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Chapter 17

Towards a robust process for integrating innovations into vehicle projects

G.Buet, T.Gidel, and D.Millet

1.1 Context

1.1.1 Characteristics of a robust "touch-down" process

No matter which carmaker is observed, it appears that very few innovations actually find their way into vehicle development projects, compared to the number ideas originally imagined.

Although it is normal practice to filter out many innovations, it is essential to maintain a certain number within the vehicle development projects. Otherwise there is a risk of not being able to keep up with market expectations or of being out of step with the competitors' market offerings.

This difficulty of transforming good ideas into innovations that find their place in vehicle development projects may be attributed to the difficulty in converging innovation development with vehicle development, a process that we shall refer to in the rest of this article as the "touch-down" process (Buet *et al.*, 2008).

This term stems from an analogy that may be made with an aircraft (innovation projects) landing on an aircraft-carrier (vehicle development projects). While landing, it is essential to specify all the conditions required, to apply all defined processes, but also to know how to react to events in order to make a successful "touch-down".

In order to keep abreast of the market, motor manufacturers are faced with coordinating innovations that have not always achieved a sufficient degree of maturity with the vehicle development projects that are likely to be their platform. The notion of "touch-down" is typified by the integration such innovations in vehicle development projects.

'The integration process itself is proving problematical in that new technology fields, organizations and timescales differ considerably from those applicable to vehicle development projects. [...] It is a complex process to successfully converge new technology developments (available at the right moment and at the right level of maturity) with product development projects.'

(Buet *et al.*, 2008)

The innovation "touch-down" process can be divided into several phases – innovation genesis, selection and, finally, lock-on to the vehicle development project.

The first phase includes identifying and selecting innovations that would appear to be relevant to one or more selected vehicle projects. This phase comes to an end with the decision to integrate one or more innovations into one or several vehicle development projects. This decision, which is taken sufficiently up-stream in the development process so as to anticipate the risk factor, may be challenged, which is not the case once it has been decided to "lock-on". Lock-on denotes the notion of effectively mating innovations with the vehicle development project. In our aviation analogy, it would be the hitching of the aircraft to the aircraft carrier with its tailhook.

The decision to lock on may be expressed as the risk of integrating versus the risk of not integrating a given innovation. When the risk of not integrating the innovation is greater than integrating it, the decision to lock on may be considered to be effective. It is preferable, at this moment, for innovation responsibility to be transferred from Pre-project to the Project Development.

We were looking at innovations in the car manufacturer's sense of the term, i.e. a technology or a service that does not exist within the company, although they might already be present at a competitor's or in another market sector.

The chosen approach takes in a global systemic standpoint of the touch-down process. For the purposes of the present article, we have generally used the term "process" in its broadest sense, i.e. including related organisation and instrumentation and decision process. Furthermore, process robustness is a relatively recent topic, notwithstanding Taguchi's work on robustness in general completed for many years (Taguchi *et al.*, 1990). We refer to the following definition to qualify process robustness:

'Capability to deliver expected results in the presence of unexpected adverse factors'.

(Chalupnik *et al.*, 2007)

In our case, this means delivering an optimised "touch-down" process that is fully able to withstand adverse factors, whether these be internal or outside the manufacturer's sphere.

1.1.2 Analysis of five Vehicle Development projects

The concept of "touching down" or integrating innovations in vehicle development projects was analysed from a vehicle project standpoint by tracing the appearance and disappearance of certain innovations throughout the vehicle design and development phases.

Our study is conducted on five recent Vehicle Development Projects: one of which was launched on the market beginning of 2010, one was discontinued and three are still under development. We traced the innovations flow from the Innovation Seminar (held immediately prior to the formal Project start-date, "Intention" milestone, which aims to re-define and prioritise potential innovations

to be integrated into vehicle projects) to the Contract milestone (which marks effective start of the development phase and is followed by industrialisation). See Fig. 1.1. We chose the Vehicle Contract milestone as the reference milestone, because, from this stage, the vehicle content is frozen until the launch phase. The average time between the formal vehicle development start-date and the Vehicle Contract milestone is two years.

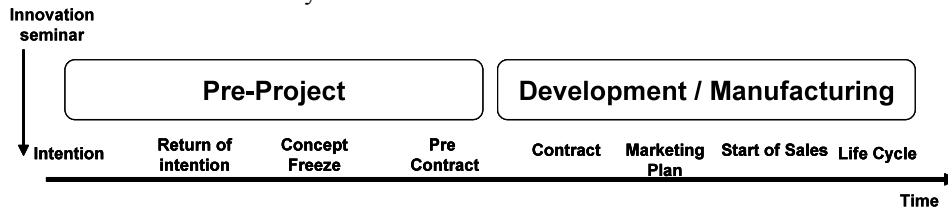


Figure 1.1. Vehicle Development Project, with milestones

A depth analysis based on 94 innovations targeted for three different vehicle projects revealed that between 25% and 50% of innovations identified at the end of the Innovation Seminar (after prioritization) find their way into the vehicle project by the Contract milestone stage. However, although some innovations are eliminated during the pre-project phase, others emerge as a result of market developments, customer expectations, competitors' activities and regulations, etc. In addition, some innovations are killed at a certain stage, only to be "resuscitated" later on.

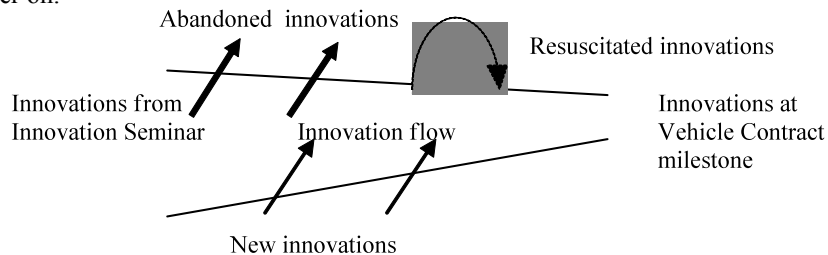


Figure 1.2 Innovation flow from Innovation Seminar to Vehicle Contract milestone

This analysis raises the pertinence of the actual innovation touch-down process: many innovations that ultimately land up in the vehicle development projects have not gone through the standard innovation process, consisting in identifying the innovations to be incorporated two years prior to the Contract milestone.

The factors that engender this situation may be:

Internal, for instance:

- technical constraints of integrating certain innovations;
- economic evaluation of the innovation reveals no return on investment
- a high degree of uncertainty (cost, volumes, potential customer value, reliability, etc.), which makes it difficult to make a decision at the right time;
- difficulty in developing the innovation in timescales compatible with vehicle development timescales;

- innovation maturity (Jahn *et al.*, 2009). From a certain stage onwards, a low level of maturity may cause a lack of confidence' in the innovation and hence a reticence to integrate it in vehicle project(s);
- lack of support from Top Management;
- inability to anticipate requirements upstream (changes in regulatory requirements, e tc.).

External, for instance:

- sudden, unexpected changes in the market;
- abrupt changes in regulations (environmental, safety, etc.) making it necessary to discontinue certain innovations or integrate others;
- in the event of co-innovation (steadily increasing over recent years), partners' level of commitment.

This global analysis suggests the need to work on a more robust "touch-down" process. A robust process does not necessarily mean a lack of flexibility; indeed, a more flexible "touch-down" may enable innovations to be integrated at a later stage, if they are not too intrusive. In addition, the innovation development timescales may be very different, depending on their field of application (safety, performance, environment, passenger comfort). Some innovations may be developed over very short periods and be integrated at a late stage without any risk to vehicle project quality, if their intrusiveness is extremely low. They can be handled outside the vehicle project cycle.

1.2 Research methodology

1.2.1 Introduction

Our methodology included six stages:

1. bibliographical research (exploratory rationale, inventory, options);
2. detailed diagnostic study, identification of initial solutions for progress;
3. modelling in order to gain a better understanding of the "touch-down" process;
4. descriptive analysis of three real cases of innovation "touch-downs", to enable comparison of the key points of the diagnostic and the modelling with actual cases;
5. formalisation of a "touch-down" theoretical model;
6. experimentation: specification logic for environmental innovations applied to future vehicle projects.

The work presented in the present article corresponds mainly to stages 1 to 4.

1.2.2 Results of detailed diagnostic study

Forty persons were consulted, representing around 80 hours of interviews. Those consulted currently play or have in the past played a role in the "touch-down" process, i.e. they were new technology project managers, vehicle development project managers, financial project managers, technical managers (vehicle

architecture, electronics, etc.), representatives of Pre-projects and of Marketing. High-level decision-makers were also questioned as part of our diagnostic study.

The aim was to gain a closer insight into real-life practices and at the same time to bring to light any differences between the official message and local perceptions.

The interviews were conducted in a semi-guided manner. The subjects covered were: innovation management by the motor manufacturer (as perceived by the persons consulted), analysis of the current "touch-down" process for innovations integrated into vehicle projects (strong point advantages, areas for improvement), feedback on some specific cases as experienced by the persons consulted.

In summary, the diagnostic study revealed four major points, outlined below, about which there were contradictory opinions:

- **Innovation requirement:** some of the persons consulted were of the opinion that the requirement should be relatively broad, providing a mere framework for the innovation specification and not limiting the area of investigation. However, others believed that the requirement should be reduced to the bare necessities, thus limiting the area of investigation quite early on in the process in order to maximise its chances of success. It should be noted that not all innovations are derived from a formal innovation requirement; many arise spontaneously (proposals from the Technical areas, R&D and from suppliers).
- **The "touch-down" process** must make reference to design/development standards, without being overly rigid. Excessive standardisation is perceived to be an obstacle to innovation, preventing good innovation opportunities from being taken up. The process should provide structure, but at the same time be flexible and able to be adapted to the different types of innovations – a single standard would not easily meet this requirement.
- **Evaluation and selection criteria:** the advantage of the criterion of cost-effectiveness (cost/value) that is widely used to decide whether or not an innovation should be assimilated into a vehicle is that it is consensual and easy to appropriate, particularly as the content and calculation methods for both costs and value criteria have recently been considerably optimised. However, cost-effectiveness reveals its limits in certain cases and sometimes needs to be completed by additional criteria relating to impact on image, contribution to corporate strategy, need to comply with regulations or to be in phase with the market and keep abreast of our competitors' market offerings.
- **Parties involved:** contradictions appear in particular with respect to the teams in charge of design and development of an innovation. For some of the persons questioned, it is a good thing that these teams are not the same - they believe that it is necessary for team members working in upstream phases, where the creative input is high, to be different from those working downstream, where the final aim is very concrete (to industrialise the innovations). For others, the weak point of the "touch-down" process is the split between the upstream and downstream phases –

they feel that it is essential to maintain the same team (or some of the team-members) throughout the entire development process.

1.3 Examples of innovations “touch-down”

1.3.1 EasyDrive and EasyNav

Three instances of innovations “touch-down” were analysed regarding theoretical models (Lemoigne, 1990; Gidel *et al.*, 2006) and these real cases were compared with the research hypotheses. In this way, we produced three “touch-down” pictures to provide an empirical description. We present in Table 1.1 two different cases; the first, EasyDrive is the result of a technology push and the second, EasyNav, was generated by market pull and was part of an “Open Innovation” process (Chesbrough, 2006).

Table 1.1. Comparison of the two cases

EasyDrive	EasyNav
Demand	
<ul style="list-style-type: none"> - Desire to set the manufacturer apart in the active safety field - An innovation that significantly changed key vehicle units (steering, chassis, suspension) gave rise to several research projects in the 1990s - These research projects, which to date had not been integrated in any vehicles, re-emerged within a vehicle development pre-project that was short on innovations. 	<ul style="list-style-type: none"> - Initial opportunity came from the marketplace with the explosion of nomad navigation systems at very competitive prices, completely short-circuiting the automotive sector, which offered much more expensive integrated systems. - Without any requirement being expressed at the outset, an in-house Technical team conversant with this technology grasped the opportunity to work on low-cost navigation solutions.
Integration (“touch-down”) process	
<ul style="list-style-type: none"> - Development: innovation initiated by Technical areas. From the outset, accent was laid on operational reliability with the aim of eradicating all potential risks. - Convergence: choice of technical solution. Production of prototypes to validate the solution and appropriation by key players. Discovery during the process (“Design Thinking” principle, Brown, 2008) that over and above active safety, driveability was revealed by the demonstrators to be a major aspect of differentiation. - Integration of the innovation into the vehicle project – the innovation was introduced at an early stage, because it 	<ul style="list-style-type: none"> - Development: the Technical team made contact with several external companies specialised in nomad navigation systems. Intensive testing of the envisaged technical solutions was conducted in collaboration with the target companies, to identify potential solutions and to draft a requirement specification. - Convergence: production of very convincing demonstrators, which facilitated decision-making. - Integration of the innovation: consultation of all vehicle projects with the aim of integrating this innovation. From the start, the innovation was designed to be transversal and was able to meet the technical constraints of different

<p>had a high intrusiveness level. The innovation was locked on to the vehicle project before the anticipated vehicle milestone. Excellent co-ordination between the different in-house entities and the key supplier.</p> <p>- The innovation was developed within the vehicle project: innovation development followed the set milestones, with good co-ordination between the parties involved (in-house entities and major suppliers). The quality of the innovation led to the manufacturer being awarded an "Innovation Trophy" in 2007.</p>	<p>vehicle projects.</p> <p>- Development of the innovation within vehicle projects: no development in the strict sense of the term – it was a question of integrating a product into the vehicle projects, each of which had specific technical constraints that had previously been identified. This explains the extremely short development timescale compared to normal standards. It was possible to integrate the innovation at a very late stage because of its low level of intrusiveness; a more conventional back-up solution also existed.</p>
Evaluation and decision criteria	
<p>- Great uncertainty concerning the cost/value ratio of the innovation throughout the vehicle design and development phases (cost changes, changes in volumes, added value for the customer, etc.) which made it difficult to make a decision. Development of the innovation within a single vehicle project restricted potential volumes.</p> <p>- The normal evaluation criterion (cost/value) revealed its limits, due to very high initial investment (complexity of the innovation) and the low level certainty regarding sales assumptions.</p>	<p>- The cost/value evaluation was extremely advantageous for the manufacturer. Potential gains were proven (declared customer expectations, volumes, etc.). When the project was presented to Executive Management, the risk of not implementing the innovation was greater than the risk of implementing it.</p> <p>- Beyond the economic aspect, the first milestones of the innovation programme plan were all achieved and initial samples (initial parts from tooling) were convincing.</p> <p>- The innovation became a vital necessity in the economic context and was welcomed by the commercial network.</p>
Roles played by the participants	
<p>- Project bearers: the initial bearer had strong technical credentials and internal support. The development pilot also enjoyed in-house renown for his technical and managerial skills.</p> <p>- Sponsors: the innovation received support from Top Management from the outset, which was essential when there was major uncertainty concerning its profit-earning capacity.</p> <p>- "Touch-down" (convergence with Vehicle Project) network: an external consultant was sought during the pre-project phase to co-ordinate the different technical areas and to manage overall project progress towards convergence. Subsequent transfer between the pre-project and project phases went smoothly. Certain players in the pre-project phase continued to be involved until the industrialisation phase.</p>	<p>- Project bearers: a small, close-knit team from the start operating according to in-house entrepreneur principles (Bouchard, 2009). This team was convinced of the project's pertinence and its potential profit-earning capacity. The team itself "sold" the innovation directly to Vehicle Projects.</p> <p>- Sponsors: during the pre-project phase, the team benefit from a "Business Angel" which meant that the necessary budget was made available. When the innovation entered a more practical phase (demonstrators, business case creation, etc.), Top Management imposed the innovation on Vehicle Projects.</p> <p>- "Touch-down"(convergence with Vehicle Projects) network: this network included persons who were extremely complementary, between the manufacturer's internal team which had worked on the project, representatives of the selected supplier who formed an integral part of the project and academic circles which had been consulted at the outset concerning</p>

	work methodology. Furthermore, there was no "break" between the pre-project phase and the development phase; the team remained virtually the same.
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1.3.2 Lessons learned from the cases presented

These two cases illustrate very different innovation "touch-down" processes, particularly during the initial stages. The lessons learned from these two cases and from our diagnostic are the following:

- **Innovation reference standard:** the cases presented and the diagnostic demonstrate the need for a flexible and adaptable "touch-down" process. This could lead to proposals not for a single, unique "touch-down" process, but two or three processes as a function of the innovations being handled (intrusiveness, etc.).
- **Origin of the innovations:** it is necessary to strengthen the links between the Technical areas, whose prime function is not innovation, but who may generate innovations by taking up opportunities, and the areas responsible for generating and managing innovation. Links are necessary for better communication between these two "worlds", via innovation-bearers and sponsors.
- **Moving the innovation downstream:** the two cases presented demonstrate the importance of a well-managed transfer between the pre-project phases and the development phase. All or some of the innovation project team members remained until industrialization and launch. Without having to keep the same team from start to finish, it would appear to be necessary to keep at least one or two team members to provide project continuity and a give "running start" for successful convergence between the innovation and the target vehicle development project(s).
- **Innovation transversality:** innovation transversality, particularly if the innovation requires major investment, must be thought about in the very early stages. Technically, the constraints of rolling the innovation out to several vehicle development projects with, potentially, very different architectures must be taken into account from the outset. The cost of "re-contextualising" an innovation may be extremely high, sometimes requiring full system redesign. However, integrating all the technical constraints inherent in each target vehicle project can compromise innovation transversality. It is thus necessary to manage the tensions between this complexity, the impact of transversality on time-to-market and potential volumes.
- **Managing risk and projection into the future:** the innovation must be globally evaluated with respect to what it can contribute to the project and to the company in terms of profit-earning capacity, but also image, contribution to strategic objectives, etc. Sophisticated decision-making tools may help, but they will never resolve the risk inherent in the decision to innovate, particularly as some criteria are difficult to quantify

(impact on brand image, etc.). Moreover, improved projection into the future should allow learning curves for cost and volume assumptions to be defined further upstream in the process. Finally, from the vehicle development standpoint, it may be expedient to define the budget allocated to all (minor and ground-breaking) innovations from the start and to keep to this budget, despite the unexpected adverse factors that may emerge during the project.

- **Management support for innovations:** it appears to be essential to have the support of the "bearers" and "sponsors" (generally Top Management) of an innovation considered to be relevant by the company for it to succeed. These bearers and sponsors may support innovations during the decision stage by top management.
- **Co-ordination between Technical areas and implementation of a "touch-down" network:** it is sometimes necessary to call upon a neutral party, or even an outside consultant to provide co-ordination between the technical areas. Moreover, it is essential to form a dedicated network of people to ensure successful final "touch-down", i.e. convergence with the vehicle project. It should be organised, structured and "open" – all potential resources should be used to facilitate convergence, be these internal or external (OEMs, academic circles, etc.).

1.4 Discussion: interpreting the research

1.4.1 Potential improvements to the innovation "touch-down" process

Ideas to improve the way in which innovations are assimilated into Vehicle Development Projects were formulated following the extremely detailed diagnostic study (40 interviews) and were developed after the work carried out on real innovation cases and analysed using a reference standard model filter. At this stage, the hypotheses expressed should not be considered to be recommendations for a more robust convergence process – they are factual observations based on a large number of interviews, bibliographical research and real-case analysis. They will undergo additional validation, notably during the specification phase – an experimental protocol will be defined to test the pertinence of these hypotheses on innovation projects undergoing final "touch-down", i.e. convergence with a vehicle project.

In summary, in order to improve robustness of innovation convergence with Vehicle Development Projects, we have marked out four fundamental hypotheses:

- **Need to structure requirement formalisation** according to a partnership rationale, involving both innovation players and vehicle project players. It is necessary to accurately define the activities expected by Vehicle Projects and to identify the innovations that allow these goals to be achieved. This clarification must enable the people responsible for designing the innovations to appropriate the vehicle projects' expectations

by limiting the area of investigation to the bare minimum. The objective is to define a simple strategy that is carried out and adjusted by means of regular feedback between the innovation project players and the vehicle project players. Methods such as Quality Function Deployment (Akao, 1990 ; Shiba *et al.*, 1993) may provide a better understanding and deployment of the requirement.

- **Need for one or more generic "touch-down" processes**, selected as a function of the specific type of innovation (level of intrusiveness in the vehicle project, need to respond swiftly to market demands, etc.) and taking into account the key events of touch-down (firing slot). These processes would form a framework that should be adaptable to each specific case.
- **Need to facilitate decision-making**, based on information from appropriate evaluation and decision-making criteria related to the concerned field (example: safety, passenger comfort, environment/CO2) and manage risk by working on different scenarios relating to volumes, costs, income and profit-earning capacity. It is essential to have, at the opportune moments (when arbitration/decisions have to be made) pertinent criteria and data (including the associated level of risk), by sufficiently anticipating innovation project design/development constraints – principle of irreversibility (Giard *et al.*, 1993 ; Chvidechenko *et al.*, 1997). This should help towards more robust decisions being made (Ullman, 2001).
- **Need to identify the players and define their role** (" project bearer", "sponsors ", "touch-down network", focusing effort - "running start" to enable convergence of all players involved. A key component is the complementarity of disciplines of the persons forming part of the "touch-down" network.

1.4.2 First approach to establishing an innovation "touch-down" model

At present, there is an identical "touch-down" process for integration of all innovations within Vehicle Projects, no matter what type. However, innovations are, by their very nature, unique in character, which could result in defining numerous " touch-down" processes. This would run counter to the need for standardisation.

Between these two extremes, it appears to us to be necessary to have two or three "touch-down" processes and not a single process, to be applied depending on the type of innovation (A, B or C). Figure 1.4 illustrates this proposal.

This outline model constitutes an initial idea for further development. This, of course, presupposes that classes of innovations are defined according to a multi-criteria approach.

Abundant literature exists on the methods of classifying innovations in relation to the specific objective : impact on integration with vehicle projects (Garcia *et al.*, 2002 ; Velloso-Rodriguez K. *et al.*, 2009).

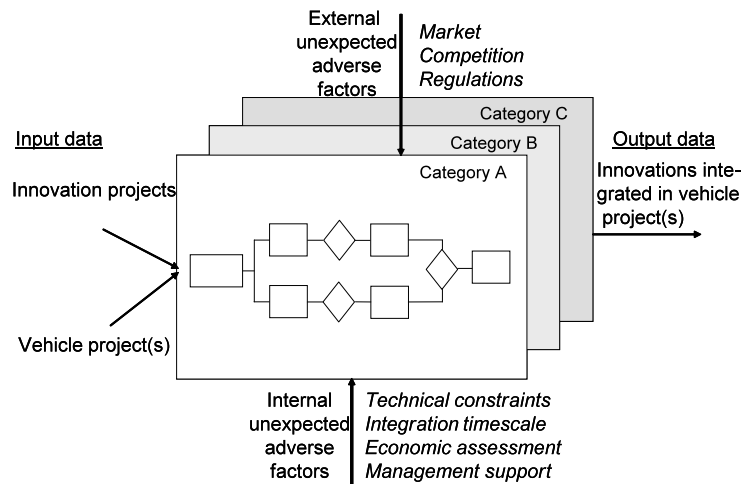


Figure 1.4 "Touch-down process as a function of the type of innovation

1.5 Conclusion / perspectives

The present article identifies the essential elements that typify the issue of "touch-down"; it identifies several concepts ("lock-on", "touch-down network", etc.), which require further in-depth study. The purpose of this work is to help to increase the number of innovations with high added-value for the customer that find their way into future vehicles.

Our detailed diagnostic study and analysis of three real innovation cases have brought to light some major factors which could have an impact on "touch-down" robustness – the need for a formal structured requirement for the people dealing with innovation projects and those in charge of vehicle development projects, an adaptive process or processes depending on the type of innovation, definition of appropriated evaluation/decision-making criteria for the concerned people plus management of uncertainty risk, and the need for key players ("innovation bearers", "sponsors") to "buy into" the innovation in order to facilitate their final implementation. These different variables enable us to act on the robustness of the touch down process, not from a statistical point of view, but from a process, an organisational standpoint.

Application of these hypotheses for improvement should help to make integration of innovations into the manufacturer's future vehicle development projects. However, this research programme is only at the conception/description stage. All the factors driving robustness will have to be detailed and validated. The experimental protocol and the "touch-down" model(s) that will emerge will

embrace all the lessons drawn from our diagnostic and from our real-case investigation. Following an experimental phase, these lessons may result in a list of recommendations to ensure successful touch-down, the aim being to propose one or more very specific models to in-house clients working on innovation projects or vehicle development projects.

Then, the aim is to move on from the descriptive stage to formulation of a specification – the hypotheses and models developed will be tested for integration of innovations into future vehicle projects, which may be internal combustion Vehicles (ICE), hybrid vehicles (HV) or electric vehicles (EV). The "touch-down" models to be developed will have to include the specific features of these markets, in particular for the electric vehicle, which introduces a new development logic (Midler *et al.*, 2009).

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