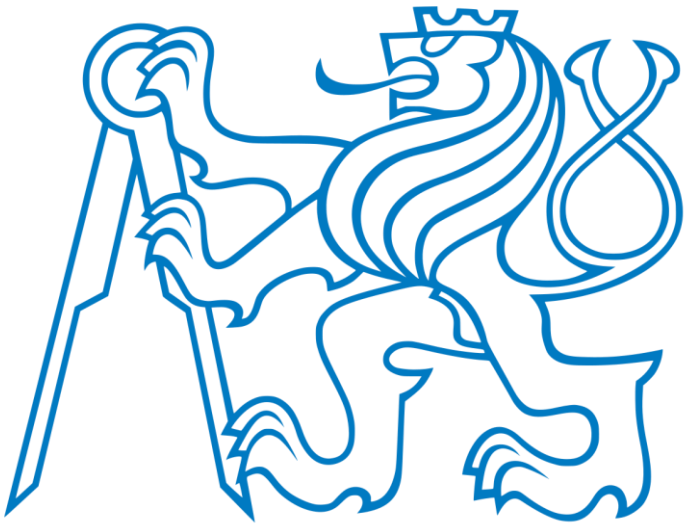
Czech Technical University in Prague
Faculty of Mechanical Engineering
Department of Automotive, Combustion Engine and Railway Engineering
Master of Automotive Engineering



Master Thesis

Study of Organization and Management of Automotive Partnership projects

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MASTER'S THESIS ASSIGNMENT

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Guidelines:

1) Definition of motivation, goal and tasks.
2) Theoretical background : management of innovations, project management
3) Analysis of the operational management of the entire vehicle project from planning phase, through development phase until manufacturing and supply phase: explain the process of lunching and developing a vehicle; exhibit the main milestones; conduct global analysis: technical , commercial, financial considerations
4) Analysis of Powertrains-related issues: technical, legal, business and strategic constraints. Pay attention mainly to the technical details: performance, emissions.
5) Definition and implementation of action plans with all company's departments
6) Evaluation of impacts and conclusions

Bibliography / sources:

BERKUN, Scott a Scott BERKUN. Making things happen: mastering project management. Sebastopol [CA]: O'Reilly, c2008. Theory in practice (Sebastopol, Calif.). ISBN 9780596517717.
DAVILA, Tony. Making innovation work: how to manage it, measure it, and profit from it. Updated ed. Upper Saddle River, N.J.: FT Press, c2013. ISBN 978-0-13-309258-5.
LESTER, Albert. Project management, planning and control: managing engineering, construction and manufacturing projects to PMI, APM and BSI standards. Seventh edition. Oxford, United Kingdom: Butterworth-Heinemann, an imprint of Elsevier, [2017]. ISBN 978-0081020203.

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Assignment valid until: _____

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III. Assignment receipt

The student acknowledges that the master's thesis is an individual work. The student must produce his thesis without the assistance of others, with the exception of provided consultations. Within the master's thesis, the author must state the names of consultants and include a list of references.

15/07/2019
Date of assignment receipt

Student's signature

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Declaration

I hereby declare I have written this Master thesis independently and quoted all the sources of information used in accordance with methodological instructions on ethical principles for writing an academic thesis. Moreover, I state that this thesis has neither been submitted nor accepted for any other degree.

In Prague, 15. 08. 2019

Abstract

Automotive industry is experiencing a turning point which raises several questions. My thesis is trying to answer some of those queries: How can OEMs use innovation and new management methods to best manage this transformation? What levers can they use to strengthen their position in the market? And how can those levers be applied to practical vehicle projects? First, my thesis explores the growth potential hidden in innovation management, new project management methods like “Agile” and their suitability to the automotive context. Second, I abstracted my experience in Renault Group to analyze the organization of vehicle projects and their milestones in partnerships context to evaluate its complexity, its potential and its limitations. Finally, my thesis devotes a chapter to a case study related to powertrain issues to apply management methods to a real problem where multiple case scenarios are analyzed in order to conduct a multiple-criteria evaluation and to propose the appropriate solution(s). Those theoretical analyzes combined with practical case studies led to several findings that allow me to conclude that the automotive industry need a push by adopting new flexible management methods to put the best products in the market. OEMs need also to concentrate their efforts through partnerships, mergers and alliances to best face those challenges. And finally, subcontracting activities like powertrain design can be beneficial to improve performances and reduce costs.

Acknowledgements

Isaac Newton wrote a long time ago: "*If I have seen further, it is by standing on the shoulders of giants.*" Those wise words of a key figure of the Scientific Revolution remind us that no great effort is achieved alone. Staying humble and working together is key to succeed any enterprise. I'm therefore grateful and would like to thank many groups and individuals who offered me help and guidance during my academic career:

Thank you Dr Miroslav Žilka, my master thesis supervisor, for all the advices and guidance you gave me generously to frame, structure and organize my thesis. Your effort and time were very valuable from the very beginning of this work until the very end. Your availability and your flexibility are greatly appreciated.

Many thanks go to the personal of Czech Technical University of Prague, Tongji University and ENSTA Bretagne. The commitment of your academic and administrative staff is remarkable and is a key factor of success for both your institutions and your students.

Thank you Mrs. Ségolène Delassus, my internship supervisor, for the welcome you showed me in your team, for your trust, your proximity, your understanding and your continuous encouragement and empowerment.

Thanks to all Groupe Renault personal especially to Small Van Program Division and to Mr. Philippe Caillette for your welcome and your trust. I understand today that great managers are not only those who achieve targets and succeed projects but also those who generously transmit their knowledge.

Finally, warm thanks go to all my family members, my friends, my elementary, middle and high school teachers for all their efforts and the support they showed me for many years. I'm eternally grateful for your presence and your contributions.

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Introduction

"Participating in the adventure of the automobile and the mobility of tomorrow". That is the real motivation driving me in my graduate studies, my internships and my career. Our modern societies are seeing their needs evolving year after year. Our planet requires more rationality and more Respect. Natural resources, energy and materials should no longer be governed by abundance, but rather Sustainability. Faced to this world in full excitement, an engineer -the motor of technical and technological progress- is brought to reconcile the evolving needs of his society to different technical, economic, environmental and legislative constraints. The mobility sector and the automotive industry are in the heart of this debate.

Within the Renault Nissan Mitsubishi Light Commercial Vehicles business unit, new vehicle projects are emerging to enter a growing, turbulent and competitive market. A task force of hardworking men and women are working as program directors or program managers to lead those vehicles from the development phase to the end of their life cycles. In this context, I was invited to join one the most prestigious teams in Renault Group to participate in managing one of the most complex vehicle projects. My tutor perimeter is about two vehicle projects: on one hand managing the KANGOO/CITAN models during their life cycle phase, and on the other hand leading the co-development of a New vehicle between several car manufacturers. The goal of my internship is therefore: **Participating in managing an automotive partnership project and dealing with its economic and powertrain-related challenges.** The reader of those lines can only imagine the richness that this internship can bring to a student thirsty to discover the automotive world in all its details. At this stage of project management, I was confronted as an intern to all kind of issues related to: Engineering, Manufacturing, Logistics, Purchasing, After-Sales, Finance, Design, Product planning, Legal, Information systems etc.

Concretely, I had to carry out during my internship several tasks described as below:

- Animating the Product Program Committees (PPC)
- Arbitrating and decision making based on the recommendations of operational teams, requests from partners, compliance with internal processes, compliance with contractual documents and strategic orientations of the company
- Drafting of PPC agendas and minutes

- Preparing and participating in meetings between program directors and board members of partner companies
- Following-up of master planning and total delivery cost (TDC) and management of retro planning, provisions and over costs
- Attending meetings with suppliers to challenge their solutions
- Following-up of changes in requests from partners
- Participating in the preparation of the commercial offer and drafting the development, manufacturing and supply contracts to the partners.
- Preparing of Black Scenarios: economic, social, product impact
- Analyzing and solving powertrain-related problems
- Participating in the definition of the van alliance strategy
- Collecting product and volume requests from regions and countries to consolidate the project
- Assisting the Deputy Program Directors to validate quality milestones (PKO, Contract, TGA)
- Participating in the annual Alliance Commercial Vehicles Convention

Those tasks are the essence of a manager daily life that he must carry out to continuously following-up his projects and keeping his planning/budget under control. The partnership context adds a strong business development aspect to this project as we must deal daily with a high-demanding partner in an industry full of constraints.

CHAPTER I: Project management: management of innovation

The first chapter presents the theoretical foundations of project management. It allows to discover the key topics related to the organization of companies. This is the theoretical framework of the project conducted within the company.

1) Definitions:

What is a project?

A project is “a piece of planned work or an activity that is finished over a period of time and intended to achieve a particular purpose” (1). A similar definition states: “an individual or collaborative enterprise that is carefully planned to achieve a particular aim” (2). Among examples illustrating what a project is, we can find: a scientific research project, a project to build a new power station, a construction project etc. A project is then defined essentially by its goal. The second word that appears in the two definitions is the term “planned”. Driving a project is therefore not a coincidence. Going further in reading, we note that the notion of time is inevitably present in a project. The latter spreads over time. This duration is a key parameter around which a project is organized.

What is management?

Management refers to “the control and organization of something” (1). It is also defined as “the process of dealing with or controlling things or people” (2). Control, as the action of determining the behavior or supervising the running of something, is the key concept of management. In a workplace environment, management is “the activity or job of being in charge of a company, organization, department, or team of employees” (1). Management is considered as a work in its own right and is governed by identified rules and framed by elaborate theories. “Being in charge” is the feature characterizing management. This phrase implies a responsibility that the one who leads the management must assume. The authority-duty tandem is therefore put into equation. Since management also concerns groups of men, it requires a human approach based on relationship and social intelligence. Hence the beginning of the complexity of the management profession.

What’s a project management?

Conjugating the two previous terms gives birth to a common-used expression mainstreamed in academic and professional circles. Historically, the term was first used in 1953 in the US defense aerospace sector (3). It was subsequently exported to other sectors of activity. The project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements. (4) A very similar definition is given by the Association for Project Management: “the application of processes, methods, knowledge, skills and experience to achieve the project objectives”. The main common part of the two definitions is that project management is a practical approach that goes beyond the simple theoretical framework. It’s an implementation of several pre-requisites. A transition between a set of skills and knowledge to a concrete realization of an objective with impact.

Who's the project manager?

Such a mission of such complexity requires a pilot with a well-adapted profile. He must be able to lead the project and achieve its primary goal. To do so, he or she needs to rely on methodical processes and appropriate resources. When those resources are human, a project manager should be able to federate his team and lead his team members to the goal achievement. Managing people requires special skills. Communication is for example a key soft skill to succeed in this type of missions. Furthermore, a manager should learn to stay focused on his goal. Many unexpected events may come to disturb the normal running of the project. Those events should not cause the manager to lose sight of his goal.

What are resources?

To carry out any project, some resources must be allocated. This allocation must be studied and calculated according to strict and objective criteria. Resources may be classified into three categories. First, Human resources which are all the actors working on the project. Second, Financial resources or the budget are the main tool for managers to afford the needs of their project. It supports the cost and expenses of the project actors' salaries, the purchase or rental of material resources and all other costs related to the functioning of the project. And last, Material resources which are all the tools, equipment, machines, software and places necessary to tasks' execution.

What are processes?

A process is "a serie of actions that you take in order to achieve a result". (1) Although the life cycles of the projects are almost similar, there are several breakdowns of its stages including the one found in the PMBOK book. This reference suggests a division into five basic stages: Initialization, Planning, Execution, Control and Closing. These steps follow a logic that can be schematized as follows:

Initialization: the purpose is to define the project. It consists in formalizing the business justification, the origin of the project, the resources to be put in place and to appoint the project manager.

Planning: the process of defining the actions needed to achieve these objectives during which the project plan providing the roadmap to be followed is delivered.

Execution: the process of execution of different actions planned in the project plan and the corrective actions in case of possible drifts of the objectives

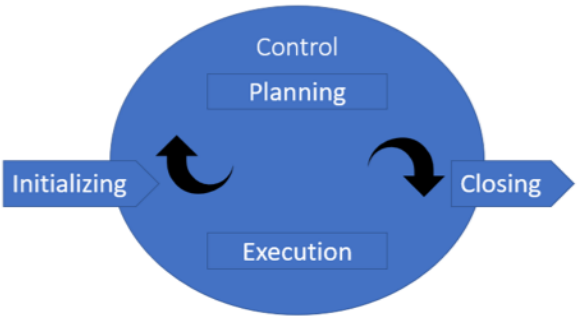


FIGURE 1 PROJECT PROCESS

Control: to regularly measure the progress of the project and identify possible drifts.

Closing: to formalize the end of the project and to ensure the formal acceptance of the various deliverables.

2) Project Planning Process:

To successfully run a project, it is essential to build it in a robust and organized way. The planning process of a project can be broken down into several stages. The decomposition described below is based on documentation from the Department of Management and Economics, Czech Technical University in Prague. It's broken down into 8 steps in order:

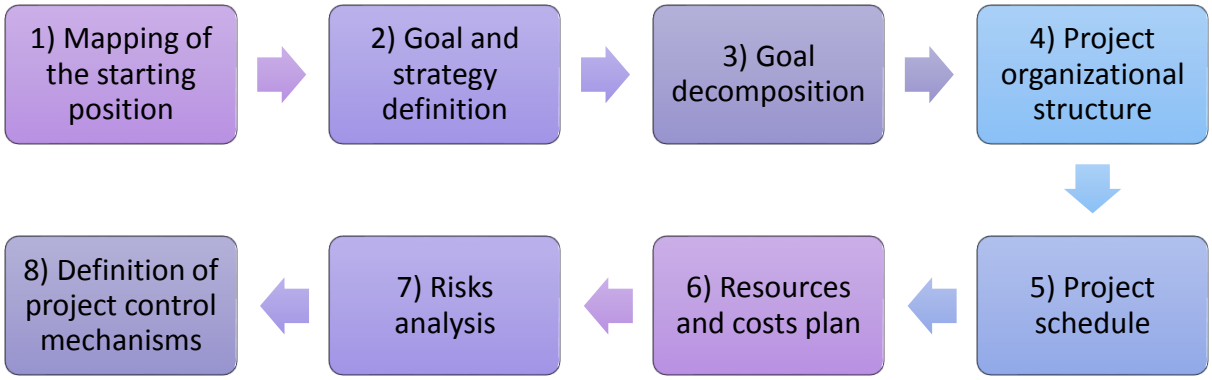


FIGURE 2 PROJECT PLANNING PROCESS

a) Mapping of the starting position

To be able to measure the impact and the evolution of the project, it's important to define the initial state. The aim is to build a baseline situation to compare the state of the places formed at each stage of the project. Otherwise, all the evaluations would be insignificant since it would be impossible to build a history of activities that would make it possible to quantify the evolutions. For example, in industry, and particularly in the automotive projects, it's important to set a Raw Material Reference which will stay fixed throughout all the duration of the project. With such a reference fixed, every evolution of material price for example can be easily measured.

b) Goal and strategy definition:

Once the starting position is clear, the project manager or the managing committee should determine the goal of the project. This goal must be clearly identified and described in detail. To make sure the goal is clear and understood by all the project's team, the person or the instance in charge should organize some workshops or meetings to discuss with all the team members. Once the goal is mature and well grasped by all, the management set the strategy to achieve it. A strategy is "a plan of action designed to achieve a long-term or overall aim". The ability to build a strategy or a plan is a key skill to lead projects. It requires a vision, a capacity to build the associated processes and the overall organization. One of the methodologies used to define a project goal is the SMART method. (5)

Specific: goals must be clearly defined to evaluate their fulfilment.

Measurable/quantifiable: a parameter should be attributes to each goal, so it can be evaluated.

Assignable: each task should be assigned to a specific person to clarify who's responsible for what.

Realistic: motivate teams to join the project requires to aim realistic goals (not too low nor too high).

Time-related: every goal or task should be limited in time.

FIGURE 3 GOAL SETTING

c) Goal decomposition:

A project goal definition is usually based on a global vision. This globality helps the manager to keep an eye on the main objectives of the project. However, a goal decomposition is needed to implement the project and to concretize the steps. The team should be oriented to a sub goals for a better understanding of project details. Moreover, since the team members have usually different jobs (Engineering, Finance, purchasing…), it's essential to divide the work into several groups of tasks.

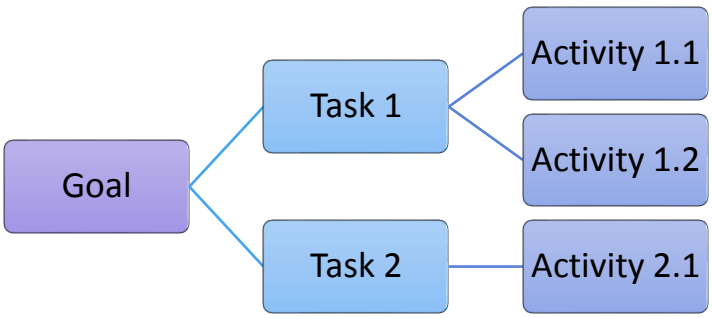


FIGURE 4 GOAL DECOMPOSITION

While determining those tasks, it's important to keep in mind that the more individual detailed project activities are defined, the more manageable and assessable they are. However, the more individual detailed project activities are defined, the more time (and financial resources) are needed for preparation, coordination and management.

Therefore, the goal is not to set an unlimited number of tasks and activities. A successful project manager would have to analyze the goal and to break it down to the relevant tasks.

d) Project organizational structure:

Once the main goal of the project is divided into several tasks and activities, it's important to set the project organizational structure. In other terms, the project manager should assign a pilot to each task. This pilot is the person responsible for executing an identified task. Identifying pilots and setting the organizational structure is not always an easy job. In most cases, the project manager works in a company where there is already a functional organization: several departments with several hierarchical links in each. The challenge then is to build the project team within the existing structures. Sometimes, a project manager can be confronted to the situation where he must set a task for his boss.

The project manager should therefore master the organizational structure of his company and build his team accordingly. Moreover, the project manager should assign tasks to the team members, monitor the terms and quality of outputs, consolidate the partial outputs in a compact form, make sure the objectives are fulfilled and even participate in solving some complex project tasks.

e) Project schedule:

When a project manager is asked: What are the most important parameters for a project? He or she usually answers, "Schedule and Budget". A schedule is "a plan for carrying out a process or a procedure, giving lists of intended events and times". (2) A project engineer or a project consultant is the person whose main task is to create schedules, updates, controls and reports them to the project managers. It requires some specific skills like planning and reporting. Many softwires exist to assist schedule creators like MS project, MINDBODY, Wrike… Gantt chart: Gantt chart or Gantt diagram is a tool used in project management that displays the various tasks against time. It allows to graphically represent the progress of a project. It contains the list of activities and tasks on the left side, and a group of bars that each represents a task on the right. The bar's position and length show the start date, the duration and the end date of the associated task. (6)

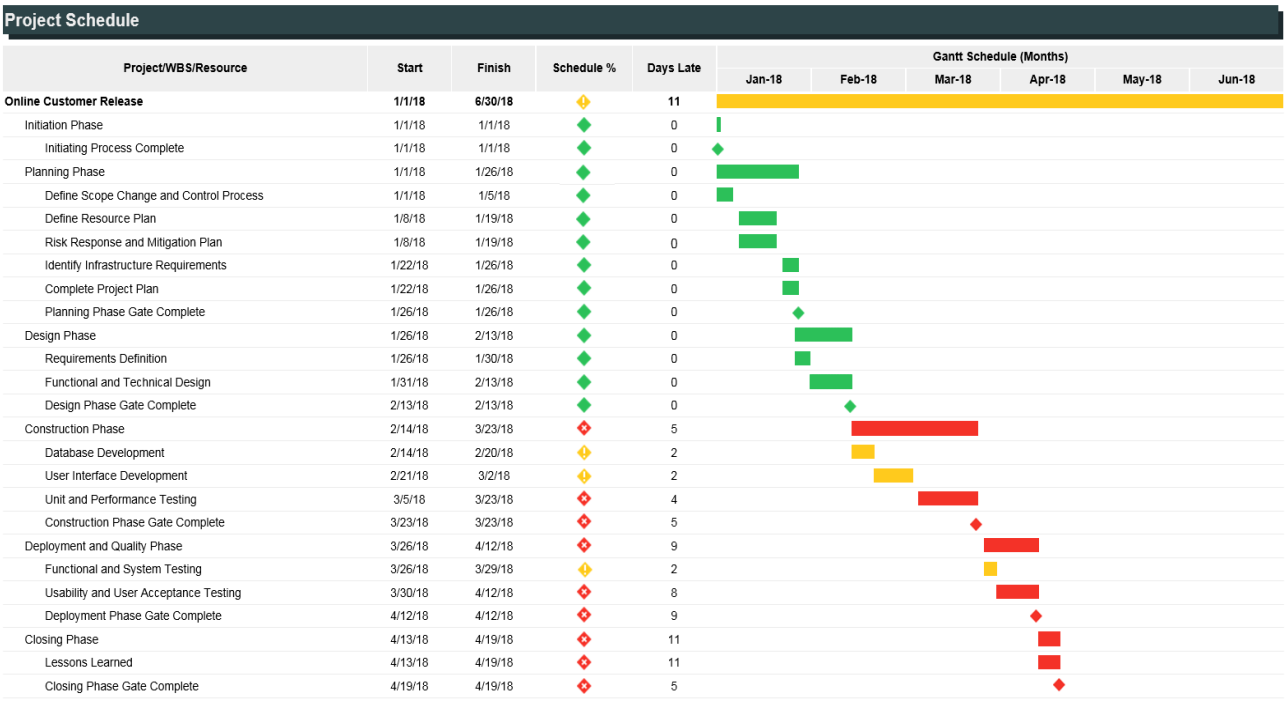


FIGURE 5 GRANT CHART (6)

The main steps to create a Gantt chart are (6):

- Define the project settings
- Define the project calendar

- Editing task names and durations
- Set up a global resources list and assign resources to tasks
- Create links to specify dependencies between the project tasks
- Set constraints on the tasks as necessary
- Make final adjustments

- Finally, and during all the project life cycle, it's necessary to inspect regularly the schedule to detect potential problems or schedule conflicts and to make the required corrections.

f) Resources and costs plan:

To make any project happen, it's important to assign resources to enable its stakeholders shaping their goal. On one hand, financial resources are usually determined by the client then validated by the company before starting the project, via the specification. This "budget" makes it possible to finance other resources. It is essential to make a consistent budget estimate to better manage financial resources and to secure some provisions in case of problems. As for material resources, they're framed according to tasks, the allocated budget, deadlines and the desired quality. On the other hand, human resources which can be qualified as the decisive factor of a project's success or failure, demand more time to identify and dispatch. To determine the necessary labor force, a project manager should follow the following steps:

List tasks: First, a project manager should list all the tasks needed to complete his/her project.

Identify the necessary skills: Next, he should determine the different skills and competencies needed to complete the different tasks. By making a list of all the know-how and skills you need: business, technical, managerial skills, etc. These skills depend on the nature of the task to be performed.

Use adapted tools: Consulting the archives of previous projects to see the different resources and skills used. This information exists and has been archived so that it can help other project managers.

Recruit the right people: The recruitment can be done internally or externally. This phase is very important because it's the moment to set up the team that will carry out the project. Any error may put the entire project at risk of failure. Besides the skills and know-how, the motivation and willingness to get involved in the project are also key choice parameters.

g) Risks analysis:

In a project, a considerable amount of resources is allocated to achieve the targeted goal. Such an investment implies a huge amounts or risks. Any failure may lead to a bankrupt or a reputation damage that can alter the global profitability of the project's holder. Therefore, risks must be properly managed.

Mr. Albert LESTER in his book "Project management, planning and control" suggests 5 main steps to analyze and manage any project's associated risks (7). Those steps are described as below:

Step 1: Risk Awareness

At this stage, project stakeholders should be aware that their project or at least a part of it can be influenced by some internal or external factors that may threat its success. Awareness is a mindset project's participants must adopt to have the necessary reflexes when needed.

Step 2: Risk Identification

Identifying a risk is an important step in a project life cycle. This is a moment when we can make a good use of members experiences in previous projects. The team can use many tools as brainstorming sessions, Prompt list, Checklist, Work Breakdown Structure, Delphi technique or asking experts... Generally, risks that should be considered can be split into four main categories as described in the table below:

Organization	Environment	Technical	Financial
Management	Legislation	Technology	Financing
Resources	Political	Contracts	Exchange rates
Planning	Pressure groups	Design	Escalation
Labor	Local customs	Manufacture	Financial stability of
Health and safety	Weather	Construction	(a) Project
Claims	Emissions	Commissioning	(b) Client
Policy	Security	Testing	(c) suppliers

FIGURE 6 RISKS CATEGORIES (7)

Step 3: Risk Assessment

Once the project associated risks are identified, each risk should be assessed to describe qualitatively its severity. Two parameters are to consider at this stage: the probability and the impact. Such an assessment can be done using a simple matrix as shown on the right, by evaluating the probability (low, medium, high) and the impact (Nil, low, medium, severe). The matrix presented should be applied for every identified risk. Once this step is done, it's very useful to build a risk summary chart to describe each risk and to assign an owner who will oversee it during the entire project life cycle.

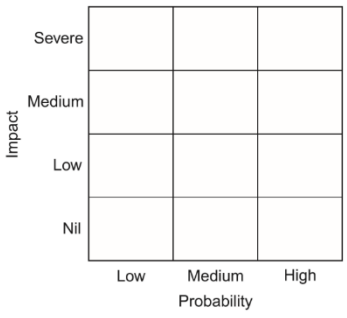


FIGURE 7 RISK ASSESSMENT MATRIX (7)

Step 4: Risk Evaluation

Once the risks associated to a project are well identified and assessed, the next step would be to evaluate them to make a comparison that would allow to prioritize the most critical of them. Such an evaluation can be done using a simple exposure table as described below:

Exposure table							
	Probability						
	Rating		Very low	Low	Medium	High	Very high
Impact		Value	1	2	3	4	5
	Very high	5					
	High	4					
	Medium	3					
	Low	2					
	Very low	1					

FIGURE 8 EXPOSURE TABLE (7)

For every risk, the formula "Impact Value × Probability Value = Risk Value" allow to assign a total value to each risk and therefore compare all risks based on this value.

Step 5: Risk Management

Finally, when all risks are identified and evaluated, the project manager can assign to every risk a risk owner who will be in charge of monitoring it and taking the right decisions to neutralize it.

h) Definition of project control mechanisms:

The previous steps of the project planning process enable the project manager to initiate successfully his or her project. Carrying out the project in the same conditions requires however a control tools and mechanisms to monitor the overall project and to evaluate the state of progress at every moment. Two reasons justify those needs: reporting and steering tasks. First, the action of reporting is important since many stakeholders are implicated in a project (sponsors, clients, contractors, authorities, etc.). Second, project manager should be quickly informed of all potential threats to take corrective actions. To simplify the process of evaluating, project management experts recommend building "dashboards" that contain all key indicators of a project.

3) Management of innovation: a must for companies' survival:

a) The power of Innovation

For any company who wants to survive the market's competition, to grow and develop its activities in a segment or even to drive the industry trends, innovation is key factor of success. For example, Facebook founders created not only an innovative product but also helped a new market of social media to emerge. Few years before, social media didn't exist. Today, those canals are multiplying, taking several supports (text, images, videos, mix of all…) and influencing trends, commerce, economy and even politics and international relations. Facebook is not the only company who made of innovation its central value. Other organizations like Amazon, Apple and Google and many others understood that big changes are essential to put its mark on the evolution of its business and even to reshape the industry rules. And by creating the new rules, innovative companies could easily impose their leadership.

Innovation's power is not restricted to business positioning, it helps also to redefine sustainable development activities and social cooperative economies. Through many examples of products and services dedicated to specific regions and populations of the world who suffer from a crisis, innovation helped to address critical issues differently and to find appropriate solutions to finally save those regions from extreme poverty and vulnerability. For example, the Kenyan startup "HydroIQ" working on the management of remote water networks, won the grand prize of the "Strat-up of the year Africa 2018" competition. (8) The project provides a concrete solution to the problem of water billing. Concretely, HydroIQ offers a connected device that is connected to existing water supply systems and automatically monitor the use of water, its quality and any leaks.

Securing the growth of a company in the long term requires a capacity to innovate continuously. It is necessary to innovate even faster and smarter than competitors. Business leaders tend to confuse innovation strategy and innovation shot. A one successful innovation should be perceived only as an opportunity for the company to get ahead of its competitors at a certain stage. Remaining in the leadership position requires however to develop a mindset of innovation and originality and to share it with all the company's employees to create the appropriate working atmosphere.

In the following sections, the focus will be on the precise definitions and types of innovation. Then, the most critical questions about innovation will be addressed: Is innovation measurable? If yes, how? What rules govern this notion? How to structure a company for Innovation? And how to make organizations better at innovation?

b) What is Innovation?

Several definitions of innovation are found in the literature. It can be defined as: "*Turning an idea into a solution that adds value from a customer's perspective*". (9) A more formal definition suggests: "*An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations*". (10) The concept of innovation contains basically an idea that we execute to make it a reality. This idea comes as an answer to a specific challenge. The goal from this intellectual effort is to bring more value to both company and costumer. To drive innovation, the main asset would be to adopt a new mindset based on a new way of thinking.

FIGURE 9 INNOVATION COMPONENTS (9)

c) What types of Innovation?

There are three main families of innovations based on two factors: the degree of novelty of the innovation and its impact on the organization.

Incremental innovation: is a type of an innovation that does not profoundly modify the operating methods existing now of its appearance. It does not replace the dominant technology, nor has it generally been designed for that purpose. If it brings improvement, it is often gradual. In the case of incremental innovation, it is usually a small technical or organizational improvement, or even an adaptation of the business model. (11)

Semi-radical innovation: semi-radical innovation is different from incremental innovation because it seeks for is a totally different product or service. Often a company will breakout an innovation that is aimed in a whole different direction than anything done before. The purpose for this is to bring a new focus to the company or brand, to differentiate itself from competitors and to increase in value. Semi-radical innovation, like any new production, does carry some risks.

Radical innovation: (also called disruptive) radical innovation refers to innovations that are new to the business, market and industry, which incorporate new technology, and bring the biggest benefit to customers. A radical innovation may include a new application of a combination of technologies into new market opportunities. They are approached from the perspective of existing capabilities of innovation, renewing and substituting themselves entirely with new skills. Radical innovations are the result of basic research and a significantly larger quota of scientific research in organizations. (11)

d) How to measure an Innovation?

Choosing to innovate is a decision that requires massive investment. Investors need to assess the evolution of their business and quantify the impacts of their efforts. Hence the two important questions:

Is innovation measurable? Yes. The proof: innovation has been measured for several years by different actors. Companies, public administrations and states need to measure innovation. The measurements are conducted to evaluate the different institutions that innovate and to judge the relevance of subsidies and aid granted.

What measurement systems can be used? Once agreed on the definition and expectations, we come to the point of being able to quantify the results to adjust and take necessary actions. Recognized methods of measurement in innovation generally come from a more traditional approach borrowed from the scientific and technical industry. The OECD currently uses two types of indicator measures: (10)

- Allocated resources, R&D expenditure incurred by companies and the government on research and development (R&D):
    - Resources allocated to increase the stock of knowledge.
    - Here we measure an effort, a resource allocated to a certain activity, but it does not measure the results of this activity.
- Patent counts:
    - Number of patents registered, and patent registered/patent accepted ratio.
    - Recognition of a right to international intellectual property on 4 continents (China, Europe, Japan and USA).
    - Here we capture a result, since the patent shows that the search resulted in an invention.

    Critic: not all inventions are patented or patentable and many patented inventions are not subsequently implemented. Hence the importance of looking at other metrics.

Practically, experts in management consulting firms suggest some more elaborated indicators. McKinsey & Company built two metrics that combine R&D spending, sales from new products, and gross margin to shed light on relative innovation performance. All three values are expressed in % of total sales.

RDP: R&D-to-product conversion: How well do your R&D dollars convert to new-product sales?

NPM: New-products-to-margin conversion: How well do your new-product sales convert to higher gross margins? It provides an indication of the contribution that new-product sales make to margin uplift.

e) What rules for Innovation?

For an organization that decides to adopt innovation as a strategic axe of development, it's essential to have a methodology for a periodic health check to follow up its investments. Experts have developed a list of important innovation axes known as the *Seven Innovation Rules*: (12)

One: Exert strong leadership on innovation direction and decisions: Clear strategy from top management that streams across the various departments and operational levels of the company. Strategy sharing with operational personnel creates a motivational atmosphere. Supporting and rewarding the teams who undertake innovation activities can boost the innovative DNA of the company. Senior management ability change business models and technology is a mark of strength.

Two: Integrate innovation into the business mentality: Innovation be considered only in its physical aspect (allocated resources and patents filing). A mindset of creativity should be developed in the overall company.

Three: Match innovation to company strategy: Innovation is not always the first key line driving the overall company's strategy. In most cases, it must cohabit with the board main driving strategy. This kind of situations requires that the management matches at best its choice of innovation type and amount with his driving master plans.

Four: Manage the natural tension between creativity and value capture: Success in business requires both creativity and value. Those two usually tend to confront each other. On one hand, researchers may easily be driven by enthusiasm and curiosity and forget the economic performance aspect. On the other hand, financial controllers tend to underestimate the return of invest of innovation activities. Management role is then to find the stable balance between those two elements.

Five: Neutralize organizational antibodies: transforming an organization into an innovative mindset can face some structural obstacles. In non-innovative companies, the organization and processes tend to slow-down and systematically marginalize innovation activities. Transformation process is then essential to neutralize those obstacles and create more flexibility and fluidity.

Six: Cultivate an innovation network beyond the organization: innovation is an opening to new and original ideas. This opening also implies an opening on its environment. Thus, it's important to build a network to exchange knowledge and experts in a certain field. This opening can be concretized in the form of partnerships with R&D centers, laboratories, universities or even by absorbing or funding dedicated start-ups working on similar topics.

Seven: Create the right metrics and rewards for innovation: proper indicators are necessary to evaluate the work done in innovation departments. It allows the management to judge the efforts deployed and to reward collaborators accordingly. The previous section deals with the subject of innovation measurement.

f) How to structure a company for Innovation?

Once executive management decides to adopt innovation as a strategic axis, the organization of the company must change to meet the new direction. For this, the company's structures must evolve to encourage innovation activities through new rules and processes.

Developing an internal marketplace

Internal talent marketplaces are already existing in an informal form inside law firms and other professional-services groups. Those marketplaces allow senior managers to find the best junior employees for some challenging assignments. Vice versa, talented junior employees come after the most glorious missions to grow their skills and develop their carriers. These marketplaces generally follow informal rules of conduct and are more efficient when the marketplace includes a small group (a scale of 100 people) of employees who know each other. (12)

However, in more complex corporate context, thousands of professionals and managers interact with each other, the talent marketplace needs then to be formalized. The goal of the talent marketplace is to match the interests of individuals with the interests of the company. Creating a formal talent marketplace requires a serious effort from the company. It must therefore invest in it to ensure that it makes a fair deal to both parties. Formal talent marketplaces can either develop around functional areas or managerial roles. Some large companies did already raise the challenge of creating a formal talent marketplace. (American Express and IBM)

Outsourcing innovation

Relying on external innovation sources became a real trend over the last 30 years: 2€ invested in outsourced R&D activities for every euro invested in in-house R&D in the period between 1993 and 2003. The major reasons for this phenomenon are the complex technologies, dispersed expertise, globalizing markets, and the high rhythm of innovations evolution. Despite an important academic literature available on this topic many strategic challenges remain when deciding when to outsource innovation, what innovation activities to outsource, where to outsource them, and how to make the cross-organizational knowledge transfer work. Researchers conducted a study of 24 outsourced development projects to identify the common drivers of success. Among these: project-specific partner competence as well as maintaining in-house competence distinguish successes from failures. In addition to those common drivers, each innovation source its own specific success drivers. Managing expectations (customers tend to get carried away thinking they can sell the technology next month) and protecting one's intellectual property in collaborations with competitors and start-ups are an example. It’s also important to consider the maturity of the technology outsourced. (13)

g) How the organizations become better at Innovation?

To trigger innovation flame within organization employees, researchers and experts from different centers and universities stress on the importance of learning as a perpetual process within a company. The concept of "learning organization" was developed in the nineties describing a company whose employees create, acquire and transfer knowledge. (14) Those talents enable their structures to be more open, creative and innovative. Such organizations became more resilient to competition and market instabilities. The following development is inspired from a summary article on Harvard Business Review that suggests some of those levers: (14)

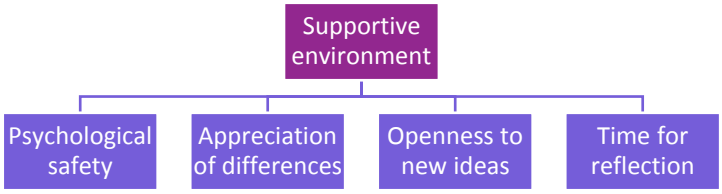


FIGURE 10 SUPPORTIVE ENVIRONMENT PILLARS

Lever 1: A supportive learning environment First, learning requires a supportive environment stimulating curiosity and interest. Such an environment has four characteristics:

Psychological safety: Learning implies to ask naïve questions, making mistakes and confronting all kind of viewpoints. Employees should therefore be assured not to be penalized for doing so.

Appreciation of differences: Making people aware of opposing ideas is necessary to recognize the value of other successful experiences and different working methods.

Openness to new ideas: The most active way to learn is to think and create. This creativity gives birth to new and daring ideas. Accepting those novel approaches and encouraging them is necessary to benefit from learning processes.

Time for reflection: Employees need some reflection time to put into perspective their thoughts and review all weaknesses they might find in their work methodology or in their processes.

Lever 2: Concrete learning processes and practices. Once the work environment is suitable for learning, managers should take concrete measures to sustain this learning process. Those processes include the generation, collection, analysis, interpretation, critic and transfer of data.

Lever 3: Leadership that reinforces learning. As explained in the 7 rules of innovation section, leadership role is central to encourage innovation. one of the concrete measures to do that is to reinforce learning mechanisms and programs through continuous training sessions.

Failure as part of the process: Iterative learning processes are the base for innovation. It flourishes particularly in environments that tolerate failure and accept it as an essential part of the process. Its importance comes from the fact that failure is source of learning, problem solving and building of original methods and frameworks. Many innovations benefited from post-failures learning. (15)

4) Agile management: from Software Development to Vehicle Project

a) Doing Agile or Being Agile?

Agile project management was first born in the software development context.

Since the mid-nineties, several software developers noticed that the classic methods of project management were no more suitable to deliver a high-value product to their clients with continually changing needs and working in an evolutive market. Very often, the final product or software delivered didn't correspond to the client's original expectations. Other times, the needs of the client themselves changed and the delivered product didn't help him solving his problems. Therefore, developers decided to start working in a different way using methods more "agile". Agility at this stage came as a synonym of flexible and adaptable. They welcomed all ideas, the new and the old, to find the best way to create a high-value product that will satisfy their clients at best. Step by step, they created several frameworks to share their findings and new methods with their colleagues. This wave of agility and those piles of documents led to drafting of two founding documents: Agile Manifesto and Agile 12 principles. (17)

FIGURE 11 AGILE MANIFESTO

The *Manifesto for Agile Software Development* above is based on twelve principles: (16)

FIGURE 12 AGILE 12 PRINCIPLES

Definition of Agile.

Jim Highsmith clearly states that adopting agile mindset is not a cure to all ills and being agile will not automatically solve all development or project management problems. He described agile in two ideas: **"Agility is the ability to both create and respond to change in order to profit in a turbulent business environment. Agility is the ability to balance flexibility and stability"**. (17) Agility is therefore an answer to the constantly changing business environment either in software development context or in any other project context. This change requires adaptability and flexibility. To put a solid foundation to the Agility concept, a group of 17 developers gathered in 2001 at a ski resort in Snowbird USA and decided to write a common framing note. After many discussions, they agreed to write the Manifesto for Agile above.

The Mindset Agile

Contrary to what some might imagine, the agile method imposes neither a new mode of organization nor a new package of ready-to-implement methods. Agile is above all a state of mind. A new approach to manage and to conduct projects. An approach based on the adequacy and the continuous improvement of its processes according to the specificities of each situation. To impose a single version of the agile method would therefore be to empty it of all meanings. The difficulty of transforming

companies in agile mode essentially lies in the difficulty of changing the mindset of both managers and employees. Both have become accustomed to establishing (or following) rigid and well-defined processes. A successful transformation should pass through a mindset switch.

Agile project management

As Agile methods became more popular in the software development projects, many professionals of other sectors started thinking about how they can use Agile principles in their respective fields. Since the Agile manifesto and its 12 principles present Agile more as a mindset, this mindset can be applied to any type of activities and in any sector. In general, being Agile in project management requires answering the question: "How might we perform project management in a way that allows us to create and respond to change and deal with uncertainty?" The two institutes "Agile Alliance" and "Project Management Institute" developed a joint effort to create the "Agile Practice Guide": a document that transposes Agile values to project management context. This document is a reference for agile mode adoption in project management.

So how can we concretely drive such a huge transformation in management in the great-sized companies?

b) FAST: The automotive way to join Agility

FAST, the "Future-Ready At Scale Transformation" is the scale-up transformation program launched in February 2019 within the Renault Group by Thierry Bolloré, Chief Executive Officer, to quickly cope with a constantly changing environment and in particular with the various competitive changes. This program therefore aims to increase customer satisfaction, reduce production cycle times while improving quality, generate even more commitment from employees and reduce costs. It will help to change working methods, simplify processes and deploy Agile mode to scale so that the Group is ready for the future. With the FAST program, Renault Group is accelerating its agile transformation across the company. The challenge is to gain speed and responsiveness in order to offer customers innovative products and services that meet their expectations. This transformation involves changing work methods, making them more agile and developing collaboration between teams. Below the testimony of **Nathalie BARBIER**, director of **Renault Digital**. She reviews her experiences and discuss the conditions for a successful agile transformation. A look at digital transformation.

Renault isn't the only big-size company to deploy agile at scale. The aerospace industry also made some steps particularly through the transformation of Air France KLM. In November 2016, the French airline began its IT transformation plan, deploying agility in close collaboration with the business lines. It recently received the first Agility Grand Prix awarded by Orange Consulting.

Interviewer: Agile, a buzz word or necessity?

N.B: Agility has become a necessity for companies due to today's markets which change a lot faster and more unpredictably.

Interviewer: Agile transformation: why and how?

N.B: Regarding agile IT transformation the goals were Time to Market, Employees commitment, Customer satisfaction of course and Quality.

Interviewer: Agile transformation at scale, how to engage?

N.B: On the Renault side, to address scale, we began to implement, beyond the team context, agile practices within management committees.

Interviewer: Three words to describe successful agile transformation?

N.B: Ongoing improvement, Value and Collaborators satisfaction. Value comes down to the fact that the company had become competitive on its market and managed to adapt to its challenges. And satisfaction I would define in terms of greater attractiveness.

Interviewer: How do you picture your company tomorrow?

N.B: I'd like Renault to become a leader in mobility, that is be a genuine reference and the "place to be". If you want to work in mobility, it must also be the place to be in terms of ways of working.

"The automotive industry is undergoing major challenges, that we believe are real opportunities. In order to shape the future of mobility, how do we adapt by going further in our thinking, in our operating methods and development of our skills? I am proud to launch a bold program of transformation company-wide, called FAST, short for "Future-ready At-Scale Transformation".
Practically speaking, the idea is to upgrade our working methods by adopting agile collaborative methods and by shortening decision-making circuits. To that end, our teams will be trained by in-house coaches, who will help them to implement the new approaches on an operational basis and also serve to upskill employees fully in line with their needs.
By 2021, 100% of the company will be transformed. These initiatives will forge three key advantages. They will shorten development cycles, with cars designed in less than 36 months and connected services updated several times a quarter; accelerate our digital transformation and enhance collaborative work among our employees; and reduce our overheads by around 5% a year over a three-year period, both internally and externally.
Our aim is clear and focused on the satisfaction of our customers, now and in the future."

Thierry BOLLORE, CEO of Groupe Renault.

A shift of organization

Transforming big firms from a classic functioning system to agile mode requires a profound shifting decision from an old mindset based on hierarchy and bureaucracy to a new one inspired by iterative teamwork and flexibility. The main step is to switch from organizations imagined as "machines" to new ones closer to "organisms". The current organizations generate silos mutually disconnected. Employees in each division or department have a detailed description of instructions and a very reduced margin of liberty and initiative. The amount of processes and the heavy decision-making cycles create an important weight of bureaucracy. This bureaucracy usually brakes innovation and prevents original ideas from rising. Moreover, the strict top-down hierarchy and the mechanical execution of instructions robs the organization of the ingenuity of its talents and resources. Such waste of grey matter became unaffordable in industries driven by tough competition and challenging constraints.

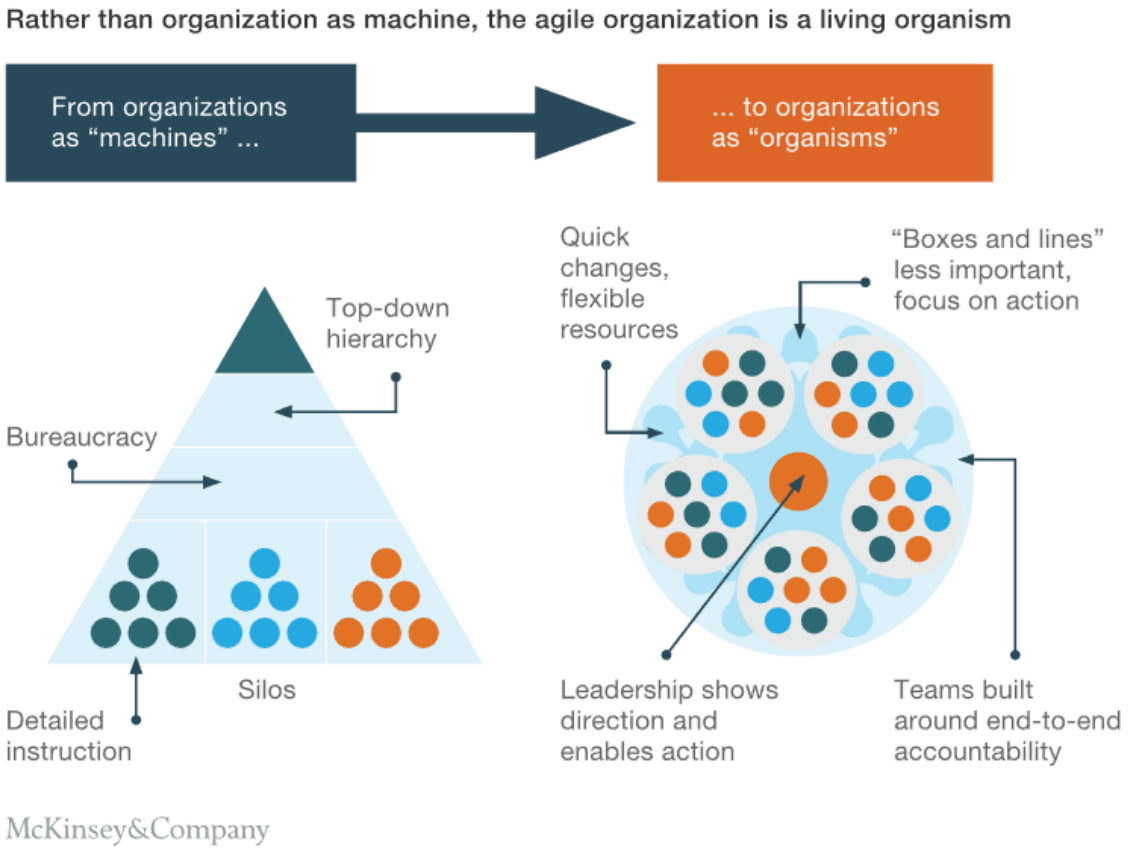


FIGURE 13 AGILE'S ORGANIZATION SHIFT (18)

The new suggested organizations are analogous to organisms by their interactions. The leader, being the core of the organization, shows direction to collaborators and enables them to undertake action. This leadership role means that the management gives employees the margin to take initiatives, to suggest ideas and to undertake actions. In this configuration, teams should be built around an end-to-

end accountability, resources must become more flexible and changes even faster. The boxes and lines should not matter anymore, and the focus should be more on action. This approach is therefore a more implicative and empowering method to keep the entire team result-oriented.

This shift of mindset can be described in more detail through five trademarks of agile organizations:

	Trademark	Organizational-agility practices
Strategy	North Star embodied across the organization	• Shared purpose and vision • Sensing and seizing opportunities • Flexible resource allocation • Actionable strategic guidance
Structure	Network of empowered teams	• Clear, flat structure • Clear accountable roles • Hands-on governance • Robust communities of practice • Active partnership and ecosystem • Open physical and virtual environment • Fits-for-purpose accountable cells
Process	Rapid decisions and learning cycles	• Rapid iteration and experimentation • Standardized ways of working • Performance orientation • Information transparency • Continuous learning • Action-oriented decision making
People	Dynamic model people that ignites passion	• Cohesive community • Shared and servant leadership • Entrepreneurial drive • Role mobility
Technology	Next-generation enabling technology	• Evolving technology architecture, systems and tools • Next-generation technology development and delivery practices

FIGURE 14 TRADEMARKS OF AGILE ORGANIZATIONS (18)

Renault Digital: The institutional tool to manage the large-scale transformation

"The creation of Renault Digital, a 100% Renault subsidiary, in January 2017, aimed to launch the Group's digital transformation and anticipate future disruptions in terms of mobility. We must now go beyond that and accelerate, "explains Frédéric Vincent, President of Renault Digital and Director of Digital Information Systems and Transformation at Groupe Renault.

Chapter II: Analysis of the project, the management and the partnership:

This chapter describes the routine work and the tasks executed by program managers within automotive companies to conduct vehicle projects. This content is a synthesis of all technical, economic and strategic aspects organized in a project logic to follow up the overall management.

1) Contextualization:

Groupe Renault: a multicultural human adventure

Groupe Renault is a French automotive manufacturer founded in 1898. Present in 134 countries, the group sold around **3,9 million vehicles in 2018**. To face the great future's technological challenges and to pursue its profitable growth strategy, Renault group capitalizes on its international development and on the complementarity of its five brands: **Renault, Dacia, Renault Samsung Motors, Alpine** and **LADA**. The company's activity is based on over 183 000 collaborators of which 25% from female gender. They're employed by the company in more than 37 countries. In 2018, the turnover has reached **57 419 M€.**

Renault Nissan Mitsubishi Alliance: necessity to lead the automotive industry

The alliance was born in March 1999 following a period of financial difficulties for Nissan, which gave Renault the opportunity to buy part of the Nissan group and put Carlos Ghosn at the head of it to restructure. In 2011, Renault-Nissan becomes the world's third largest car group, behind Toyota and Volkswagen. The Renault-Nissan-Mitsubishi Alliance is consistently ranked in the top four in the world in terms of sales, reaching first place ahead of Volkswagen AG, Toyota and General Motors in the first half of 2017.

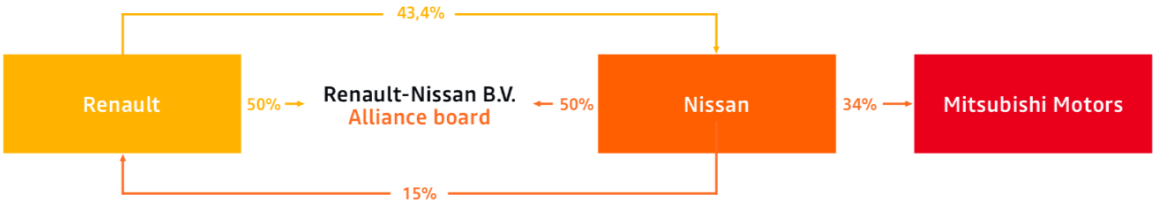


FIGURE 15 ALLIANCE BUSINESS MODEL

Light Commercial Vehicle (LCV) Business Unit:

"The special nature of the LCV business generates a number of interlocking issues, including customer expectations, dedicated plants, specialized engineering, an expert sales network, and longer life cycles." Said Ashwani GUPTA, the former head of the LCV business unit. In his statement, A. Gupta lists the reasons why the Senior Management created the Light Commercial Vehicle Department. The LCV business unit is composed of LCV program departments (including Small Van program) and head-office departments (sales, management control, partnerships and international rollout, etc.). The "program" in the automotive industry is the management unit that unifies, and coordinates dedicated teams of engineering, design, purchasing, product, aftersales, IS/IT, finance and quality. The LCV

models are produced in different regions of the world. It also benefits from the expertise of six plants: three in France (Batilly, Maubeuge and Sandouville) and one each in Brazil, Argentina and Morocco.

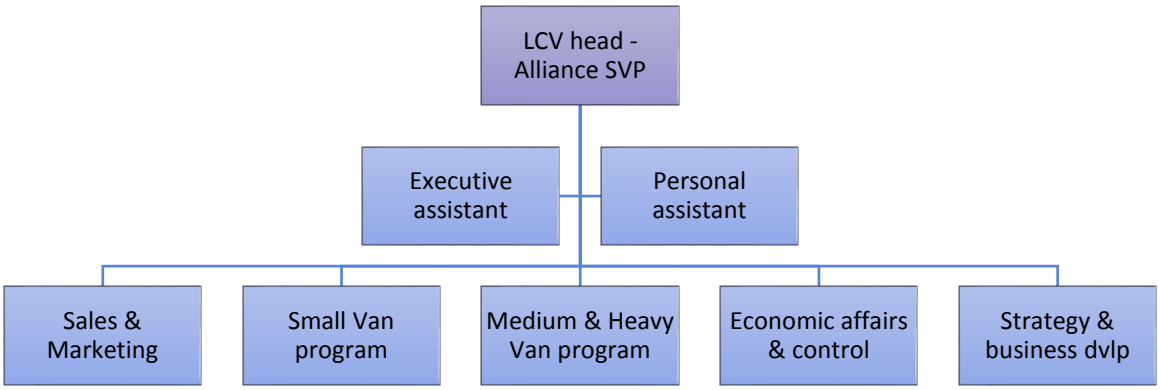


FIGURE 16 LCV BU ORGANIZATION CHART

Small Van Program: The Small Van program is the division responsible for leading the group's small van's models through Upstream, Development, Industrialization and Serial Life phases. It's the main entity in the company that is responsible for the overall technical and economic success of a vehicle project. For each vehicle, a program manager is assigned to steer the project. His main roles are: Cross-functional team management, challenging all the functions to achieve profitability targets, Deciding the balance between customer value and cost, Arbitration between the functions and to Report Milestone decision at level 1(CEO) & 2(other C-level executives).

XFK Project: The internal code name of the project

XFK project is the new small van vehicle project developed by Groupe Renault. The new model is supposed to join Kangoo and Dokker in the small van segment. The vehicle management is driven by small van program division and include several car manufacturers as partners for the project. The partnerships in this kind of segments became essential as the economic conditions (entry tickets and big-size plants for example) are getting higher. Those raising costs are mainly due to the huge diversity required for small van market: passenger car, commercial vehicle, thermal powertrain, electric powertrain, manual transmission, automatic transmission, several lengths etc... As this type of vehicle can be used either for passenger's transportation or goods carriage, two versions are needed: passenger car and commercial van. For each, several powertrains (gasoline, diesel, natural gas…) are required to satisfy all segments of clients, individuals and professionals. Moreover, the evolution of the small van segment gave birth to different length parameters needed both for transporting more people (from 5 to 7 seats) or enabling more storage volume. Finally, recent legislative regulations made essential to have an electric version for every vehicle to compensate the CO2 produced by thermal versions. This compensation is called CAFÉ system. Among the several partners' projects included in this project, the sub-project destined to XXX is assigned to a partnership program manager.

2) Description of the project

a) The product definition:

Important! The following data are inspired by different vehicles in the small van market and do not disclose in any case the actual values and technologies of the project or any Renault internal project's data. The aim of the section is to give a global idea on how a vehicle is specified by manufacturer and which parameters are considered.

General vehicle description:

Small van projects as all light commercial vehicle projects are known to have a large panel of diversity. In fact, those vehicles are supposed to meet with professional client's expectations (usually big fleets) and should therefore adapt to various needs and use cases. For that reason, those vehicles require a massive investments and development effort. The usual small van projects have many versions among them:

- Passenger car or Cargo van
- Normal length or maximum length
- Thermal or electric powertrain
- Gasoline or diesel engines
- Automatic or manual transmission
- Small range of large range (for electric vehicles)
- Other options related to air conditioner and other…

In partnership projects, defining and fixing the product to develop or to manufacture is primordial. The partners should agree that a jointly evaluated and agreed Specifications must be frozen from the date of execution of their Development Agreement. The content of the Specifications consists mainly of:

The general Vehicle description; Differentiation parts overview; Territories, The Vehicle Lay-out, dimensions and pay-load; The Powertrain line-up and mix; The Customer Performance targets; The list of the Partner Lead Parts; The color and trim; The Territories' homologation requirements; The product definition list. Each Party should ensure that the requirements set out in the Quality agreement, for which it is responsible, will be met.

The specifications take the form of the following table. The table is composed of several levels. Each level is described by one or more target parameters. The targets should be described to have a clear idea on their content and the parameter is specified with a numerical value.

Level	Target parameter	Target description	Unit of measurement	Cargo van	Passenger car
Payload	Max. Payload		Kg	---	---
Vehicle Dynamics	Accelerating 0-100 km/h		s		
Vehicle Dynamics	Top speed		Km/h		
Vehicle dimensions	Vehicle length		mm		
Reliability	Mean number of annual recognized complaints per 100 vehicles (12 months after initial registration)	SOP (start of production) + 9 months	Failure per 100 vehicles		

Among the many levels and specifications' topics, some are very essential to understand the content of the project and the vehicles' main characteristic and use cases. The following section describes those levels:

Dimensions and payload:

Payload: can be described by its two main parameters: Max. Payload and. Axle payload; For commercial vehicles, payload is a key selling point. Users -usually professionals of transport and delivery sector- pay a specific attention to this parameter before considering purchases. In many cases, the more mass drivers can transport the more their profits increase. Therefore, OEMs work to maximize the possible payload to distinguish themselves from competitors and to seduce more costumers. This race for payload maximization is challenged by security standards and even pollution standards since the heavier a vehicle is the more its engine (consumption and pollution values) and its security items (breaks) are challenged.

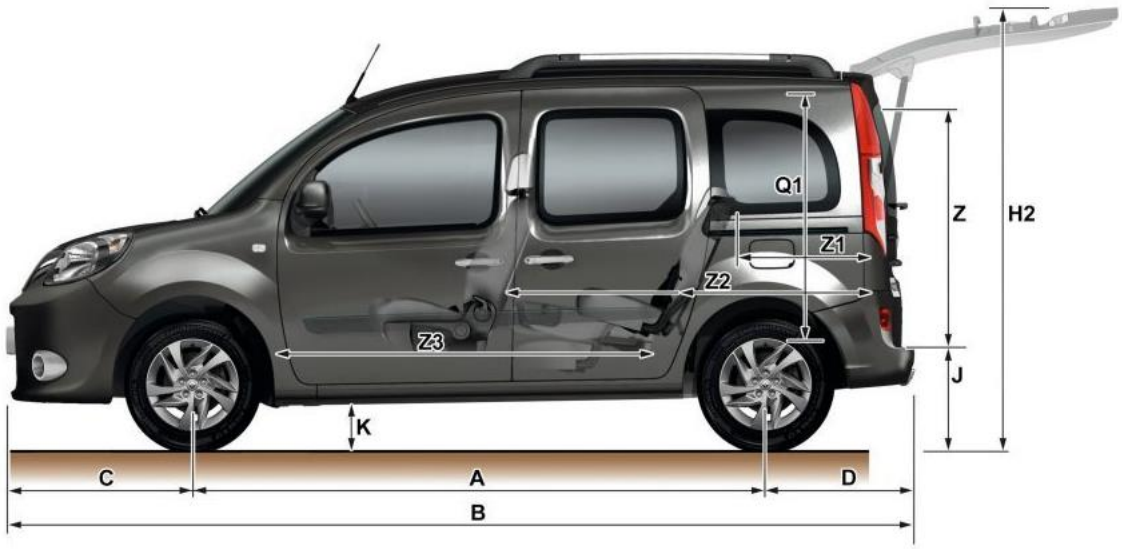


FIGURE 17 DIMENSIONS OF PCL1 VEHICLE

Vehicle dimensions: vehicle length, vehicle width, overall width of vehicle with outside mirror, vehicle height. Dimensions are very critical for LCV vehicles. They are described in a dozen of parameters (A, B, C, D, H1, J, K, Q1, Z, Z1, Z2, Z3) to give clients a tool to compare the volume for an old version or a competitive version. Recent small van projects have developed a new length of vehicles for both passenger cars PC (5 seats vehicle used for Taxi purposes) and cargo van CV (for extra charging volume).

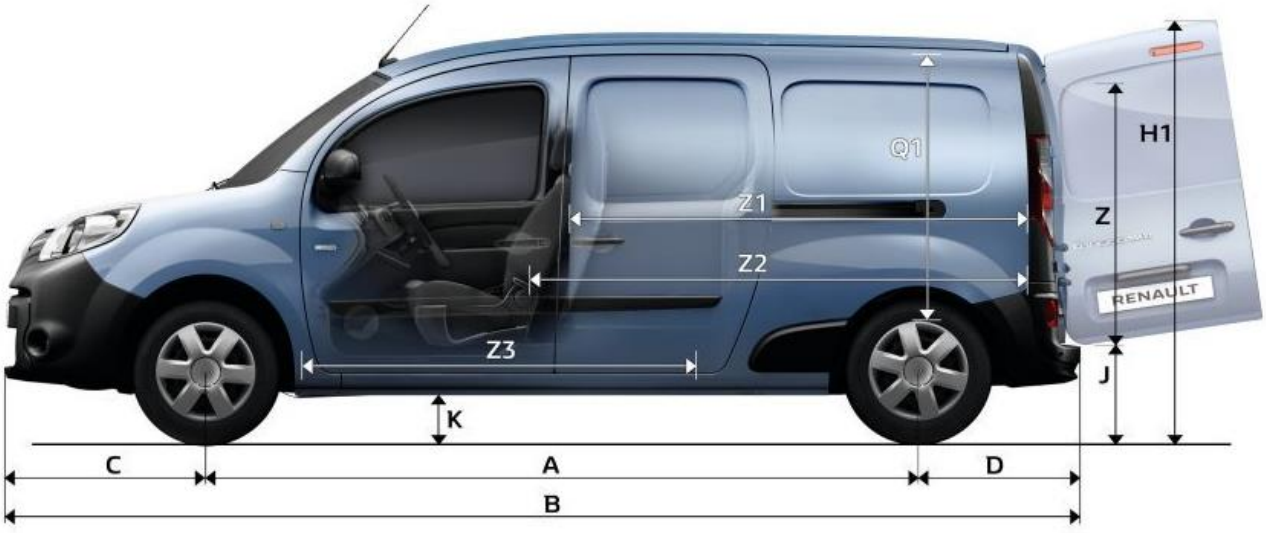


FIGURE 18 DIMENSIONS OF CRL2 VEHICLE

Powertrain line-up:

In addition to payload and dimensions' considerations, small van vehicles (alike all vehicles) are positioned in the market based on their powertrain line-up and performances. Among those characteristics:

Power characteristics: acceleration from constant driving 100km/h; response/reaction time; acceleration from 0-100 km/h; acceleration 0-60 km/h; Maximum speed

Diesel motors: diesel engine power ; Gasoline motors: gasoline engine power

Fuel consumption: g CO2/KM for each type; drive option (l/100km); time for recharge HV battery; zero emission range NEDC; drag coefficient

Customer performance targets:

Vehicle dynamics: accelerating 0-100 km/h, accelerating 0-60 km/h, top speed

Brake: Braking distance cold from speed 100 km/h, Gross vehicle weight, Braking distance "warm" from speed 130 km/h, with empty vehicle; Braking distance from 80% maximum speed, empty / gross vehicle weight; Brake noise; pedal feel

b) The partnership deal:

The following section describes how the partnership deal is organized between two car manufacturers: the heart of the cooperation is a bunch of legal documents/contracts that precise the details of the project organization (stakeholders, meetings, functions and responsibilities). Different types of contracts are signed depending on the project phase such as master cooperation agreement (MCA), non-disclosure agreement (NDA), development agreement (DA), Manufacturing and Supply agreement (MSA) and other… Three main types of contracts are described in this section to cover the overall project life cycle:

Below the timeline and the structure of contracts that cover the project during its entire life cycle:

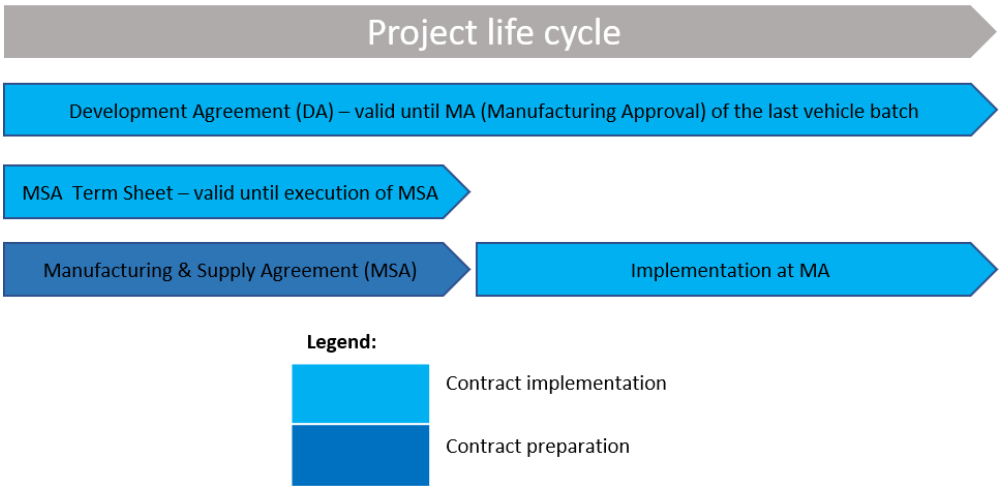


FIGURE 19 CONTRACTS TIMELINE AND STRUCTURE

NDA: To lunch any cooperation between organizations (companies, laboratories, universities or research centers…), it's essential to secure the interests of all parties by signing a non-disclosure agreement (NDA) to preserve the intellectual property of each party. The importance of this document increases when partner organizations are competitors and their mutual business may be impacted.

DA: When a cooperation takes the form of a project, it is necessary to determine with precision the product or the technology in question, to agree on its mode of development as well as the responsibility of each party. Those elements are documented in the Development Agreement (DA) which sets all technical/economic/legal details of all aspects of projects.

MSA: Once the agreed product (vehicle in this case) is developed, partners may engage or not an MSA. This Agreement defines the terms under which partner A should manufacture and supply Vehicles to partner B compliant with the Specifications agreed. Vice versa, it precise also that partner B should purchase the Vehicle from partner A. Such agreement has a greet legal value and should therefore be consistent by coveting all topics related: Production capacity, Quality, Logistics etc.

RASIC table:

To make sure that every party is aware of its responsibilities, the RASIC table is set to precise what every stakeholder should do. Five main shades of responsibilities can be identified: Responsibility, Accountability, Supporting, Informing and Consulting according the following description:

R	**Is Responsible to do**	« R » fulfills the task. There is only one « R » for each task.
A	**Is Accountable for the task**	« A » is Accountable for the task. When there is an « A » for a given task (not always the case), only one « A » (and only one) can be set. Being « A » means to be totally accountable for a given task. An « A » can also be « R » for a task.
S	**Supports**	« S » contributes to the task to be fulfilled by « R ». Several « S » can be assigned to support « R ». Contrary to « C = Consulted », « S »'s help is needed to fulfill the task assigned to « R ».
I	**Is Informed**	« I » is a person or a group who must be informed of the project progress. The information runs one way only, from « R » or from « A ». There can be several « I » for any task.
C	**Is consulted**	« C » is a person or a group who must be consulted (by « R » or « A »). The information runs two ways. Although « C » is consulted, « A » has the final word as the only accountable for the task.

FIGURE 20 RASIC DEFINITION

Below a RASIC matrix example in case of an automotive partnership project:

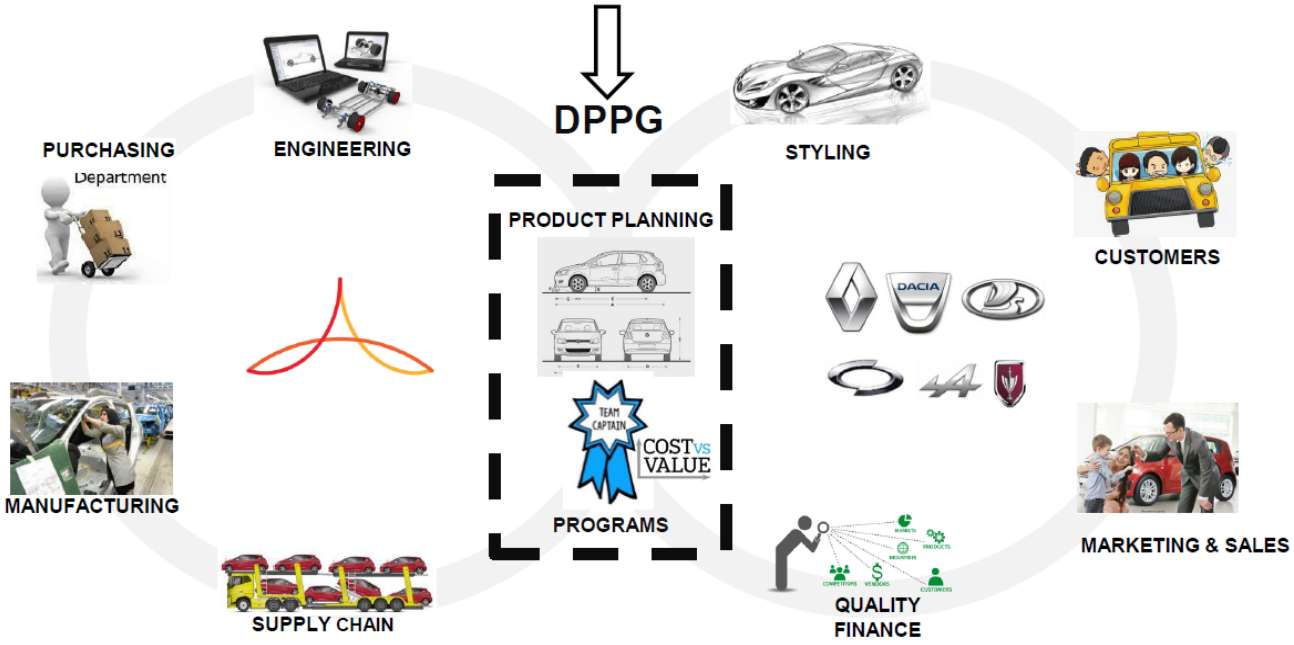
#	Function	Activity description	Renault	Partner
1	Project management	Development Master schedule	A, R	I
		Diversity management	A, R	S
2	Product	Planning SOS (start of sales)	A	R
3	Styling			
4	Homologation			
5	Engineering			
6	Prototypes			
7	Manufacturing			

The RASIC table is included in legal documents (DA & MSA). The non-compliance with RASIC may have legal consequences that result in heavy fines and therefore must be carefully established.

3) Analysis of the management:

a) Management of the project:

The general management of project in OEMs is very complex. That is due mainly to the mass production volumes, the high investments cost, the long cycles (2 years for upstream, 3 years of development and industrialization and over 7 years of mass production) in addition to the several challenges of the automotive industry (emissions, connectivity, autonomous driving and new mobilities…). To face this complexity, OEMs developed a complex organization to manage vehicles projects that can be described as follow:



The structure of the project is built around many departments gravitating around the program, the captain of the project

Program: Its main role is to make Cost/Value decisions, to guarantee profitability and to handle time to market issues. It's the main instance monitoring projects and making arbitrations.

Product Planning: The planning department is in charge of analyzing customers' needs and performance requirements. Product planners lead the projects at the upstream phase until making a final concept proposal. They are responsible of setting the entire products line-up of Renault Group.

i) Planning management:

V3P: value up product process program mile stoning method: the Renault internal model of management.

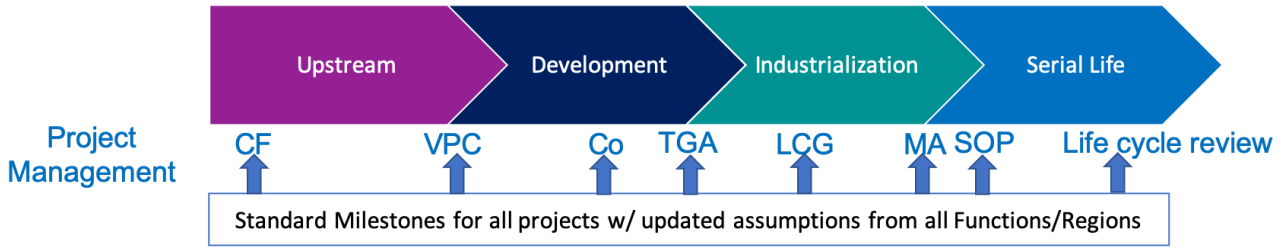


FIGURE 21 VP3 PROJECT MANAGEMENT

The construction of the Projects new logic of development, V3P-2 (Value up, Product, Process, Program), is based on 3 phases, upstream, development, industrialization, and was carried out on the hypothesis of a " mother "pattern, then declined for the other patterns.

j) Financial management within Renault Group:

What's financial management?

Renault defines an investment as a type of expenditure made by a company to acquire the equipment or goods required to hopefully make a profit in the future from their use. An investment project involves a series of financial flows (expenditure and income) throughout its lifetime. Any investment project must be profitable, i.e. it must generate more income than costs. The decision to invest (or not) therefore depends on multiple criteria which are described below, and which are used to arbitrate, prioritize and plan investment projects.

As in every project, the finance analysis is key to conduct and to the reach the overall goal. In Renault projects, the financial control is led by the ECOs (Economic Performance Controllers). The ECOs work closely with the program manager. They are the only entity directly attached to the program department. The main reason for this situation is that the program manager (and director) is driven through the project by two key indicators that must be watch continuously:

NPV and **COP**

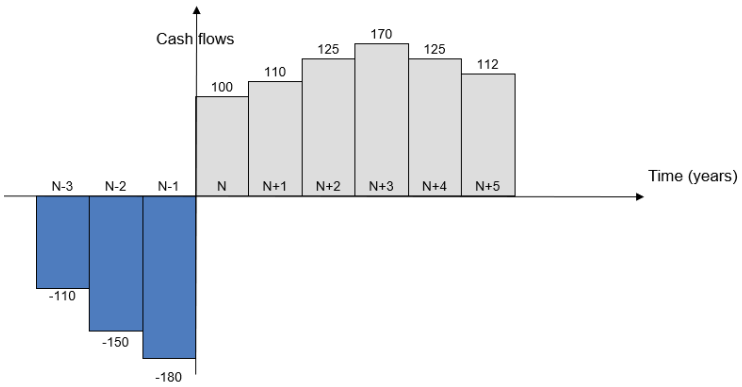
What's an NPV?

The NPV (for Net Present Value) measures the value created by the project for the company. It is the reference measure in terms of investment. It reflects the difference between the income and the expenditure. To any project to be accepted, it must create value i.e. have NPV > 0. The formula below enables the ECOs to calculate the NPV for the following project's example:

$$NPV = \sum_{k=1}^{N} \frac{Cash\_flows_k}{(1 + discount\_rate)^k}$$

Two rules: Investments are capitalized & Incomes are discounted

The Discount rate is a factor used to neutralize financial flows which occur at various dates and which are not directly comparable, providing a shared basis for comparison.



What's a COP? The COP (for Consolidated Operational Profit) is equal to the difference between the sales and the operating costs. It analyzes the project's ability to make a profit and is therefore one of the major indicators for measuring the commercial and industrial performance of a given vehicle project. The board of the group pays an exceptional attention to this indicator because it contributes in the company COP that is communicated twice a year to the public and to the shareholders. The COP of the project doesn't include only the vehicle COP, it considers the contribution of Spare Parts and financial services too. Those two additional elements can be very profitable for the company and can sometimes exceed the profit generated by the simple sale of a car. Hereafter the formula to calculate the COP:

Project COP = Vehicle COP + contribution of Spare Parts (after sales services) + contribution of RCI (financial services)

Two levers to control the Finances: The program manager work with the Finance, Engineering and Product Planning to maximize his project's NPV and COP. To do so, he acts on two parameters: the **ET** (entry ticket) and the **TDC** (total delivery cost).

ET: The ET of a vehicle project includes all costs incurred to design and industrialize this project. A more detailed definition is given in Chapter III, Budget constraint paragraph.

TDC: Total delivery cost is the overall cost to manufacture a product.

QCDP: is the process conducted by program managers, economic controllers and engineers in chief to check the evolution of costs (total delivery cost among others) and entry tickets.

k) Vehicle life cycle:

Upstream phase:

Principles of the upstream: During the upstream phase, the business, the concept of vehicle and the possible solutions are centered for the milestone Concept Freeze, before optimizing the technique and the design. Concretely:

FIGURE 22 UPSTREAM PHASE DETAILS

1) The business is built on a world base and working on the enrichment of a vehicle of entry of the range.

2) The technical-economic breakthroughs are identified in limited number and their solutions are defined before the Concept Freeze. All the technical-economic feasibility is locked at the milestone VPC-GW1.

3) The concepts of vehicle, the requirements differentiating us of the competition (USP: unique selling point), the themes of style, lead to demonstrators which are clear enough to ensure cost-value arbitrations and robust choices.

Milestone V3P	Global Result
PKO : Project Kick-Of	The project team shares the input data of the project on the base of [V]
Int : Intention	The business strategy is defined: target markets, product concepts with target customers and associated areas of differentiation. The framing of economic playground (costs and profits) is achieved.
PreC : Pre-Concept	The concept, candidate with its potential USP, is chosen and consistent with economic objectives. The platform is chosen.
CF : Concept Freeze	The concept of the vehicle and its USPs, robust in cost/value balance, are defined and match with the customer requirements. The technical solutions are consistent with the economic target.
VPC : Vehicle PreContract	The pre-commitments are signed in compliance with the model retained in GW1, the costs value balances and the technical solutions defined in Concept Freeze. The trajectory towards the contract is shown

4) The convergences on platform and on upper-body are separately handled; the rival studies (ex: concepts, styles) are identified and organized to be managed in parallel.

The Hand-Over: An upstream-development Hand-Over consists in validating activities transfer between upstream (UVE) and development (CVE) supplying project deliverables and validated action plans for issues on going on the project.

Development phase:

Principles of development phase: The conception has to be "Feasible", for the milestone "Consistency"; the use of the digital is maximized; the milestone "Tooling Go Ahead" marks the end of the conception.

FIGURE 23 DEVELOPMENT PHASE DETAILS

1) A digital vehicle, 100 % complete, (Digital Lot) is analyzed in synthesis of every loop.

2) All the digitalization supplied by the GFE for D-Lots are validated by the suppliers and comply with the rules of conception.

3) The developments of the platform and the upper-body are resynchronized, during the 1st loop of development, to ensure the coherency.

4) The calculation and the simulation give robust previews for the requirements, as soon as the milestone "Consistency".

5) The milestone "TGA" confirms the robustness of the end of conception: 100 % of the parts are studied with guaranteed files, the vehicle is consistent, the performances for manufacturing, after-sale and QCP are confirmed.

V3P Milestone	Global Result
AB D-Lot Cy: Agreement to Build D-Lot Consistency	Each 'metier' commits on the conformity of its digital parts to the expectation at Consistency (with product-process feasibility and commitment of supplier and toolmaker). The D-Lot can be kicked off.
CO: Contract	Interfaces and volumes are contracted to finalize the convergence of Product /Process /Style /Requirements. It integrates the solving of pbs met during the loop Cy. The surface development drawing (PdF) 100% is official.
AB D-Lot Cp: Agreement to Build D-Lot Completion	Each 'metier' commits on the conformity of its digital parts to the expectation at Completion (with coherency of architecture and surface drawing 100% BPRO). The D-Lot can be kicked off.
TGA: Tooling Go Ahead	The technical definition "Good for RO" (Tooling construction)" is feasible, in consistency with the commitments of the contract

Industrialization phase:

Principles of the industrialization: Bodies in white are made in plant; conformity of parts is a due; application of the validation systems is maximized; modifications are limited at most as possible.

1) Tooling and 1st parts out of tools (IOD) are achieved with the target of conformity as soon as possible, based on the reliable data of the milestone "TGA". – The validation is made by successive level of integration component / system / synthesis car, with a strong usage of benches for system, to reduce the need of vehicles of validation.

2) The means for manufacturing are quickly transferred on the final site of production.

3) The ramp-up is prepared to be successful: the convergence towards the certification product – process is managed continuously.

FIGURE 24 INDUSTRIALIZATION PHASE DETAILS

V3P Milestone	Global Result
ABVC: Agreement to Build Vehicle Check	Authorize the manufacture of vehicles for validations on the critical path and those for assembly burn-in. These vehicles are rolling. An AVES check is carried out on these vehicles (Zero point of AVES ratings)
LCG: Launching	The sales department commits on the result to obtain and the methods of its implementation.
ABPT1: Agreement to Build Plant Trial 1	The vehicle can be manufactured in plant on mass production equipment. The definition of the PT1 allows to make all the planned "44étier" validations. The entire start up batch is found in this batch.
ABPT2: Agreement to Build Plant Trial 2	The PT2 definition enables to carry out the product/process certification. The entire start up batch is found in this batch.
PPC: Product Process Certification	The product/process is robust, and it is 100% compliant with these specifications. It makes it possible to manufacture saleable vehicles in second-hand.
MA: Manufacturing Approval	The process is suitable for manufacturing the vehicles compliant and at the required rate. The made vehicles are saleable as new.

Commercialization	
DA: Dispatching Approval	Plant has demonstrated its ability to supply sales networks at expected volume and quality
Life Cycle	The objectives of the Contract are reached and the strategy of life of the vehicle is described.

Serial life phase:

Serial life is the phase during which the vehicle is already developed, produced in factories and marketed in sales networks. At this stage, problems are far from being finished. There are mainly two inexhaustible sources of troubles:

- The evolution of regulations
- Unsatisfied customer complaints

On one hand, regulators and standards organizations continue to evolve their requirements and are increasingly demanding updates and enhancements on different components. Manufacturers must then remain permanently responsive to continue to produce and sell their vehicles. On the other hand, customer feedback managed by the after-sales department is also an alarm calling into question the quality of the product delivered. In this section, examples of complications that arise during serial life are presented. They come mainly from an LCV project in serial life in a partnership context. Although these problems may be technical, regulatory or commercial, the program is responsible for piloting action plans to ensure the overall profitability of the project with two targets in mind: the NPV and the COP.

b) Management of the hierarchy:

As in all organizations, hierarchy is important to make appropriate decisions and to take consequent responsibilities when needed. The more complex a project is, the more clarity becomes important in decision-making processes. For instance, the vehicle project has many decision instances and processes. That is because the project includes several departments and units (Engineering, Finance, Logistics, Design, Manufacturing…). Each instance (meeting or committee) has a specific goal that can be either a Decision, an Action or an Information or sometimes a combination of all. The following section describes the ones that are the most significant in a vehicle project. All of them are internal instances and do not include partners representatives in case of partnership context.

CPP4: Committee Program Product Level 4 is a weekly meeting leaded by the Deputy Program Director. It is the first meeting (hierarchically speaking) where the Program Department officially interferes. Its main goals are to inform the Program Manager of the project's state of progress, blocking points and all relevant topics. In the particular case of partnership project, it's the occasion to communicate the partner's evolving requirements, to discuss its feasibility (opportunities and threats) and to build an internal ONE VOICE to answer those requirements. The most active member of this instance is the Vehicle's Engineer in Chief (VEC). He's the representative of Engineering department

and is responsible for the technical convergence of the vehicle. The VEC ensures that the planning is respected and prepares the necessary documents (quality sub-milestones) to pass project's milestones.

Specific Point: In real life, all topics cannot be discussed in a half-day and several executives cannot be always present in CPP4 due to other commitments (meetings with clients, suppliers, partners or hierarchical managers). In addition, some subjects are more complicated than others and need several meetings and negotiations before closing them. To make sure all relevant topics are evaluated discussed, program managers tend to organize several specific meetings called also Specific Points. The agenda and minutes of those meetings can take the simple form of an email.

CPP3: Committee of Program and Product level 3 is a weekly meeting leaded by the Program Director and organized by the Deputy Program Director. Among its permanent members: Deputy program directors, chief engineers, global chief marketing manager, product range director, design range director, economical manager and range program quality engineer. The committee last approximately 3 hours and can be delegated if necessary. The topics may be either upstream project related or serial life related. The main goals of the CPP3 are the preparation of files for levels 1 and 2 (C-level executives), the preparation of economic files before milestones, approval of level 3 reviews, purchase decisions, and industrial decisions.

CPP2 and CPP1: Committee of Program Product Level 2 includes Senior Vice Presidents of the company. When the CEO is present at this committee, it's called CPP Level 1. At this stage of hierarchy, topics that have been escalated from CPP3 are discussed and arbitrated. Moreover, those instances allow to take big-scale decisions (lunching of new projects, freezing ongoing projects or cutting diversity). Usually, whether a decision should be taken at CPP3 or escalated to CPP2 depends on the business impact (the amounts in question).

The previous committees are formal, and all mentioned topics are documented to ensure the trackability of decisions. For that, the program manager/director prepare upstream (respectively downstream) the agenda (respectively the minutes) stored in the secured e-room.

Date	Start	End	Subject	Topic	Pilot	Attendees

FIGURE 25 EXAMPLE OF CPP4 AGENDA

Reporting	Deadline	Pilot

FIGURE 26 EXAMPLE OF CPP4 MINUTES

RDS: RDS (as in French Reunion de Service) is a weekly internal unit's work meeting. In Program Department's RDS, the Program director gathers his deputy program directors and program managers. He or she gives his or her team the general orientations, communicates top management key messages and define the roadmap and strategy to implement those orientations into operational level. It's also an opportunity for team members to informally express their opinions about several topics related to their work, management methods and daily routine.

If hierarchy is important to ensure the fluidity and clarity of decision-making processes, human relationships between managers and employees or between managers themselves are more complicated to manage. In fact, several ways of thinking offer several approaches to define and build a healthy relationship that maximizes productivity at work and avoids unnecessary conflicts. The following sections make a focus over those two key relationships:

Manager/Collaborator relationship:

In modern societies, relationship between employer/employee or manager/collaborator became one of the central subjects discussed in professional environments. In the business world, there are several types of relationships depending on managers and their philosophies. Some people, considering themselves of the old school, prefer to keep a certain distance from their collaborators and restrict their exchanges to purely professional subjects. They care less about the conditions of their subordinates outside the professional environment and formalize all their discussions. In this case, employees feel that they are dealing with a personified process and expect less understanding of their conditions and potential constraints. Other managers, and not only young people from new generations as it can be imagined, have a different approach to this relationship. For them, it is first of all a management of the Human that takes precedence over the management of the employee. This involves taking into consideration all aspects and topics that concern the employee. The key to this relationship is communication. We are seeing more and more managers who organize original parties and exchange moments outside of work hours. They preempt proximity and are interested in anything that could directly or indirectly impact the mood and the productivity of their team members. This notion of proximity and management of the human extends today to become institutional within the organization of the company by creating what is called Chief Happiness Officer. But whether the manager chooses the first or the second approach, or in somewhere in between or in any other configuration, the success of this relationship is conditioned by a central element: trust. It is observed that the healthiness of a manager / collaborator relationship depends on the trust each person has in the other. This trust makes it possible to see clearly, to move forward and to resolve conflicts that may occur.

Manager/Manager relationship:

Even if the Manager/Collaborator relationship is very complex to analyze, it's not the only one that requires management's attention. Within organizations, and especially in the most complex projects, several managers have to work together. Those managers can be at different hierarchical levels, sometimes not belonging to the same structure tree. It is interesting to observe the behavior and attitude of those executives during multidisciplinary meetings. We observe, for example, protective managers who refuse to expose their collaborators to the criticism of others. To do this, they prefer sometimes not to invite their collaborators to these meetings even if their presence could be beneficial. Such attitude is generally badly perceived by employees who feel excluded. Other managers refuse to let their associates contact another department and demand that all information flows through them. They believe that they control the information better and protect the company from possible short circuits. This in most cases translates into a considerable loss of time and an impression of a lack of transparency in certain divisions. Those observations show that managers should also learn to work with each other in a cooperative mindset to enable their structure to reach its goals.

Top management influence:

In large-scale projects, the operational and strategic structures of the company often come into contact or even face each other. The operational part of an organization works on a tangible project, develops it, manages it and ensures its success. As for the strategic part, it takes into account long-term parameters and ensures the overall survival of the company. It may occur that the company's interest requires a project that has made considerable progress to stop. Such decisions can lead to frustration among employees who - for the most of them- have gone to great lengths to achieve their previously defined goals. This frustration is unhealthy for the company. It lowers employee motivation and disconnects them from the overall reality and direction of the company. It can in some cases bring the best talents of the structure to leave it to new horizons. Often, senior executives engage in advanced arguments with the press or with the competition and forget to convince their employees first. For this, a visionary management has every interest to communicate well on these major decisions both externally and internally. It must be able to include the operational part of the business in the decision-making process. Such an attitude will not only strengthen the transparency of the organization and its departments but could also boost the motivation of its employees. The latter having more confidence in their management, will engage more seriously in reaching then objectives. They will be convinced that their efforts are well recognized and that the general interest of the company requires courageous decisions.

c) Management of the partnership:

Steering a vehicle project in a context of partnership is very particular. If making partnerships benefit to all partners by reducing their costs and sharing knowledge and expertise, managing this resulting organization is not always simple. Bringing two existing big-size organizations from different work cultures to work together requires a new organization that would exploit the strengths of each and cover their misfunctioning problems. In addition, the pre-established structures in each may not be quite parallel which makes even more complicated to build a new resulting structure.

In the case of the above small van project, the organization issue had been handled as follow:

Constitution of work packages:

Work Packages are nominated by the JMC on specific areas. They should enable the Parties to exchange appropriate functional data and information and to enter into a process of exchange throughout the execution of the Agreement. To ensure achievement of the Master Schedule, the Parties agree that at Work Package level, a progress report of their respective status of work will be prepared and shared at the JMC on a regular basis (4 weeks approximatively).

Work Package	Role
After-sales	Diagnosis, after sales documentation, labeling and spare parts and accessories subjects
Finance	Invoicing, costs related to Design Changes, and pricing evolution subjects
Quality	Quality level with target and achievement and action plan and warranty issues such as warranty targets and statistics
IS/IT	IT/IS and documentation issues and the definition of the interfaces and the required data conversions
Styling	Inter alia styling issues and convergence
Manufacturing	Manufacturing issues
Logistics	Inter alia ordering, delivery and logistics issues
Purchasing	Inter alia suppliers' parts and suppliers tooling and capacity issues
Product planning	Inter alia vehicle content definition issues
Engineering	Engineering and design issues, such as R&D schedule, Prototypes, Homologation, preparation of Design Change Management and decisions on technical topics which do not have any financial or planning impact

TABLE 1 EXAMPLE OF WORK PACKAGES ORGANIZATION

Constitution and meetings of joint management committees:

The JMC consists of several representatives from each party belonging to several departments depending on the topics to be decided in the meeting. It's is co-chaired by the Program director of each partner and meet either in person or by audio/video- conference. The members of the JMC meet on a regular basis and at least every two months for ongoing activities (such as review of progress of the Work Packages and resolution of outstanding issues). Minutes of each meeting of the JMC are signed by a representative of Renault and by a representative of the partner. Special meetings can also be held from time to time for special activities.

The JMC is therefore in charge of the follow-up of the implementation of the Development Agreement and of the following issues:

a) Coordinating between the Parties of inter alia the several activities such as: Master Schedule updates and Action Plan confirmation; Specifications updates; Review of Vehicle development status regarding Vehicle quality (targets, follow-up and resolution of quality problems), costs (incl. investment forecasting if needed), Vehicle commercial launch schedule, Vehicle Purchase Price, of risk assessment and production volumes forecast.

b) Discussing and arbitrating any outstanding issues or conflicts arising within the Work Packages and the operational levels described in this Agreement.

c) Instigating a reporting and reviewing structure of the project's key measurement criteria and status to the JSC.

Constitution and meetings of joint steering committees:

The JSC consist of the Alliance Senior Vice President, head of Light Commercial Vehicles BU, the Partner's head of the Business Unit Vans, and the LCV Program Director, the program manager, the head of engineering Vans, the Finance and Cost Control Director for LCV of both Renault and its partner. It's co-chaired by the Alliance Senior Vice President, Light Commercial Vehicles BU and the Partner head of the Daimler Business Unit Vans. The JSC meet for the management of the Project at least once every three months. One representative of Renault and one representative of the Partner are appointed to maintain and sign complete and accurate minutes of meetings in English.

The JSC main role is to perform the following functions:

a) to review the progress of and take major decisions related to the Project

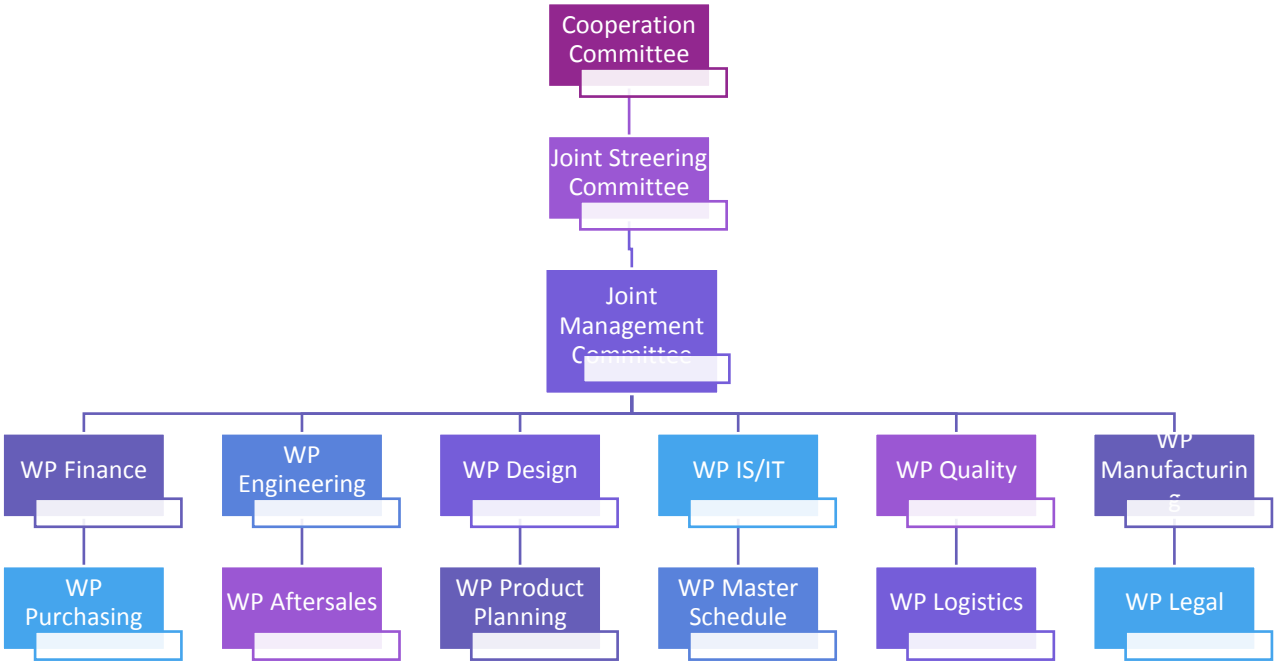
b) to review status of the achievement of agreed quality targets

c) to review the project's key measurement criteria and status

d) to resolve any matters arising from the JMC

The previous instances of decision have a hierarchical organization as below:

This hierarchy follow an escalation logic. When subjects are not aligned on the work package level, they are escalated to the JMC. If managers couldn't find an arbitration, issues are escalated to the JSC where senior executives have large authority to take appropriate decisions. The Cooperation Committee ensures that the conditions of cooperation and partnership remain present throughout the project period.



Non-formal meetings:

To enhance communication between partner teams, other forms of exchange may take place. In fact, predefined committees with a contractual status for which the declarations of each party are documented and archived create barriers. To find a consensus, to clarify a position or to carry out a negotiation, it is essential to have other channels of communication. These can be either through Skype or GSM calls or SMS/WhatsApp text messages. All with great vigilance to avoid anti-thrust issues (especially when the partner is also a competitor). Those exchanges allow to build with the partner a relation of trust based on the collective will to succeed the project. This is an opportunity for the teams to get rid of the cumbersome processes and exchange freely (and in accordance with the law) since their statements have no contractual value. Moreover, those non-formal meetings can also take the form of a diner or a small party. Those occasions help to get rid of the usual stress dominating the work environment and to build a healthy cooperative relationship based on mutual trust, understanding and transparency.

Partnership Challenges

Partnerships offer a considerable potential for growth and cost reduction in the automotive industry especially in large-scale projects demanding massive investments. However, those organizational models present limits and face several challenges observed in the operational management of projects and deals. Hereafter some examples of the most common weaknesses and threats:

Asymmetry of organization: To couple two structures, it is necessary to have a minimum of parallelism between them. Otherwise, dysfunctions may affect decision-making processes and accountability mechanisms. When two interlocutors from two companies work together without having the same hierarchical rank in their respective enterprises, an imbalance of power can take place, which induces a lack of credibility of one party and a mistrust of the other.

Staffing Imbalance: When two companies in partnership have unequal or disproportionate means, cooperation can be disturbed. In fact, the less staffed partner could feel a surplus of workload which could be frustrating. On the other hand, the lucky partner could feel that the other party is not engaged in the project with the same effort nor motivation which can threaten the partnership. It is therefore important to ensure a certain balance in the human and material resources allocated to each party.

Information, Communication and Interpretation: Communication is a key parameter for success in multi-party projects. First, the information flow enables to show progress, to exchange data and to resolve disagreements. However, communication channels may sometimes alter this flow. In multinational projects for instance, using a foreign language by one or several parties can lead to some misunderstandings. On one hand, the transmitter may poorly express what he thinks. On the other hand, the receiver may interpret the message and information ends up getting lost between the parties.

Expertise gaps: In cooperation, it often happens that one party has more know-how than the other. It's usually the case in competitive industries driven by fast-growing innovations. In those cases, the most "ignorant" party tend to be more careful and risk-sensitive while the other experienced one can make more bold assumptions assured by its advanced know-how. It gets more complicated when the parties play on the same ground and are legally forbidden from exchanging data for antitrust reasons.

Strategic planning evolution: Finally, top management changes and new chief executives' strategies may come to cancel one or more projects or even cooperation which could alter the institutional relations between organizations and threatens massive investment's' projects. It's important therefore to secure the cooperation by signing master agreements that survive punctual events and temporary economic and financial situations. Those agreements can be guaranteed by entire companies' boards and not only one of few top executives.

Chapter III: Case study: PC L2 Powertrain dilemma

The following chapter is a practical case to apply all methods and knowledge related to project management and internal combustion engines. It takes its origin from a conflict topic between partners. The thesis author was assigned to conduct an internal study and to propose an appropriate action plan.

1) State of play

a) Genesis of the problematic:

During one of the Joint Management Committees (JMC), the partner's Program Director (PD) made a specific request to have a clear maturity report of one the vehicle variants: The Passenger Car Length 2 (PCL2). The PCL2 vehicle is a passenger car derivate from a van with 7 seats. The PCL2 is known to be very heavy and is therefore more demanding in terms of depollution and fuel consumption. Due to some budget constraints developed in the following section, Engineering was obliged to cut the PCL2 version from development to focus on more prioritized projects. The product planning department was not very motivated to defend this variant because the assigned volumes were not consistent. In such industry, consistency of volumes is key for the survival of projects. When the partner PD was informed of that situation, he explained that this version is key for the project and that the entire business deal could be threatened if this version were not included in the offer as agreed in the previous development agreement. Renault PD was then obliged to commit to find a solution to this issue. The following sections describe the method to manage this problematic situation. To organize thoughts and to make sure that all steps required were done, the goal and the steps of the project were set as follow:

Goal: Develop the appropriate powertrain for PCL2 vehicle in both Mid and Long-term periods.

Steps:

1) Understand the constraints of the project: in this section, the goal is to understand why and how the PCL2 project was frozen at a certain time and which difficulties made its development so demanding in term of budget end effort. The focus is made especially on budget conditions, regulations evolution and complexity, strategy and product planning considerations.
2) Analysis of the current powertrain and other motorization alternatives: in this section, the aim is to better understand the powertrain solutions that can be implemented, the focus is on both technical and financial aspects. Those two parameters being key for any project's survival.
3) Evaluation of impact of each case-scenario: once the solutions are described, it's important to make a comparison to evaluate their respective impacts to help the project manager taking the appropriate decisions.
4) Establish an action plan and implementation of solutions: mid-term solution and long-term solution.

b) Budget Constraints

In the automotive industry, alike in all heavy industries, investments required to lunch a project are too massive and often undergo arbitrations. Thus, managers use the procedure called: **ECONOMIC MANAGEMENT OF INVESTMENT IN DEVELOPMENT PHASE.** This procedure applies to both vehicle projects and mechanical organs. The objective of the process of piloting the Investment Entry Ticket for a Project at the Vehicle Design and Industrialization phases is to provide the Program Management and the Businesses with a reference system enabling the implementation of a project. ET Investment guaranteeing the respect of the Project's profitability objective.

Budget building: The Entry Ticket of a vehicle, platform or organ project includes all the costs incurred to design and industrialize the project. It represents the commitment of engineering to the company, comparable to product planning and quality commitments. The Project Entry Ticket is one of the components of the evaluation of the economic performance of a project. It is reviewed at each economic milestone to update the profitability calculation of the project. The Entry Ticket of a Project consists of several types of expenses:

• The Engineering Entry Ticket • The Investment Entry Ticket • The Supplier Entry Ticket

• Start-Up Costs (sometimes also called "Pre-Act Costs or "Product Introduction Costs")

The Project ET is calculated globally, whether costs are totally born by Renault or shared with one or more partners.

Arbitration:

Projects Entry Tickets are of the order of several hundreds of million euros for passenger cars and commercial vehicles. Due to different free cashflow issues, top management is often obliged to ask for some right-sizing (soften specs and cancel some unnecessary items) or in critical cases to reduce diversity (cut one or several versions of a given vehicle). In similar conditions, PCL2 version has suffered from ***temporary freeze*** since it requires large amounts of money while its customer value has not been defended because considered not central from the point of view of Product Planning department. With the partner exigency to develop this specific gasoline version, the budget argument is no longer consistent because the partner bears a considerable share of the costs of this development. From a business point of view, the abandonment of this version could lead to the failure of the partnership and put the whole project in a difficult situation.

c) Regulatory constraints: Standards and Legislation

EURO 6-7 and Other

Several regulations governing pollutant emissions exist and are applicable depending on the country of production and sales. They may be strict depending on the economic interests of the regions and its ecological conditions. Overall, the current trend is to limit more and more pollutant mass (and size for particles). In this section, the focus will be on European emissions standards. European emission standards, known as Euro standards, are European Union regulations that set the maximum pollutant discharge limits for rolling vehicles. It's a set of increasingly stringent standards for new vehicles.

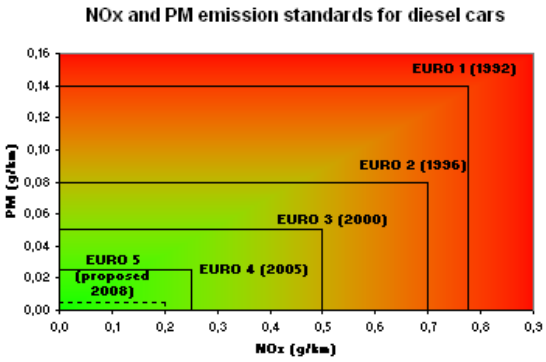


FIGURE 28 FROM WIKIPEDIA ENCYCLOPEDIA

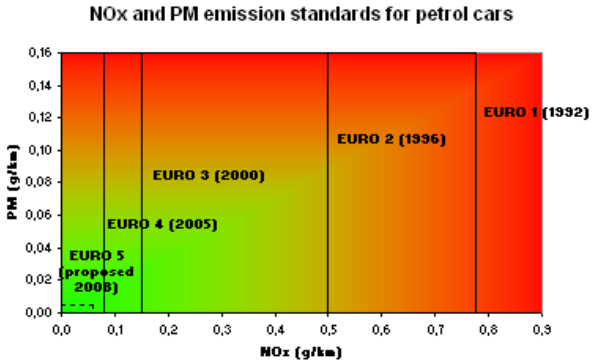


FIGURE 27 FROM WIKIPEDIA ENCYCLOPEDIA

Their goal is to reduce air pollution from road transport. CO2 emissions (resulting naturally from the combustion of carbonaceous materials) are not considered in these standards because this gas is not considered by the European automotive legislation as a direct pollutant gas (breathe CO2 is not toxic for humans and animals except at very high doses). The monitoring of CO2 emissions by vehicles is, however, the subject of further work by the European Union.

Within Renault Group, the regulations follow-up and homologation preparation of powertrains are assumed by the DEA-TRM department. The department is divided into 2 teams:

Regulations: The so-called GMP (Moto-Propulsion Group) regulations deal with the following subjects:

Polluting emissions - Emissions of greenhouse gases - Fuel consumption – Power – Smoke, GMP fuels GMP regulations are constantly developing in Europe and internationally. The DEA-TRM Service follows these changes and in the necessary cases defends Renault's interests. To formalize the regulatory changes within the Renault group, the DEA-TRM service broadcasts several tools:

RER (Regulatory Evolution Report): The RER is a summary, an explanatory note of a project, a new text or a regulatory evolution. It is written in English by regulatory pilots, to be intelligible by readers not expert in regulation. The RERs are archived in the Regulatory Summaries database.

NER (Regulatory Evolution Note) World (for gasoline vehicles, diesel VP and diesel VU): An NEC is necessary during a regulatory evolution, it is likely to be subject to conditions of cost, design or approval, development projects (having passed their pre-contract) or serial life. In practice any regulatory change with impact, applied within 3 years, is the subject of an NEC.

The Memento: The Memento contains more detailed information on homologation and GMP testing and is published in collaboration with Nissan. It is updated once a year.

WEC (Worldwide Emission Chart): The WEC, in collaboration with Nissan, presents the current regulations finalized emissions as well as trends and forecasts regulatory N + 5 years, for passenger vehicles and light commercial vehicles, gasoline and diesel. It is updated once a quarter.

Homologation: The service is responsible for the APPROVAL of the GMPs of the entire Renault and Dacia range with the Authorities to allow their marketing on all markets, at the scheduled dates.

Within this department are also defined the methods to demonstrate to the authorities that the certification tests are in compliance with the regulations and to do all the monitoring that guarantees the COP (Conformity Of Production) for emissions and performance. engines. Approvals related to the release of new vehicles and their technical evolutions are carried out jointly with the RTx in coherence with the range plan and the industrial schedules.

PCL2 Case: the values of emissions limits in the current case are given in table below (PV category).

- PV (M1 + M2 categories) emissions limits:

"Social needs" category is deleted (all M categories vehicles are submitted to the same limits)

Limits in mg/km (Particles Number in #/km) :

CO		THC		NMHC		NOx		THC+NOx		Part. Mass		Part. Number	
PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI (1)	CI	PI (1)(2)	CI
1000	500	100	—	68	—	60	80	—	170	4.5	4.5	$6.0x10^{11}$	$6.0x10^{11}$

(1) Positive ignition particulate mass standards shall apply only to GDI vehicles
(2) From 1 Sep 2014 for new types and 1 Sep 2015 for all types, until the implementation of post Euro 6b step, at the choice of the Manufacturer, a PN limit at $6.0x10^{12}$ shall apply.

- CV (N1 Class 1, 2, 3 and N2) emissions limits:

Limits in mg/km (Particles Number in #/km):

	CO		THC		NMHC		NOx		THC+NOx		PM mass		Part. number	
	PI	CI	PI	CI	PI	CI	PI	CI	PI	CI	PI (1)	CI	PI (1)(2)	CI
Class 1 ≤ 1305	1000	500	100	—	68	—	60	80	—	170	4.5	4.5	$6.0x10^{11}$	$6.0x10^{11}$
1305 < Class 2 ≤ 1760	1810	630	130	—	90	—	75	105	—	195				
1760 < Class 3	2270	740	160	—	108	—	82	125	—	215				
N2	2270	740	160	—	108	—	82	125	—	215				

FIGURE 29 RENAULT INTERNAL EMISSIONS LIMITS TABLE

d) Strategic constraints: Line-up powertrain

Powertrain design is one the most critical, expensive and strategic decisions for car manufacturers. From one hand, OEMs need a diverse engine offer to target each segment with the appropriate performances and the associated cost. On the other hand, developing engines is an extremely expensive investment due to the required quality and manufacturing reality. When a new engine is needed in the powertrain line-up, many opinions, studies and validations are needed from several stakeholders before engaging such decision, for instance:

Powertrain Product planning request:

OEM powertrain strategy: each OEM has already a set of strategic axes to follow, it can be for instance a shift from ICE to EV, the use of HEV or PHEV as a transition towards EV, improvements for a given engine or a reduction/optimization for another.

Context: Many factors influence engines strategy. Some of those factors are totally out of OEMs control, like Emissions regulations, CAFE (19) regulations, market trends.

Role in line-up: each engine existence must be justified by a power coverage.

Segment Coverage: Depending on the power delivered by an engine, the latter can cover multiple segments. The more segments the engine covers, the cheapest its cost will be. On the other hand, the same engine may be overperforming for some segments and the cost/performance would not be optimized in such cases.

Volumes: As in any mass production industry, volumes are a key parameter to justify mass investments. The more volumes sold (or manufactured) the more its cost is low (low fixed costs).

Customer expectations: for all business topics, market studies and evaluation of customer expectations help to target the right reasons of purchase and enable to have an attractive product.

Power/Torque trend and targets: the two main performance parameters for engine development.

Customer Satisfaction: Fuel consumption and Acceleration must be well considered.

Request formulation: Product Planning build a consistent request based on the previous data.

Research and Development answer: Powertrain department suggests one or two concepts to develop.

Economical synthesis: Economical criteria (ET, TDC) must be conducted for each proposition.

Quality opinion: Quality department must give their opinion about the expected quality of the engine.

Validator's opinion: all stakeholders must validate the engine concept before engaging investements.

2) Analysis of case scenarios

a) The 1.3 TCe engine analyses:

The original engine supposed to motor the PCL2 vehicle is the 1.3 TCe. This decision is taken mainly by the program department following the recommendations of Product Planning department and Powertrain Program Department. The choice is made based on the target performances, diverse constraints and according to the engines available. A car constructor had only a limited number of engines that must power all his vehicles of all ranges. In this section, the technical details of 1.3 TCe engine are described to better understand its performances and its limits.

FIGURE 30 THE 1.3 TCE ENGINE GENERAL VIEW

General description:

The 1.3 TCe engine, codenamed HR13 is the first engine designed jointly by Renault and Daimler. First launched on the Renault Scénic and the Mercedes-Benz A-Class. (20)The HR13 comes in three-power range: 115 hp, 140 hp and 160 hp.

	1.3 TCe 115	**1.3 TCe 140**	**1.3 TCe 160**
Displacement	1333 cm^3		
Power (hp)	115	140	160
Max Torque (Nm)	220	240	260/270
From (rpm))	1500	1600	1750/1800

TABLE 2 PERFORMANCES OF 1.3 TCE VERSIONS

These various variants differ from each other **only by electronic calibration**. Subsequently, other variants are developed, including electrified versions with 48 V light hybridization.

The 1.3 TCe is a **four-cylinder** engine. Each of the four cylinders has 4 valves making it a **16 valves** engine. The engine bloc is made of **aluminium**. The number 1.3 at the beginning of its name refers to a **displacement of 1333 cm^3**. He's fuelled by high pressure injectors (**250**

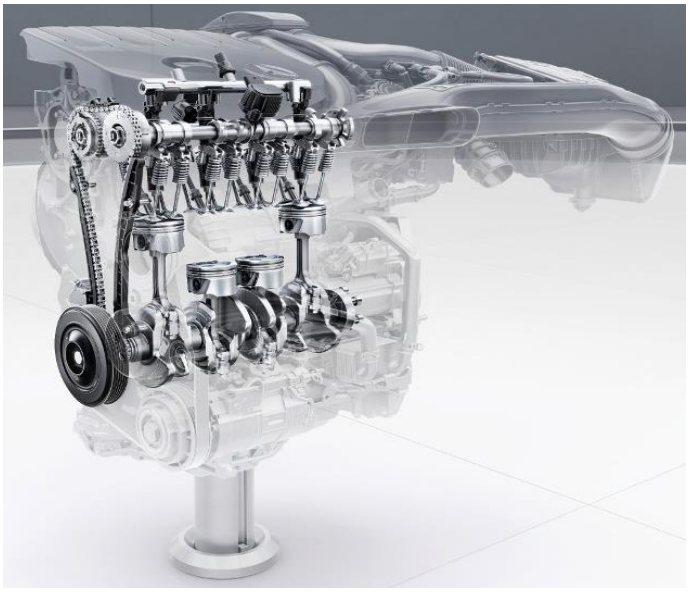


FIGURE 31 1.3 TCE TRANSPARENT VIEW

bars) configured for a **central direct injection**. The engine is **turbo-charged** with electrically controlled discharge valve. To reduce friction, the engine has a plasma cylinder coating (called BSC technology, see details below). In place of usual hydraulic pushers, 1.3 TCe has a distribution system by pawls. The cylinder head had a delta shape to reduce the amount of material. Finally, the engine had a 5-stage crankshaft and a chain distribution. The stroke's length is of 81.4 mm. It is therefore a long-stroke engine favouring low-end torque. In addition, the compression ratio was increased by 0.6 compared to its predecessor to reach 10.6: 1.

HR13 foundry takes place entirely in Renault plant in Cleon. However, it's assembled in different plants and countries since all Renault, Nissan and Daimler are using it on their vehicle models. For example, for Renault models, he's assembled in both Valladolid plant (Spain) and in China at Dongfeng. For Daimler models, it is assembled in both Kölleda (Germany) and in China at BAIC. And finally, for Nissan models, it is assembled in Sunderland (UK).

Friction reduction, Bore Spray Coating:

If an aluminium engine block reduces the overall mass of the engine, this material poses a problem in the cylinders because the aluminium does not support the friction and the heat that it generates. The enemy of a combustion engine is undoubtedly the number of moving parts that reduce the efficiency of the engine. For that reason, motorists bring the greatest attention to this phenomenon. As a rule, when the engine block is aluminium, it is necessary to insert a steel liner 2 to 3 millimetres thick in which the piston is sliding: this is the principle that is in force on previous gasoline engines. On the 1.3l TCe, there is no more steel insert. A cylinder coating technology has therefore been developed (already used in some Nissan engines). It improves performance and consumption through the reduction of friction between the cylinders and pistons for a better compression ratio and better control of rattling. It consists of depositing, via a "plasma torch", on the cylinders a very thin film of very hard steel to improve the thermal conductivity during combustion. The walls of the cylinder are covered with a very thin layer of steel projected by a plasma torch (approximately 0.15 to 0.2 millimetres thick) to solve the problems of friction (after application, the barrel of the cylinder has a mirror effect). In addition to the reduction of friction, this coating makes it possible to reduce the mass of the engine (thanks to the reduction of the quantity of steel), to optimize its rigidity and to improve the dissipation of the heat generated inside the cylinder (thus decreasing the risk of rattling). The gain estimated by Renault in terms of consumption is 1%. Always for friction reduction purposes, the distribution that until recent models was done with pushers, is here pawls with hydraulic stops.

Variable Distribution, also called VVT:

The intake and exhaust valves are controlled by Dual Variable Timing Camshaft depending on the driver's demand for power. This variable distribution concept consists in varying several engine parameters, such as variable valve timing ("VVT"), opening and / or lift (Variable Valve Lift) of the intake and exhaust valves. All according to the driver's solicitation determined by the engine speed or the accelerator pedal stroke. Although this technology, or the concept of this technology is old (the first patents were filed by Fiat in the 60s), the first engine so equipped arrived at Alfa Romeo only 20 years later. General Motors, then Nissan also adopted this system before Honda, with its VTEC proves its performance.

It also allows, in the case of Mercedes, to propose the deactivation of the cylinders. At partial load and up to the speed of 3,800 rpm, the cylinders 2 and 3 can be deactivated: the valves of these two cylinders remain closed and the injection is cut off. Finally, the 1.3l TCe resumes the timing of variable valves at the intake and exhaust. Variation of the setting is done by means of a hydraulic actuator for each of the camshafts.

Increased injection pressure and Delta cylinder head:

The (direct) injection of gasoline was also revised to increase the pressure and bring it to 250 bars against 200 on the former 1.2 TCe, an increase of 25%. As a bonus, the injectors, installed in central position, have 6 holes to optimize the spraying of the mixture.

The block also inaugurates a cylinder so-called "Delta" i.e. triangular to offer a more compact form, guarantee of better integration especially in small vehicles, and a reduced weight. It partially integrates the exhaust manifold guaranteeing a more efficient cooling of burned gases.

Exhaust:

The exhaust manifold is integrated in the cylinder head. So that engines comply with the Euro 6b standard, they are equipped with a conventional **3-way catalyst**. From September 2018, all engines comply with the Euro 6c standard. As such, they receive the contribution of a **particulate filter**. To be homologated according to Euro 6d temp standards and, the engine uses a **particulate filter**. On the other hand, the pollution control systems are thermally insulated in order to limit the temperature of the latter at the surface, which can facilitate the implantation of electronic devices in the vicinity, the latter generally not supporting high temperatures. The built-in collector and thermal insulation keep a maximum amount of heat generated by the exhaust gases within the exhaust line. Thus, the pollution control systems rise much faster in temperature, to improve the efficiency of the latter from the first moments. Very useful during a cold start for example. Finally, the turbocharger is associated with an

electrically operated wastegate valve. This component allows a much finer management of the boost pressure, from the lowest engine speeds. Thus, during a cold start, the wastegate substantially reduces the supercharging pressure to allow a large portion of the exhaust gas to go directly from the collector to the catalyst. These exhaust gases are hotter than the exhaust gas passing through the turbocharger, so the pollution control systems rise faster in temperature and reach their maximum efficiency quickly.

Three levels of power: 115, 140 and 160hp

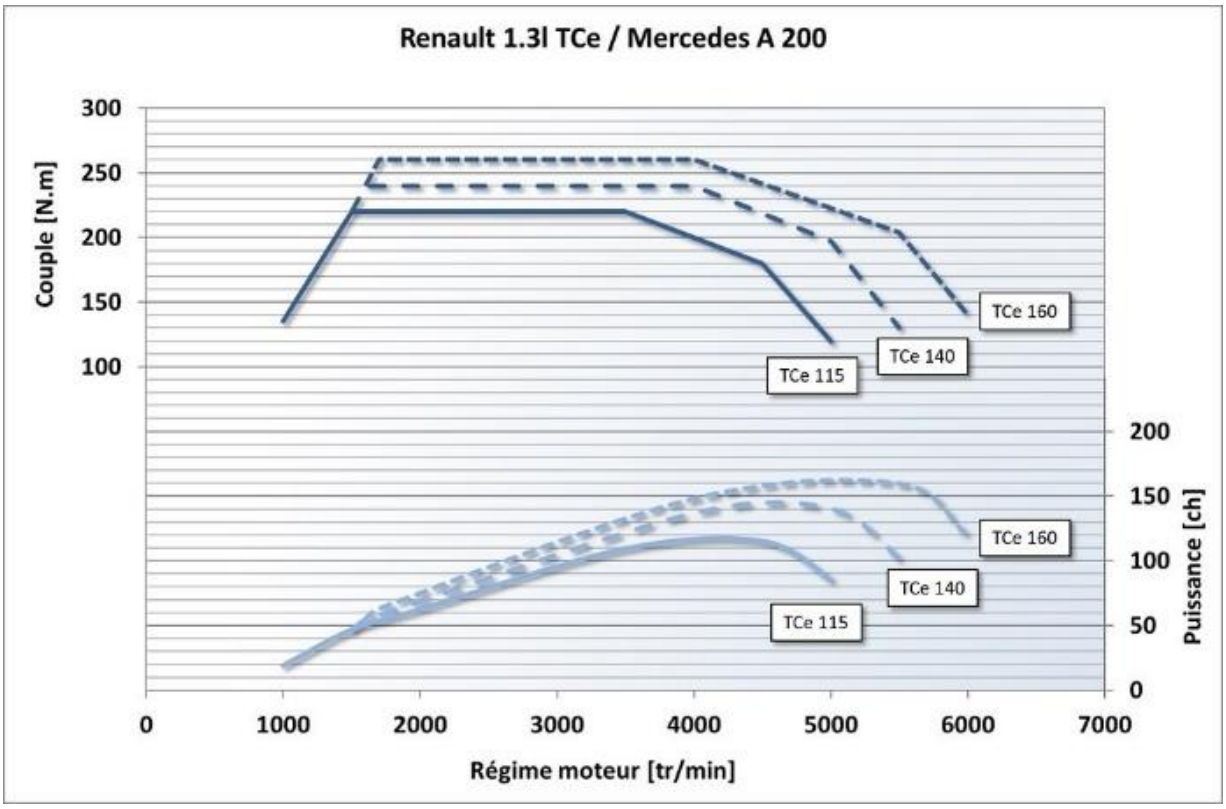


FIGURE 32 1.3 TCE VERSIONS POWER & TORQUE

Among other Renault engines, 1.3 TCe engine is inserted in the range between the small 3-cylinder TCe 90 (H4BT) and the TCe 165 (M5MT). At the entry level, the 115 hp version delivers a torque of 220 Nm which is 30 Nm more than the old TCe 115 which has a considerable effect when the pedal is pressed. In addition to the increase in torque, it is available at a low speed, as on a diesel, at 1500 rpm. That is 500 rpm lower that its previous version offering greater flexibility. Accreditation should be greatly improved. In intermediate, there is a 140 hp version at 240 Nm of torque (from 1600 rpm). Compared to the old version H5FT 130, it is a considerable 35 Nm won, again 400 rpm earlier. Finally, a third version, 160 hp and 270 Nm of torque (at 1,800 rpm) exceeds widely the existing 1,6 M5MT, with a surplus of 20 to 30 Nm of torque. (21)

Limits: According to initial Renault powertrain department assessment, 1.3 TCe cannot be suitable to Euro 6 D Full standards on all vehicle versions. The PCL2 for example, which has a huge mass to support couldn't pass pollution tests.

b) Analysis of a new gasoline powertrain: 1.2 TCe

After presenting the engine initially planned for the PCL2 vehicle, it is advisable to analyze the closest engine closest to the 1.3 TCe in the Renault powertrain line-up to establish a representative comparison: the 1.2 TCe.

The 1.2 TCe is another **gasoline direct injection** (GDI) engine developed as an **in-line three-cylinder** engine with a **1.2 L displacement**. It has a **compression ratio** (CR) of **12**. In its original version, it developed a power of 96 kw (128 hp). The engine in question shares several common characteristics with the 1.3 TCe engine. Among them: The Variable valve lift system, and the Direct fuel injection.

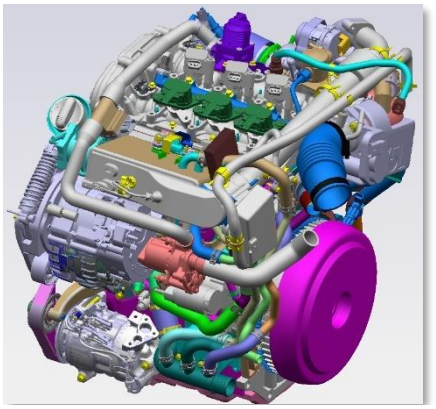


FIGURE 33 1.2 TCE ENGIN GENERAL VIEW

Displacement (L)	Power (hp)	Torque (Nm)	Speed max (rpm)	Bore (mm)	Stroke (mm)	CR
1.2	128	230	6500	75.5	89.3	12

TABLE 3 1.2 TCE ENGINE CHARACTERISTICS

Technical path: In addition to the previous common shared characteristics, the 1.2 TCe engine has its own technical path that make it very different build mainly among the following axes: Higher CR, Miller cycle + LP EGR + 80 KW/L + full λ=1

Combustion Efficiency and Performance: 80 Kw/L ??

Miller cycle: A classic engine uses a four-stroke Otto cycle (also known as Beau de Rochas cycle in French car makers), for which the compression stroke and the relaxation (power) stroke are equal. In the Miller cycle, the inlet valve is left open when the piston is raising, so that part of the already sucked mixture is forced back into the intake. There is therefore less air admitted and the power of the engine is reduced. Power stroke occurring throughout the stroke allows a more complete energy recovery for a given amount of fuel. The low compression is compensated using a compressor, volumetric predilection (roots, for example) to have a good compression at low speed. The main feature of the Miller cycle is that the compression stroke starts only after the piston ejects

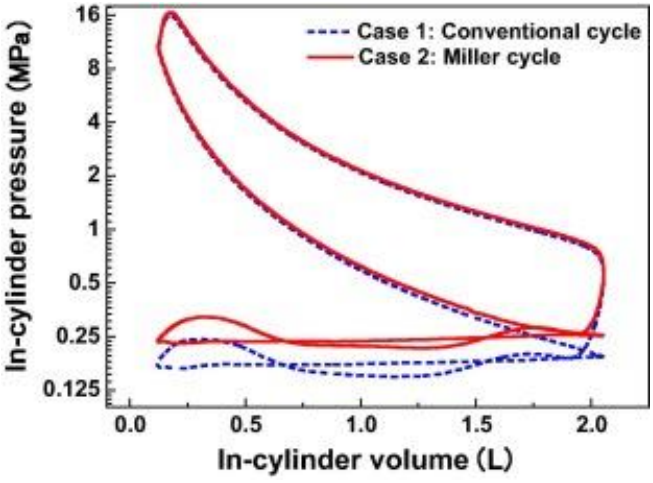


FIGURE 34 MILLER CYCLE VS OTTO CYCLE

part of the load. This occurs at about 20 to 30% of the stroke. The miller cycle has an advantage if the energy spent on compression is less than that spent by a piston to do the same job. Over the entire compression range of an engine, the compressor is used to generate a low pressure, and the additional high pressure is provided by the piston. The Miller cycle uses volumetric compressors in their area of their best efficiency. Miller cycle production engines typically have variable timing to return to a conventional cycle where the Miller cycle is no longer effective. Which is the case in 1.2 TCe engine with it variable valve timing technology. (22)

High compression ratio (CR): On one hand, to maximize the efficiency of Miller cycle-based engine, increasing the compression ratio can be an axe to explore. In a traditionally controlled spark ignition engine, the compression ratio is limited by the self-ignition temperature of the compressed air. Due to the reduced compression stroke, a higher pressure in the cylinder (by compression + compression by the piston) is possible, and the Miller cycle offers a better performance. On the other hand, and in general, increasing the compression ratio of an engine increases the efficiency of its cycle. This fact can be illustrated by the following equation: (23)

$$\eta_{Otto} = 1 - \frac{1}{r_v^{(\gamma-1)}}$$

Where: η_{otto} is the efficiency of an ideal air standard Otto cycle.

r_v is the compression ratio and γ is the ratio of gas specific heat capacities c_p/c_v

However, it's important to recall that increasing compression ratio values increases the probability of knocking phenomena. Increasing CR should therefore take into account this side effect.

350 bar injection system: For 1.2 TCe engine, a clear increase in injection pressure is observed. (From 250 to 350 bar i.e. 100 bars more inject the fuel into the cylinders.)

Low pressure EGR system: EGR or exhaust gas recirculation is a strategy to reduce NOx emissions from internal combustion engines. (24) The NOx reduction effect comes from lowering the oxygen concentration in the combustion chamber, as well as from absorbing heat. In this engine configuration, low pressure EGR technology has considerable potential for reducing NOx emissions. It recirculates the exhaust gases between the two points of low pressure - the tailpipe of the exhaust system and the turbocharger inlet. When a portion of the exhaust gas is recirculated into the intake air, the oxygen content decreases and the heat capacity increases, resulting in a lower maximum combustion temperature and reduced formation of nitric oxide.

c) Analysis of Electric Powertrain:

Nowadays, and for most vehicle projects under development, car manufacturers design -or at least consider the studies for- an electric version. This trend is explained by several reasons including the evolution of standards and legislation, zero emission (ZE) car-makers strategies and a rising customer demand. This new electric motorization opens the way to several discussions both at the level of design and engineering as for business topics. Generally, optimism drives electric vehicle growth in global markets (China, European Union and United States). Ecology-conscious individuals and environment-responsibility-centred companies are increasingly considering buying EVs leading a growth rates that exceeded 60% in recent years for the most important auto-markets (2 million EVs sold in total in 2018). This trend can be confirmed by a survey made In the United States showing that between 10 and 30 percent of potential consumers indicated their will to consider an EV as their next purchase. In Europe, the reported share of consumers considering EV purchase is even higher, where 40 to 60 percent have an EV preference. This share goes up to 70% in china due to the application of strong government incentives to purchase EVs. Finally, a considerable effort made by political powers and legislations are also pushing OEMs to increase the size of their electrical fleet and consumers to buy more of those zero emission models.

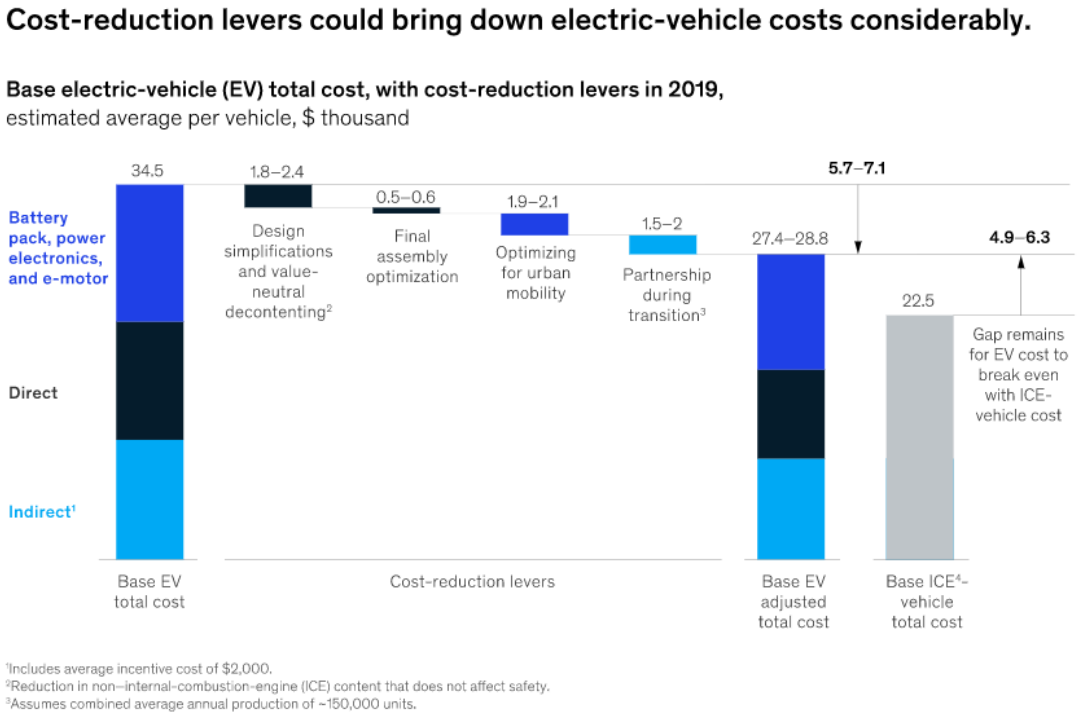


FIGURE 35 SOURCE MCKINSEY & COMPANY

The figure above (25) presents some levers car makes can use to boost their competitiveness in the electric segment. Those levers came as a conclusion of a world-wide study driven by McKinsey & Company Consulting group. They can be organized into two categories:

1) Technical levers:

Design simplifications and value-neutral Decontenting:

Automotive engineers can take advantage of the transition from thermal to electrical vehicles by simplifying the design of many components. For example, user controls can be simplified, and functionalities can be improved via less complex electronic components. Extra displays buttons switches, wiring, modules and other structural components can also be eliminated. In addition, designers can develop straightforward body styling and lighting, in a way that optimizes functionality and reduces cost. That requires to ignore complicated seat designs and to encourage more simplified interior trim. Those design simplifications are estimated to save 600$ which is considerable in the automotive industry. Those cost savings still can be maximized according to EVs experts. Through a dedicated EV platform, a better packaging of interior cabin space, power electronics, motors, and battery packs are possible allowing further material cost savings. Other simplifications can also be done by extracting best practices from non-EV low-cost designs via several benchmarks. Getting inspired from those benchmarks can help car makers creating safe vehicles that are also fun-to-drive, simple and 1300$ to 1800$ less expensive. In two words, the above-mentioned cost reduction levers through design simplification can be summarized into: Creativity and Simplicity. Those two key words are not only key driving values of EVs industry but also a new mindset OEMs should adopt to continuously face automotive industry challenges.

Final assembly optimization:

The EV-dedicated platform principle can be extended to an EV-dedicated assembly plants. Such a facility could boost cost savings even further. In fact, since dedicated EV platform would be much simpler to assemble, having less components to handle, the plant would have a lower fixed-cost allocation. A dedicated assembly plant would also reduce OEMs costs since it would allow them to save investments in complex plants that combine ICE-vehicles and EV assembly lines.

Optimizing for urban mobility:

The current race for improved ranges and performances may ignore the real needs of EV clients. Today's EVs come either in too little range or too much. On one hand, small EVs with ranges less than 100 miles are barely enough for urban clients. On the other hand, luxury cars with ranges exceeding 300 miles don't really match with real driving patterns. This situation poses an optimization problem. Therefore, a smart move would be to reduce battery capacity to 40 kWh instead of 50 kWh. It would allow to save $1,900 to $2,100. With that configuration, most consumers would still be able to complete their daily trips and occasional travels without any sacrifice.

2) Business levers:

Partnerships strategy:

The current decade is marked by the transition of the automotive industry toward electrification. This transition period brings several difficulties related especially to profitability issues. That should push OEMs to think about developing partnerships and collaborations with each other. As the period of transition requires a massive tooling changing, platforms transforming and R&D activities' boosting, automakers have all reasons to share those costs while keeping a diverse electrical offer to enrich the EV market and to challenge competition. Sharing platforms and plants would save massive investments from being wasted by optimizing the effort needed. In addition, creating alliances between automakers would give them even a better position toward their suppliers: first because the scale effect reduces automatically the costs and second because the weight of the partnership would make them even more attractive in the eyes of suppliers who will make more efforts to seduce them. We can observe already many OEMs who paid early attention to this strategic path and concretely concluded several deals inspired by this principle. Estimated cost savings for such alliances goes from 1500$ up to 2000$ per vehicle: a huge potential to explore.

Exploring new business models:

Technical leavers are important for automakers to optimize their development and manufacturing costs. However, it might not be enough to close their profitability gap. The EVs industry offers in contrast some new business segments to explore. Two simple examples: targeting sales to big fleets and adopting a battery leasing model instead of selling them.

Targeting fleet customers is a relevant economic move for many reasons: first, fleets consider the total cost of ownership (TCO) as a major factor for purchase more than other costumers. Their high-mileage use mode makes EVs TCO very beneficial for them. Second, direct selling to this category reduces costs generated by showrooms requirements. Finally, fleets behaviours are known to be predictable making their business cases very positive.

Today, many OEMs have already a battery leasing offer, how far is this policy relevant? Batteries today still have performance and degrading capacity problems. Many consumers still have some uncertainties about this EV's major component. An EV costumer prefers to pay a monthly fee to lease the battery rather than buying it. This model could add over a 1000$ per vehicle in revenue during the lease term going from five to seven years depending on automakers.

To conclude, EV models of vehicles can be a great new source of profits for OEMs and an appropriate answer to client's expectations for zero emission's mobility.

3) Evaluation of impact

Evaluation criteria:

To make decisions concerning powertrain choices, it's essential to determine all relevant criteria, to set all targets and to collect all corresponding values. The key criteria are economics, performances, standards and product strategy. All those elements are synthetized in the table below:

Criteria Type	Criteria	Unit	Target	1.3 TCe	1.2 TCe	EV
Economics	ET: D&D	M€	minimum	128	154	190
	ET: CAPEX			356	400	310
	Average extra TDC (cost) vs current engine	€	minimum	0	400	-
Performance	Fuel Economy vs current engine	%	10	3	8.1	∝
	Power	kW	120	120	128	44
			95	100	96	44
			75	85	75	44
	Torque	Nm	270	270	270	225
			230	240	230	225
			175	220	175	225
	Acceleration 0-100 km/h	s	10.2	11.2	10.5	20.6
Standards	Euro 7	-	OK	NOK	OK	OK
	China 7	-	OK	NOK	OK	OK
Strategy	Role in Line up	kw	{75:120}	{75:120}	{75:128}	{44}
	Segment Coverage	seg	B; C; C SUV; D	A; B; C; LCV; D	A; B; C; LCV; D-	A; B-; B+; C-; C+; LCV; D-
	Volumes	Million unit/year	2.5	2.5	2.5	0.1

Methodology:

In a situation where there is multiple options, choices or concepts, it's important to use some logic tools to make the appropriate decision. For the following section, the **decision-matrix method**, also known as **Pugh Concept Selection,** is used. This methodology is a qualitative technique to rank possible options. It can be even basic (all criteria are equal) or weighted (each criterion has a weight). The steps to establish such weighted matrix used for this problematic are described as follow:

Step1: Identify the evaluation criteria by which the concepts should be judged.

Step2: Weight the evaluation criteria in proportion to its relative importance.

Step3: Set up the decision matrix. See figure below.

Step4: Assign Values to each concept to judge its adequacy regarding the given criterion.

Step5: Calculate overall score for each concept by summing the value*weight for all criteria.

Step6: Rank the concepts by the overall score and interpret the results.

Conclusion: For the period: 2021 to 2022:

Criteria Type	Criteria	Weighting	1.3 TCe		1.2 TCe		EV	
			Score	Total	Score	Total	Score	Total
Economics	ET: D&D	3	4	12	3	9	1	3
	ET: CAPEX	5	4	20	3	15	1	5
	TDC	5	5	25	3	15	1	5
Performance	FE	3	1	3	3	9	5	15
	POWER	2	5	10	5	10	1	2
	TORQUE	3	4	12	5	15	3	9
	ACCELERATION	1	3	3	4	4	1	1
Standards	EURO 7	Non relevant						
	CHINA 7	Non relevant						
Strategy	Role in line up	1	4	4	5	5	1	1
	Seg covering	2	4	8	4	8	4	8
	Volumes	2	4	8	4	8	1	2
Total		20	105		98		51	

Decision: According to the previous evaluation, the most appropriate short-term strategy 2021-2022 would be to keep the 1.3 TCe engine to benefit from its low cost as long as the standards allow it. The EV version should also be developed to keep benefit from CAFÉ, to diverse the offer and to stay in conformity with Renault EV strategy: LCV models should continue to have an electric version.

For the period: From 2023:

For this period, the 1.3 TCe engine option is automatically eliminated. It's due to the obligatory aspect of pollution legislations. Since the engine doesn't meet with new standards, it's forbidden to use it.

Criteria Type	Criteria	Weighting	1.3 TCe		1.2 TCe		EV	
			Score	Total	Score	Total	Score	Total
Economics	ET: D&D	1			3	9	1	3
	ET: CAPEX	2			3	15	1	5
	TDC	3			3	15	1	5
Performance	FE	3			3	9	5	15
	POWER	2			5	10	1	2
	TORQUE	3			5	15	3	9
	ACCELERATION	1			4	4	1	1
Standards	EURO 7	Non relevant						
	CHINA 7	Non relevant						
Strategy	Role in line up	1			5	5	1	1
	Seg covering	2			4	8	4	8
	Volumes	2			4	8	1	2
Total		20	-		98		51	

Decision: According to the previous evaluation, the most appropriate md-term and long-term strategy 2022-2030 would be to abandon the 1.3 TCe engine, to develop and ro manufacture the 1.2 TCE gasoline engine mainly to stay in conformity with new pollution legislations. Moreover, and even if the electrical version is still presenting a low value (51<98), the product program committee will adopt the decision to continue the development of the electrical version mainly because of the group EV strategy and because of the agreements with the partner. The cost of this development will be covered by the overall NPV (net present value) of the project XFK.

4) Action plan:

Impact evaluation of different case scenarios requires data collection, discussion and many decision-making processes by different actors of the project. Hereafter the synthesis of several steps undertaken to manage the PC L2 problematic situation following a methodic approach summarized in 8 main actions:

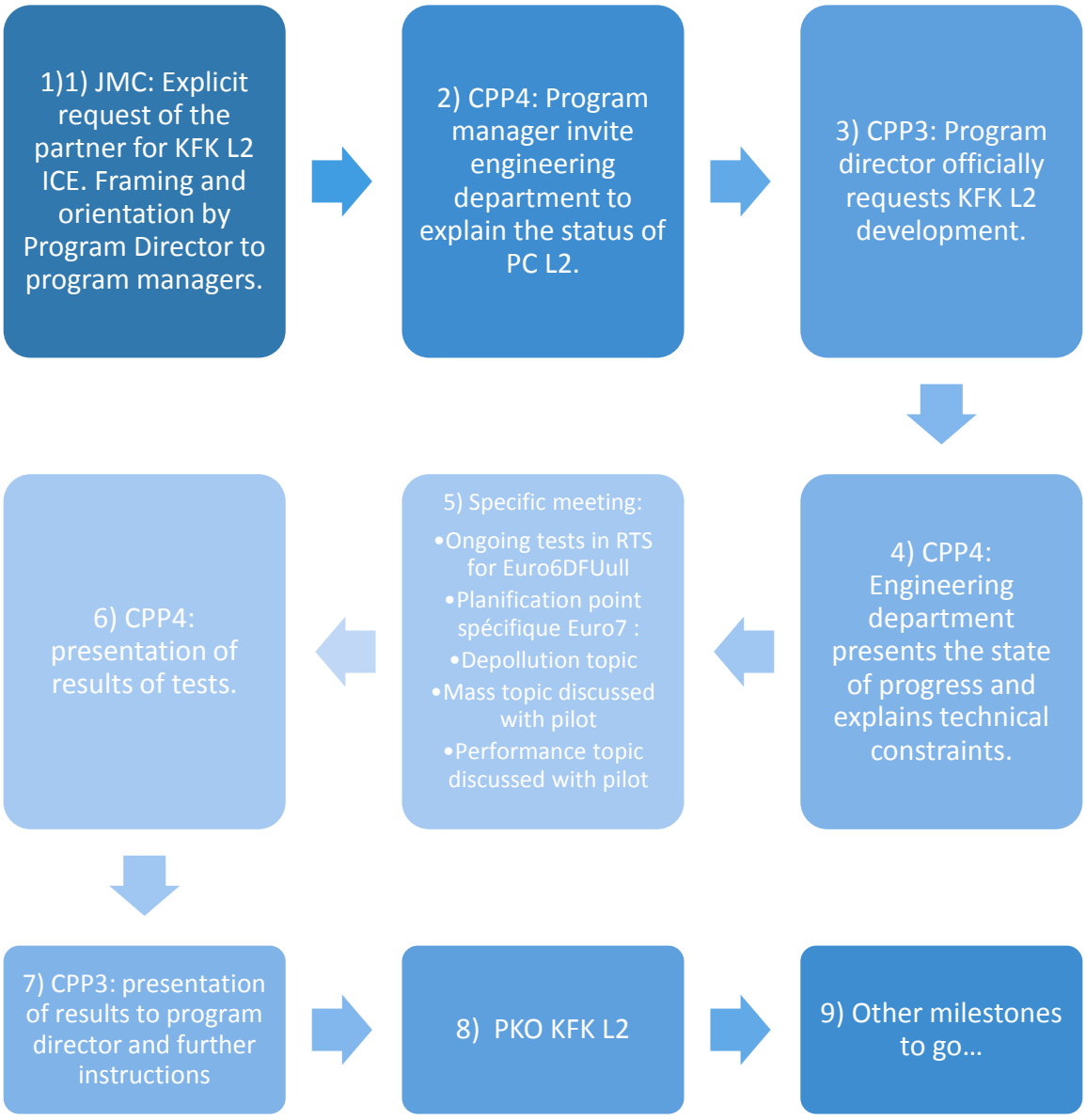


FIGURE 36 PC L2 ACTION PLAN

STEP 1: In the Joint Management Committee (JMC) meeting, the partner, through its program manager, requests KFK L2 ICE development 'state of progress. Renault team did not have all relevant information and requested time to investigate the topic. The partner insists on the sensitivity of this vehicle and its potential impact on the project/deal. Renault program director Framing and orientation by Program Director to program managers.

STEP 2: During the CPP4 committee, Program manager invites Engineering department to explain the status of PC L2 ICE. It announces that the version was frozen for budget reasons. Those reasons were developed in this document in the previous sections. Vehicle engineer in chief presents a summary of risks and opportunities of developing that version for highest instances.

STEP 3: Program managers give a feedback to the program director in the CPP3 committee. The Program director officially requests KFK L2 development from LCV Range Engineer in Chief. The decision is argued by the necessity of that vehicle for the partner, and the necessity of the partner for the overall economic success of the project.

FIGURE 37 CPP3 MAIN PARTICIPANTS

STEP 4: Engineering department presents the state of progress and explains technical constraints. The vehicle may not pass depollution tests due to high mass. In fact, the vehicle is supposed to support 7 passengers (70 kg for each) and an additional payload of 50 kg.

STEP 5: To follow the progress of the projects, Program manager conduct several "specific meetings" with different stakeholders to keep a detailed global idea on the project' specificities. Among those specific meetings:

Meetings with Powertrain Manager: to ensure the coordination between several actors (depollution, mass and performance pilots…) and to validate human and material resources allocation to teams.

Meetings with Depollution Pilot: he explains test protocols: when, where, how and by who they are conducted and states the hypothesis and approximations used to deliver expected results.

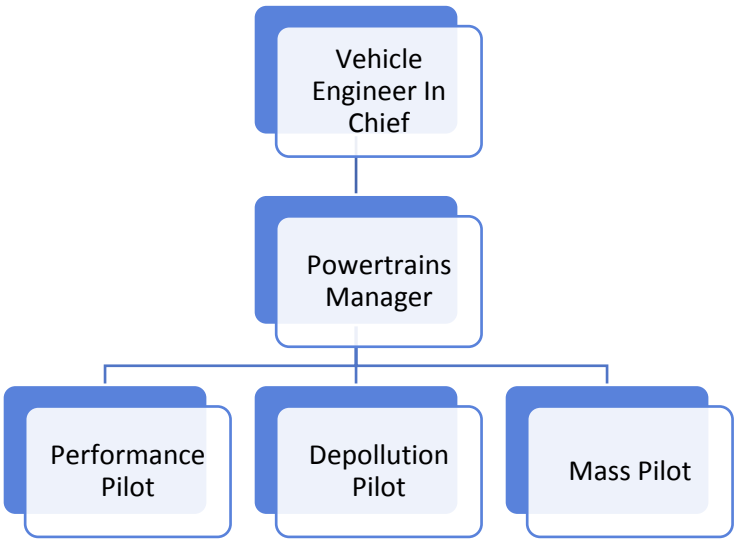


FIGURE 38 POWERTRAIN MAIN STAKEHOLDERS

Meetings with Mass Pilot: The latter explains the mass distribution of the vehicle. He introduces mass types and requirements for passenger cars and cargo vehicles. He presents the particularities of passenger cars ‘mass requirements making them more demanding in term of depollution effort.

Meetings with Performance Pilot: The aim of those meetings is to evaluate the overall performance parameters that impact the product attractiveness and to make sure the targets are aligned with product planning recommendations and engineering knowhow.

Meetings with EURO7 powertrain expert: As in any strategic planning process, a project manager should consider long term solutions. For that reason, it was important to discuss with powertrain experts which alternatives can be used to cover the vehicle motorizations for the upcoming standards. New engines have been introduced with increased features and specific segment coverage.

STEP 6: Presentation of tests results. Powertrain manager and depollution pilot explain at the CPP4 committee that the current PCL2 powertrain showed better results to meet with depollution standards after some efforts of engine tuning. Engineering new opinion is more optimistic and can give a first GO for this version.

STEP 7: Presentation of results in the CPP3 committee. The engineering committed to the results of new tests and officially declared new feasibility signals to make the current powertrain compatible to depollution standards. Program Director gave further instructions to engage next steps and to secure short term, mid-term and long-term solutions for PCL2 motorization.

STEP 8: PKO KFK L2 As a first step in the short/mid-term solutions, Electric Program Manager decides to lunch the PROJECT KICK OFF (PKO) for the electric version of the PCL2. This milestone is prepared jointly with product planning department and engineering department. During a presentation with all the project PCL2 stakeholders:

- The Program Manager presents the product definition, the master planning, ENTRY TICKET and TOTAL DELIVERY COST framing.
- The Product planner presents the Diversity offer, the Partnerships potential and the Volumes expected. He explains the Unique Selling Points (USPs) and the powertrain line-up associated to this PCL2 vehicle.
- The Chief Vehicle Engineer presents then the detailed planning, masses and depollution opportunities and some architecture/platform studies results.

STEP 9: After the PKO, other milestones are expected to come in the coming months of the project life cycle, for instance: Concept Freeze, Contract, Tooling Go Ahead, Manufacturing Approval etc.

Conclusion

The professional integration of a semester within the Renault group is a rich experience in events and apprenticeships. In addition to the business climate and the management of large-scale projects, the problems encountered led to the discovery of several strategic, technical and economic issues relating to the development of engines and powertrains. On one hand, driving a vehicle program develops the skills of project management, team management, communication, coordination and concertation. Conducting a multi-stakeholder project requires an open-minded talent to grasp all ideas and opportunities suggested and to lead all to achieving goals using an inclusive approach. Hence the importance of a new generation of management methods focusing on innovation and the human resource. On the other hand, working in the automotive industry is considered nowadays as one of the most challenging responsibilities. The Auto industry is on the front line of the international debate about climate change and global warming. OEMs are pushed to make greater efforts to meet with both mobility increasing requirements and emissions/pollution regulations. Car makers around the world must bet on innovation by adopting smart mobility strategies and consolidating their investments in research and development activities to face those opposite constraints. Three main conclusions can be deducted from this experience:

First, Management methods in the automotive industry should be more adapted to the new cycles' speed of the associated market. Vehicle projects should be conducted in a more "flexible" way that take into consideration the permanent change in customer expectations and states regulations. This "new way" of managing automotive programs should also guarantee a minimum of "stability" in a mass production industry historically linked to evolving continuity rather than technological ruptures.

Second, Partnerships are clearly a strategic axis to develop business. Most of OEMs today are convinced that forging alliances and concluding partnerships is inevitable to survive and to protect their margins especially in new mobility projects. The period of this internship had known a public debate about a potential merger between two European big size car makers. This can be seen as a proof that auto industry is evolving without fail in a logic of concentration to face the upcoming decades.

Finally, Powertrain design industry became so challenging it may be a good idea to subcontract this business. In fact, states restrictive regulations and global thermal vehicles volumes potential decrease may push OEMs to abandon engines development activity to a dedicated company. Such a move would concentrate investments' efforts and R&D activities which would result in a more innovative engine with a considerable cost reduction and manufacturing expenditures (plants, tooling, logistics…)

References

1. www.dictionary.cambridge.org. *Cambridge Dictionary.* [Online] 2019.

2. www.oed.com. *Oxford English Dictioanry.* [Online] Oxford University Press, 2019.

3. *Project Management Professional (PMP) Handbook.* s.l. : Project Management Institute, 2000.

4. www.pmi.org. *Project Management Institute, Inc.* [Online]

5. Ing. Miroslav Žilka, Ph.D. *Project Management: basic terms, rules, project planning process.* s.l. : CTU Prague Project Management.

6. www.gantt.com. [Online]

7. Lester, Albert. *Project Management Planning and Control: Managing Engineering, Construction, and Manufacturing Projects to PMI, APM, and BSI Standards.* Oxford : Elsevier Ltd, 2014.

8. *Startup of the year Africa 2018.* HuffPost Maroc. Huffpost Maghreb : s.n., 2018.

9. Skillicorn, Nick. What is innovation? 15 experts share their innovation definition. *www.ideatovalue.com.* [Online] 2016.

10. Gault, Fred. *Extending the measurement of innovation.* Maastricht : OECD Blue Sky Forum III, 2016.

11. *INNOVATIONS RADICALE ET INCRÉMENTALE : UNE RÉFLEXION SOUS LA PERSPECTIVE DE LA THÉORIE DU CHAOS.* s.l. : Universidade FEEVALE.

12. Lowell L. Bryan, Claudia I. Joyce, Leigh M. Weiss. *Making a Market in Talent.* s.l. : McKinsey & Company, 2006.

13. Cui, Zhijian, et al. *Outsourcing Innovation.* 2009.

14. *The importance of learning in organizations.* David, Garvin, Amy, Edmondson and Gino, Francesca. Harvad Business Review.

15. *Creating An Innovation Culture: Accepting Failure is Necessary.* Virginia, University of. Forbes.

16. www.agilealliance.org. *Agile Alliance.* [Online] Agile Alliance, 2019 .

17. Renault Group. *Renault Intanet.* Paris : s.n., 2019.

18. Wouter Aghina, Karin Ahlback, Aaron De Smet, Gerald Lackey, Michael Lurie, Monica Murarka, Christopher Handscomb. *The Five Trademarks Of Agile Organizations.* s.l. : McKinsey & Company, 2018.

19. Hess, David. www.britannica.com. *Corporate Average Fuel Economy.* [Online]

20. Guillaume Darding. www.guillaumedarding.fr. *Presentation engine: Renault 1.3l TCe.* [Online] Avril 06, 2018.

21. FERRIERE, LOIC. PLANETE RENAULT. *www.planeterenault.com.* [Online] 12 07, 2017.

22. Science Direct. *Effects of Miller Cycle.*

23. *Introduction to Internal Combustion Engine.*

24. Hannu Jääskeläinen, Magdi K. Khair. *Exhaust Gas Recirculation.* s.l. : DieselNet.

25. Yeon Baik, Russell Hensley, Patrick Hertzke, Stefan Knupfer. *Making electric vehicles profitable.* s.l. : McKinsey & Company, 2019.

26. BearingPoint, Management Consulting. *Measuring Innovation, Sustaining competitive advantage by turning ideas into value.*

27. Marc J Epstein, Robert Shelton, Tony Davila. *Making Innovation Work: How to manage it, measure it, and profit from it.* 2005.

28. SKILLICORN, Nick. *The secrets of ongoing Innovation Success.* 2014.

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