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SYSTEM SOFTWARE (OS)



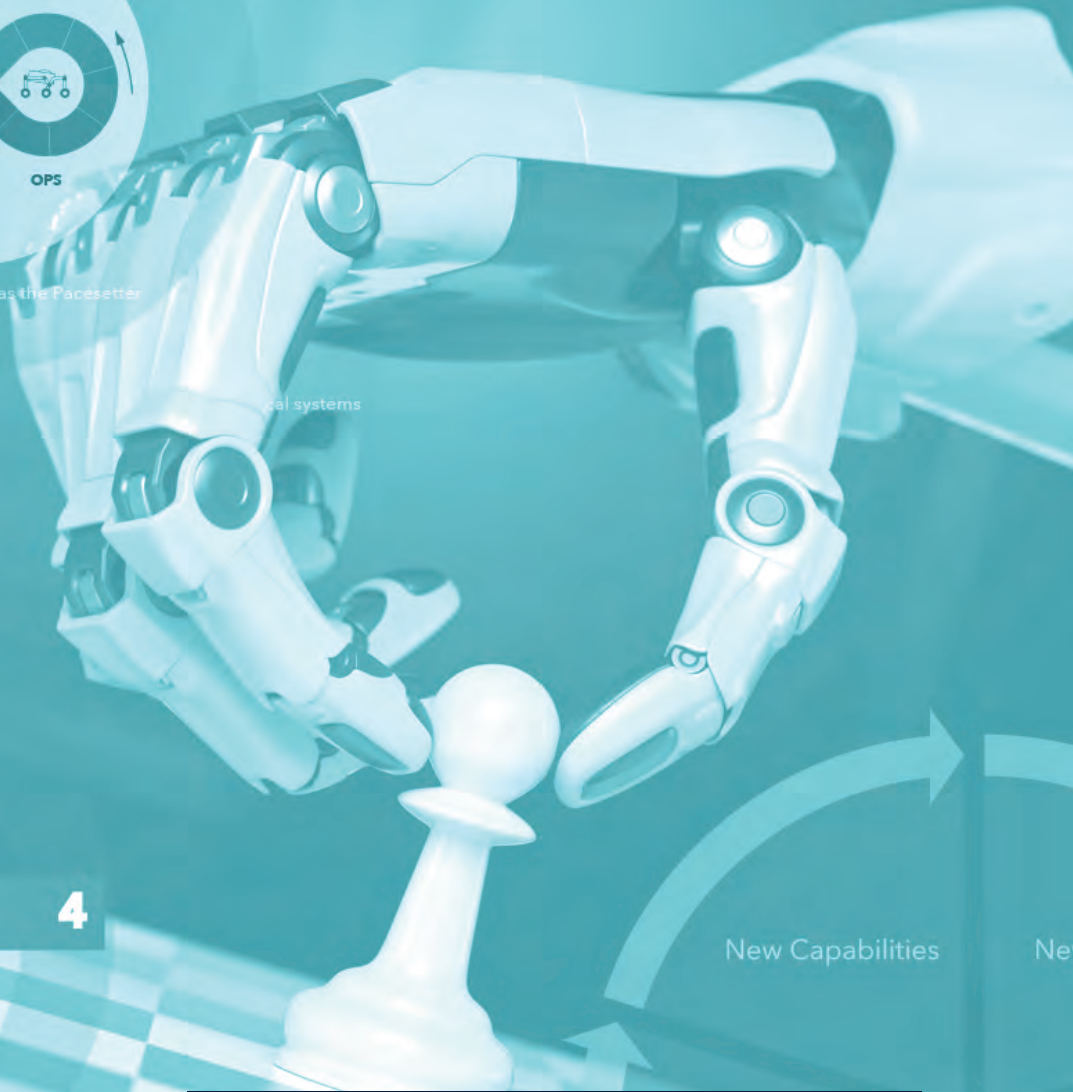
New Development and Synchronization concepts



Software Intelligence as the Pacesetter

Hardware Cycles

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Strategy Discussion

New Capabilities

Ne

Responsibilities



prostep IVIP

prostep ivip White Paper

Strategy options for the prostep ivip Association

reflected in the needs and changes in the industry

New Value Chain / Partnership

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Dear Sir or Madam,

a range of strategic action areas in which the Association must act in order to be optimally equipped for the future.

We are convinced that the association's products and services must more closely reflect the paradigm shift brought about by the digital transformation in terms of development practices. Many industrial companies are searching for individual approaches to ways in which they can use digital tools to transform their development, manufacturing, service operations, etc. and develop new data-driven business models. Based on our observations of the context in which such companies act, we want to fine-tune our vision of the future and offer our members collaborative concepts that will help them get to grips with the digital future.

In this White Paper, we consider three of the strategic action areas, namely the association's image, its target group and area of activity, and its vision of digitalization. Based on observations of the current context and a definition of the main drivers of the digital transformation, we want to elaborate the association's vision of the future before going on to indicate the measures necessary for the realization of these aims. But we do not want to do this alone. We are constructing an extended working environment in order to enter into a dialog with key stakeholders and supporters of the association and discuss future collaboration in order to fine-tune the direction we want to take. This White Paper is intended as a basis for discussion and will be gradually extended by suggestions and ideas from external contributors. We want to promote the shared awareness which will help the association and its board set the right priorities for our future work.

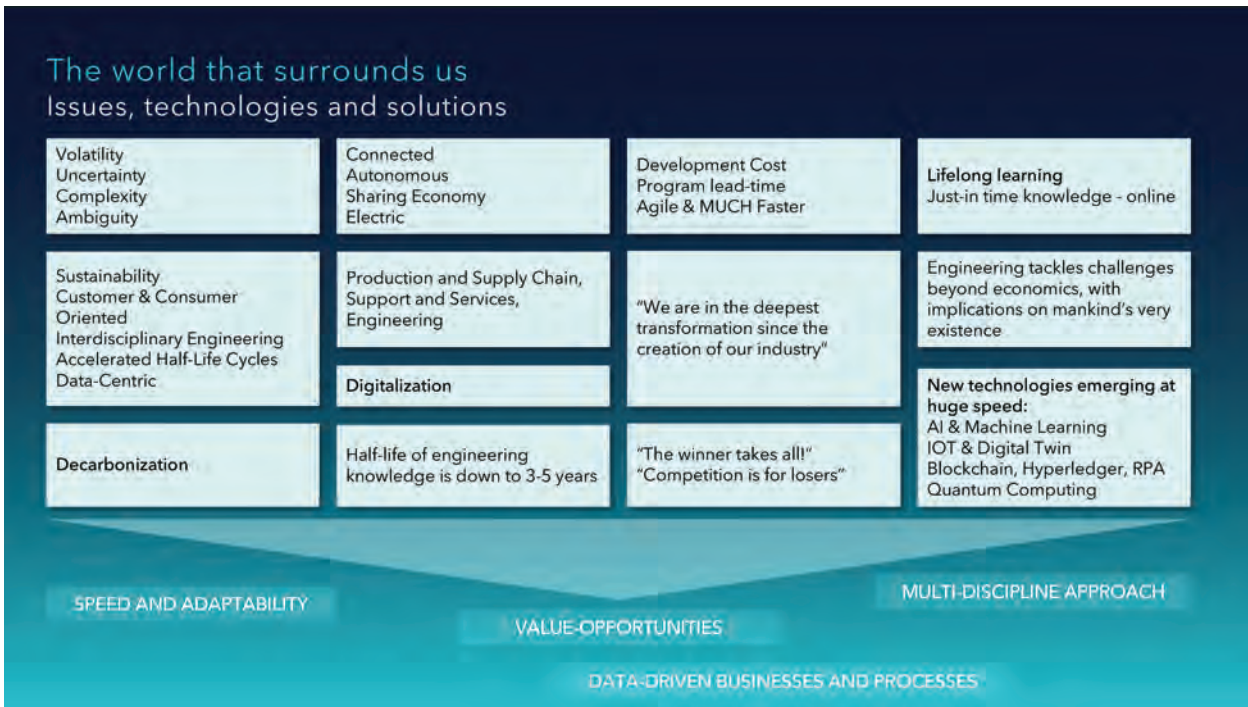
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We would be delighted to have you "on board" with us and are certain that you will be able to give us valuable feedback so that we, acting as a community, can take the measures required by the digital transformation of industry.

Best regards,

pp Dr. Alain Pfouga
General Manager
prostep ivip e.V.

1. The context of the transformation



It is not just since the Covid-19 pandemic that the world has been characterized by a new normality, which many authors describe using the acronym VUCA (Volatility, Uncertainty, Complexity, Ambiguity). This is intended to express the fact that the world is becoming more complex, is constantly changing and that these changes will become increasingly difficult to predict. Companies must therefore be able, or be made able, to react in fast and flexible (if not to say agile) ways to new technological challenges and market demands. One of the greatest of these challenges is digitalization itself. Companies are looking for new potential value-added through data-driven business models and processes and have to understand that the platform economy will, at least for a time, take precedence over the rules of the market economy. If the principle is "the winner takes it all" then competition is something for losers.

Digitalization is borne on the wings of dynamic technological change. New technologies such as the Internet of Things, digital twins, artificial intelligence and machine learning, blockchain, quantum computing etc. are in a state of constant development and inspire and feed into one another. Among other things, one effect of this is that the half-life of our technological knowledge is shrinking. Engineering knowledge is also undergoing ever more rapid change - three to five years after completing one's university degree, it is obsolete. We must all therefore get used to the idea of life-long learning and companies must find ways to provide their employees with up-to-date knowledge whenever they need it.

More than ever before, engineers are having to address questions that will influence the future of humanity, such as climate change or how to feed the world's population. Sustainability is one of the most important market and customer requirements and many of the associated aspects are set out in legal provisions. At the same time, customers are becoming ever more demanding and place value on individuality even in standard products, thus resulting in increasing numbers of product variants. Many manufacturers are attempting to map this variance in software, which is quicker to develop and adapt than mechanical components. The growing software content of products and the service offerings this gives rise to (e.g. updates over the air) demand not only interdisciplinary engineering but also closer collaboration between engineering, supply chain, support and service.

Particular challenges confront the automotive industry, which is faced with the greatest transformation since the invention of the automobile (according to Toyota's managers). It has to cope with four technological megatrends simultaneously, for which industry experts have coined the acronym CASE. This stands for Connected, Autonomous Shared and Electric. In some cases, these megatrends reinforce one another: Autonomous driving requires networked systems, and autonomous vehicles in turn promote new business models in which users share their vehicles. It is as yet unclear what concrete effects this will have on the traditional value chains in the automotive industry.

2. The core drivers of change

All the issues mentioned in the preceding section have something to do with speed, adaptability and multidisciplinary, i.e. integration and collaboration. The question, however, is how to concretize this mixture of problems, possible solutions and technologies in relation to actual action scenarios.

That is why, in this context, we have attempted to identify the main drivers of the transformation, those which exercise the greatest pressure for change on businesses and therefore also on the association.



2.1. Ecological footprint

One important driver of change - and not only in the automotive industry - takes the form of the ever more stringent legal requirements concerning climate protection and the reduction of CO₂ emissions. They define absolutely binding constraints for the development, manufacture and use of products. Legislators in various countries, for example, want to know the ecological footprint of manufacturers' vehicle fleets. Some of them are considering completely banning internal combustion engines in the shorter or longer term. In other sectors such as the steel industry, the ecological requirements focus more closely on the production processes. However, the issue of sustainability should not be thought of first and foremost as a restrictive constraint, but as the driver for important innovations in key sectors, such as the automotive, high-tech or aviation industries. Companies must react to the new social demands in their product development, production and marketing operations and this is where the association may be able to help them.

2.2. Future market and customer requirements

Globalization and urbanization are major drivers of future markets and customer requirements. While companies today are developing their operations throughout the world, they must nevertheless take account of local requirements and specificities. The direction that the mobility of tomorrow will take will probably not be decided in Germany or Europe, but in the USA or China. The economic importance of Europe is generally declining, whereas that of upcoming countries such as China and India is growing. One unanswered question is that of the economic role that Latin America and, in particular, Africa will want to play this century - continents in which the population is growing dramatically. To an even greater extent than population growth, increasing urbanization will influence the mobility and consumption behavior of people in many countries.

2. The core drivers of change

What is clear is that in future, we will all purchase fewer products and more services, or use increasing numbers of products in the form of services. This will transform the value chains and networks. Due to product-service systems and products as platforms, value creation is increasingly shifting from hardware to software and consequently to new actors in the value chain. It is not for nothing that the OEMs in the automotive industry have now identified software as a strategic domain and are attempting to extend their own expertise in this field. Otherwise they run the risk that tomorrow's customers will buy a mobility solution from WAYMO coupled with an outstanding hardware design from Mercedes. In the future, companies will require support in order to position themselves optimally in the changing value chain. This could be a new area of activity for the association.

2.3. Digitalization

Digitalization is a driver of change in many different ways. At present, IT is gaining entry into products in the form of software and taking over the control of functions which are, in part, becoming increasingly critical for safety. Many automotive OEMs are founding separate companies for in-vehicle software because they have recognized the need to act in this area. The association currently offers them little support. It is only a short step from software in products to the networking of devices. IoT platforms are becoming the common hub for the evaluation of the data acquired by these devices. Households and cities are developing into networked worlds with a multiplicity of systems of systems which communicate and exchange data with one another. The development, as well as the manufacture and operation, of these systems of systems are

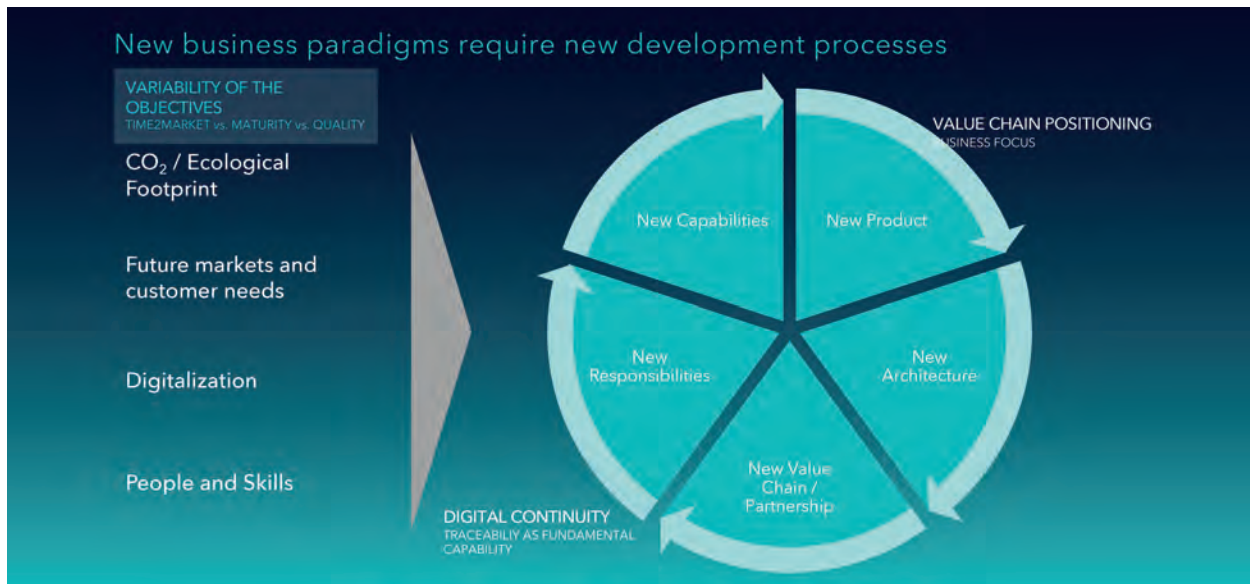
placing new demands on the overall image that companies want to project of themselves. Here, the association could play an advisory role.

2.4. People and skills

People are the protagonists of change which, in turn, demands new skills and capabilities of them. For them, the shrinking of the knowledge half-life represents an enormous challenge because it demands that they constantly learn new material not only in terms of the content of work but also in their way of working. Yesterday they still had to be agile, today they have to work together online with colleagues around the world from their home offices. Although globalization has harmonized the work culture in various countries, there are nevertheless still considerable differences, for example the error cultures in different companies and the relationship to superiors. Enabling people and adapting their processes could be an important task for the association.



3. How does change work



The four core drivers that we identified above are interconnected and cannot be discussed independently of one another. This raises the question of how we can adapt our actions to the situation as it is and evaluate their effects. Clearly, we must consider the drivers in the context of a company's overall system structure. The development of a new, intelligently networked product-service system raises, for example, the question of whether a company or its business architecture is equipped for this holistic product concept, starting with the organization and processes and moving on through the level of data and applications and onto that of the technical infrastructure. A Tesla is not just a piece of hardware but a traveling IoT device which can be functionally modified via software updates. This means, for example, that Marketing can offer further services in addition to the sale of the vehicle itself.

However, in the world of systems of systems and product platforms, it is no longer enough just to think in terms of the corporate architecture. Manufacturers must also rethink their value chains and partnerships and possibly also restructure these. The boundaries of the system extend beyond those of the enterprise itself. It is possible, for example, that manufacturers of household appliances will at some time have to integrate their products in a comprehensive smart-home platform and allow third-party software to access their devices so that they can, for example, use weather data or trigger ordering processes. In extreme cases, the value chains will be turned on their head and manufacturers of premium vehicles will be degraded to the status of pure hardware suppliers that deliver interchangeable components of an overarching mobility concept. This will go hand in hand with a transfer of liability-related and other responsibilities to the manufacturers/operators of the product-service systems,

thereby increasing the pressure of verification requirements in system development.

Depending on the role a company wants to play in the value chain in the future, it may need to construct new capabilities, for example in the field of model-based systems engineering (MBSE) or system development and recruit employees with the corresponding skills. First and foremost, however, it will have to qualify more intensively than ever before the end-to-end digital traceability of the development steps and deliverables as well as possible combinations of the previously disjointed and extremely heterogeneous development approaches (e.g., V-model, DevOps).

The correct composition of the value chain and the company's own position within the chain of partners are critical success factors for achieving the development aims, which may vary on a case-by-case basis. But how is it possible to measure the success of the development goals? The key point is that in a global approach, the maturity of the overall system is more important than that of the individual components. Thanks to this, it is possible to avoid missed synchronization points and late changes, all of which can cost a lot of money. For this to be possible, it is necessary to adopt other approaches, for example model-based harmonization for design reviews. To sustainably improve the ecological footprint of products, I not only need new drive systems but also have to ensure the traceability of the digital information at all times as set out in the legal requirements.

4. The future vision of the prostep ivip Association

On the basis of these core drivers of change, this section aims to develop a vision of the work the association will perform in the future. It is essential that this future vision takes account of our history of more than 25 years as a pre-competition collaboration platform for standardization because we cannot and will not disown our heritage, if only out of respect for our members. The question is whether it is more efficient to start by addressing the context and then deriving a vision of our new target groups from this or to consider which target groups would represent a meaningful extension of the association's scope and then adapt our vision accordingly in order to meet their requirements (the chicken-and-egg problem).

4.1. The role of the prostep ivip Association

The association sees itself as a globally active, independent network embracing industry, IT and research. The focus of our work lies in digital transformation in the fields of product engineering and production. To this end, we formulate and bring together the needs of manufacturing industry vendors and suppliers, define standards and interfaces, offer IT vendors a forum for greater interoperability, and perform neutral benchmarking. Our members appreciate the opportunity to work together in a comprehensive technical program and network with other members in order to enhance our combined power to influence user groups, vendors or regulatory authorities. They have recognized the overall significance of the interaction between the different membership groups in making it possible to remain up to date with technological developments without always having to be active in each individual field.

IT vendors primarily join the association because they expect this to bring about added value for their products and entire service spectrum. However, as an association, we stand above the individual interests of our members and attempt to achieve optimum solutions for them irrespective of the employed software through mutual collaboration that embraces the entire community. This neutrality is an important characteristic of the association and one that makes it a unique trust-based network for industry. We are convinced that other target groups can also benefit from this role.

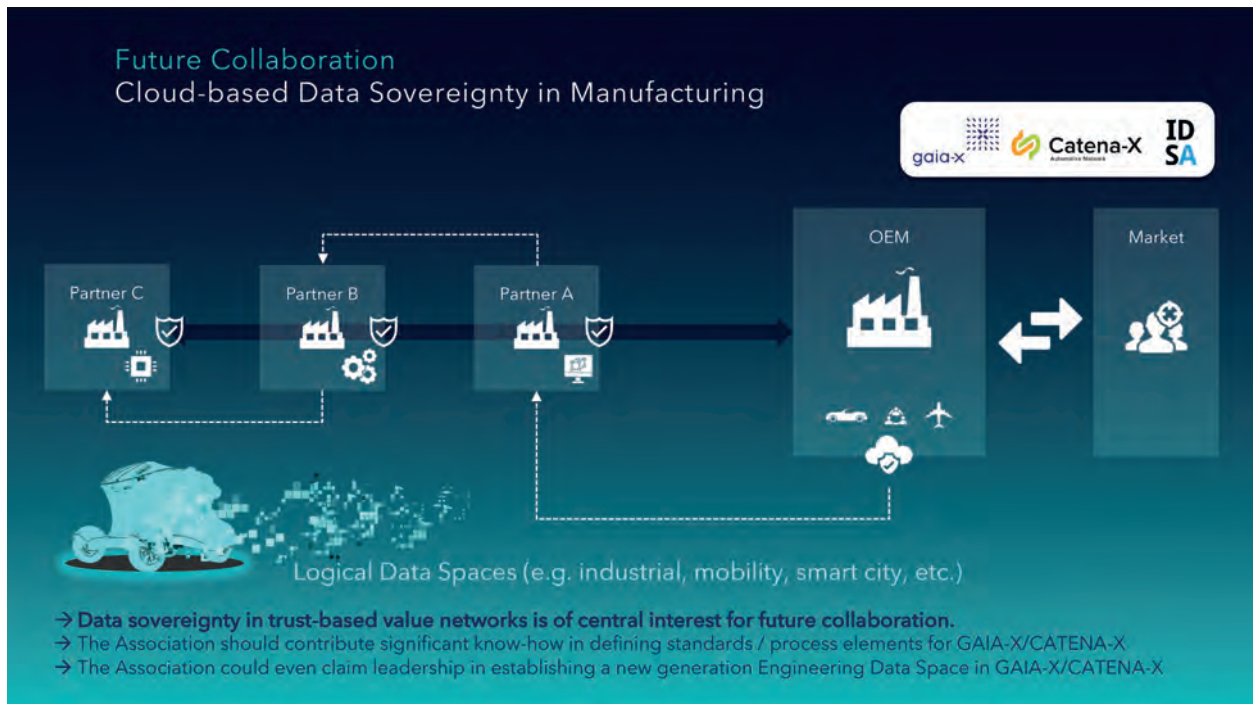
4.2. Addressing new membership groups

We are a highly IT-oriented association. New subject areas and projects are usually initiated by engineering IT. In the light of the core drivers of change, we should broaden our horizons and open ourselves up to new membership circles. First and foremost, we should integrate the specialist areas more intensely in the individual disciplines as well as at the cross-disciplinary level by addressing the issues of process expertise and skills more closely. The focus is moving from data formats, with which we have concerned ourselves in the past, toward end-to-end data flows. The question is how far we can go in this direction without alienating our existing members.

Model-based systems engineering (MBSE) is a key subject area if we are to establish new, model-based cooperative structures in the value chains. That is why a number of the association's project groups have been working intensively on this issue for years. However, if we are to make the results of our work known more widely, we need more support through cooperations with other partners.

In-product IT or software has grown enormously in importance in recent years. For example, many of our members have started to develop vehicle operating systems themselves. We are convinced that we must pay heed to this development; however, the question is just how far we should go. Although our current technical program is receptive to all sorts of questions and issues in the field of software development, there are many highly domain-specific areas such as branching, quality assurance, SIL/HIL etc. in which we possess no expertise and are therefore considering whether this is a strategic direction that we should pursue. The same applies when we look at in-the-field product-service systems, an area in which topics such as the digital twin and IoT play a central role. Here, we must broaden our horizons and acquire new user groups from the service and operating environments.

The association has supported industry in the past with methods-related questions concerning development strategies and will do this even more in the future. It would be desirable to work together with important



stakeholders from the automotive and aviation industries in order to establish a discussion forum on underlying digital methods and IT strategy-related questions that will help us clarify the necessary changes and set the right priorities.

4.3. The options available for change

In principle, three options are open to the association for its change of orientation, and these may even demand that it reconsider its very purpose. We, as the elected board, must let ourselves be guided by the goals we wish to achieve on behalf of our members.

- The first option is to continue our successful efforts in the field of cross-enterprise process optimization, possibly by initiating standardization measures suitable for the age of digitalization. In this option, the association will, first and foremost, take on a leading role in defining the corresponding IT standards, build up a good relationship with the standardization boards and bring new knowledge to the engineering processes, in particular.
- The second option is to pursue our mission of digitalization based on a forward-looking package of measures because we recognize that digitalization will be so all-embracing that everything we have done so far is no longer enough. We consider that profound changes are necessary if we are to use digitalization purposefully in the engineering collaboration context. However, this option demands tough discussions about the extent to which digitalization is truly meaningful and profitable, or whether it is simply a source of additional effort and special problems. Such discussions have

not yet taken place in the association because we have primarily addressed the possible solutions and less so the identifiable risks.

- The third option means a complete realignment, away from traditional IT process excellence and towards new value-creating topics for the future. Instead of concerning ourselves with standards and implementation, we will address completely new subject areas in order to take proper account of the massive changes brought about by digitalization. Over the next five years, we would have to address these in a number of stages which would have to be defined in more detail. However, even now it is possible to identify radical changes which would have to be addressed: Engineering via cross-platform data and model streaming, transition from gateway-oriented project management in engineering to incremental, data and model-based compatibility, validation and verification, as well as the disappearance of conventional OEM/supplier relations.

The more radical the changes turn out to be, the more intensively we would have to think about how we are to initiate them, whom we are to bring on board to help us with them, how we carry our existing employees along with us on this path, and how we can ensure that we are noticed by new membership groups. And we would have to be clear about the processes and new capabilities that we require for the products of tomorrow.

5. Suggestions for the realization of the future vision

To realize its vision of the future, the association needs new avenues for collaboration. It might be necessary to adapt the technical program more intensively than previously thought. It will be necessary to set up project groups that can continuously address these new digital processes in the fields of development, production and service. The association's very DNA will have to adapt.

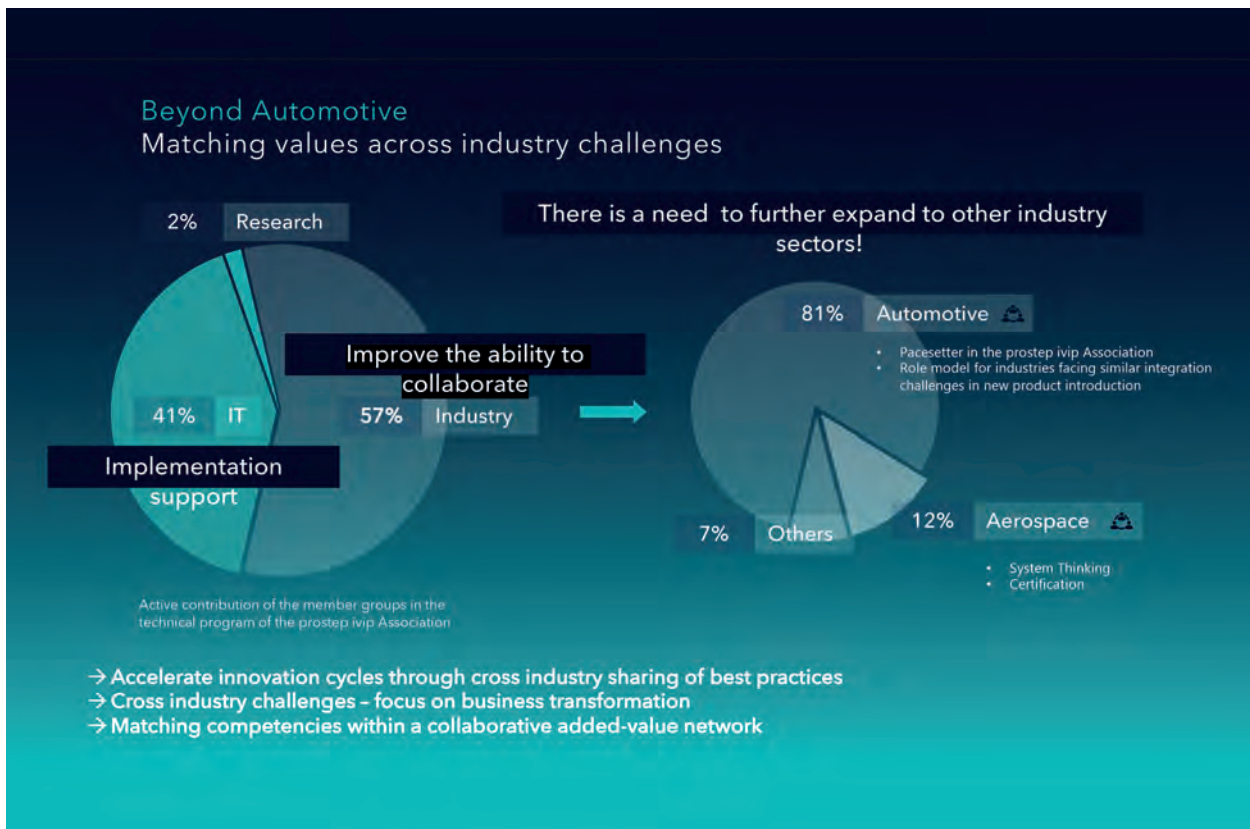
To do this, we need to unite all membership groups in a concerted effort that exceeds anything in the past. So let us all agree that the effort will be worth it!

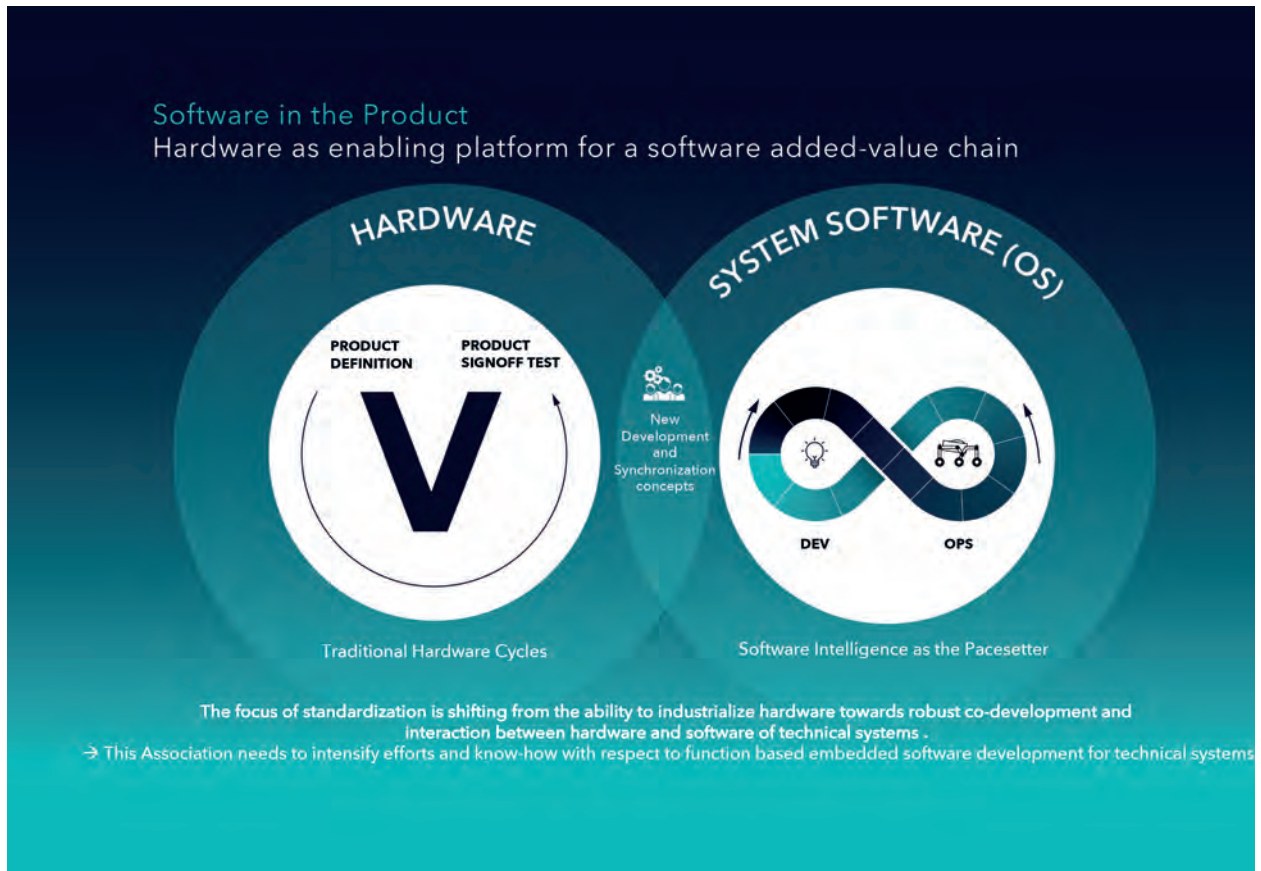
5.1. Beyond automotive

To acquire members from other industries who bring with them value added for our existing membership structure, we must offer them the potential that is created by a synergistic approach. On the one hand, we must intensify networking with new associations, in particular in the context of autonomous driving and networked products. On the other, we should establish ourselves in the aviation industry and other sectors as a forum for the digital transformation of industry. Over and above all of this, we should seek out contacts with distinguished experts with whom we can investigate questions relating to the identified core drivers and publish these.

5.2. Burden of proof/Homologation

The approval of products and of software packages which modify the characteristics of these products during operation demands new approaches to virtual validation and verification which must, in turn, be accepted by the regulatory authorities. To highlight our recommendations for verification and validation and put these into effect in practice, the association should intensify its cooperation with the regulatory authorities and technical services in Germany as well as at European and international level. The aim must be to use validation through virtual tests such as the Aircraft Static Test or Automotive Crash Test for approval purposes. To this end, it is necessary to





ensure the end-to-end continuity of the models and model parameters as well as the applicability of the assumptions from the sphere of the products themselves. This will make the trail of validation and verification tests identifiable in real time and retrospectively traceable for specialists and decision-makers both in enterprises and in the regulatory authorities.

5.3. Data engineering

The association should support its members in establishing data engineering as a new enterprise discipline by extending its membership and the issues it addresses to include the conditioning of field data using algorithms and software. Data engineering goes far beyond current product data management activities and demands new roles and responsibilities. Its task is to determine the data required for the development processes, the production processes and for application in the field, to condition this and prepare it in a way suitable for analysis.

5.4. In-product software

Software is becoming the very heart of the functional intelligence of products. And the association must take account of this. We are convinced that we need a new

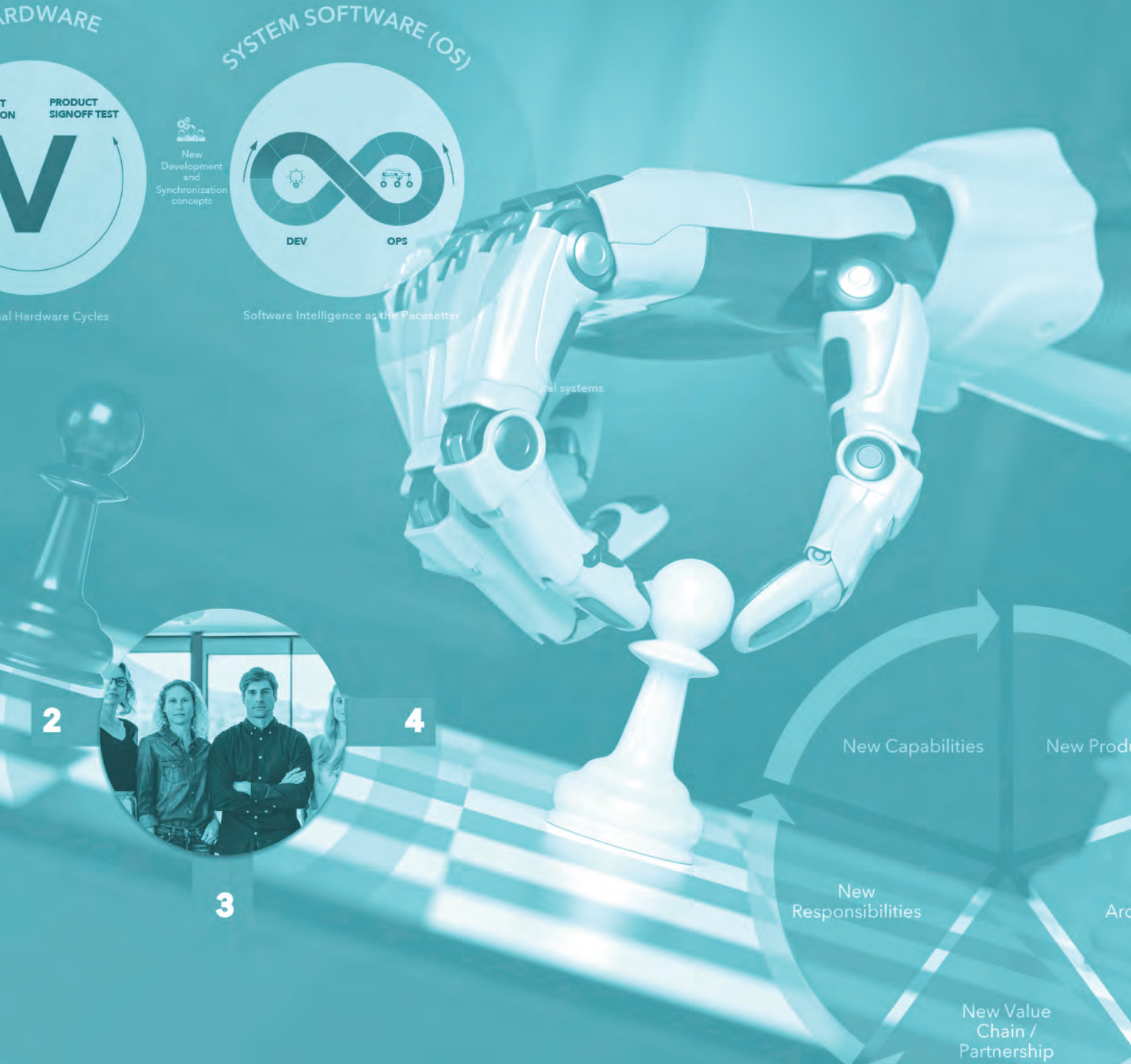
symbiosis and intelligence within the development process in order to intermesh software development and technical system development more closely. The tools and methods used for software development (CASE) and PLM do not sit happily together. We need new information items as part of a future overall description of in-product software based on artifact groups issuing from model-based systems engineering (MBSE). In the absence of this type of overall description, we lack digital test environments for the comprehensive examination and testing of software as a core enabler of functional intelligence. The association should extend its offering to include platforms for the comprehensive digital testing of software in a technical system.

5.5. Digital twin

For companies in a range of industries, the digital twin is developing into a multifaceted approach for the digitalization of their business processes and cross-enterprise value chains. The association should therefore develop a community-wide understanding of the different variants and views of the digital twin, and not only from the developmental perspective or that of any one specific industrial sector.



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