in order to avoid that line warm-up affects the Available Time. However, in the case study, there is only one shift per day and, as a consequence, line warm-up has to be done every morning. Because of the lack of operators, it cannot be asked to one operator to arrive one hour earlier every day to do line warm-up. This is the reason why line warm-up is considered a Planned Downtime as long as it lasts less than one hour. This is one of the many differences to take in consideration in the case of a Production Launch on a new manufacturing line, where standard processes are not yet in place.

In order to obtain the Number of Planned Parts, it is necessary to determine the Ideal Cycle Time of the production process. In general, the Ideal Cycle Time can be considered as:

- The best Cycle Time ever achieved,

- The design Cycle Time (also called Tack Time),
- An estimation of Cycle Time (Stamatis, 2010, p.31).

In the case study, it has been decided to consider the Ideal Cycle Time as the best Cycle Time ever achieved, which is 120 sec/part. Instead, the design Cycle Time could not be used as the Ideal Cycle Time because during the Production Launch the manufacturing line was not ready at 100%. Only when the manufacturing line will be ready at 100%, the Ideal Cycle Time will be the Takt Time, which is 22,5 sec/part.

Therefore, the number of Planned Parts in week 50 has been calculated as follows:

$$N°\ Planned\ Parts\ in\ Week\ 50 = \frac{2149\ min * 60\ sec/min}{120\ sec/part} = 1075\ parts$$

In conclusion, OEE in week 50 was calculated by considering that the Total Parts Run was equal to 805 parts, whereas the Total Defects was equal to 120 parts, with 76 scraps and 44 reworks. Consequently, OEE in week 50 was 64%, according to the following calculation:

$$OEE\ in\ Week\ 50 = \frac{805\ parts - 120\ parts}{1075\ parts} * 100 = 64\%$$

Figure 4.12 represents OEE results during the Production Launch. In this way, it is possible to visualize the trend of OEE improvement or deterioration at the first glance. In the case study, it is evident that OEE struggles to maintain a positive trend and is still far from target.

In particular, in Figure 4.12 it can be noticed that there is one label reporting that data have not been collected in a specific day. This is due to the fact that during a Production Launch, especially in the case of a new manufacturing line, it can be very hard to collect data for different reasons: operators and team members are overworked, the traceability system is not working at 100% etc.

In the following sections, the analysis of how to improve OEE is provided. In general, this is done by considering its three components: Availability, Performance and Quality. Each component focuses on a different and isolate portion of the process or product, on which activities can be accomplished for improvement.

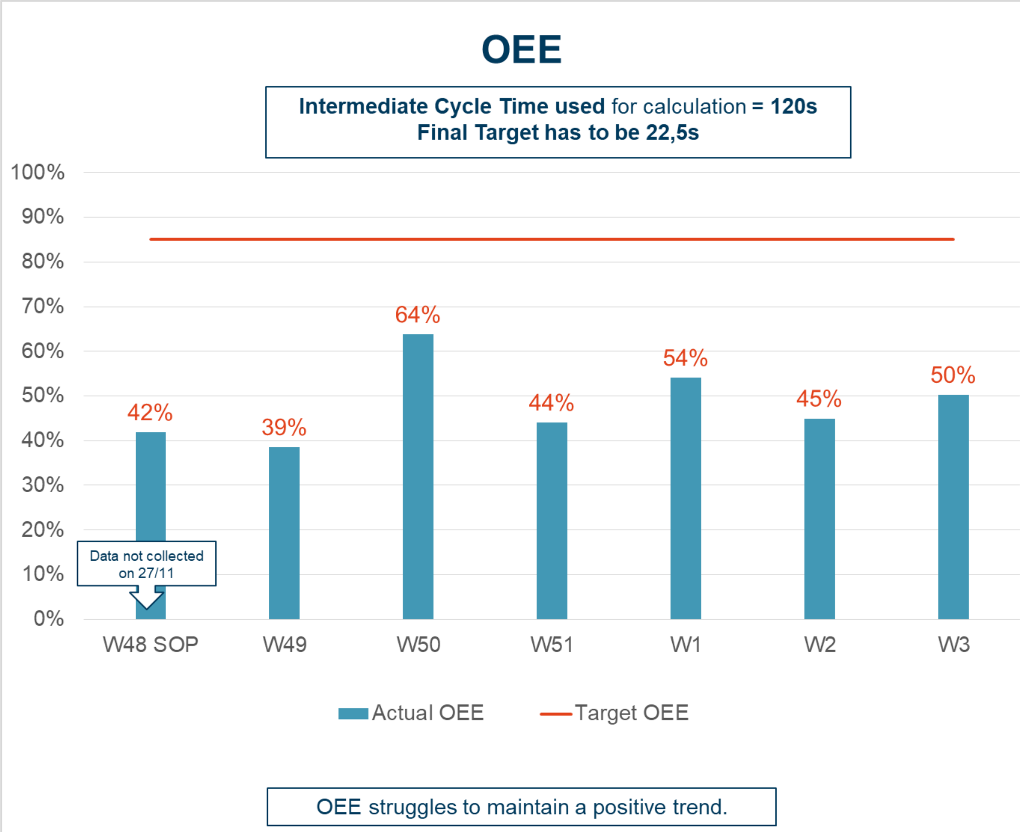


Figure 4.12: *OEE (Overall Equipment Effectiveness)*

4.3.3.1 Availability

Availability is the part of OEE that indicates the percentage of time of actual production (Stamatis, 2010, p.23). Therefore, together with OEE, it is used as a KPI as regards the *Production Capacity Readiness*.

Availability is calcolated as follows:

$$Availability = \frac{Net\ Available\ Time - Unplanned\ Downtime}{Net\ Available\ Time} * 100$$

$$Net\ Available\ Time = Available\ Time - Planned\ Downtime$$

$$Unplanned\ Downtime = Breakdowns + Setups\ \&\ Adjustments + Minor\ Breakdown$$

Usually the target of Availability is 90% (Stamatis, 2010, p.23).

In the case study, Availability has been calculated on weekly data in order to provide a more reliable measurement, for the same reasons explained previously for OEE. For example, Availability in week 50 was obtained by considering that the Net Available Time was equal to

2149 minutes, as already illustrated in the previous section for OEE. Instead, total Unplanned Downtime in week 50 was equal to 108 minutes. As a result, Availability in week 50 was 95%, according to the following calculation:

$$Availability\ in\ Week\ 50 = \frac{2149\ min - 108\ min}{2149\ min} * 100 = 95\%$$

Figure 4.13 represents Availability results during Production Launch. In this way, it is possible to visualize the trend of improvement or deterioration in Availability. In week 50 Availability has improved of 39%, exceeding the target. This significant improvement has been achieved thanks to the scrupulous use of two analysis tools: the Ishikawa Diagram for identifying the root causes of Unplanned Downtime and the Downtime Pareto for the development of effective action plans. These two tools are illustrated below.

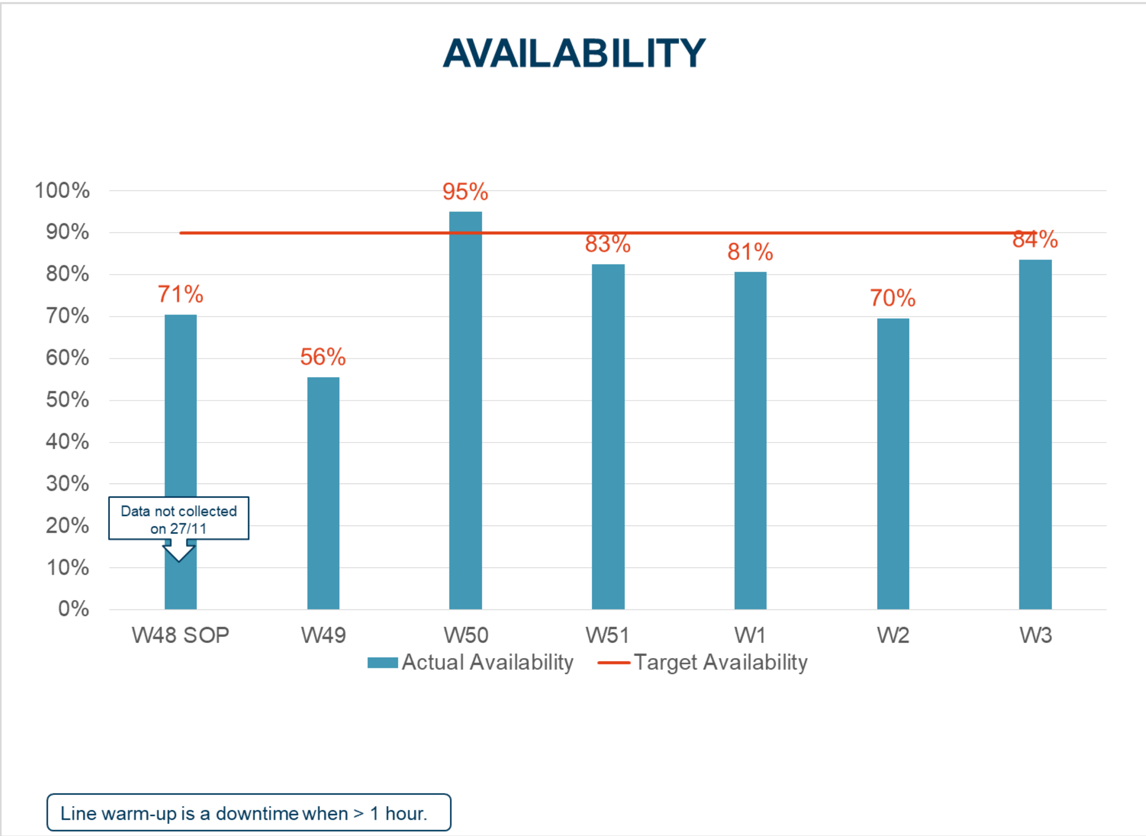


Figure 4.13: *Availability*

The Ishikawa Diagram in combination with the Downtime Pareto is used to analyze the areas of improvement and support the decision making process.

The Ishikawa Diagram (also called Fishbone Diagram or Cause-and-Effect Diagram) is the starting point of the improvement process. It guides the identification and classification of the causes of a specific effect (Firican, 2018). Figure 4.14 representes an example of the Ishikawa Diagram. Also in this case, sensitive information are omitted in order to be compliant with the privacy policy of the company. Instead, an example of the application of Ishikawa Diagram is provided.

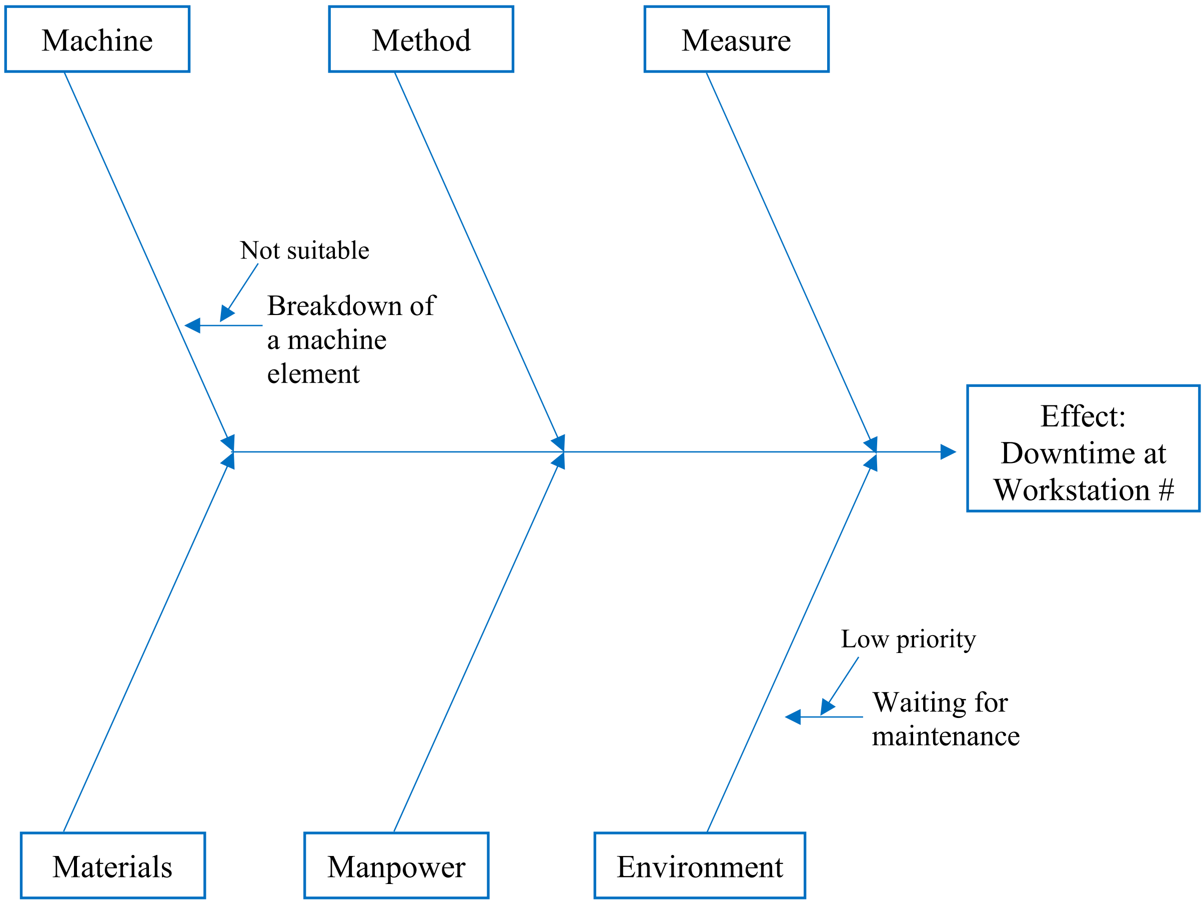


Figure 4.14: *Example of an Ishikawa Diagram*

The Ishikawa Diagram facilitates team brainstorming because it is an easy-to-use visual tool (Firican, 2018). It is built by carrying out the following three main steps.

The first step consists in describing the effect or problem in correspondence of the head of the fish on the right of the diagram. This is the issue for which the root-cause analysis is carried out (Firican, 2018). In the case study, the problem is the event of a specific Unplanned Downtime. Unplanned Downtimes are registered by the Leader of the operators who reports the workstation where the problem occured. Therefore, in the Ishikawa Diagram, in correspondence of the head of the fish is written the specific workstation number.

The second step for building the Ishiwaka Diagram consists in identifying the categories of the causes. Causes are grouped into categories in order to facilitate its identification. Categories are established through a brainstorming and are at the discretion of the team members. In the case study, the brainstorming involved the Leader of the operators and the Manufacturing Engineer because these team members are the ones that have the better understanding of the causes behind an Unplanned Downtime. However, the most common categories used in manufacturing are the *5 Ms and 1E*, which are briefly described below:

- *Manpower*, which for example includes operators, technicians and suppliers (Master of Project Academy, n.d.);
- *Machine*, which includes equipment and technology (Master of Project Academy, n.d.);
- *Material*, which includes raw materials, data and information (Master of Project Academy, n.d.);
- *Method*, which includes process, procedures, policy and practice (Master of Project Academy, n.d.);
- *Measurement*, which includes input and output metric for quality, quantity, process performance, calibration and inspection (Master of Project Academy, n.d.);
- *Environment*, which for example includes temperature and humidity (Master of Project Academy, n.d.);

Once chosen, categories are reported in the Ishikawa Diagram as shown in Figure 4.14.

The third and last step for building the Ishiwaka Diagram consists in investigating the causes of the problem through a brainstorming. In the case study, the brainstorming involves again the operator Leader and the Manufacturing Engineer. However, if necessary, other team members are involved in the analysis during daily meetings. Once identified, the causes are reported in the diagram in the appropriate categories (Firican, 2018). For each identified cause, the root cause has to be determined. In fact, only by solving the root cause the problem will no longer arise. The root cause is identified by applying the "5 Whys" technique, which is an interative approach that consists in keeping asking the question "Why?" until the root cause is established (Firican, 2019). In the generic example of Figure 4.14, the team identified two causes for the specific downtime: the breakdown of an element of the machine and the delay of maintenance intervention. For the first cause, the question "Why did the element break?" was asked to the team members. The root cause was identified in the stress under which the element was submitted, for which the element was not suitable for the production process and had to be changed with another type. Again, for the second cause, the question "Why was maintenance intervention in delay?" was asked to team members. The answer was that at that moment maintenance intervention was required by other manufacturing lines for which priority is higher.

After the root-cause analysis has been done through the support of the Ishikawa Diagram, the decision-making process for developing an effective action plan is guided by the Downtime Pareto. This is a Pareto Diagram of Unplanned Downtimes in a specific week. Figure 4.15 represents a template of a Downtime Pareto. Also in this case, sensitive data are omitted in order to be compliant with the privacy policy of the company.

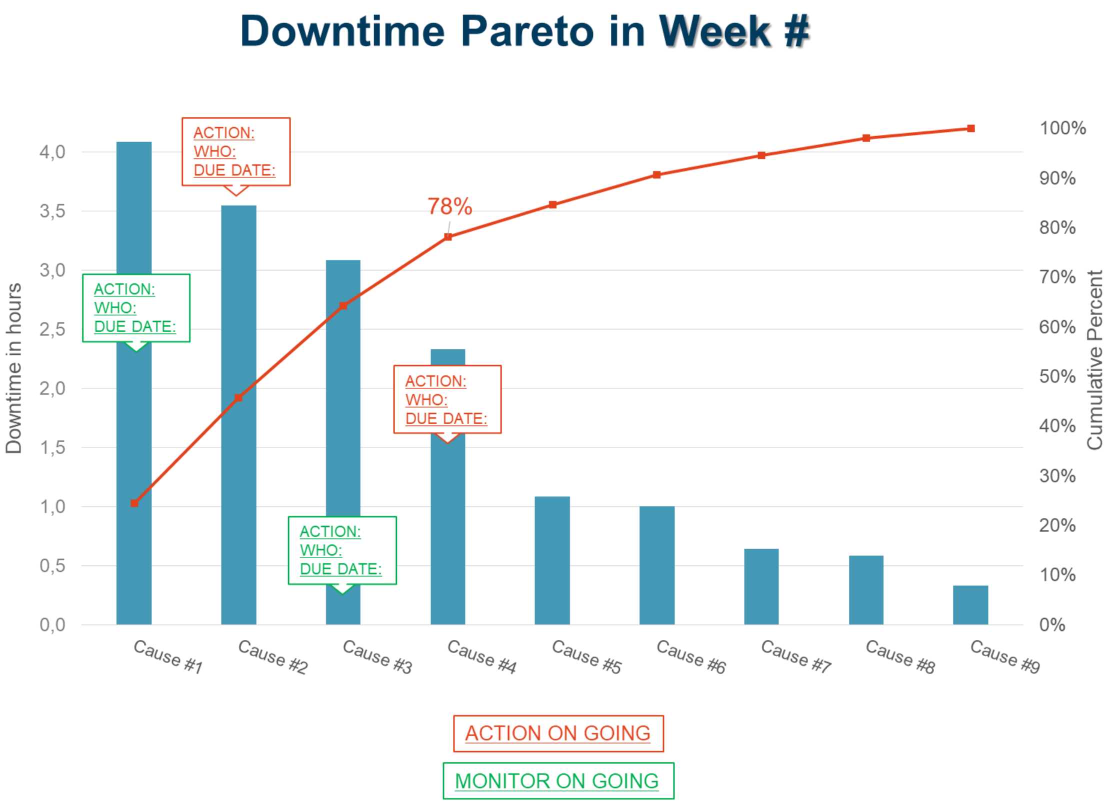


Figure 4.15: *Template of a Downtime Pareto.*

In general, the Pareto Diagram is a graphical representation of the process problems, in descending order of the most frequent, down to the least frequent, from left to right. Therefore, the Pareto Diagram indicates the frequency of fault types.

The Pareto Diagram is a fundamental analysis and decision-making tool. This because it allows to identify the most serious faults and hence to concentrate scarce resources on a few problems, neglecting all others. It provides to the organization a means to prioritize problems. The basic underlying rule is called the 80/20 rule, which states that the 80% of effects are determined by the 20% of causes (50minutes, 2015, p.5). The now called "Pareto's principle" was invented by Vilfredo Pareto (1848-1923) in 1897, an Italian economist and sociologist who studied at the Polytechnic University of Turin in Italy (50minutes, 2015, p.6). While he was analysing the wealth of his country, he discovered that only 20% of the Italian population owned 80% of the country wealth. By applying the same rule to other countries, he found out the same result. The theory was later confirmed and recognized in the 1940s by Joseph Juran, an American engineer working in quality management.

Going more into detail, the Pareto Diagram is built by carrying out the following nine steps:

1 The time period to consider has to be defined. For example, in the case study it has been chosen a time period of one week. This because a time period of one day would not have provided enough data and, besides, data would have reflected the variability of the specific day; whereas, a time period greater than one week would not have allowed to tempestive actions.
2 The time period has to be clearly stated above the diagram; in the case study it is reported the number of the week in question.
3 All causes of process problems have to be identified. In the case study, these are the root causes determined through the application of the Ishikawa Diagram.
4 The frequency of each cause is determined according to the time frame considered. In the case study, the frequency is the number of hours of unplanned downtime that can be blamed to the specific cause; for example, the number of hours of downtime due to the delay in maintenance intervention in the specific week.
5 The different causes are reported on the horizontal-axis of the diagram in descending order of frequency from left to right. In the case study, the identified causes are written

on the horizontal-axis from the cause for which downtime had been the longest to the cause for which downtime had been the shortest.

6 The frequency of each cause is then reported on the vertical-axis of the diagram thorugh a blue column. It is important to clearly state the unit of measurement of frequency (e.g. hours or units) in order to facilitate the reading and understanding of the diagram.

7 The cumulative percent of frequency is then calculated for each cause according to the descending order of frequency. To determine the cumulative percent of frequency of the cause i the following calculation has to be done:

$$Cumulative\ percent_i = \frac{Frequency_i}{Total\ Frequency} + Cumulative\ percent_{i-1}$$

8 For each cause the cumulative percent of frequency is indicated on the diagram by a red dot. A red broken line then connects all red dots.

9 The causes that contributed to the 80% of the process problems are identified and highlighted on the diagram. According to the 80/20 principle, these typically are the 20% of all causes of process problems.

For each high-priority cause that has been identified through the Pareto Diagram, an action plan has to be developed in order to eliminate the cause and hence prevent the problem from recurring. The action plan is formulated through a brainstorming that involves again the Leader of the operators and the Manufacturing Engineer. They collectively decide:

- The activities to do in order to solve the specific cause;
- The person responsible for the activity execution;
- The due date by which the activity has to be done.

This information is summarized in a red label, as shown in Figure 4.15. Once the activity has been performed, the label becomes green. These labels allow to communicate key information to all stakeholders. For example, this diagram is discussed during weekly team meetings; through the labels, it is possible to share the action plan with the rest of the team in a quick and clear manner.

4.3.3.2 Performance

Performance is the part of OEE that determines the speed at which the production process runs as a percentage of its established speed (Stamatis, 2010, p.23). Therefore, together with OEE and Availability, Performance is used as a KPI to determine *Production Capacity Readiness* within the *Launch Readiness Review.*

Performance is calculated according to the following formula:

$$Performance = \frac{Actual\ Rate}{Stardard\ Rate} * 100$$

$$Actual\ Rate = \frac{Total\ Parts\ Run}{Net\ Available\ Time - Unplanned\ Downtime}$$

$$Total\ Parts\ Run = Good + Bad$$

$$Net\ Available\ Time = Available\ Time - Planned\ Downtime$$

$$Unplanned\ Downtime = Breakdowns + Setups\ \&\ Adjustments + Minor\ Breakdown$$

$$Standard\ Rate = (Ideal\ Cycle\ Time)^{-1}$$

In particular, for obtaining the Actual Rate not only Good parts but also Bad parts have to be taken into account. In this way, the measure of Performance is not affected by Quality. Furthermore, again for the calculation of the Actual Rate, to the Net Available Time is subtracted the Unplanned Downtime, so that Availability does not affect Performance. In fact, the three components of OEE are designed so that they do not influence each other. In this way, it can be clearly stated where the problem is and act accordingly.

Usually the target of Performance is 95% (Stamatis, 2010, p.23).

As already mentioned, Performance relates to the speed of the machinery. There are two types of loss of speed:

1 *Reduced operating speed*, because of quality defects or problems on a machine (Stamatis, 2010, p.31);
2 *Minor stoppages*, which are usually not registered as Unplanned Downtime (Stamatis, 2010, p.31).

An example of calculation of Performance is provided with reference to the case study, for which Performance in week 50 can be determined according to the following considerations and calculations.

First, the Standard Rate is calculated by considering the Ideal Cycle Time equal to 120 sec/part, as already explained:

$$Stardard\ Rate = (\frac{120\ sec/part}{3600\ sec/hour})^{-1} = 30\ parts/hour$$

Instead, the Actual Rate in week 50 was equal to 23 parts/hour, according to the following calculation. This is based on the fact that in week 50 the Total Parts Run were 805 parts, the Net Available Time was 2149 minutes and the Unplanned Downtime was 108 minutes.

$$Actual\ Rate\ in\ Week\ 50 = \frac{805\ parts}{\frac{(2149\ min - 108\ min\ )}{60\ min/hour}} = 23\ parts/hour$$

At the end, Performance was calculated by dividing the Actual Rate to the Standard Rate:

$$Performance\ in\ Week\ 50 = \frac{23\ parts/hour}{30\ parts/hour} * 100 = 77\%$$

In week 50 Performance was equal to 77%, far from the target of 18%.

Figure 4.16 represents Performance results during Production Launch. In this way, it is possible to visualize the trend of improvement or deterioration in Performance. Performance values struggles to maintain a positive trend. However, they are approaching the target.

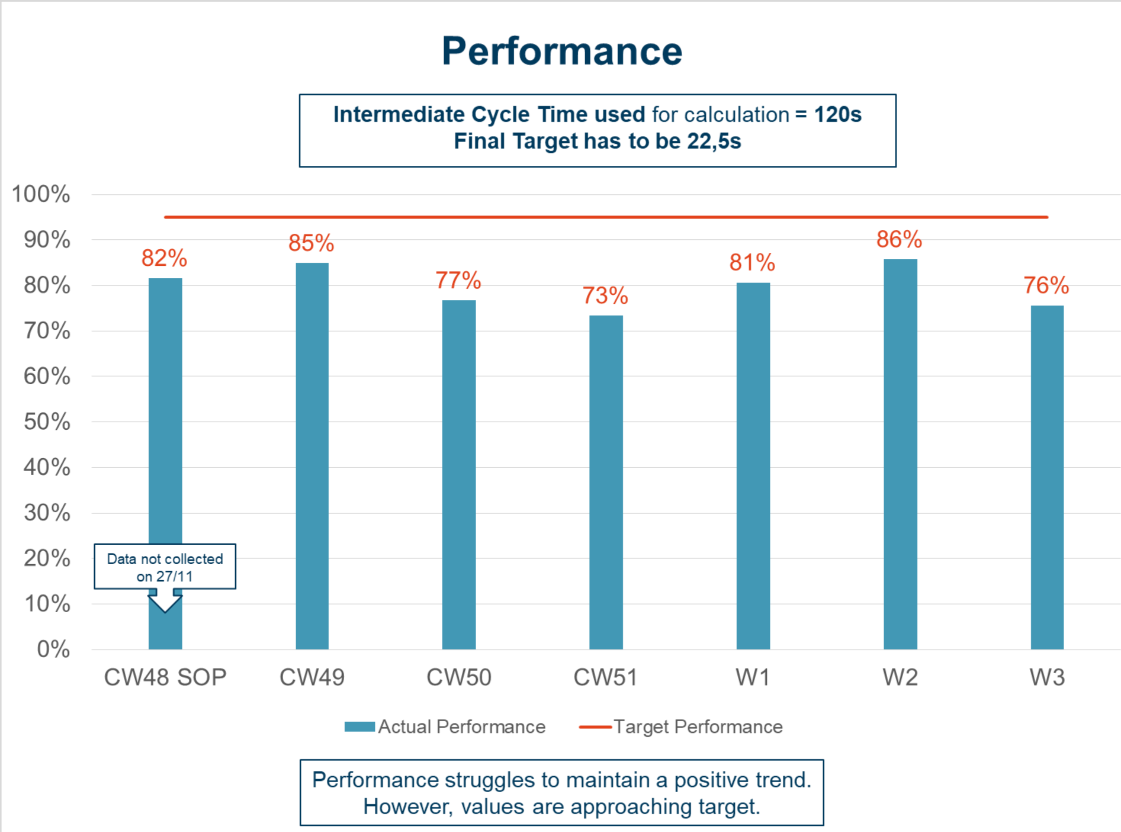


Figure 4.16: *Performance*

Again, as in the case of Unplanned Downtime, a brainstorming involving the operators' Leader and the Manufacturing Engineer takes place in order to analyze reduced operating speed and minor stoppages that occured in the previous week. During the brainstorming, the following two analysis tools were applied:

- The *Ishikawa Diagram* for determining the root cause of a slowdown, that is considered as the effect;
- The *Slowdowns' Pareto* as a decision-making tool for prioritizing major slowdowns and concentrating scarse resources on them. On the horizontal axis, slowdowns' causes are indicated from the most frequent to the least frequent, from the left to the right. Instead, the time lost for each slowdown's cause is expressed in seconds on the vertical axis.

In particular, the time lost for slowdowns is estimated as follows. For example, in the case of a minor stoppage of a machine, once the operator has reactivated the machine, she/he put a cross on a paper placed on the machine itself. In this way, it is possible to count how many stoppages there are in one day on the particular machine. The number of minor stoppages is then multipled by the average time taken by the operator to reactivate the machine.

4.3.3.3 Quality

Quality, also called First Time Throughput (FTT) or *First Time Quality (FTQ)*, is the part of OEE that determines the good units produced as a percentage of the total units started (Stamatis, 2010, p.23). Therefore, in support of OEE, Quality is used as a KPI as regards *Production Capacity Readiness* within the *Launch Readiness Review*.

Quality, which in the case study is referred to as FTQ, is calculated according to the following formulas:

$$FTQ = \frac{Total\ Parts\ Run - Total\ Defects}{Total\ Parts\ Run} * 100$$

$$Total\ Parts\ Run = Good + Bad$$

$$Total\ Defects = Scrap + Rework$$

Usually the target of Quality is equal to 99% (Stamatis, 2010, p.23). Quality has a higher target compared to Availability and Performance because rejecting bad parts means also losing the money spent for raw materials.

In the case study, FTQ has been calculated on weekly data in order to provide a more reliable measurement, as for OEE, Availability and Performance. For example, FTQ in week 50 was determined as follows. First of all, the Total Parts Run, which comprehends both Good parts and Bad parts, was equal to 805, whereas the Total Defects were equal to 120. Consequently, FTQ in week 50 was equal to 85%, as follows:

$$FTQ\ in\ Week\ 50 = \frac{805 - 120}{805} * 100 = 85\%$$

Figure 4.17 represents FTQ results during Production Launch week by week. In this way, it is possible to visualize the trend of improvement or deterioration in FTQ.

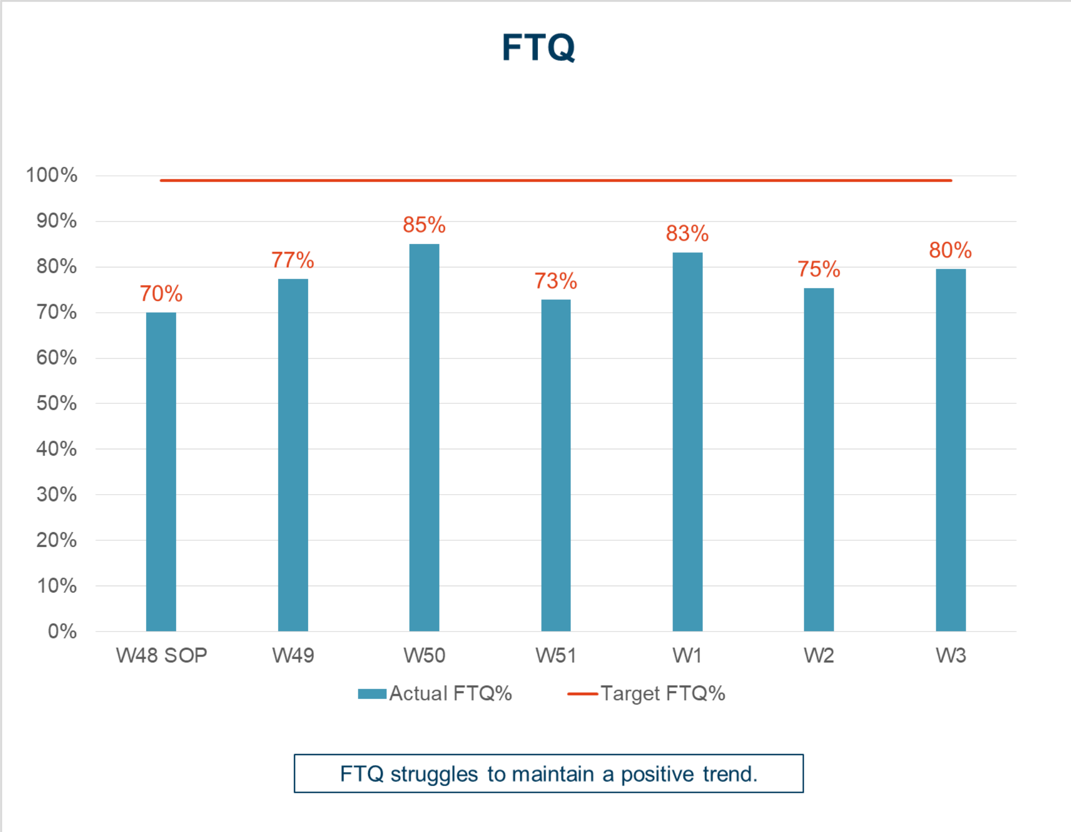


Figure 4.17: *FTQ (First Time Quality)*

For example, in week 50 FTQ was improved to 85%, but was still far from the target of 14%. In particular, the trend of FTQ indicates how efficiently defects have been decreased week by week. Therefore, a stable or negative trend points out that the team is having a hard time in solving quality issues. This is a warning for the Program Manager, whose intervention may be required in order to remove major obstacles and support the team activities.

Again, a brainstorming involving the operators' Leader and the Production Quality Technician takes place in order to analyze the defects that occured in the previous week. During the brainstorming, the following two analysis tools were applied:

- The *Ishikawa Diagram* for determining the root cause of a defect, that is considered as the effect;
- The *Scrap Pareto* as a decision-making tool for prioritizing major defects and concentrating scarce resources on them. On the horizontal axis, defects are listed from the most frequent to the least frequent, from the left to the right. Instead, the frequency of defects is expressed in units on the vertical axis.

4.3.3.4 Another example from the Case Study

A significant example from the Case Study is here described to show how these measurements are key to prioritize actions.

After manufacturing line improvements, Cycle Time should have been equal to 30 seconds. Consequently, from that moment on, OEE as well as Performance were calculated using this ideal cycle time. Results, which are shown in Figure 4.18, clearly indicate that the team should focus on those actions that will improve Performance in order to significantly improve OEE. In the case of scarces resources, actions to improve FTQ and Availability could have been postponed instead.

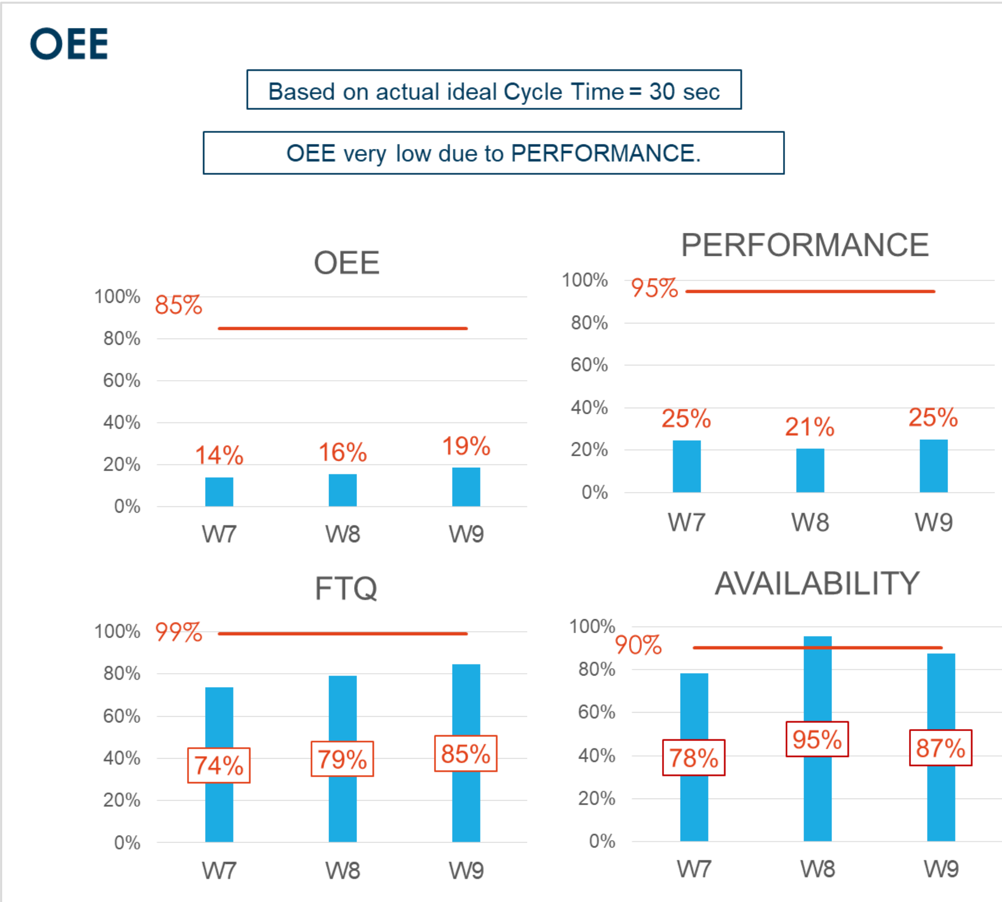


***Figure 4.18**: Another example from the Case Study*

4.3.3.5 Final Considerations on OEE

The value of OEE in week 50 has already been determined at the beginning of the paragraph and was equal to 64%. Now it can be confirmed by taken into consideration Availability, Performance, and Quality:

$$OEE\ in\ week\ 50 = 95\% * 77\% * 85\% = 62\% \cong 64\%$$

In conclusion, OEE identifies equipment potential, losses and opportunities. Its goals are to increase productivity, reduce cost, focus on machine productivity and increase equipment life (Stamatis, 2010, p.21). The analysis of its main components shown how OEE indicates the overall utilization of facilities, time, and material for production.

In particular, through the examination of the three main components of OEE, it can be explained how OEE includes six major losses in equipment:

1. *Breakdowns*, which are included in Availability;
2. *Setups/adjustments*, again in Availability;
3. *Idle/stops*, again in Availability;
4. *Reduced speed*, which instead are included in Performance;
5. *Scraps*, which are included in Quality;
6. *Start-up yield*, which are included in Performance.

4.3.4 Cycle Time Evolution

At SOP (Start Of Production) the manufacturing line was not ready at 100%. This is a typical situation of the Production Launch of an automotive product on a new manufacturing line. In fact, as already mentioned, nowadays phases in automotive projects are so squeezed in time that are overlapping more and more. Consequently, *Cycle Time* was not yet at *Takt Time*. However, in a Production Launch, the number of product parts requested by the Customer is significantly lower than what has been established in the contract. In fact, a production ramp up is typical of a Production Launch.

However, when Customer demand for Q1 2020 arrived, the need to monitor Cycle Time improvement arised in order to be able to increase Production Capacity of the manufacturing line and hence satisfy demanded quantities. In fact, monitoring Cycle Time evolution is important in order to determine not only *Production Process Readiness* but also *Production Capacity Readiness*.

Cycle Time is the measure of how frequently a part is produced (Dennis, 2007, p.53). It is the reciprocal of Production Rate, which has already been determined in the section about Performance:

$$Cycle\ Time = Production\ Rate^{-1}$$

In particular, in order to determine *Production Process Readiness*, it is important to monitor the *Ideal Cycle Time* of the manufacturing line and compare it with Takt Time. As already explained for Performance measurement, the Ideal Cycle Time is the best Cycle Time ever achieved. During the Production Launch, the Ideal Cycle Time was 120 seconds, far from 22,5 seconds of Tack Time. Takt Time instead is how frequently a part has to be produced by contract.

Consequently, a tool to monitor Cycle Time evolution has been developed, as shown in Figure 4.19.

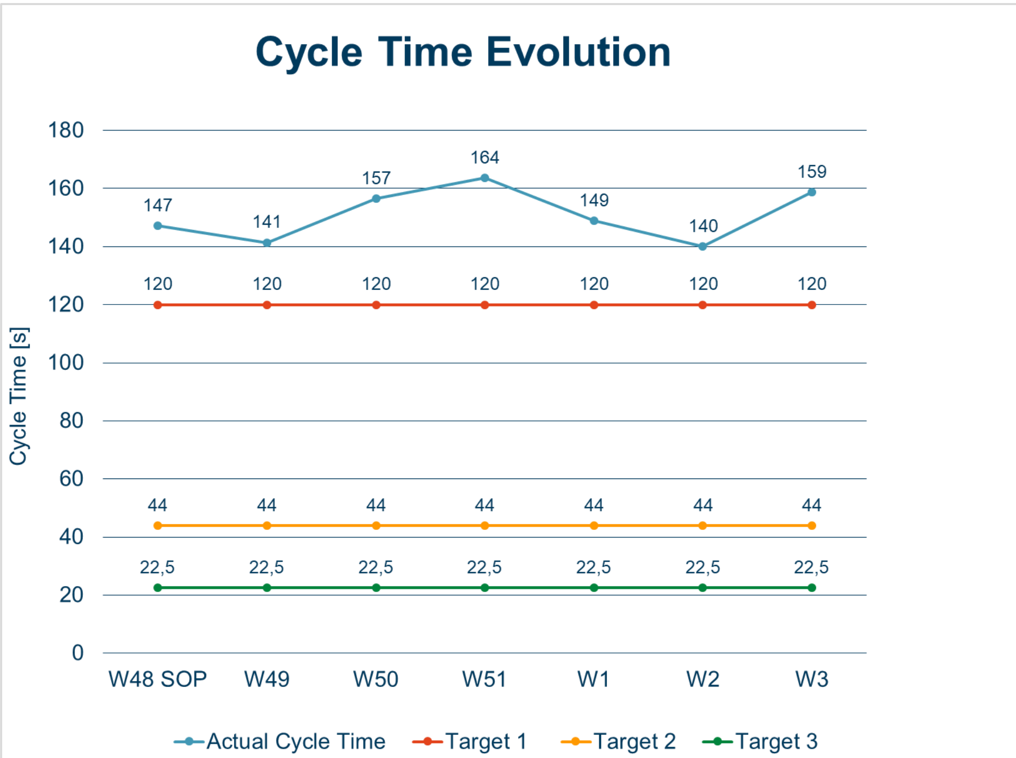


Figure 4.19: *Cycle Time Evolution*

For example, in week 50 Cycle Time has been determined by considering that the average Actual Rate has been 23 parts/hour:

$$Cycle\ Time\ in\ Week\ 50\ =\ (\frac{23\ parts/hour}{3600\ sec/hour})^{-1} = 157\ sec/part$$

This means that, on average, in week 50, every 157 seconds a part was produced. Actual Cycle Time was very far from Takt Time.

From Figure 4.19 it can be noticed that there are gradual targets between Cycle Time and Takt Time. In fact, the goal is to synchronize Cycle Time and Tack Time (Dennis, 2007, p.53), by reaching the intermediate targets one after the other through a detailed action plan. Targets are represented by different colors according to their urgency, from red to orange to green, whereas actual result is represented in blue.

Gradual targets were established on the basis of an analysis on bottleneck workstations. For each workstation of the manufacturing line, the average time spent by a production part has been determined. This allowed to identify the bottlenecks of the manufacturing line, which are those workstations in which the production part lasts more than Takt Time. In the case study, three were the bottleneck workstations of the manufacturing line:

- The first workstation to tackle had a production time of 240 seconds;
- The second workstation to tackle had a production time of 120 seconds;
- The third and last workstation to tackle had a production time of 44 seconds.

Following this analysis, the Manufacturing Engineer developed an action plan for each bottleneck workstation. A concise description of the steps for Cycle Time improvement together with the road map is provided to all stakeholders through the analysis tool in Figure 4.20. Here sensitive data are again omitted in order to be compliant with the privacy policy of the company; a template of the analysis tool is provided instead.

Cycle Time Improvement				Road Map			
Step	Initial Cycle Time	Target Cycle Time	Cause of gap	Action	Who	Target Date	End Date
1	240 s	120 s	Bottleneck at Workstation #				
2	120 s	44 s	Bottleneck at Workstation #				
3	44 s	22,5 s	Bottleneck at Workstation #				

Figure 4.20: *Template of the Analysis Tool of Cycle Time Evolution.*

4.3.5 PPAP (Production Part Approval Process) Glidepath

In order to ensure *Production Launch Readiness*, within the *Materials and Supply Readiness* section, it is important to verify that suppliers are qualified and that supply quantities are demonstrated. This is particularly relevant for the case study of this paper, in which the production process consists in the assembly of eleven main components that are all bought from Asian suppliers (Figure 4.21).

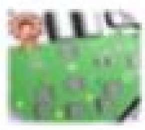
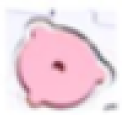
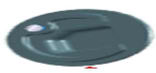
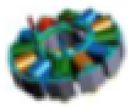
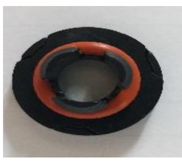
PCBA - ECU	Cover Bearing	Alubox	Cover Inverter	Rotor Assy	Stator Assy
					
LV Wiring	**Bearing C/FAN**	**Membrane**	**Stop ring**	**Wave Washer**	
					

Figure 4.21: *Main Components of an eCF*

PPAP (Production Part Approval Process) is a standard tool of the automotive industry that allows suppliers and customers to clearly state the requirements for approval of supplier manufactured parts (AIAG, n.d.). Thus, PPAP guarantees that engineering design and product specification requirements are met (AIAG, n.d.). Thanks to PPAP, delays as well as non-conformances are decreased during part approval. The output of this process is a collection of documents. However, the most important document is the Part Submission Warrant (PSW), on which the supplier has to report specific information once all required measurements and tests have been successfully completed (Nethics, 2013).

In the case study, it has been decided to develop a tool to monitor the activities for PSW obtainment. This because of the large number of product components that require PPAP. Furthemore, suppliers were all Asian and consequently the process was challenged by cultural differences and communication problems. Therefore, it was important to monitor the progress of PPAP on a weekly basis in order to ensure PSW obtainment in time for SOP (Start Of Production).

In detail, PPAP is structured into *19 elements*, which have to be carried out for PPAP completion (Nethics, 2013). These elements are listed below:

1. Product Designs;
2. Documents relative to Project Changes (if any);
3. Customer Engineering Approval (if required);
4. Project FMEA (if the supplier is responsible of the project);
5. Process Flow Diagrams;
6. Process FMEA;
7. Dimensional Measurements;
8. Performance and Material Test Results;
9. Initial Process Study;
10. Measurement Systems Analysis Studies (MSA);
11. Qualified Laboratory Documentation;
12. Control Plan;
13. Part Submission Warrant (PSW);
14. Aesthetic Approval Report (AAR) (if applicable);
15. List of Raw Material Requirements (only for PPAP of raw materials);

16 Product Sampling;
17 Master Sample;
18 Means of Control;
19 Documents of Conformity with Customer Specific Requirements.

PPAP have five different levels. According to the level required by the customer, the supplier has to provide to the customer different types of documentation (Nethics, 2013), as is illustrated below:

- *Level 1* requires the PSW (Part Submission Warrant) and, for those parts that have aesthetic requirements, the AAR (Aesthetic Approval Report);
- *Level 2* requires the PSW with the product sampling and a part of the supporting documentation;
- *Level 3*, which is the defaul level, requires the PSW and all the supporting documentation;
- *Level 4* requires the PSW and only what is explicitly requested by the customer;
- *Level 5* requires the PSW, the product sampling and all the documentation available for examination at the supplier.

In response to the presentation of the documentation and of the product sampling to the customer, the PPAP process can have three different results:

- *Full Approval*, in the case the product satisfies customer requirements and specifications (Nethics, 2013).
- *Interim Approval*, which releases the requirements for shipping the product for production of a limited quantity or for a limited time period. This is granted in the case the supplier has identified the root cause of the non-conformances that prevent from Full Approval. Besides, the supplier must have already prepared an action plan for interim approval in accordance with the customer. Re-presentation of documentation is mandatory in order to obtain Full Approval (Nethics, 2013).
- *Rejected*, which indicates that product sampling, its production batch and the accompanying documentation do not satisfy customer requirements (Nethics, 2013).

PPAP is lead by the SQE (Supply Quality Engineer), who deals with the supplier and the other participants to this process. These other participants are the Purchasing Department, the Product Engineering, the Labs, and the Quality Department (Nethics, 2013).

After this excursus on what PPAP consists in and why it is important in order to ensure *Launch Readiness*, the tools through which the process is monitored in the case study are presented below.

First, it has been developed a tool able to represent graphically the actual status of PPAP advancement against the forecast. An example of this tool, which has been called PPAP Glidepath, is provided in Figure 4.22. Also in this case, sensitive information are omitted in order to be compliant with the privacy policy of the company. A generic example has been provided instead.

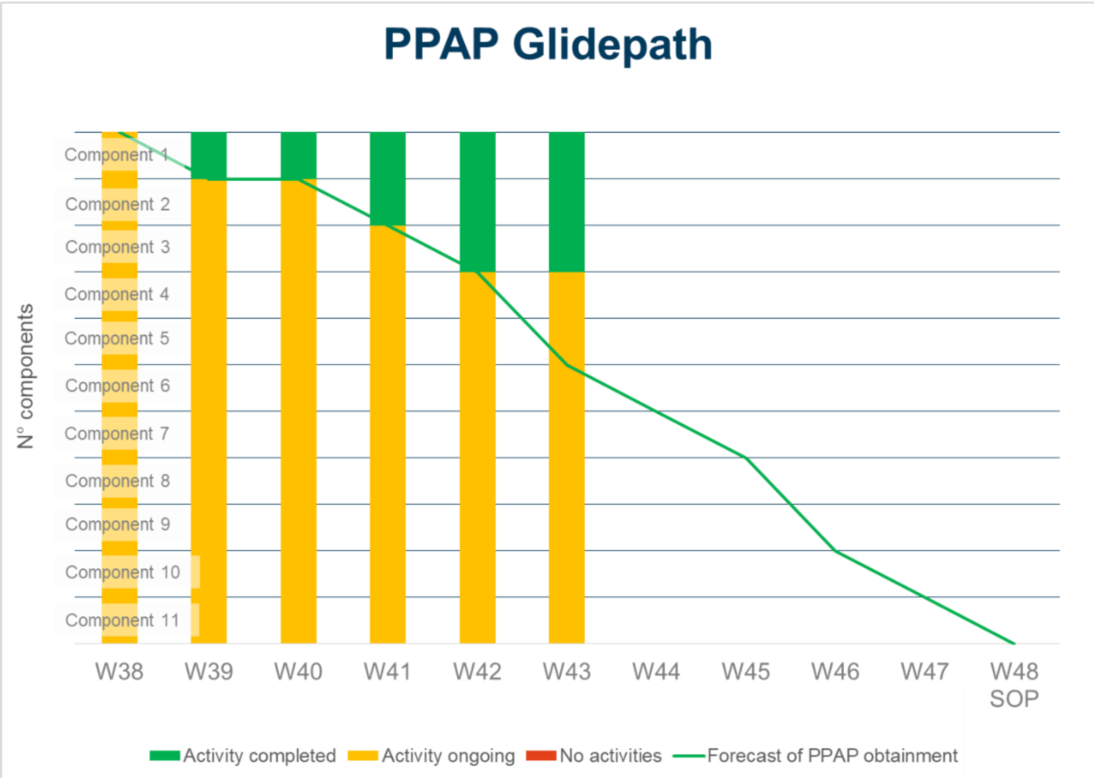


Figure 4.22: *A Generic Example of PPAP (Product Part Approval Process) Glidepath*

On the horinzontal-axis are represented the weeks of Production Launch, whereas on the vertical-axis are represented the number of components that require PPAP.

At the first glance, for each component it is possible to visualize the forecast of PPAP approval, represented by the green line. From the trajectory of the green line comes the graphs' name "glidepath", which means aircraft's landing path. The forecast can be used as a target. For example, component 2 is expected to obtain PSW in week 41, whereas total PPAP is expected to end in week 48, which is the week of SOP (Start of Production).

Week by week actual results are compared to target, so that in the case of a delay in activities these can be speed up in time. This is done by determining the current PPAP status, which can be of three types, according to the legend in Figure 4.22:

- PPAP status is green if activities has been completed and hence PSW has been obtained (e.g. component #1 in week 39);
- PPAP status is yellow if activities for PPAP obtainment are in place, but PSW has not been obtained yet (e.g. component #2 in week 39);
- PPAP status is red if there are no activities ongoing to obtain PSW.

In the case of components that to do not obtain PSW when expected (e.g. components 4 and 5 in Figure 4.22), PPAP activities have to be particularly monitored in order to prevent further delay and if necessary speed up activities. The analysis tool used in this case is illustrated just below. These components may receive an *Interim Approval* in the case PSW is not obtained at SOP (Start Of Production), while waiting for PPAP completion

Sometimes a new forecast of PPAP completion is required, because of major obstacles that cause irreducible delays in activities. In this case, the new forecast is represented on the graph as well, as already illustrated for the ECR glidepath. However, the previous forecast is still indicated on the graph, because it is also important to track the delay in PSW obtainment.

Instead, if a component has a red status, it is not possible to do a forecast of when it will obtain PSW, because there are neither activities nor a plan in place. This is a major warning for the Project Manager, who has to put in place actions as soon as possible to remove the major obstacle to PPAP completion. An example is provided in 4.23.

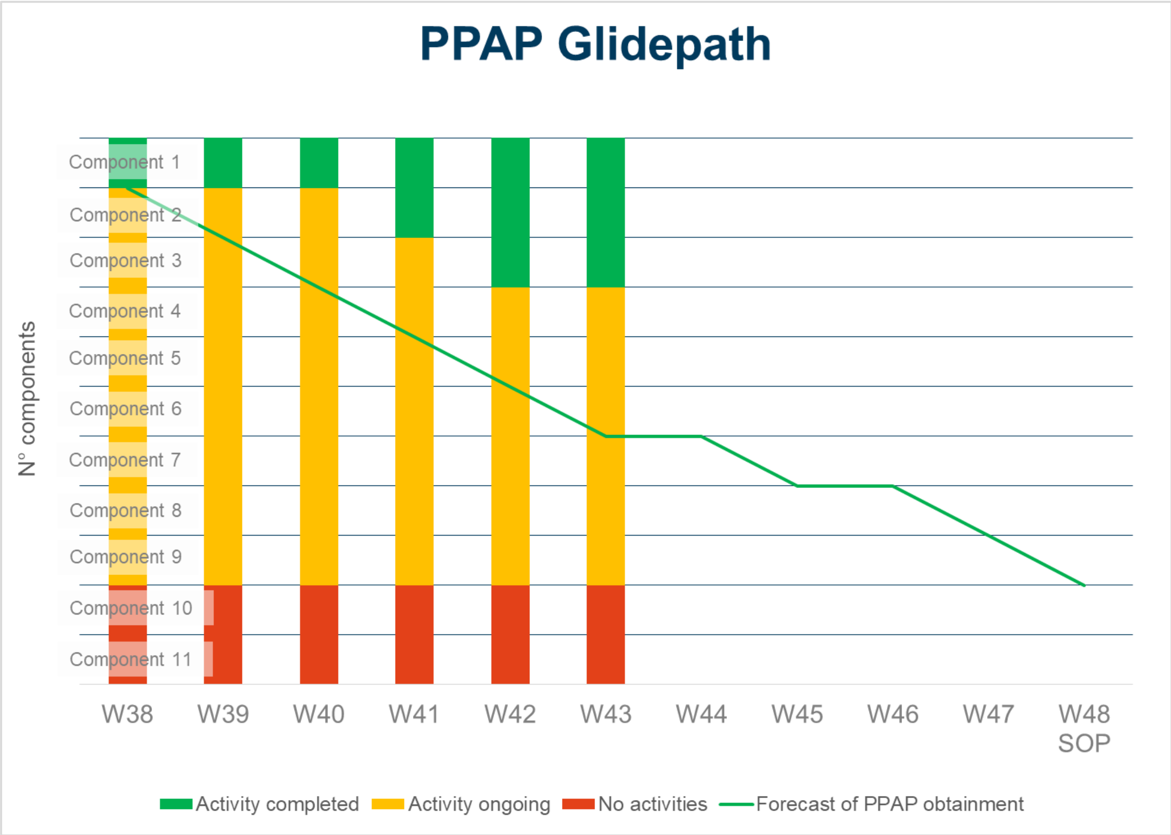


Figure 4.23: *A Second Example of PPAP Glidepath*

For further insight on issues, an analysis tool is provided that for each component summarizes the following information within a table:

- Component's name;
- Supplier's name and location;
- SQE (Supplier Quality Engineer);
- Whether the component is a carry over or not;
- Company component code;
- Customer SOP (Start Of Production) date;
- Due date of Company PPAP approval, according to customer SOP date;
- Whether the nomination letter has already been released or not;
- Delivery date of prototype components;
- Due date of PPAP level 3 documentation;
- Actual date of PPAP documentation release;
- Actual date of PPAP release;

- Measurements to be done with due date;
- Whether IMDS/CAMDS are open or close;
- Expected date of PSW signature.

4.3.6 Delivery Performance

Within the *MP&L, Logistics and IT Readiness* section of the *Launch Readiness Review*, it is important to monitor the Delivery Performance. This indicates whether the product quantity requested by the Customer has been delivered on time.

Delivery Performance is calculated according to the following formula:

$$Delivery\ Performance = \frac{Actual\ Quantity\ Delivered\ On\ Time}{Requested\ Quantity\ Delivered} * 100\%$$

In particular, with Requested Quantity Delivered is meant the number of product parts that have to leave the plant on the delivery date in order to satisfy Customer request. The delivery date takes into account the ETA (Estimated Time of Arrival), which is based on the type of transport used.

An example of calculation of Delivery Performance is provided below. The Requested Quantity Delivered on 8 January is equal to 1530 parts. As the request was satisfied on time and hence on 8 January were delivered 1530 parts to the Customer, Delivery Performance was equal to 100%:

$$Delivery\ Performance\ on\ 8\ January = \frac{1530\ parts}{1530\ parts} * 100\% = 100\%$$

However, it is also fundamental to do a forecast of future Delivery Performance based on Process Capacity. In fact, this initial phase of Serial Production still experiences capacity issues, as already illustrated. As such, it is important to determine whether Customer requests will be satisfied on time according to actual conditions. If this is not the case, an action plan has to be put in place tempestively.

The forecast of Delivery Performance is calculated as follows:

$$Forecasted\ Delivery\ Performance = \frac{Forecasted\ Qty\ Delivered\ On\ Time}{Requested\ Qty\ Delivered} * 100\%$$

For example, the Customer requested 2970 parts on 11 March. However, through considerations that will be explained below, it is expected to have a stock of only 750 parts on that day. Consequently, the Forecasted Delivery Performance on 11 March is equal to 25%, according to the following calculation:

$$Forecasted\ Delivery\ Performance\ on\ 11\ March = \frac{750\ parts}{2970\ parts} * 100\% = 25\%$$

The remaining parts are expected to be delivered with two weeks delay, according to the forecast.

Figure 4.24 represents in the same diagram three key information: actual Delivery Performance, Target Delivery Performance, and Forecasted Delivery Performance for the period of Production Launch. The purpose is to monitor all this information on a weekly basis.

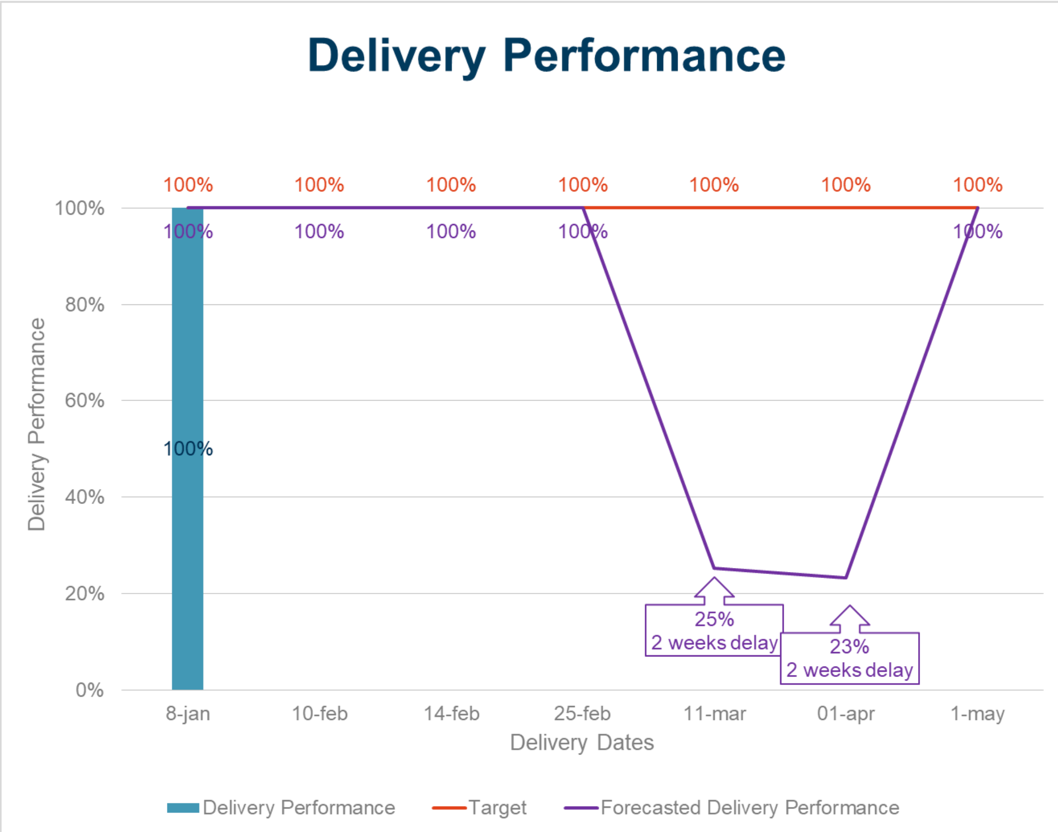


Figure 4.24: *Delivery Performance*

On the horizontal-axis are represented the delivery dates, whereas on the vertical-axis is represented the Delivery Performance. Again, the delivery dates are meant as the dates in which product parts have to leave the plant, and not as the dates in which they have to arrive to the Customer.

Blue columns indicate actual results, which are compared to the target. The target is a red line and is equal to 100%. Satisfying Customer requests, especially in terms of quantities, is a priority during a Production Launch. Otherwise, there is a high risk of losing the business. However, when the team members realize that there is a gap between actual and target results, it is too late to satisfy the Customer quantities on time. This is not acceptable when dealing with Customer delivery satisfaction. For this reason, the forecast of Delivery Performance is represented as well in the graph by a purple line. In this way, in the case Forecasted Delivery Performance is below 100%, it is possible to put in place an action plan in time to satisfy Customer requested quantity. Besides, on the graph, a label indicates the weeks of delivery delay, according to the forecast.

The analysis tool in Figure 4.25 is used in order to determine the Forecasted Delivery Performance.

Week	Date	Production Plan	Planned Qty	Planned Stock	Requested Qty
WK4	20-gen	No Serial Production; Line Improvements			
	21-gen	No Serial Production; Line Improvements			
	22-gen	No Serial Production; Line Improvements			
	23-gen	No Serial Production; Line Improvements			
	24-gen	No Serial Production; Line Improvements			
	25-gen				
	26-gen				
WK5	27-gen	Serial Production	180	910	
	28-gen	Serial Production	180	1090	
	29-gen	No Serial Production		1270	
	30-gen	No Serial Production		1270	
	31-gen	No Serial Production		1270	
	01-feb			1270	
	02-feb			1270	
WK6	03-feb	Serial Production	180	1270	
	04-feb	Serial Production	180	1450	
	05-feb	Serial Production	180	1630	
	06-feb	Serial Production	180	1810	
	07-feb	Serial Production	180	1990	
	08-feb			2170	
	09-feb			2170	
WK7	10-feb	Serial Production	180	2170	**2070**

After line improvements:
- Best case: cycle time = 45 sec/parts, hence 613 parts/day
- Worst case: cycle time = 150 sec/parts, hence 180 parts/day
Worst case considered

Figure 4.25: *Delivery Performance Simulation Tool from week 4 to week 7*

For example, a simulation has been performed by considering the worst Cycle Time possible after line improvements have been done in week 4. According to this simulation, on 10 February the forecasted stock is equal to 2170 parts, which is greater than the requested quantity on that day.

However, according to the same simulation, it is expected that the delivery on 11 March of 2970 parts will not be satisfied. In fact, the forecasted stock on that day will be equal to 750 parts. It will be possible to satisfy Customer request only on 28 March, when the forecasted stock will turn again to positive values, as shown in Figure 4.26.

Week	Date	Production Plan	Planned Qty	Planned Stock	Requested Qty
11	09-mar	Serial Production	180	390	
	10-mar	Serial Production	180	570	
	11-mar	Serial Production	180	750	**2970**
	12-mar	Serial Production	180	-2040	
	13-mar	Serial Production	180	-1860	
	14-mar			-1680	
	15-mar			-1680	
12	16-mar	Serial Production	180	-1680	
	17-mar	Serial Production	180	-1500	
	18-mar	Serial Production	180	-1320	
	19-mar	Serial Production	180	-1140	
	20-mar	Serial Production	180	-960	
	21-mar			-780	
	22-mar			-780	
13	23-mar	Serial Production	180	-780	
	24-mar	Serial Production	180	-600	
	25-mar	Serial Production	180	-420	
	26-mar	Serial Production	180	-240	
	27-mar	Serial Production	180	-60	
	28-mar			120	

Figure 4.26: *Delivery Performance Simulation Tool from week 11 to week 13*

The tool also allows to develop an appropriate action plan by putting in place different scenarios. For example, through a simulation, it can be determined how many weeks of *double shifts* are required in order to meet Customer requests on time. In this case, in order to meet deliveries on 11 March and 1 April, double shifts would be required in weeks 6, 7 and 8. Other solutions may be the followings:

- *Changing the type of transport*, for which ETA (Estimated Time of Arrival) is decreased, and hence the delivery date can be postponed;

- *Improving Cycle Time* of the manufacturing line, by putting in place line improvement actions;
- *Negotiate with the Customer*.

4.3.7 Training Timetable

In order to ensure *Personnel and Training Readiness*, it has been decided to use the *Training Timetable*. In general, the Training Timetable is a tool used for visualizing the training status of employees and organizing training activities according to organizational needs (Dinero, 2005, p.171). In particular, in the case study, the Training Timetable is applied for monitoring the training status of the operators working on the new manufacturing line. Therefore, it is also used to organize the training of the operators according to the needs of the manufacturing line. In fact, it indicates which operator is able to perform the task on the specific workstation.

A template of a training timetable is represented in Figure 4.27. Also in this case, sensitive information are omitted in order to be compliant with the privacy policy of the company.

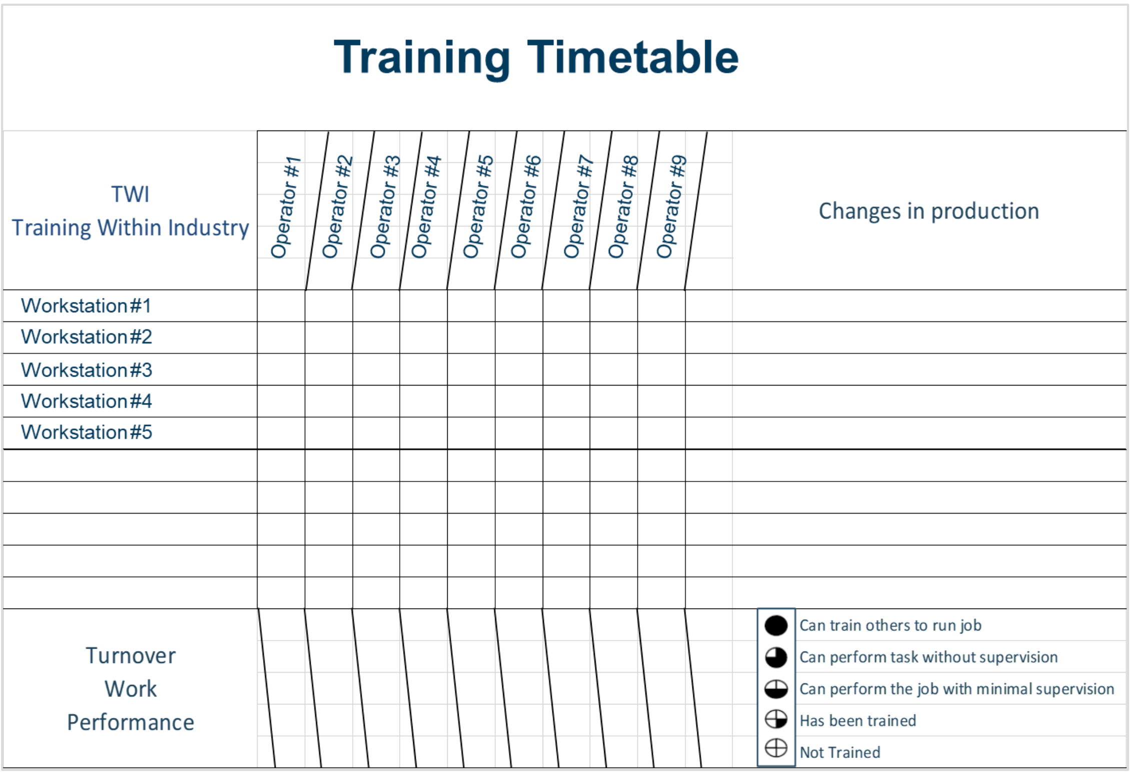


Figure 4.27: *Training Timetable*

The Training Timetable is merely a spreadsheet that allows to register for each operator its degree of training for a specific workstation. The operators are listed in correspondence of the columns, whereas the workstations that require an operator to work are listed in correspondence of the rows. The degree of training is established by the Leader of the operators team, because is the person who is most informed about it. The degree of training is established according to the legend on the lower right in Figure 4.27:

- In the case the specific operator is not trained on the specific workstation, then the circle is completely white;
- If the operator has been trained on the specific workstation, then one quarter of the circle is filled;
- In the case the operator is able to perform the job with minimal supervision of the team leader on the specific workstation, then the circle is half-filled;
- If the operator is able to perform the task without supervision of the team leader on the specific workstation, then the circle is filled for three quarters;
- In the end, in the case the operator is also able to train others, then the cicle is completely filled.

The degree of training is constantly updated in order to reflect the current training status of the line. The Training Timetable also allows to organize additional training by indicating the reason and the due date.

Additional training of an operator may be required because a change has been introduced in production. These changes are written down in the column called “Changes in Production” in correspondence of the workstation involved in the change. In this way, it is possible to determine training needs. For example, this tool was used to evaluate the possibility of introducting a long shift of 12 hours. The number of operators already trained and the degree of their training was visualized immediately thanks to the Training Timetable. In this way, it was possible to determine the training needs. Once the date of the training was set, it was written in the square that intersecates the specific operator with the specific workstation.

Additional training of an operator may also be required by turnover work performance. Reasons are indicated in the apposite row in correspondence of the specific operator. For example, operator #1 may require additional training because of difficulties in meeting the standard on a specific workstation. Again, the date of the training is written at the insersection between the operator and the workstation.

4.3.8 Motor PPAP (Production Part Approval Process) Checklist

At last, to ensure *PSW Readiness*, it is key to monitor the activities for PPAP completion as regards the final product. The process for PSW obtainment is the same already described in section 4.3.5. However, in this case, PSW has to be obtained for the final product, and not for its components. The process is carried out by the Quality Engineer.

The tool used for monitoring PPAP activities is shown in Figure 4.28 and is basically a checklist. Also in this case, sensitive information are omitted in order to be compliant with the privacy policy of the company. A template of the tool is provided instead.

Motor PPAP Checklist

		Availability				Completion Status		Action Plan		
	PPAP element	N/A	Yes	No	Previous version	% of Completion	Comments	WHAT	WHO	WHEN
1A	Design Records of Saleable Product (Drawing)									
1C	IMDS report									
1E	Open AIMs/Concerns/Builds issues									
2	Engineering Change Documents Deviation/Alert/TPD/PCR/SREA/Saleable									
3	Customer Engineering approval (DV and PV test results sign off)									
4	Design FMEA (approval for CC components)									
5	Process Flow Diagrams, including rework and scraps flow									
6A	Process FMEA (approval for CC components)									
6B	CC/SC agreement									
7	Control Plan (approval for CC components)									
8	Measurement System Analysis studies (ANOVA, 50 pcs for atribute)									
9	Inspection Report									
10C	BOM (PSW Dates & Status for all Subcomponents - table)									
####	Sample Production Parts									
15	Master Samples GOOD /NG									
16	Checking Aids (Boundary samples approved)									
	- Packaging approval									
18A	PPAP Warrant									
18B	Planned functional build date for Post J1									

Figure 4.28: Template of PPAP Cheklist for Final Product

First, the tool in Figure 4.28 lists all PPAP activities, which correspond to the ones already illustrated for the PPAP of product components. Then the tool is organized in three main sections in order to made information clear and easy to find: Availability, Completion Status, and Action Plan.

In the section “Availability”, for each activity it is indicated:

- Whether it is not possibile to determine if PPAP element is available (in column “N/A”);
- Whether PPAP element is available (in column “Yes”);
- Whether PPAP element is not available (in column “No”);
- The date of previous used version of document/requirement.

In particular, if PPAP element is available, the activity status is indicated according to the following legend:

- In the case that the activity is on time, the activity status is green;
- In the case that the activity is on delay, the activity status is yellow;
- Lastly, in the case that the activity is on delay with no action in place, the activity status is red;

In this way, all the team members and in particular the Project Manager is able to identify critical activities at the first glance. In particular, in the case of a red status, the Project Manager may act in order to speed up the activity. Consequently, this tool can be considered the KPI of PPAP advancement.

In the section “Completion Status”, further information is provided on the progress of PPAP activities. In particular, at the first sight it is possible to understand the level of completion of the activities. In the case of necessity, further comments are provided in order to acquire more information about the completion status of the activities.

At the end, within the “Action Plan” section, what has to be done, who has to do it, and by when is clearly stated. This is a road map for the team members. Besides, in the case of a red status, it is a clear and concise tool for the Program Manager in order to solve major issues and speed up actions.

For example, let us consider PPAP element n° 5, which regards the Process Flow Diagrams. As there was a delay in the activity, its status is yellow. In particular, the completion of the activity is at 80%, as represented by the blue bar. In fact, according to the comments, rework and scrap flow had still to be checked. The action plan stated that this part had to be included within the control plan by the manufacturing engineer, and a due date was indicated.

4.4 KPIs application and monitor

KPIs application and monitor need the collaboration of all team members in order to be effective. In fact, this activity is based on the *collection of information*.It takes place during weekly meetings, called the *Launch Readiness Review (LRR) Meetings*, in which actions plans are developed in order to ensure a flawless Launch These key topics for KPIs application are discussed in the sections below.

4.4.1 Collection of Information

In order to apply the system developed, the first step consists in collecting information from data. This is not as simple as it might seem for different reasons. First, team members might be over-worked, and hence collection of information becomes secondary. Secondly, team members might also obstruct a smooth flow of information. This because for example they want to minimize a problem in which they are involved. Furthermore, in the case of a Production Launch on a new manufacturing line, standard systems of collecting data may not be already in place and, as such, registration of data becomes difficult.

For these reasons, it is very important that the Project Manager makes understand to the team members the importance of collecting information. In fact, this is the basis for providing a grounded direction to the project. Furthermore, it allows to prioritize project activities in the case of scarse resources. Team members have to understand that the purpose of collecting and sharing information is not controlling them and judging their work. Instead, the aim is to facilitate their work in order to achieve project success in a smooth way.

To this end, it is fundamental that team members use the system developed and value its usefulness. After the required information has been collected, this is first analysed between specific team members. Results of this first analysis are then shared and discussed with all the team. This is done during the weekly Launch Readiness Review (LRR) Meetings.

4.4.2 Launch Readiness Review (LRR) Meetings

Launch Readiness Review (LRR) Meetings take place three days per week, which is Tuesday, Wednesday and Thursday. In particular, the Tuesday Meeting is dedicated to the analysis of the KPIs of the previous production week.

LRR Meetings take place close to the manufacturing line, in front of the LRR Board, as shown in Figure 4.29.

***Figure 4.29**: Launch Readiness Review (LRR) Board*

The Launch Readiness Review (LRR) Board is a support for the LRR meetings. On the left side of the board, in yellow folders, the KPIs are placed, together with the corresponding analysis tools. Instead, on the right side, further information is provided, such as the LOP (List of Open Points), which is described in the following section, parts availability, the last BOM (Bill Of Materials) that have been released etc.

In front of the LRR Board, there is a high table. In this way, the LRR Meetings are done in front of the LRR Board around the table. This configuration, for which people stand and is not sit down, has the aim of shortening meetings. As already discussed in chapter 2, team meetings should last no more than twenty minutes. They have the purpose of sharing key information to all team members. In the case it is necessary to discuss specific issues, dedicated meetings should be organized with only interested team members involved.

4.4.2.1 LOP (List of Open Points)

From the analysis of the KPIs during Tuesday LRR meetings, a LOP (List of Open Points) is used for tracking the activities to do in order to solve the major issues arised. A blank example of a LOP is represented in Figure 4.30.

LOP					
Problem	Action	Responsible	Due Date	Actual Date	Status
					⊕
					⊕

Figure 4.30: *LOP (List of Open Points)*

On the Tuesday Meeting, the team examines the information provided by the KPIs and identifies the problems to address with the support of the corresponding analysis tools. The identified problems are briefly described in the apposite column within the LOP.

The appropriate countermeasures are consequently discussed among the team, and the actions to do are reported in the appropriate column within the LOP.

The person responsible to do the action and the date by which the action has to be done are identified and written in the apposite columns within the LOP. In this way, the appointed team member is committed in carrying out the specific activity within the timeframe dictated by project needs. In this way, the risk that the activity is neglected is very much reduced.

In the case of a delay in the execution of the action, an actual date is pointed out in the appropriate column within the LOP. This allows to monitor the perfomance of the team members relative to the execution of project activities.

Finally, at every LRR meeting, the status of each action is updated and shared with the rest of the team, according to the PDCA cycle (Plan-Do-Check-Act cycle) illustrated in Figure 4.31:

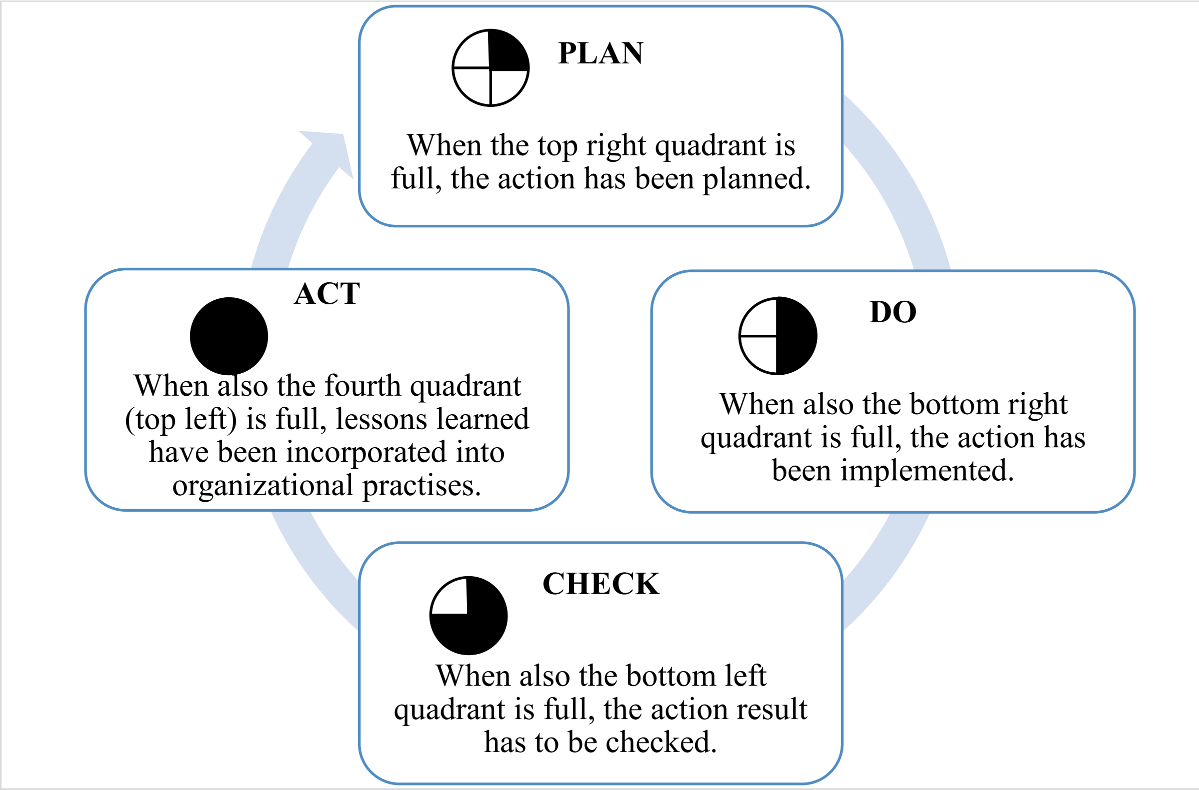


Figure 4.31: *PDCA Cycle (Plan-Do-Check-Act Cycle)*

4.4.2.2 Scrum

At a certain point of the project, the activities that were required to improve the performance of the manufacturing line were stucked. The LOP was not enough to deal with the great number of these activities. It was necessary to strictly monitor the single actions to complete and speed up activities by quickly identifying the bottlenecks. To achieve this aim, the Agile method, which has been described in Chapter 2.7, was applied.

In applying the Agile method, a Task Force was organized to support Project activities. A dedicated team, called the Task Force team, was formed. This is focused on solving Project bottlenecks and holds up the already in place Project Team. In particular, the Task Force team includes the sponsor, who gives an additional support in the case actions do not progress.

In order to monitor the single actions and speed up activities, the Scrum method was applied. With a strict monitor on small actions, it has the aim of solve bottlenecks in no more than four weeks. This period is called the Sprint.

First, activities from the LOP were divided according to the following three areas, for which a leader was identified:

1. Product Modification,
2. Process Improvement,
3. Components/Suppliers Excellence.

A Scrum Backlog was dedicated to each of this area. A template of Product Modification Scrum Backlog is shown in Figure 4.32, where the related activities to complete where listed in the column called "Goal".

1. PRODUCT MODIFICATION

Leader:

GOAL	MONDAY 02	TUESDAY 03	WEDNESDAY 04	THURSDAY 05	FRIDAY 06

Figure 4.32: *Template of Product Modification Scrum Backlog*

At the beginning of every week, for each goal, the Task Force team identified the actions to do in the week to come. The action was written on a post-it. The post-it colour indicates the function in charge of the action; for example, if the post-it is yellow, it means that the action is in charge of the Manufacturing Engineer. On the post-it, it is also reported the Task Force members involved in the action. The post-it is placed in correspondence of the day in which it has to be carried out.

Once the action has been executed, the post-it is removed from the Scrum Backlog. If the post-it is not removed, it means that the action is a bottleneck, and more support is needed to remove the obstacle.

4.5 Conclusion

The system of indicators has been developed with the aim of effectively managing project activities by priority in a particularly complex phase of the project life, which is the Production Launch. In order to reach this purpose, the indicators have to communicate clear and concise information to all stakeholders. They have to provide a direction for project activities. In this way, the tool becomes fundamental in supporting the decision-making process of the Project Manager.

In particular, indicators have to point out which are the major risks and issues on which focusing the resources. These are usually highlighted with colors (from yellow to red), as it is able to attract the attention of all level of stakeholders, from the project team members to the management board directors.

However, this system becomes useful only when all Project Team members understand its value and apply the tool. In this regard, the Project Manager has the important task of engaging team members in the method developed.

5 Conclusion: lesson learned and next step

The core work of this paper has been developing and applying a system of indicators to monitor the performance of Production Launches in the automotive industry. This allows to effectively manage activities during this complex moment of the project life.

The Launch phase is a very critical phase of a project, especially in the automotive sector. During this phase, production starts with ramp up towards full production rates. However, product design as well as the manufacturing line are not at the full maturity level. This because Development suffers from reduction in time, budget and resources and therefore Development and Launch phases are overlapping more and more.

In order to develop an effective system of indicators, the existing company approach that supports Production Launch management has been analyzed. This mainly consists in the completion of a Checklist, which is the responsibility of the Launch Leader. The Launch Readiness Checklist is completed by the Project Team members three times during the life of the project, during Development, Pilot and Launch phases. In particular, the LR Checklist is completed in advance of key milestones and reviews. Questions are standard and are organized in ten categories, which are:

1. Product Maturity
2. Tooling, Facilities and Equipment Readiness
3. Production Process Readiness
4. Production Capacity Readiness
5. Measurement and Test System Readiness
6. Materials and Supply Readiness
7. MP&L, Logistrics and IT Readiness
8. Personnel and Training Readiness
9. Quality System Readiness
10. PSW Readiness.

For each question, the question owner has to assign the GYR (Green, Yellow, and Red) status and describe the gap and the countermeasure to close the gap.

The Launch Readiness Checklist is included within enterProj, which is a cloud based enterprise business management system. EnterProj provides different types of reports of the Launch Readiness Checklist, according to the needs of the specific stakeholder. For example, these reports allow to filter only items with red status and hence can be used during the monthly Management Board review to focus only on the most important issues and risks.

However, the Launch Readiness Checklist could not be used to guide everyday team activities, because is not completed on a daily or weekly basis. Besides, a data driven and less time consuming tool was preferred. In this framework, the need to develop a system of indicators arose.

In order to be aligned with company requirements and support the existing approach, the system of indicators has been developed from the analysis of the existing Launch Readiness Checklist. At the same time, the indicators were applied to a real Automotive case study, in order to make adjustments if necessary. From the standard questions of the ten categories of the Launch Readiness Checklist, the following indicators have been identified:

1. ECR (Enginerring Change Request) Glidepath, to assess Product Maturity;
2. Customer Claims Glidepath, to assess Product Maturity;
3. Cycle Time Evolution, to evaluate Production Process Readiness;
4. OEE (Overall Equipment Effectivess), together with Availability, Performance and FTQ (First Time Quality), to assess Production Capacity Readiness;
5. PPAP (Production Part Approval Process) Glidepath, to evaluate Materials and Supply Readiness;
6. Delivery Performance, to assess MP&L, Logistrics and IT Readiness;
7. Training Timetable, to evaluate Personnel and Training Readiness;
8. Motor PPAP Checklist, to determine PSW Readiness.

Together with these indicators, appropriate anaylsis tools were developed to provide more insight on risks and issues and, therefore, develop effective action plans. For example, in the case of FTQ (First Time Quality), a Pareto Chart of the scraps was used to reduce those causes that determined the 80% of the scraps.

In particular, with reference to the case study, the Launch Leader was the responsible of reviewing Launch Readiness. The Launch Leader had to collect the necessary information from the appropriate Team Members and provide the indicators. This work was done on a weekly basis, in order to ensure timely actions. Results of the previous production week were analyzed with the Project Team during the weekly Launch Readiness Review.

Besides, indicators results were also presented to the Management Board directors. In particular, performance results of the previous week were forwarded to them every Tuesday. In this way, the main stakeholders within the production plant were informed about Production Launch performance through a clear and concise communication and on a regular basis.

In order to effectively apply the tool, the involvement of the Project Team members is key to provide accurate indicators. In this regards, the Project Manager has the fundamental task of engaging Team members in the application of the tool. In fact, during a Production Launch, team members might be over-worked, and hence collection of information becomes a secondary activity. Team members might also obstruct a smooth flow of information because for example they want to hide a problem. Besides, in the case of a Production Launch on a new manufacturing line, standard systems of collecting data may not be in place yet, and, as such, registration of data becomes time-consuming. As a result, it is very important that the Project Manager makes understand to the Team members that the tool of indicators has the aim of providing a direction to the project, and hence facilitating their work in order to achieve project success in a smooth way.

Besides, after activities to do have been identified, it is important to strictly monitor their execution in order to ensure that the issue encountered will no longer show up. Different methods can be used, based on the complexity of the activities to execute. In the case study, a LOP (List of Open Points) was used to track the progress of Team activities. However, when the necessity to speed up activities arose, the Agile management was applied through the use of the Scrum method. This allows to strictly monitor small actions and quickly identify bottleneck in order to execute activities in no more than four weeks.

In conclusion, a standardized approach is able to effectively guide activities even in a complex situation and ensures the application of the same methodology within all the plant. Here the encouragement to extend the developed tool to all future Production Launches within the plant, even if at the beginning it may require effort to adopt a new way of working.

6 References

- Larson, E.W. and Gray, C.F. (2011) *Project Management: the Managerial Process.* Fifth edn. New York: McGraw-Hill Irwin.
- Project Management Institute (2019) *What is Project Management?* [Online] Available at: https://www.pmi.org/about/learn-about-pmi/what-is-project-management [accessed 2 December 2019].
- Kerzner, H.R. (2013) *Project Management: A Systems Approach to Planning, Scheduling, and Controlling.* Eleventh edn. New Jersey: John Wiley & Sons, Inc.
- Bove, A. (2008) *Project Management: la metodologia dei 12 step.* Milan: Ulrico Hoepli Editore S.p.A.
- AIAG (n.d.) *(PPAP) Production Part Approval Process* [Online] Available at: https://www.aiag.org/quality/automotive-core-tools/ppap [Accessed 24 December 2019].
- Parmenter, D. (2010) Key Performance Indicators: Developing, Implementing, and Using Winning KPIs. Second edn. Hoboken, New Jersey: John Wiley & Sons, Inc.
- Dennis, P. (2007) Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System. Second edn. New York: Productivity Press.
- Stamatis, D.H. (2010) The OEE Primer: Understanding Overall Equipment Effectiveness, Reliability, and Maintainability New York: Productivity Press, Taylor & Francis Group
- 50minutes (2015) Pareto's Principle: Expand your business with the 80/20 rule. Namur: Lemaitre Publishing
- Frican, G. (2018) *How ro use the fishbone diagram to determine data quality root causes* [Online] Available at: https://www.lightsondata.com/how-to-fishbone-diagram-data-quality-root-causes/ [Accessed 30 December 2019].
- Frican, G. (2019) *Data quality root cause analysis – 5 whys* [Online] Available at: https://www.lightsondata.com/data-quality-root-cause-analysis-5-whys/ [Accessed 30 December 2019].

- Master of Project Academy (n.d.) *Lean Six Sigma: Fishbone Diagram* [Online] Available at: https://blog.masterofproject.com/fishbone-diagram/ [Accessed 31 December 2019].
- Nethics (2013) *Che cos'è il PPAP* [Online] Available at: https://www.nethics.it/ppap/ [Accessed 3 January 2020].
- Farnell (2019) *Motore CC senza spazzole (BLDC)* [Online] Available at: https://it.farnell.com/motor-control-brushless-dc-bldc-technology# [Accessed 4 January 2020]
- Renesas (n.d.) *A BLDC Motor* [Image] Available at: https://www.renesas.com/us/en/support/technical-resources/engineer-school/brushless-dc-motor-01-overview.html [Accessed 6 January 2020]
- Dinero, D. A. (2005) Training Within Industry: The Foundation of Lean. New York: Productivity Press, a division of Kraus Productivity Organization, Ltd.
- NGS (2019a) *What is enterProj* [Online] Available at: https://www.enterproj.com/ [Accessed 20 January 2020]
- NGS (2019b) *Our Solutions* [Online] Available at https://www.enterproj.com/solutions.html [Accessed 20 January 2020]