ELECTROMOBILITY AND MODULAR STRATEGIES ON THE EXAMPLE OF AUTOMOTIVE

Reduction in cost and complexity by using identical propulsion-specific modules across manufacturers

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Abstract

Within the context of branch-specific change processes driven by external variables in the automotive industry, modular strategies are outlined as a tool to reduce cost and complexity in the branch and arguments provided for the use of modular and platform strategies as a way for technologies of the future such as electric propulsion to keep pertinent costs within reasonable limits in the mid-term providing that identical key propulsion components are used across competitors.

1 Introduction and Subject Matter

In the automotive industry, a momentous change is ongoing that has been on the horizon since decades.[64] Boosts to productivity and improvements to production processes alone are insufficient anymore to effectively place products in the international competition. Those players in automotive keen on hedging the competitiveness of their products and their output in general in the international context need to focus more consistently on efficiency within Supply Chain Management (SCM).

A key success factor in the process at all levels in corporate hierarchies for a sustainable future has been continuous optimisation of cost, quality and temporal performance aspects.[65] This also includes a steady search for potential innovation options.

In this context, a number of manufacturers and suppliers in the automotive sector have been aware not least in view of rising environmental awareness of customers of the importance of

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64 Cf. Kurek (2004), p. 9 ff.

65 Cf. Meffert/Burrmann/Kirchgeorg (2008), p. 45 ff.

embracing and building up lines of hybrid and electric vehicles within their own brands as a key future success factor to boost their competitiveness.[66] Among such developments, for instance Daimler joined forces in March 2009 with an investor from Abu Dhabi to reinforce its future business activities not least by advancing the development of electric vehicles and low-weight composite materials for fuel-efficient cars.[67]

Further the automotive industry has been faced since years with advancing differentiation as a result of growing customer expectations.[68] This means a larger variety of product variants at shorter lifecycles. In order to reduce complexity, strategies have been conceived so as to contain the diversity of variants with sc. product platforms and the modular concept.[69]

Platform and modular strategies provide a way for technologies of the future such as the electric propulsion to keep pertinent costs within reasonable limits over mid-term providing that identical key propulsion components are used across competitors.

2 Modularisation as a Tool to Reduce Cost and Complexity

There has been a consensus in the automotive industry as regards the definition of modularisation. Modularisation at the product and component level signifies as a technical design principle the breakdown of a product into interchangeable, replaceable parts or modules.

By using modular concepts, automotive manufacturers as industrial producers pursue the ability to produce in a cost effective manner a wide variety of product variants in order to comply with growing demands on part of their customers as regards customisation. In the process, the automobile in its entirety is broken down to individual units to predefined criteria. Figure 1 exemplifies modules used by GM across models and/or worldwide in the architecture of their mid-class vehicles.[70]

66 Cf. Agentur für Erneuerbare Energien (2009), p. 1.
67 Cf. Buchenau (2009), p. 18.
68 Cf. Strassner (2005), p. 66 f.
69 Cf. Schwenk (2001), p. 20.
70 Cf. Anonymus (2008), p. 1.

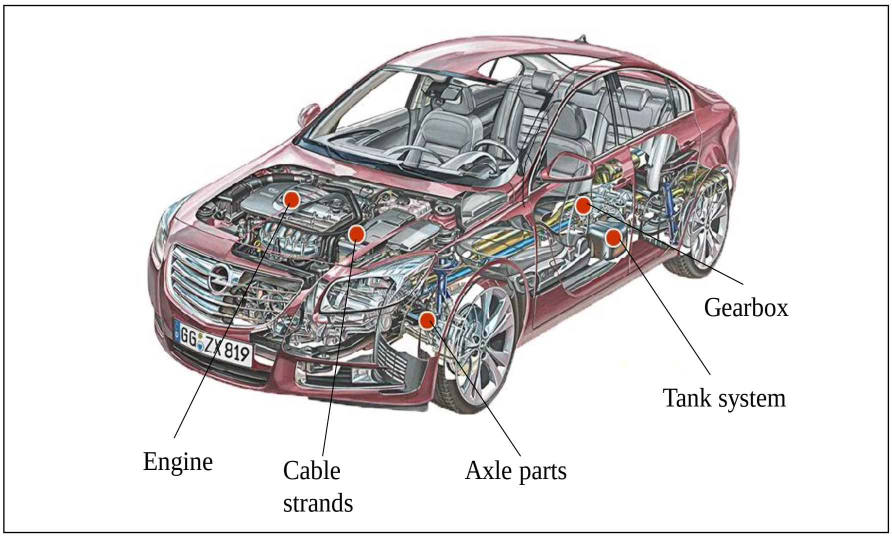


Figure 1: Shared modules across models at GM for Opel Insignia.

Source: author's own visualisation based on Anonymus (2008), p.1.

The key strength of modular strategies lies in the reduction of variants and ensuing economies of scale, which means effectively lower development costs, smaller investments and a cutdown in manufacturing costs.

Modular strategies entail for newly designed and implemented (electric) vehicles using the concept the potential of further cost reduction within automotive design and manufacturing processes. For example the OEM Daimler is developing a modular component system for its electric vehicles, embracing the modular concept as a strategic line of thought for the future.[71]

In this context, cooperations are observable as a promotor and a trend in the automotive industry that focus on further advancing and refining not least also the classical platform strategies.[72]

For instance by using modules, complexity in production is to be curtailed and cost savings achieved.[73]

OEMs and most suppliers have been increasingly involved in advancing the electric age of automobiles.

71 Cf. Daimler AG (2010), p. 1.
72 Cf. Volkswagen AG (2010), p. 1.
73 Cf. Herz (2010), p. 1.

In view of the developments, the discussion in the following parts examines the strategic chances and risks of using platform and specifically modular concepts in connection with said technology of the future.

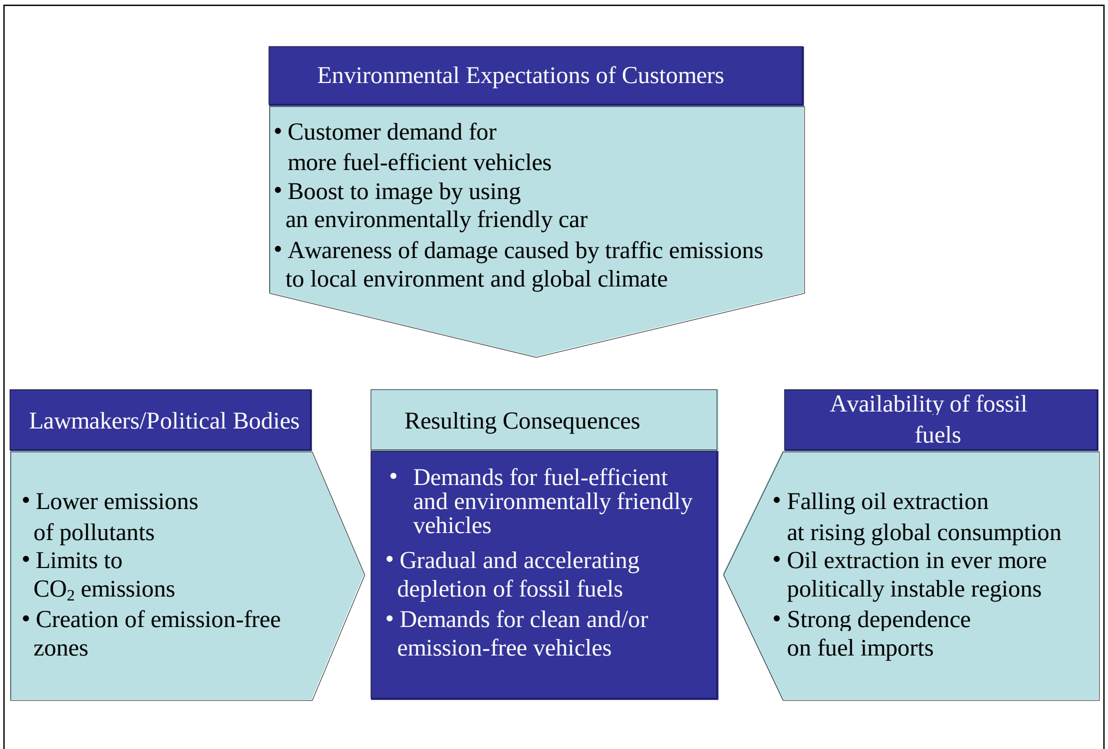
3 Electromobility and Modular Strategies

3.1 Determinants: Diversification and Electrification of Propulsion

The key driver even in 2011 still is identifiable with the ongoing shift towards and development of hybrid and electric vehicles and underlying technologies. Figure 2 provides an overview of the drivers behind the advancing diversification and electrification of propulsion in automobiles.

Environmental awareness as a factor has been on the rise of both private car drivers and logistical service providers. A note is due in this respect that customer knowledge of environmental protection activities and climate-friendly mobility has been improving all along as well.[74]

When buying an environmentally friendly car, the customer is faced with the task to correlate the acquisition cost with the vehicle operating costs. On the one hand the purchase of something like a hybrid car entails higher acquisition cost.[75] These are offset however with savings in operating costs such as fuel costs, and tax allowances. According to experts, "in terms of comparison of total costs (...), the customer is likely to benefit from the purchase of an environmentally friendly vehicle in the long term."[76]



[74] Cf. Deutsche Post AG (2010), p. 1.
[75] Cf. Aberle (2010), p. V 11.
[76] Wallentowitz/Freialdenhoven/Olschewski (2010), p. 23.

Figure 2: Determinants of diversification and electrification of propulsion

Source: author's own scheme based on Wallentowitz/Freialdenhoven/Olschewski (2010), p. 3.

As regards determinants at play on the demand side, it may be held that the shift in customer attitudes towards higher weight of environmental protection efforts has an effect on customer purchase decisions, hence makes a relevant promotor in as far as both OEMs and their suppliers have to adapt their product strategies accordingly. In order to comply with customer expectations into the future, more consequent effort is needed in the development and serial production of electric vehicles.[77]

The trends have been confirmed also by Wyman (2007) who outlines a paradigm change in the stances and attitudes of potential car buyers. Accordingly, the buyers intend on their next car purchase…

- 80 percent of customers to pay better attention to environmental factors;
- 30 percent of customers are likely to switch to a more environmentally friendly form of propulsion;
- 18 percent of customers are likely to prefer an environmentally friendly variant of an existing line of products;
- 12 percent of customers plan to buy a car with a smaller engine.[78]

In conclusion, it may be held that due to rising complexity in the automotive sector, product structuring schemes are needed that enable OEMs to react in real time to external developments.[79]

3.2 Strategies of OEMs for Electromobility

As regards optimisation of vehicle drive systems, OEMs have been intensifying their efforts towards electrification of propulsion.[80] For instance Audi has erected in Ingolstadt, Germany its research facility for electrical engineering. The institute is located next to the OEM's manufacturing plant. A 1.000 scientists at the center have been involved in researching and designing electric systems and components for the Audi E-Tron. The model development is due to be completed

[77] Cf. Fasse (2010), p. 6.
[78] Cf. Wyman (2007), p. 1.
[79] Cf. Plapper (2008), p. 28 f.
[80] Cf. Dörner/Eberle/Herz (2010), p. 5.

within a mere four years. In contrast the standard completion time for such projects is typically around seven years.[81]

Electric vehicles have become a key technology of the future for the branch.[82]

"Electric drive systems are going to further grow in significance in the future for use as traction in hybrid and all-electric vehicles given that electric propulsion as a multifunctional torque actuator can be used in a wide variety of applications and makes a significant contribution towards environment protection and conserving resources."[83]

A particular characteristic of electric propulsion as compared to other propulsion concepts is its emission-free operation on the basis of an energy carrier with versatile application. A full electrification of drive systems also means a full-scale replacement of the combustion engine.[84]

However, this also implies that a change in thinking is needed with regard to those parts and components in vehicles that rely indirectly in their function on the engine. The one core and common feature of the electric drive concept is the so called 'pure' electromotor as the only energy converter. Differences exist in how the energy is supplied to the motor. As the variant with potential for the future, battery and fuel cell-powered electric vehicles have found support. Ultimately, electromotors draw their energy from a single source, which is the electric socket. For the purpose, a traction battery is connected to a socket and/or docking station and recharged. The battery storage capacity determines the vehicle driving range.[85]

To ensure competitiveness, for instance the OEM VW pursues an efficiency increase of about ten percent annually over the next years. This combines with the target of a substantial increase in sales of VW vehicles. As compared to 6.3 million vehicles sold in 2009, the OEM aims at target sales of over ten million automobiles in 2018.[86]

Within the strategic targets, electric vehicles enjoy material significance.[87]

By 2018, VW aims to reach the status of market leader in the electromobility sector and production of electric vehicles on an industrial scale.[88] Electric vehicles are projected to account for three percent of sales volumes by 2018, which corresponds to sales figures of about 300,000 battery-powered vehicles. The figures are based upon VW’s expansion plan that aims at a sales figure of ten million automobiles worldwide.

Despite the positive trends outlined, persistent difficulties remain in some areas as regards electrification of propulsion in automobiles.

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81 Cf. Herz/Fasse (2010), p. 20.
82 Cf. Flauger (2010), p. 62.
83 Schäfer (2009), p. 1.
84 Cf. Helmers (2009), p. 112 f.
85 Cf. Helmers (2009), p. 139.
86 Cf. Schneider (2010), p. 3.
87 Cf. Wallentowitz/Freialdenhoven/Olschewski (2010), p. 156.
88 Cf. Dörner/Eberle/Herz (2010), p. 4.

In the research and design stages of all-electric vehicles, one needs to be aware that the price and cost factor is going to remain a key determinant of customer preferences also in the future.[89] The currently most pressing issues include cost aspects, the vehicle driving ranges as determined by battery technologies and grid availability and dependability.[90]

Though practically every OEM worldwide has been steadily coming up with new models with fully electric drive[91], the vehicles currently are not economically viable for the mass market. The key reason in particular is the high cost of batteries. Due to this single factor, electric vehicles typically are priced about twice as much to comparable models with classical combustion engines. A C-segment electric car currently costs despite substantially shorter range by about 10,000 to 15,000 euros more than an equivalent car with combustion engine. Schraven (2009) stresses out the still significant amount of time needed until the electric car becomes a full-fledged alternative to classical combustion engine. Experts estimate this period to last as much as up to 20 years. A steady progress in the field is hindered particularly by the high cost of electromotors and batteries. The accumulator alone weighs in at about 8,000 euros.[92]

Battery technologies also are the root cause of another frequently mentioned obstacle to market penetration of electric vehicles on a wider scale, which is their driving range. The range is limited by the battery storage capacity and currently stands at around 200 kilometers on average. Contemporary battery solutions are suitable for short to medium distance trips, thus make a viable option for driving around in urban centers and agglomerations[93]. Finally, prerequisite to effectively succeed in the markets is a properly functional and comprehensive grid of docking and/or recharging stations so that vehicle user of a typical small car has sufficient options available to recharge their vehicle. In addition, charging takes fairly long at typically around 3.5 hours.

On the other hand since 2009, a common standard has been in place for docking plugs and sockets as a result of agreement between OEMs and utility providers. This allows to shorten charging periods.[94] As part of its analysis of pertinent chances and potentials, the German Federal Ministry of Education and Research (2010) identified the following weaknesses relative to electromobility that need to be addressed: .[95]

- Insufficient level of maturity of manufacturing processes for battery systems;
- A need to expand R & D with view to battery technologies and to focus more consequently in training the new generation of scientists on electromobility-related fields;

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89 Cf. Vahrenkamp (2007), p. 4.
90 Cf. Fasse/Flauger (2010), p. 28.
91 Cf. Aberle (2010), p. V11.
92 Cf. Schraven (2009), p. 1.
93 Cf. Wallentowitz/Freialdenhoven/Olschewski (2010), p. 60.
94 Cf. Schraven (2009), p. 1.
95 Cf. Bundesministerium für Bildung und Forschung (2010), p. 16.

- Cooperations between OEMs, utilities/the power industry and battery producers only starting to take off;
- Lack of manufacturing experience with electric drive components;
- Optimisation of norms and standards

Accordingly, the changes needed to vehicles as a result of electrification of drive systems concern a broader range of players as opposed to OEMs only such as VW or BMW.

Carmakers typically operate in sc. networks and engage in cooperations with suppliers and battery producers, political bodies and utilities in order to advance the new technologies further.[96]

The cooperation-related aspects are discussed further herein.

4 Cooperations with Regard to Platform and Modular Concepts

Cooperation amounts to a form of coordination within the value creation process between two or more enterprises and/or institutions.[97]

Cooperations involving players from the automotive and utilities ensue as a result of a comprehensive perspective on value creation applied to electromobility as a technology of the future. This allows by exploiting diverse strengths such as specialisation in the particular field of battery development to steadily overcome various difficulties.[98]

A key difference between the cooperations and classical trade relations relates to the fact that the cooperations ultimately aim at a long-term business relationship. In general, the main purpose of cooperations in the automotive industry involving modules has been joint targeted action of different players in order to reach e.g. economies of scale.

The core focus in the process is on coordination of activities "that are directed at a shared set of targets (…)."[99] In July 2010, top officials of OEMs BMW and Mercedes-Benz held talks on potential mutual cooperation schemes. Accordingly, the players pursue substantial savings by using e.g. shared identical modules in smaller-scale future projects. Specifically, the two OEMs have reached agreement on developing shared seat sets for all vehicle classes of BMW and Mercedes. The deal involves planned investments in double-digit million figures.

By using the new seat modules in BMW and Mercedes-Benz models throughout their respective portfolios, experts predict annual savings for each of the two OEMs to around 150 to 200 million euros. To sustain the effort, BMW and Mercedes-Benz have defined common standards for a total of 50 parts in order to facilitate purchases of modules at better prices.[100]

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96 Cf. Wallentowitz/Freialdenhoven/Olschewski (2010), p. 159.
97 Cf. Bundesvereinigung Logistik (BVL) e. V. (2003), p. 70.
98 Cf. Wecker/Froschmayer (2003), p. 513.
99 Vahrenkamp (2007), p. 17.
100 Cf. Anonymus (2010), p. 57.

Through cooperations as a means of further advancing electromobility as a technology of the future, the following aims are to be achieved among other motivations:

- Specialisation, with existing staff insights in their respective fields such as optimisation of battery technologies given that the activities amount to core competences of the respective firm such as Panasonic. Also the high frequency at which such tasks are performed aids shorter training-in periods. This goes along with shorter machine setup times. Accordingly, effects can be exploited of the learning and experience curve.
- Cost degression, with the ability to distribute corporate fixed costs among a larger number of business transactions. Through engagement on behalf of several customers, options arise to bundle a number of orders with ensuing increase in volumes, hence opportunities to implement economies of scale. In the process, the higher output promotes an advanced level of automation at reduced personnel costs, thus exploiting effects of scale.[101] For example the battery producer Sanyo is engaging in cooperations with OEMs Honda and VW.[102]

"Cooperations that are motivated by future electrification of drive systems mainly are seen in the fields of battery technologies, electromotors and integral vehicle design with joint development and use of platforms and modular systems. Such cooperations may take place at various levels such as between OEMs, within corporations or intergroup, and between OEMs and suppliers or utilities."[103] For instance the cooperation of Audi and VW is a case example of intragroup cooperation. The cooperation involves project for a new model, the Audi A2, an all-electric car that is to be built on one of the already existing platforms in use within the group and take modules from the shared modular system assessed by both VW and Audi. For electric vehicles, such modular systems are significant where the aim is to offer customisability and variety to the customer even despite initially low numbers of units sold.

Through economies of scale and the use of shared component strategies, such strategies facilitate savings in production costs.[104]

Notwithstanding the positive effects however, there are also apparent risks in practical applications concerning cooperations of OEMs and shared use of specific modules.

The following Figure 3 provides an overview of the range of respective chances and risks. These relate to cooperations and working in conjunction in the development of technologies for the future or in sharing specific modules.

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101 Cf. Thommen/Achleitner (2006), p. 174.
102 Cf. Wallentowitz/Freialdenhoven/Olschewski (2010), p. 159.
103 Wallentowitz/Freialdenhoven/Olschewski (2010), p. 156.
104 On the subject, compare Junge (2005), p. 91; Schwenk (2001), p. 20.

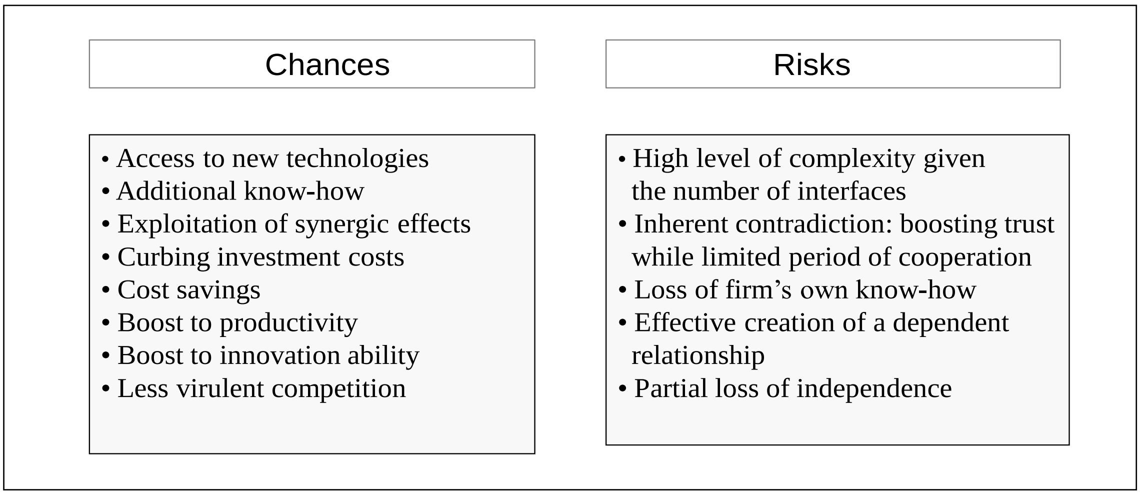

Figure 3: Risks and chances of cooperations and in sharing specific modules

Source: author's own compilation based on Wallentowitz/Freialdenhoven/Olschewski (2010), p. 155.

5 Conclusions

Given the increasing competition, OEM are faced with the need to continuously scrutinize and optimise both their internal and external processes in automotive development. The aspects involved in the process include reduction in complexity in product design and manufacturing processes, full compliance with market and customer expectations and cost savings in all areas. These are the essential prerequisites to boost efficiency of OEMs.

Given the various promotors and environment variables at play, fully electric drive makes the ideal concept for environmentally friendly propulsion of vehicles for the future. With view to current status as of 2011, it may be held that electromobility as it is called has been in a progressively dynamic development process. Along the way, not even technologies of the future cannot escape the principle of causal adequacy between product and process structures and cost structures.

As tools to shape the automotive development and manufacturing processes more efficiently and to advance electromobility as a technology of the future, the modular and platform concepts have been briefly outlined herein. Specifically platforms comprising a number of modules each can be used across different segments. Platform strategies and modular concepts may help reach maximum customer-perceived benefits while also providing useful ways to reduce and/or contain complexity. According to experts by using modular strategies, savings are possible of up to 20 percent in investment costs, 20 percent in material costs and 30 percent on throughput times.[105] Ways in which modular strategies may aid cost reduction include for instance using identical

[105] Cf. Hackenberg (2011), p. 1.

modules for several different personal car models and across brands. Given inclusion in all the existing platforms of an OEM, a new module only needs to be developed once. Consequently, the key strength of modular strategies relates to reducing the number of variants and pertinent effects of scale.

With view to potential future use of platform and modular strategies in relation to electric drive as a technology of the future, the concepts provide a viable means to keep respective costs within reasonable limits over mid-term. For the purpose, more consequent engagement is needed in research and manufacturing cooperations of the players involved. In a further step, competitors need to coordinate and find agreement on the use of 'identical' modules and/or key propulsion components. In essence, no OEM may expect to idle and stand by amidst the dynamic changes in the branch. The order of the day involves using platform and modular strategies with a view to electrification of vehicle drive systems. Obviously not every innovation by OEMs spells instant success. However, lack of innovation on the other hand invites failure in competition and a loss of market leadership in view of technologies of the future. Those OEMs who respond best to market and customer expectations in the field of technologies of the future, relying on cooperations where needed, and acting at the forefront of both the development and real-time implementation of the technologies, may be expected to prevail also in future global competition. The concepts discussed herein may prove helpful tools in the process.

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