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A framework for strategic action with technology roadmapping: an action research in converging automotive and consumer wireless technologies

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Abstract

This paper is about the Action Research project carried out by a leading Tier-1 automotive firm aiming to implement a customized Technology Roadmapping process to recognize and deal with a fast changing context, and to manage implications within the organization, in its decision making processes and strategic projects selection. In fact the penetration of wireless technologies in vehicles represents a trend of growing importance, with vast consequences. The convergence of such markets, namely the wireless consumer industry and the automotive connectivity and infotainment, brings research possibilities, on one hand, and both opportunities and threats for involved companies, on the other.

Keywords: Automotive, Roadmapping, Convergence

Purpose

Technology Roadmapping (TRM) is a tool of growing importance, for practitioners and in academic field (Carvalho et al., 2013). TRM is often defined as a needs-driven technology planning process to help identify, select, and develop technology alternatives to satisfy a set of product needs (Garcia and Bray, 1997), while a Technology Roadmap itself identifies precise objectives and helps to focus resources on the critical technologies that are needed to meet those objectives. This process results important because it allows increasingly limited R&D investments to be used more effectively (Garcia and Bray, 1997). TRM therefore appears to be a suitable and powerful management tool, needed to link technology to business planning practices, to provide integrated project planning, and to engineer new systems and products, supporting communication between company functions (Phaal et al., 2004).

One of the main problems when important but unusual – if not unexpected – market and technology information, collected in whatever way, converge and become available for a firm, and powerfully suggest urgency for action and adaptation of business objectives, lays in the introduction and coordination of changes and measures needed by the management and within the organization. This is particularly true and challenging in case of architectural innovations (Henderson and Clark, 1990): gaps between habitual management practices and new needs have to be fulfilled with adequate solutions.

There have been abundant studies on the subject of project evaluation and selection, while there is little evidence of the integration of TRM and Project Portfolio Management (PPM) (Oliveira and Rozenfeld, 2013). One of the main problems is ensuring momentum and follow-up activities to the TRM process, where PPM comes into play, and when other tools are already in use. In the TRM literature there seems to be a gap with regard to a realistic and effective introduction of such managerial tool in parallel and not as substitute of practices already in place. On the other hand, TRM in our case is to be tested in particular in a mature market, the automotive sector, whereas and whilst architectural innovations emerge. In fact, in maturing product areas, firms even cease to invest in learning about alternative architectures (Kappel, 2001), and a lack of studies with regard to the application of TRM in case of mature product areas and/or architectural innovation seems apparent. This might lead to the need of developing custom TRM procedures able to help recognize and deal with such innovations and changing linkages of existing concepts, as well as with new patterns and trends. Therefore, our underlying research questions are:

(1) how can the TRM process be customized to meet the objectives of a multi-project oriented company operating in such scenarios;

(2) how a so customized TRM process can eventually be integrated with the existing strategic tools and management practices to help identify relevant trends and patterns, and sustain strategic decisions and projects.

A vast literature on concepts and techniques ranging from dedicated architectures and modularity to multimedia and telematic platforms in automotive is available and may help characterising such competitive landscape (Weber, 2009). Specifically, investments and novelties in the so called "electrical/electronic" (E/EE) vehicular areas seem making the pace in this sector, as stated in a recent McKinsey&Company report, if "approximately 90% of automotive innovations in 2012 featured electronics and software, especially in active safety and infotainment options" (Mohr et al., 2013).

Wireless systems are particularly impacted, and so are the companies competing in that field, to efficiently realize seamless coexistence of incumbent and emerging services (Beaume et al., 2009). Furthermore, the lifecycles of vehicles and consumer wireless products and services are clearly unsynchronised and generating new challenges in analysing market trends, understanding and eventually adopting or discharging emerging technologies and offerings, and consequently planning strategic projects for future products and processes (Gil-Castineira et al., 2009).

The need to integrate so many features (i.e. AM/FM (analog radio), Digital Audio Broadcasting (digital radio), Digital Video Broadcasting (terrestrial and satellite television and services), telephony, geo-localization, remote keyless entry, Vehicle-2-Vehicle, etc.), while the convergence of consumer and automotive wireless use cases and business models emerges, is leading to architectural changes and innovations within vehicles, with the redefinition of E/EE systems and linkages of elements and devices of dedicated Vehicular Ad hoc NETworks (VANETs), and, ultimately, of automotive antennas, the latter being necessary to enable each present or foreseen wireless ecosystem and the coexistence of old and new standards (Zamberlan, 2012). Similar

situations, where TRM has also been used, can actually be seen in other areas (i.e. the convergence of pharmaceutical and biotech industries into biopharmaceuticals; or lighting, mobility, information technologies and so on converging in the so called smart cities, etc.), resulting each time hard to indentify and demanding to manage, as far as new business dynamics and models, competences and competitive landscapes are realized (Lee et al., 2013). Incidentally, in our paper the concept of convergence is intended as "the unification of functions, the coming together of previously distinct products" (Yoffie, 1997, p. 2).

Calearo Group is a leading Tier-1 automotive firm that for decades has been operating with many car manufacturers, in particular in the design and production of antennas and cable harnesses, on strict specifications of the customers. In the frequently not balanced supplier-customer relationship, struggling to anticipate, recognise or react to demands for new functions, products or processes, or other innovations (Schiele, 2010) has been a normal activity for such company. As an example, in the oligopoly of automotive suppliers, it is not unusual that one-to-one workshops and meetings are held between a car maker and one supplier at a time. These events, often taking place on a yearly basis, mainly represent a good opportunity for the car maker to know in better detail about the activities of the suppliers, to monitor and assess their innovativeness and attractiveness, as well as a way, virtually free of charge, to collect information and ideas, particularly on new technologies, developments and processes, both from incumbent and new suppliers, and indirectly from competitors too. Furthermore, each supplier will tend to use such occasions to show off and cultivate its image and reputation, and therefore shall present sketches, ideas, prototypes, processes, and so on, originated directly for the occasion, or deriving from internal research activities, or even produced while working for other customers. Vice versa, the flow of information from the car maker to one supplier or another, especially at system level, but eventually at component level as well, will be often very limited (Takeishi, 2002).

Our hypothesis is that TRM, already used and in use in many fields, carefully applied and tailored for the described environment and related issues, also with an iterative process of Action Research (AR), can help the particular firm that has recognised these problems and risks, and is struggling to deliberate the right strategic decisions and projects, so to let it remain in a leading position in its challenging and changing business field.

Design/methodology/approach
In the perspective of the named firm, it was evaluated and decided to analyse and map the described phenomena, planning and operating actively within the organisation, in particular with help of the TRM managerial tool. It immediately emerged that the ideal dynamics of TRM, with technology push and market pull working together (Phaal et al., 2004), remain quite far from their real applicability, especially when, as in our case, the supplier-customer relationship is not balanced, as mentioned above. So, the practical and urgent managerial needs, in parallel with the opportunity and academic will to investigate and track rigorously and continuously such context and endeavour, suggested to carry out such a project urgently, and in form of AR (Karlsson, 2009, p. 70).

With the issues, the scope and the objectives described, the role of action researcher has been undertaken by one of the authors, being him in the particular and favourable condition of top manager as well as doctoral student. Under these circumstances, the action researcher could both manage the AR project and study and follow all its phases and outcomes with direct participation and with adequate primary and secondary access

(Coghlan et al., 2010). In fact, this research methodology, with the chance to do research while at work in the organization, was applied implementing the four steps of constructing, planning, taking and evaluating action, in a 2-year corporate project, and with three full AR cycles of TRM processes. While the whole AR project itself was carried out and monitored in parallel to the AR operative cycles, the overall project context and purpose was consistently related to the background and hypotheses previously described, from the perspective of Calearo Group, as Tier-1 leading firm in the automotive business.

Even if Coghlan and Brannick state that "in any AR project there are multiple action research cycles operating concurrently", considering to have different time spans (Coghlan and Brannick, 2010, p. 10), in our case three AR cycles were substantially performed in sequence, one after another. This deviation from the standard AR "clock metaphor" in our implementation helped keep the purpose and focus on the context in perspective. In fact:

- The first AR cycle was operated by doing the TRM process at Technology/Product level, for the Strategic Business Unit (SBU) of the firm;
- The second AR cycle was successively carried out in the same SBU, at Technology/Product level, on a more specific field of interest;
- Finally, the third AR cycle was done by exploiting a Technology-Product TRM at corporate level.

Some of the most relevant data gathered during the various AR cycles and the corresponding TRM phases are reported in the remaining part of the present section. As a matter of fact, the first AR cycle was possibly the most critical, as no practical experience on the methodology was available in the company and no budget for external support, i.e. consulting, was allocated. An initial idea to achieve a corporate level TRM process at the first attempt was immediately aborted, as it resulted in many ways not credible. At this stage, the TRM process described in the literature, defining 3 phases, preliminary, development and follow-up (Garcia and Bray, 1997) was considered and taken into account, among others. Therefore, in the "constructing" phase for the first AR round, where the first TRM workshop needed to be defined and organized specifically for the context and the SBU defined, the action researcher had first to explain the idea and the objectives to obtain the "go" from the owner of the company, and then to involve and motivate the potential team members. The team itself, composed of 5 persons selected primarily from sales, R&D, engineering and accounting, found challenging to stimulate and obtain awareness and sense of urgency within the firm, especially while other ordinary activities, or emergencies, and business processes were occurring as usual. It immediately appeared clear to the involved team, as well as to other members of the company occasionally involved, that the ideal situation of full availability and stability of purpose was just unrealistic, at least in such a medium-size company. It was fundamental to get and keep the company owner involved and convinced, at least informally, about possible specific improvements deriving from the new initiative, also on a short term and at many levels, including technical aspects (i.e. reactivity to changes in mobile technologies), organizational aspects (i.e. growing gap of competences with respect to digital communications), market aspects (i.e. speed of competitors), etc., while mitigating the tendency to rush to "quick and dirty" shortcuts and changes. Exercising leadership and inspiring commitment while illustrating the methodology was also necessary: for this reason, papers on TRM and TRM examples from the literature were distributed and presented to key colleagues and to the owners. Gathering concerns and taking them into account, as well as setting clear responsibilities and illustrating potential benefits for internal

teams and involved stakeholders was important: sales people (possibly narrow minded, jealous of their information, unaware or indifferent of time-to-market issues, pulled from needs and habits of customers); R&D people (eventually too innovative and remote from real needs, open to new and risky technologies); finance people (unaware of future trends, not willing to invest); operations people (mainly lamenting lack of time for such initiatives) were informed and eventually involved.

In the "planning" phase for the first AR round the first TRM process was planned, defining what and how to focus on: who to involve in the organization, depending on the scope, and from what level(s) people should be; what support and resources were needed, depending on the specific tasks; how commitment could be sustained and how resistance and potential skepticism could be mitigated. Indeed some were involved as temporary team members, as specifically dedicated to the most reactive and interesting car makers with respect to the trends described, and key to the context. With these preconditions in place, the TRM workshops (in sequence on markets, products, and technologies) were organized and arranged in detail.

In the "doing" phase for the first AR round of the first TRM process, three 1-day TRM workshops were carried out, going across past-short-mid-long term and vision time horizons, placed and organized on a grand visual board. Afterwards linkages among the outcomes of the different workshops were discussed and drawn. This last part was done by a subset of the team members, recognizing the implicit difficulty of this final step, which led to the definition of relevant projects and priorities. These "candidate" projects were assessed with help of the existing financial analysis, risk analysis and strategy alignment tools in use in the firm, presented to the board of directors, and eventually prioritized and inserted in the existing multi-project management system.

In the "evaluation" and final phase for the first AR round of the first TRM process, it was assessed that the gaps (internal methods, awareness, urgency, new technologies not properly studied, etc.) were actually very present and threatening, at least at SBU level. The resistances of various colleagues and the short term expectations were occurring quite often and mitigated continuously. The risky feeling that an external consultancy would have been better than the job done by internal people remained a problem to consider with attention. The "post-it" cards placed on the board during the workshops required careful standardization, whilst more coherent information on each topic was needed, up to generating an early and compact business case and a scorecard for each idea, before assessing each project or product feasibility, possibly with dedicated people (whereas this critical follow-up task resulted often in contrast with the existing resource allocation process and practice, and with the pace required in such process). Importantly, the technology workshop was evaluated necessary and pivotal before the product workshop, and not vice versa.

The first AR cycle took about 6 months for its execution.

Having consolidated some internal expertise and confidence in the TRM process, the following second AR cycle was a "zoom in" from SBU level into a specific business field that had been under study in that SBU for some time, namely the Digital Video Broadcasting – Satellite Handheld (DVB-SH) technology, as it represented an important and promising new technology for the automotive and mobility sectors, and where eventually the firm had earlier decided to invest (Zamberlan et al., 2013).

In the "constructing" phase for the second AR round, which took around 4 months, a new TRM process was considered so to evaluate and decide the most appropriate actions in perspective of DVB-SH future strategy and developments. The scope of this TRM process was therefore narrower and more vertical on a specific technology and

product strategy. The idea and need in the background was, on one hand, to obtain a roadmap with indications on possible new investments and projects in this ecosystem, and on the other hand to refine the TRM process customization, in particular addressing precisely the issues emerged in the first AR cycle and TRM process and the coexistence with other procedures already in place in the company.

With such practical and research objectives in scope, the new "planning" phase was rather delicate and took another 3 months. The team focussed on the criticalities emerged, at execution level, in the previous AR cycle and TRM process, in particular in the "doing" and "evaluation" phases. The critical phases and customization of the process, the necessary or key functions and persons, the delicate roles, the main tools used, and other emerging issues were among the themes clustered and analyzed at this stage.

The "doing" phase was then conducted in 4 successive workshops (differently from the previous AR cycle, on markets, technologies, products, and linkages), of an average duration of 5 hours each, based on the same grand visual board used in the first TRM process, with the same core team, but aided by 3 new persons. This aspect was introduced in response to some of the aspects emerged in the first AR cycle: the person in charge of feasibility studies, the person in charge of the Project Management Office, and a colleague from the finance department were involved. This novelty boosted and simplified the successive dissemination and support in the activities of follow-up and project sponsoring, creating direct commitment of key personnel. Furthermore, a "quick business planning" and standardization for each project and product proposal was assessed and validated directly during the workshops, improving the general quality and insightfulness of each potential project and product proposal.

The final "evaluation" phase of the second AR cycle, parallel to the exposition of the results to the board, was this time more dedicated to the analysis of the outcomes and the possible ways and schedules to implement the proposals emerged, rather than to criticizing practical aspects and the methodology itself. On the other hand, some issues and refinements for successive TRM processes were apparent: based on the patterns recognized during the workshops, and on the market and technology trends in particular, the projects aiming at future products were hard to define and therefore to release, due to the high risks related to the inner instabilities highlighted. It happened that crucial information were available only at key persons and players of the specific ecosystem, and therefore hard to collect and to trust. Furthermore, it was clear that R&D decisions were pushed beyond some market needs, stressing the threatening mismatch between technical and sales priorities, and engaging discussions between different departments, which did not help the exploitation of the TRM central phases. Finally it emerged that, whenever possible and acceptable, riskier projects and product developments should have been or be financed with use of external fund rising, rather than by internal resources, typically already allocated otherwise. The TRM process outcomes are being published separately (Zamberlan and Pannozzo, 2014).

The second AR cycle took about 11 months for its complete execution.

After 2 AR cycles a third and, as far as the team is concerned, conclusive AR cycle was carried out, according to the latest AR project plan. The TRM process for the first time could be applied and executed at corporate level. The consolidated expertise, the general confidence in the tool, the released and ongoing projects stemming from the previous TRM processes, played in fact the role of best internal sponsor for the leverage of a company-wide, autonomous TRM initiative. After the initial AR cycle and TRM process at SBU level, and the second AR "zoom-in" cycle and TRM done at a more specific level, the third AR cycle could finally take place "zooming-out" with a TRM

process at corporate level, as initially desired. Actually, the fact that the first and second AR cycles and TRM processes were developed by and at the Strategic Business Unit, as described, appeared fundamental for this final research and practical step. The involved team this time was again the same, with an additional member coming from the family owning the firm, previously informed on the activities anyway. The entire AR cycle went on quicker and smoother, surely as a consequence of the experience and momentum gained in the previous cycles, even if the scope was actually wider.

In this case the "constructing" phase took less than two months, in which the standard tools were prepared and the current state of the ongoing projects was collected. The following "planning" phase was also rather short, with the confirmation of the 4 workshops and the preparation of a short and homogenic analysis for each already ongoing or planned project within the firm. The "doing" phase, exploited in half-day workshops, showed that data on market and business evolutions and trends were rather consistently available in the firm, while an accurate analysis of the relevant or potential technologies could not be done simply by means of such internal workshop. This led to the necessity to investigate at some key customers, and to involve major current or potential suppliers, as actually suggested in the literature (Petrick and Echols, 2004) or, in some cases, to meet with competitors and possible co-operating companies, so to adequately map, understand and select the technologies currently available or foreseen in the near or far future. An important university was also involved to support in particular the literature review on technologies used for new wireless solutions and antennas in automotive. In practice, along the supply chain, especially suppliers and potentially co-operating firms were called in dedicated meetings and half-day workshops to assess and crosscheck technology trends, patterns and further information, useful to complete the technology workshop of the ongoing TRM process. This unexpected investigation delayed the "doing" phase, but donated more consistent and robust data also to the consequent workshops dedicated to products and linkages between the various emerging outcomes. In any case, as expected, the final integration phase of the TRM process required the highest levels of effort (Gerdsri et al., 2010). Actually, the evaluation phase of this third AR cycle is still ongoing and its preliminary or expected results, mostly related to all the previous phases here described, are briefly mentioned in the next section.

Findings
According to the classification present in the literature, throughout our workings we have clearly focussed on "long range" and "program planning" roadmap types (Phaal et al., 2004). Our outcomes and resulting framework aims at, and in fact in our particular case it seems able to, change the corporate decision process and allow its evolution into a more effective and holistic practice. From a typically mere market and, even riskier, customers' pull (as in Figure 1, on the right), the defined framework (as in Figure 1, on the left) allows a credible and continuous balance of market pull and incremental approach, in parallel to a technology push and possibly disruptive one, therefore without removing the classic internal way of doing. Depending on the unit of analysis and on the timeframe in scope (corporate, BU or Technology/Product level, as seen in our AR project) the so enabled integration in the firm, and the deriving linkages, allow a crucial flow of information as well as bottom-up and top-down continuous exchanges. In case new patterns, or trends, or architectural changes are recognized while carrying out the corporate process, a specific TRM process can now be enabled swiftly, and conducted consistently in the dedicated field of interest. Furthermore, if a business unit is suffering from critical situations or foreseeing a new strategic need, a TRM process at BU level

might be organized and exploited directly and locally. The resulting practice, especially in a typical situation of chronically scarce or limited resources, and especially if the TRM process can be kept alive and activated quickly and when actually needed, and not only at designated intervals, represent a major achievement for the firm under analysis.
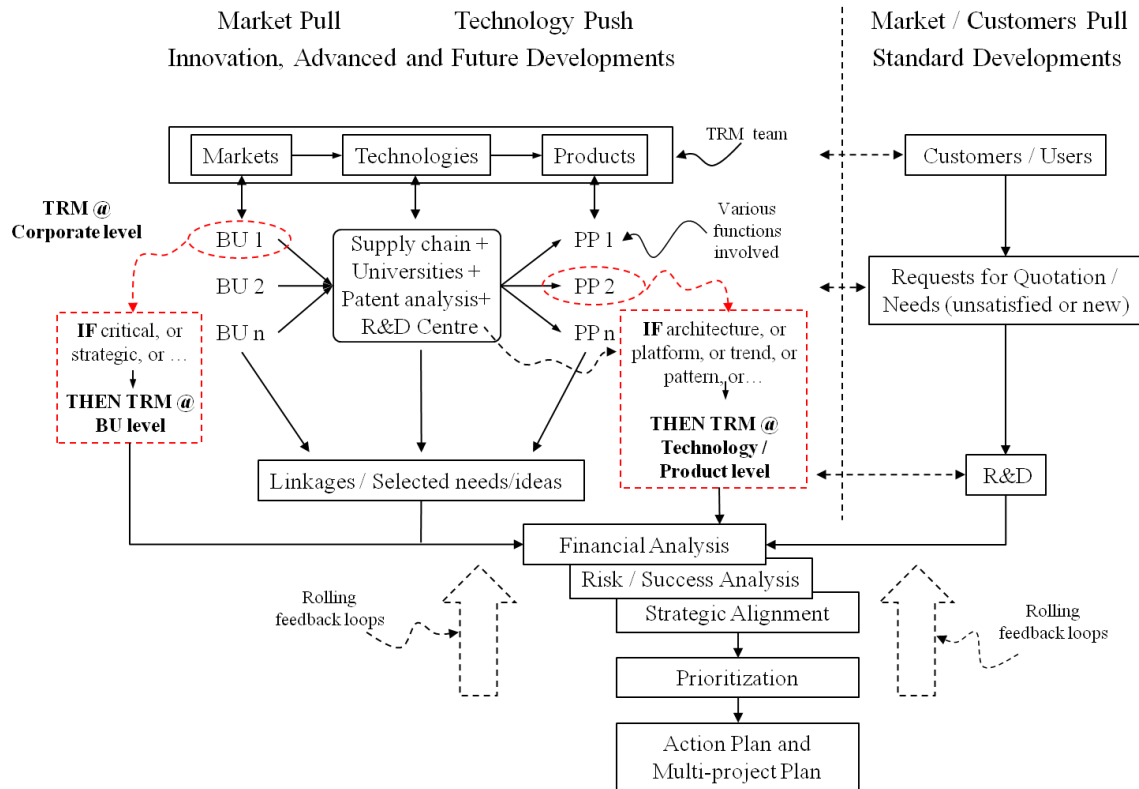

Figure 1 – Proposed Framework

Furthermore, the introduction of a systematic scouting and collaboration along the supply chain, with key customers, and in particular with selected suppliers, the latter practice having being a reason for a certain delay in the "doing" phase of the third AR loop, as described, together with the analysis of patents, of competitors, and with universities, contribute adding confidence and concreteness to the outcomes. It also allows better availability of data and consequent lean convergence of processes and information for the support of decision makers and business strategy alignment. With respect to this achievement, the "zoom-in" and "zoom-out" performed during the AR project, as described above, has actually enabled trust in the tool at various levels, and might have improved the methodology itself. Another key success factor and enabler of the rationale supporting the AR cycles and TRM as implemented was the fact that the involved team members were consistently the same, primarily employed in the same SBU, and that specific SBU is substantially in charge of the R&D program and innovation projects for the firm. This has allowed and facilitated one of the possibly most critical aspects in TRM, namely the capability, within the firm, to use such tool and exploit the various phases effectively, or even virtually on-demand, especially if related to an external consultancy, as often seen in the literature, which possibly is one of the main reasons why the follow-up phase results so critical.

Compared in particular to another framework available in the literature (Cooper et al., 2010), we separate our framework from the strategic phase at the beginning of that

model, as our TRM processes aimed to intervene aside and in parallel to the existing strategy and set of tools, as well as practices and projects already in place. Furthermore, the gained confidence and speed in executing the TRM process appears fundamental in its real application and to sustain its potential in a fast paced business environment.

Table 1 summarizes some of the outcomes emerging from the data as collected, described and analyzed during the AR project, at its various and main stages.

Table 1- Summary of emerging key points and findings

	AR Cycle 1 (Business Unit)	AR Cycle 2 (Technology/Product)	AR Cycle 3 (Corporate)
Process critical phases	Constructing action; team assembly; planning action	Taking action; evaluating action	Evaluating action
TRM process customizations and criticalities	Preliminary activities (motivation; sense of urgency...); teamwork; methodology; follow-up; lack of resources	Careful preparation of materials; involvement of customers; finding patterns/architectures; follow-up; linkages; more accurate "post-its"	Role of shareholders; Roles of key suppliers and customers; TRM in parallel to present tools; TRM as multilevel process; deep financial assessment for priorities
Most critical roles	Methodology expert; team leader	Technical and sales personnel	Shareholders; persons of key suppliers
Main tools	Internal data; available papers; workshops	Workshops; data on internal projects	Internal and external workshops
Open issues	TRM activity due to limited knowledge of the methodology	Dynamics in the involved team and various phases	High expectations; Outcomes of previous rounds and follow-ups

Furthermore, the AR process guaranteed quick and focussed growth of internal resources and their competences in field of TRM, going from initial difficulties in understanding the tool itself, to confidence in applying it and thinking boldly.

Relevance/contribution
This paper contributes to prove the applicability of TRM as an internal tool to introduce in parallel to existing practices, and to indicate a methodology based on the dynamic coexistence of three different and concurrent TRM levels, which might help strategic operations and managerial decisions in environments characterized by rapidly changing technologies, architectural innovations and converging businesses, threatening phenomena of difficult interpretation for incumbent firms.

The methodology, here applied in case of automotive and consumer wireless convergence, could be applicable in general in other firms and sectors, where patterns as described require ambitious management measures and projects, till updates of business models, competences and practices. Also other contexts might require practices to balance between continuity in the evolution of today's products and disruptive architectures and solutions, in parallel to a consistent attention to patterns and future trends, as seen in the presented project.

The multilevel TRM framework here defined and under test actually allows better linking of technology trends to corporate business planning, aligning R&D investments to PPM, sustaining fundamental communication and networking activities in the organization. This framework promotes the extension of TRM to resources along the supply chain, from key suppliers to relevant customers, and other partners, at least.

The maturity of the presented framework and its future application require further validation, in particular with follow-ups, roadmaps maintenance, and measurements of TRM contribution to business performances.

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