Abstract

The SMAP, Standard Multi-Application Panel, is a new in development concept for a side panel of a railway vehicle for passengers’ transportation. The functional analysis of the panel was done regarding the main structural characteristics, from the engineering point of view, and the required functionalities related to the manufacturing and assembly processes and, the fundamental ones, introduced by the panel interaction with the final user and the surrounding environment. The new panel concept is an innovation by itself. It will be developed following a modular approach, within a parametric design and in a single piece with an interior and exterior coating. The objective is to simplify the manufacturing process, to avoid several long operations in the assembly phase and to contribute, through the modularization and standardization, to the maintenance economy.

Introduction

A deregulation of large segments in railway market has been led, at differing rates, to railway networks denationalization. Competitive advantages are facilitating the access to previously closed markets and are creating new opportunities in the industry. Railway vehicles industries are facing the prospect of a fundamental strategic re-examination of their business activities, product and services portfolio.

The success of the companies in sales and development has been connected and remains on their technical expertise in the specialized market of railway engineering. This includes product engineering expertise and knowledge of their customers’ requirements and demands. But in a continuously changing market the decision-making to quickly develop meaningfully alternative scenarios is constant and highly complex.

It is in this context that the concept of a Standard Multi-Application Panel (SMAP) emerges. The objective is the development of a new product concept, which, through a deeper product modularization and specialization and multiple aesthetic arrangements, will enlarge the potential market and will create the foundations to new opportunities exploitation. This approach requires an entrepreneur spirit and a systematic and comparative observation of rail markets and engineering solutions to underpin business decisions and support the operational and strategic orientations in accordance to the trends directions.

As assumed by the European Commission in the Green Paper on Entrepreneurship in Europe, an entrepreneur spirit is, above all, a mental attitude. The most part of new business created by European entrepreneurs aren’t much different from the existing ones: there is no innovation. The main purpose of the SMAP concept is to develop a new and innovative product and new manufacturing methods to achieve new ways to improve quality and to reduce the final life cycle cost. In fact, this new concept for a side panel of a railway vehicle considers all life cycle steps (design, manufacturing, use and reuse) in order to:

• Improve industrial competitiveness through product/services quality and quick response to market evolutions.
• Minimize environmental impact in product life cycle regarding all aspects specially components reutilization.
• Contribute for people mobility in urban areas with comfort and design appealing.
• Reduce energetic consumption through weight reduction.

Passenger Transportation

Rail is an important mode for passenger transport, particularly in what concerns urban accessibilities. However statistics show that the relative share of rail transport has declined considerably over the last 30 years as we can see in the next table.

<table>
<thead>
<tr>
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<th>MODAL SHARE</th>
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<tr>
<td>Rail Transport (billion pkm)</td>
<td>10.1 %</td>
<td>74 %</td>
</tr>
<tr>
<td>Car Transport (billion pkm)</td>
<td>81 %</td>
<td>26 %</td>
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1970: 217 ▲ 1580 ▲
1980: 212 ▲ 30 % 3764 ▲ 140 %
2010: 327 ▲ 12 %

Tabela 1 - Passengers Transport Preferences

In 1970, rail accounted for 10.1% of modal share (all the passenger kilometres - pkm). In 1999, this figure dropped to 6.1%. In absolute terms (Individual Evolution) there was an increase of 35%, from 217 billion pkm in 1970 to 292 billion pkm in 1999, but the increase of passengers transported by car was significantly higher: from
1.588 billion pkm in 1970 to 3.784 billion pkm in 1999, which represents an increase of almost 140%. The car modal share rose from 74% in 1970 to 79% in 1999 while the rail share dropped. For 2010 European studies foresee 12% increase in the passengers transport by rail (Individual Evolution): from 292 billion pkm to 327 billion pkm. However its modal share will still drop: from 6.1% to 5%. To keep the current modal share (6.1%) rail should increase the transport volume by almost 25% to 364 billion pkm! [1]

In future, opportunities in the public transport, particularly regarding customer-orientated solutions, will flourish. Good examples are long distance transportation with the French TGV and the German ICE, which already challenge the place of private cars and air travel. Also in short distance transportation there are good examples of successful public transport systems. When rail transport system becomes the core of comprehensive service packages permitting the attractive solution for the largest number of individual customer requirements, then it has the chance to restore the quality of life in the urban zones. Within such considerations the urban light rail system has especially high chances of success. It offers a high performance capability with simultaneously high friendly compatibility. Moreover it can be implemented in stages and be combinable with other transport systems. [4]

Recent innovations in railway sector have been focus in different areas of engineering. Some of the most important patents in railway sector involve subjects like: wheel/rail contact force analysis for high adhesion locomotives; advanced GPS algorithms for high-precision monitoring of rail position; opportunities for enhancing the capacity and performance of railroad terminals; active control of railroad car vibration: low energy suspension systems; machine vision effective for weed control in railroad ballast.

Clearly there is a need to improve I&D effort on areas related with emotion design, reducing claustrophobic effect and promoting an easy refurbishment of the inside vehicle environment adapted to local context (social, cultural, geographic, etc…).

The Industry point of view

All the transportation industrial sectors, and in particular the automotive sector, has been faced with a continuous and profound change. Intense pressures (internal and external, upstream and downstream) have not only been shaped a new industry structure but have equally been responsible for a change on the products concept.

Nowadays, the consumer is an active player in the industry. Conscious of his role and, as such, demonstrating a higher level of expectation, the consumer defines new and grater requirements. Additionally, as we have already described for railway industry, the regulatory framework to which the automobile is bounded is highly restrictive, namely in what concerns certain attributes such as safety (passive and active) or the life cycle environmental impact.

A re-configuration of the type of components and of the price requirements have occurred, due to external pressures replicated throughout the industry value chain. As a consequence, the search for efficiency emerges for the components supplier companies as one of the main development axes. Rationalization is an imperative, and the direct suppliers of the OEMs are faced with enormous pressures seeking the cost reduction, with a tendency towards a greater level of integration, and the contribution to the continuous improvement of the vehicle’s attributes valued by the final users.

Reacting to these pressures, the suppliers have been following reorganising processes to boost the level of competencies and capabilities, to assure a growing presence in different geographical regions, namely though mergers and acquisitions. Moreover, further down the supply chain, at the 2nd tier supply level, the upstream pressures are not only directed towards cost reduction and responsiveness, but also related to the growing importance of the product development capabilities. [2]

Manufacturing Strategies

Within this framework, and regarding solicitations that are inherent to their competitive positioning, the manufacturers have been implementing measures that seek to respond to these global tendencies. Fundamentally, these measures have been developed according to some axis [6]:

Standardisation, though the development of common platforms1 and the implementation of common process. The teachings of Henry Ford and Alfred Sloan are very much present in today’s automotive industry and have assumed different dimensions: all manufacturers are involved in the development of global automobiles, through the use of common parts in vehicles of similar dimensions. An important effect of standardisation is the creation of manufacturing plants able to produce various vehicles simultaneously and respond to sudden changes in demand. The

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1 The platform strategy is a cause for the establishment of partnerships aiming the cost reduction. The partnership between Renault-Nissan is a good example of this strategy.
objective underlying the use of platforms is the search for economies of scale and for the increase of the life cycle of the components. An increased competitiveness of the products is guarantee by the decreasing unit cost associated to development and production. Notwithstanding this effort, the consumer has the last word and the success of these initiatives should be subjected to careful planning: the specific characteristics of the regional markets have led to a better rationalisation of the vehicle contents and have contribute to avoid costs that local consumers are unwilling to pay.

Thus, the use of common platforms that harmonise the structure of the vehicle and permit the use of various exterior panels is the prevailing concept. Particularly in the European market, market gains will tend to be based on the differentiation and in the development of market niches, which will cause the number of vehicles based on the same platforms to be higher than in the case of vehicles produced for the American market. This different behaviour has a double effect: by one side, the differentiation associated to several market segments reduces the amplitude of the use of common parts; by the other side, the American automotive constructors will tend to relocate their development centres, associated to the low and medium segments, to Europe where these segments possess strategic importance.

An emblematic example of the use of common platforms is the case of the VW group A4 platform on which vehicles such as the Skoda Octavia, the Audi A3 or the VW Golf are developed, guaranteeing the differences between models and brands.

Modularisation denotes the delegation of responsibilities to the integrated parts suppliers has a double objective: increasing the productivity in the assembly line, through the time and cost reduction, and give to the suppliers a greater margin for the exploitation of innovations associated to the supply of integrated parts. In the case of the optimisation of assembly, the advantages are evident: the conversion of Ford’s Valenta’s assembly line to the assembly of the Ka introduced 1200 new parts in each vehicle, instead of the traditional 3000. As a consequence, the lead time of the conversion was reduced by 25%. [2]

The role of OEMs on the top of the industry value chain has been changing. Together with productivity, they have been focusing their efforts in the design and assembly phases. Suppliers have been given more responsibility, which has led to a growth in the supply industry, namely with the establishment of global scale suppliers.

The search for synergies has been a determining strategy for the development of the industry, and led to a wave of mergers and acquisitions. Productivity challenges and the search for new business positioning by complementing the product range, have not only generated economies of scale but equally economies of scope. The automotive industry assumes oligopolistic characteristics, meaning it is dominated by a small number of large companies, with a tendency towards further concentration.

A. Troman, from Ford Motor Co., commented: “In the future, there will not enough space for more than a dozen global manufacturers, with production volumes above 5 million vehicles. On the margin of large groups, there will only be enough space for small local of niche oriented manufacturers”.

In the automotive sector, the wave of mergers and acquisitions that spread all over the world, has the previously referred to industrial logic: synergies in the common use of production systems, or in the sharing of platforms, motors and components, in the negotiation with suppliers and in the marketing effort. These synergies will enable cost cuts in an industry marked by greater competition and excess of installed capacity, which is putting downward pressure on the profit margins.

Modular and Platform Approaches in Rail Industry

As it appended in automotive, the rail industry are transferring responsibilities in terms of the development of parts and, more importantly, the design and assembly of modulus and systems. Nowadays, the side panel of a railway vehicle is not conceived based in modular components or standardized platforms. The idea of the SMAP development is to introduce these concepts in the rail vehicle. This strategy will directly influence the role of component suppliers and their technological and economic behaviours. In particular it will promote the transference of responsibilities at the design and engineering level and the consequent emergence of global suppliers. They will have to supply more complex systems and modules, within the objective of attaining simpler vehicle assembly process.

In this context the suppliers’ responsibility will increase. Influences will be felt on sector investment and research effort, in response to the
Growing engineering needs. Moreover, suppliers must develop competences in project management as well as in the development and manufacturing and integration of complex systems. The capability to undertake joint development efforts with other companies is a crucial tool in the pursuit of cost, quality and time related objectives. Additionally, in the rail industry the capability to innovate will become a major key for technological development and a fundamental competitive factor. Consequently, the 2nd tier supply base of the sector, characterised by SMEs companies, will feel a strong pressure towards reorganisation. The investments associated to the development of new products are such that suppliers tend to specialise on certain items. So, the high level of investment required has equally contributed to mergers, acquisitions and long term partnerships undertaken to achieve a sustainable dimension, acquire the set of competences and share the involved financial, technological and marketing risks.

The modularity should be worked out with attention in design process. Standardisation involves a design and manufacturing process optimization, which improves product flexibility and variety. Taking the Swatch’s example, it’s easy to understand the platform concept and the way it added product value creating flexibility to several different configurations and it’s clear which components are maintained from each model.

However the frontier between functional and physical architecture of the product structure is not always clear and easy to define in terms of modularity and integration. SMAP product architecture combining with simple assembly and technical constraints limits some product differentiation, but tries to balance standardization and differentiation as a key for the success of a modular platform for the side panel.

The first step involved in this process is to acquire a clear understanding of the challenges of the rail vehicle market and to analyse strategic scenarios. Simultaneously, one must be aware that the development of a modular platform requires the definition of the modularity frontiers, involves a more-extensive interaction of product design and supply chain, and calls for an extra management effort in the design process.

Modular Platform precise meaning is often unclear. It is used in many different ways, leading to confusion about what it really is. Ron Sanchez proposes a definition that capture the essential concept and practical characteristics of a platform:

“A platform consists of strategically motivated and operationally coordinated modular product and process architectures designed to create specific forms of strategic flexibility that will be the drivers of business goals”, [Sanchez, 2004]

Modular is another term that assumes many meanings in current management discourse. Follow the definition of modularisation exposed in the analysis of the automotive industry some authors call it “Technical Modularity”. It presupposes an interface specification between components to allow their free substitution within some extension without any interface modification.

In this context SMAP, as a product architecture designed to enable an easy configuration and re-configuration of a family of side-panels and successive up-graded generations, will be a modular platform. It should be noted that modular products and process architectures enables engineering designers to “design in” a number of important forms of strategic flexibility in the rail vehicles. Side-panels variation intended for different markets segments can be quickly configured by combining different physical component within the modular architectures. Additionally, it can discipline the re-use of standard common components. New functions, sources of perceived differentiation, can be just-in-time introduced, promoting the variety and the innovation, without deteriorate the supply chain efficiency and the final cost (Fig. 1). Moreover, the new side-panel will allow an evolution from the traditional low-volume manufacturing process of railway vehicles to a mass-producing process at high quality and low cost standards on dedicated production lines.

![Fig. 1. Modular Platforms as a solution for just-in-time adaptation to change](image)

As a modular platform the SMAP panel must be based on an architecture which integrates several parts, modules and systems in order to create a range of models with different combinations of functions, features, performance levels, and styling (Fig. 2). The strategic partitioning of the product architecture allows the configuration of a broaden range of product models and a low production cost can be globally achieved through the mass production of common component sets used in all models.

The SMAP strategic partitioning architecture was defined based on precise terms for cost targets, product diversity requirements and supply chain performance capabilities, segmented in 5 and 10 years planning horizon. A list of performance targets to be attained was developed, based on the rapid expansion of market share,
especially in the rapidly growing market for inexpensive panels and the average unit production cost; and on the product diversity which influences significantly the number of “varying components” specified in Figure 2. Note that, even with a large increasing in the product diversity in the future, the manufacturing and assembly costs, the carrying and obsolescence cost of finished goods inventories will be substantially reduced, due to the large set of common components (Fig. 2). All this, closely coordinated with a design process which integrates the supply chain planning creates the foundations for an improved side panel in terms of time-to-market, life cycle cost, perceived quality, and reliability.

**Conclusions**

Platform engineering designers must work closely with business goals and market strategy - the key to carrying out this design task is providing business managers with better ways of analyzing and representing consumer perceptions and wishes. Only after such analyses the business goals and strategies can be defined to give a clear direction to a platform development process. The market success doesn’t only depend of the physical form and technical performance of the product. It also depends on the available supply chain. The platform engineering designers must therefore interact intensively with the supply chain professionals to fully grasp the overall operational implications of alternative product designs.

The results achieved recently by the automotive industry evidenced that the modular platforms are a powerful design approach that requires a full definition and discipline – as well as creativity – in conceiving a focused and coordinated strategy for a modular product and process architectures. That platform thinking and platform-driven strategy as well as systems integrated supply chains, will increasingly become an integral part of state-of-art design management practice. In rail vehicles industry modular platforms will lead to drastic changes in the design and manufacturing approaches in the near future.

The modular approach to product development in railway vehicles will contribute to the establishment of a new specific market, allowing a deeper product specialization, multiple aesthetic arrangements and a market overture to other applications (trailers, buses). From the train manufacturer perspective, it is expected that this approach will allow a drastic reduction in the train carriage assembly time, from an average of 28 days to approximately 12 days. Its competitive advantage will increase and the influence, though the effects of scale, introduced by a deeper standardization, will be extended to all levels in the railway vehicles value chain.

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**Fig. 2.** Modular architecture of SMAP product line
Key words
Modular Platform Architectures; Rail Vehicles; Supply Chain; Manufacturing Strategies.

Bibliography