IIWH

INNOVATION INITIATIVE WIRE HARNESS

Results of Phase 1

Foreword ARENA2036

Professor Peter Middendorf

Speaker of the Research Directorate ARENA2036

Head of the Institute for Aircraft Design (IFB) at the University of Stuttgart

Dear Readers,

Since the opening of the ARENA2036 research campus, the University of Stuttgart has become a top address for co-creative automotive research. Thanks to the wide range of technologies that ARENA2036 will bundle in the future in its tech areas, partners will have access to a wide variety of competencies that they can incorporate in their application cases smoothly and with little lead time.

The wire harness is a vehicle component whose challenges and potential likely only become apparent at second glance. With that in mind, that makes it all the more important to look at things from different perspectives: these can be from the points of view of other industries or in terms of other approaches to power and signal transmission, which provide better access *per se* for automation solutions.

ARENA2036 offers ideal conditions for partners working together on-site to effectively and efficiently assess and validate the application potential of scientific research approaches geared towards the automation of the wire harness. We invite the partners of the Innovation Initiative Wire Harness to make use the potential of the various scientific institutes on the University of Stuttgart campus and to deepen this cooperation.

Foreword ARENA2036

Peter Froeschle

Executive Director
ARENA2036 e.V.

Dear Readers,

The wire harness has always presented a particular challenge when it comes to automation. The feeling has always been: If you can automate the wire harness, you can automate everything. Here at ARENA2036, these are exactly the sort of challenges we are looking for. After all, anyone can do simple.

The added value at ARENA2036 lies, in particular, in mastering complex challenges in close cooperation between established companies, academia and start-ups. This is an area in which ARENA2036 offers ideal prerequisites: state-of-the-art infrastructure, great scientific environment, support capacities for the start-up and a legal framework supported by membership of the ARENA2036association.

Many of the partners at ARENA2036 offer complementary competences for the Innovation Initiative Wire Harness. We in the ARENA2036 management have actively supported networking. With success – several of the partners of ARENA2036 have joined the Innovation Initiative Wire Harness. And for phase 2, we are confident that, conversely, the Innovation Initiative Wire Harness will set up and test the ideas and concepts developed in phase 1 in pilot projects and demonstrations in our hall. In this sense, we are delighted about the successful start to phase 1 of the Innovation Initiative Wire Harness and welcome the partners for phase 2 to the ARENA2036workshop!

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Viewpoint: BMW

Peter Doubek
Head of Physical Wiring System
BMW AG

The physical on-board electrical system is an essential enabler for a constantly increasing range of functions in the field of electrification, vehicle networking with the environment, with online platforms and the growing scope of assistance and comfort functions.

The development of vehicle electrical systems needs to keep up with the times, both in terms of the technology use and the processes they carry out. What worked well in the past is now becoming increasingly challenging.

The growing number of E/E components that need to be supplied with power and data, the increasing combinatorial complexity of individual functions and the quantity of individually tailored solutions are reaching the limits of feasibility and manufacturability.

To enable continued innovation, it is necessary to reduce variance and complexity. Clear, comprehensible wire harnesses that can be set up with consistently high repetitional reliability are the prerequisite for automated production.

When developing a wire harness for the future, the focus must be on automation: from the initial idea and the first design sketches to the final concept. To make this guiding principle tangible, standardisation is necessary at many levels.

There is a need for action in the data description of the virtual models, in the type description of the individual components and in the specifications of the overall wire harness.

The aim of the IIWH project is to achieve the level of standardisation that is critical for success together with all our partners in the value chain.

This objective is a bigger than average challenge. That is why we are tackling it together. Anyone who can contribute to the solution is invited to participate in the IIWH!

Viewpoint: Dräxlmaier

Dr Karsten Rüter
Head of Concept Development, Electronics
DRÄXLMAIER Group

After the chassis and – where applicable – the high-voltage battery, the on-board electrical system is the largest and heaviest component of a modern motor vehicle. While the first two are largely manufactured fully automatically, the wire harness is mainly assembled manually.

This has always been based on the high level of variance of the components used and the individual vehicle-specific equipment options offered, especially in the premium segment. The constantly increasing level of electrification in vehicles due to new or enhanced safety and comfort functions also increases the demands on the central power and data distribution systems. These thus become the complexity drivers for the physical on-board electrical system.

Any further increase in electrical functions while maintaining the same installation space also requires further miniaturisation, especially of the connectors.

With manual production, both can – if at all – only be achieved with considerable additional effort. Increasing the degree of automation in the production of vehicle electrical systems is therefore a key factor in meeting these increasing requirements.

It is made particularly difficult by the enormous number of different individual components that make up a wire harness these days. It is therefore essential to reduce this high variance and to standardise components as much as possible.

The IIWH provides a platform to drive this precompetitive standardisation of both physical products and virtual product descriptions and to define an industry standard. This creates investment security in automation technology for all those involved along the value chain, while still leaving enough scope to offer individual, standard-optimised solutions on the market.

It also lays an important foundation for the automated – and thus cost-efficient and high-precision – production of wire harnesses.

Viewpoint: Gebauer&Griller

Dr Holger Fastabend
Managing Director (CSO/CTO)
Gebauer & Griller Kabelwerke Gesellschaft mbH

The long-term trends in the automotive industry, such as alternative drive trains, autonomous driving and connected mobility, must be constantly supported by innovative solutions in the wire harness.

Increasing demands on the reliability of functions, higher data transfer rates, additional voltage levels, etc., are all drivers that further increase the complexity of the already widely diversified on-board electrical system. This complexity is difficult to master along the engineering process chain: production and assembly of the wire harness. In addition, the increasing complexity runs counter to the desired automation and actually increases the manual work and employee requirements, which are currently covered primarily in best cost countries. This increases the effort and risks involved in the necessary production and logistics networks, especially at a time of increasing political uncertainty.

In this sense, intensive efforts are required from OEMs and wire harness manufacturers especially, but also from control unit and connector manufacturers to reduce complexity. This complexity is mainly measured by the number of versions and the degree (level) of processing that can be automated. The involvement of individual companies is important, but can only bear fruit through close (precompetitive) cooperation when it comes to defining long-term standards.

We are happy to contribute our expertise in the areas of product and process development of standard and special cables, wire harnesses (including simulation) and contacting technology. As one of the leaders and innovation leaders in the field of automotive data cables, we can also contribute the relevant know-how and thus realise higher data transmission rates in smaller installation spaces.

Through the daily management of cables, connectors, metal and plastic components, the realisation of sealing solutions as well as modular and scalable production concepts for wire harnesses (including test and inspection concepts), we are constantly increasing our knowledge of the complexity drivers and possible solutions for automation. As this knowledge is largely complementary to that of other members of IIWH, we are pleased to jointly develop basic principles for norms or standards for the automation of production and assembly of the wire harness.

Viewpoint: Komax

Beat Wicki
Vice President Automotive
Komax AG

The physical on-board electrical system carries out a key role within the vehicle. However, the previous strategy of manual production in countries with low labour costs is coming ever closer to its inevitable limits. A higher level of automation is vital in order to ensure reliable cable production and stable supply chains.

We regard the IIWH as a central platform for precompetitive cooperation with important representatives of the industry in sub-projects and for joint discussion of the various solution pathways. This is particularly important because frameworks have already been defined during the vehicle concept development phase, which have a direct impact on wire harness production.

Thus, when locating control units or selecting wire harness components, unexpected challenges may arise for subsequent automation.

We consider our cooperation in the IIWH to be very goal-oriented, because it brings together experts from all stages of the value chain. In our view, this approach is essential if the automotive industry is to make significant progress towards automation of the wire harness. It is therefore desirable that other partners participate so that we can find viable solutions that are recognised throughout the industry.

The Komax Group is striving to make full use of its extensive expertise in crimping, twisting, assembly, taping and testing.

Viewpoint: KOSTAL

Dr rer. nat. Jens Haun
Director Product and Project Management
KOSTAL Kontakt Systeme GmbH

Connectors are central components of a wire harness. They represent the connection between the E/E components of the physical on-board electrical system and the cables. The demands being made on connector systems have increased steadily in recent years. Reduced installation space, higher power transmission and reliability at reduced costs are just a few obvious goals. The requirements of the connectors are directly linked to the changing demands of the physical on-board electrical system. The sometimes revolutionary changes being made to the vehicle architecture, new drive systems, digitisation and the desire for autonomous driving have fundamentally changed the wiring system architecture and thus also the wire harness.

Conventional wire harness production in low-cost countries is reaching its limits. Political uncertainties, personnel fluctuations, high logistical costs and thus low sustainability require a higher degree of automation in wire harness production, which is making it feasible to bring production back closer to the OEM production sites again.

In order to be able to meet current and future requirements, a higher, more consistent level of automation in processing is a central element in wire harness production. Connector production is already automated to a certain extent. And crimping processes are almost fully automated these days. With new connector systems, however, it is important to ensure good automation capability, high reliability and also the possibility of direct process testing during production.

To enable continued innovation, it is necessary to set standards and define industry-wide design guidelines. This will enable all process partners in the value chain to achieve a higher level of automation, which can then be realised by different automated machine manufacturers thanks to the clearly defined standards. KOSTAL Kontakt Systeme has a great amount of experience in working with various automated machine manufacturers. Working within the IIWH project, we hope to define and standardise holistic design guidelines for future connector systems together with all our interdisciplinary partners.

This is a challenge that can only be tackled by working together. We are happy to lend our support and would also like to encourage new partners to join this medium- to long-term goal.

Viewpoint: Kromberg & Schubert

Dr Wolfgang Langhoff
Chief Development Officer
Kromberg & Schubert Automotive GmbH & Co. KG

The structure of information and power transmission in automobiles has grown over many decades; characterised by the highest-possible level of adoption of components and control units.

Up to now, the complexity of the "customer-specific wire harness" and a high level of variance and volatility have favoured flexible manual production with short implementation times. Accordingly, many components have also been optimised for the limitations of manual assembly (e.g. visually distinctive secondary contact locking).

These interfaces are often defined by existing parts at a very early stage of the wiring system development process. This results in a mixture of different contact and connector systems for comparable tasks, which in turn are subject to short-term adjustments in the context of model maintenance or change management.

In recent years, numerous cost reduction and optimisation approaches have already been made to this important and comparatively cost-intensive component of the vehicle. Taking another innovation approach based on small steps is therefore only of limited effectiveness. It is only through extensive standardisation of product specifications and production conditions that a significant innovation boost is made possible.

With an existing product portfolio and an active concept for reusing existing parts, the only way to change both product and production at the same time is through precompetitive cooperation.

Therefore, a concerted action by several companies along the "on-board electrical system" value chain is, in our opinion, a promising way to achieve the goal of further automating the wire harness.

Viewpoint: Mercedes-Benz

Dr Rainer König
Senior Manager
Wire Harness and DMU
Mercedes-Benz AG

The wire harness industry is a microcosm within the automotive sector with persistent players, which is something that can be seen at the various conferences.

Since the wire harness basically represents the nervous system of the vehicle, it is affected by almost every technical change and its complexity is constantly increasing.

In order to meet the increased requirements, a paradigm shift towards the automation of production and continuous digitisation of the process chain is necessary. Unfortunately, however, it has become apparent that this turnaround cannot be achieved by individual partners alone, as isolated, promising efforts made in the past have not been able to prevail.

If you look at the dynamics of change in the industry from the perspective of many years of experience, you will notice a considerable resistance to change when it comes to automation – despite all the innovation. One of the reasons for this is not that automation means replacing a manual production process, but that is needs to be taken into account in the product creation process by ensuring suitable designs.

As tackling this is obviously difficult for individual players, then it is something that should be tackled together. And this was the idea behind the creation of the Innovation Initiative Wire Harness.

The fact that more needs to happen than has been the case so far is beyond question for us. In the foreseeable future, we will increasingly come up against the limits of what is physically possible with wire harnesses. At the same time, user requirements and complexity will continue to increase. That is reason enough to discuss the idea with several players in the industry and suppliers from different stages along the value chain. Our membership of the BMBF ARENA2036 research campus provides a suitable platform to pick up the ball and run with it.

In autumn 2019, we were able to start working on a wide range of products, initially with 10 different partners from the clothing, components and machine manufacturing sectors. The initial results are impressive and are inspiring us to continue. Nevertheless, the road ahead is challenging. And, of course, the transformation of an entire industry does not happen overnight. But a start has been made and I am confident that we will still be talking about this at future events.

Viewpoint: Nexans

Claudius Grüner
Head of Product Development
Nexans autoelectric GmbH

Without automation and digitisation in all of the important process steps – with all the associated issues such as standardisation, modularisation and reduction of the variety of parts and components – improvements in the security and cost-effective production of future on-board electrical systems is unthinkable. This is the only way to combine the sometimes contradictory requirements such as process reliability and miniaturisation, a high level of flexibility and automation, complexity and short process times.

Nexans autoelectric began semi-automated production of motor wire harnesses back in 2010 and developed the necessary processes for a safe and economical manufacturing process in pilot projects together with machine manufacturers and parts suppliers. We have consistently pursued this path for many years. The successful automated production of wire harnesses, especially under the aspect of increasing complexity and safety requirements, strongly depends on the quality of the preceding and accompanying process steps. While we have been practising modularisation, designs optimised for automated machines and the necessary reduction in the variance of parts and lines right from the start, we have been intensifying the automation of our engineering and logistics process for several years: Using in-house software solutions as well as individually adapted and customised applications. Design rules as well as the reduction of the complexity of component and cable diversity play a significant role. Bearing in mind our aim of reducing end-of-line testing to a minimum, the selection of robust components and processes as well as consistent process documentation are coming into ever sharper focus.

Since, in addition to the high level of complexity, the production of vehicle electrical systems basically involves a custom wire harness capability, all processes must be adapted or further developed to meet the requirements. The necessary dovetailing of internal processes, including in-house IT competence, and cooperation with parts and machine manufacturers is an established practice at Nexans autoelectric and will become even more important in the future.

Viewpoint: Rosenberger

Martin Zebhauser
Vice President PM&Design BA –Automotive Rosenberger Hochfrequenztechnik GmbH & Co. KG

Shaping the future of the on-board electrical system: acquiring knowledge, learning from this, bundling creativity and establishing it in the form of standards and guidelines.

The on-board electrical system is a constantly evolving overall concept. The evolution in automotive transport is demanding ever shorter development cycles with increasing demands on quality and costs. In order to meet these new requirements in the best possible way, comprehensive action and cooperation in partnership are necessary. Even in the year 2000, highly automated production of 'special cables' such as the FAKRA connector seemed unthinkable. Thanks to close cooperation between leading automobile manufacturers, assemblers, cable, machine and connector manufacturers, an innovative approach has been implemented which now forms the basis of all subsequent products in this area. Based on this experience, a high degree of automation can be achieved very quickly in the field of high-voltage assemblies. But close cooperation between automobile manufacturers and suppliers throughout the entire supply chain is crucial if we are to realise this.

Rules, standards, benchmarks and variables must be clearly defined and are often not sufficiently addressed due to the high pace of development. However, possible synergies are often neglected under the holistic approach. The transition to current standards is also taking place too late and leading to a high number of variants and additional costs for all parties involved.

The working group Innovation Initiative Wire Harness is another building block in creating this space and provides a good basis for the future of the on-board electrical system. We at Rosenberger are pleased to be a part of this group.

Viewpoint: Schäfer

Alexander Schäfer
Managing Director
Schäfer Werkzeug- und Sondermaschinenbau GmbH

The on-board electrical system, or the wire harness, plays a central role in automobile development. Like a nervous system, it connects all of the electrical components with each other and thus ensures the flow of energy and signals throughout the vehicle.

The global transformation of the automotive industry towards e-mobility and autonomous driving entails a number of risks but also opportunities for the value chain concerned. The associated increase in electrical functions and safety requirements will further increase the complexity of wire harness production along all process chains in the future. For this reason, a high level of innovation and automation in connection with constant technological development and consistent quality assurance needs to be our aim.

For the Schaefer Group, a medium-sized family business, the Innovation Initiative Wire Harness (IIWH) launched by ARENA2036 therefore offers a valuable opportunity to face the above-mentioned complexity and the resulting challenges together with a network of experts from along the entire value chain. As an experienced machine tool and special machine manufacturer, we contribute our core competence in the field of automated wire and contact production and at the same time expand our own range of knowledge through the interdisciplinary discussions within IIWH.

I am happy to invite other partners to join me so that together we can all achieve the IIWH' goals together.

Viewpoint: Siemens

Sven Neeser
Harness Domain Leader – Siemens Digital Industries Software

Change should be seen as an opportunity. Today, more than ever, we are confronted with new and greater challenges. If you look at the history of the development and manufacture of on-board wiring systems, you will see that there have been very few really groundbreaking innovations in the overall process chain. Particularly in terms of standardisation, agreement so far has only been reached in certain specific areas, e.g. using uniform data exchange formats.

One fundamental problem that still remains pertains to the transfer interfaces between the individual areas produced by OEMs, component and equipment manufacturers and ultimately the development partners and assemblers. A seamless interaction between these companies is the key to efficient wiring system development and production. The IIWH topics in this initiative address precisely these stages of the value chain, and now it is important to intelligently link them together to ensure effective data exchange between the individual companies.

The members of this innovation initiative represent the consolidated competence concerning the on-board electrical system. The challenge will be to pool our knowledge and experience to implement technological innovation, radical process changes and the necessary organisational changes in parallel.

We at Siemens Digital Industries Software would like to actively support this endeavour with our know-how and our software solutions. The digital twin plays a crucial role in carrying information through the value chain, from product definition to the maintenance of the final product. The coherence of the data makes it possible to trace back relevant information at every point of the product life cycle, e.g. in order to be able to carry out appropriate analyses and optimisations before their physical implementation (wire harness production, installation in the vehicle, maintenance, etc.). This facilitates an earlier production start, but also helps to prevent errors (right-first-time). A smooth flow of information must be guaranteed, especially when it comes to realising higher levels of automation in all areas of the product creation and utilisation cycle in the future, as machines are known to be less flexible than humans.

We are looking forward to an open cooperation.

Viewpoint: Yazaki

Andreas Di Vece
Vice President Logistics, HQ Supply Chain & Logistics
Yazaki Europe Ltd.

If one compares today's wire harness with that of a few decades ago, the differences are immense. Thanks to technologies such as Industry 4.0, autonomous driving and ever-growing connectivity for vehicles end users, the complexity of the wire harness has increased enormously. Production methods, however, have hardly changed since the introduction of automated crimping.

Due to the high proportion of manual value added in the production of wire harnesses and the increased complexity (the many individual components – sometimes over 10,000 per vehicle – and the resulting number of suppliers), there is a lot of room for error. Wire harness manufacturers and also OEMs will be faced with requirements related to autonomous driving and the associated liability, and quality and traceability issues, which will make the automation of production indispensable for realising product safety.

Even today, on-board electrical systems are partly designed redundantly in order to provide a safety net in the event of a connection failure. However, it is not feasible to lay each individual cable in the on-board electrical system twice. The only solution here is actually automated and fully controlled production. However, it requires more than the isolated solutions that exist to some extent today.

In our view, the approach adopted by the Innovation Initiative Wire Harness within the framework of ARENA2036to bring all the players in the value chain together at one table and to drive forward standardisation to reduce the complexity of the wire harness is the right way forward. Because one thing is clear: producing today's wiring systems automatically is not possible with the current state of the art in production methods.

We at Yazaki are looking forward to working with all these interdisciplinary partners on this project and actively tackling the challenges of the industry.

The automation of the wiring harness

1 The automation of the wire harness

1.1 Innovation Initiative Wire Harness

“The production of the wire harness lags decades behind the state of the art in many respects.” This is representative of the kind of answers that we were getting from interview partners during our requirements analysis. Mostly, when it comes to questions relating to typical Industry 4.0 topics, such as the degree of automation, universal digital networking, standards, etc.

There may certainly be different interpretations of this, but there is a whole range of facts on the table which illustrate that a core component of the automobile – the wire harness – has barely crossed the threshold of Industry 3.0, let alone 4.0, in its development to date. First and foremost, there is the question “Which solution is the most cost-effective?” Expansion into Eastern Europe provided the answer: the one that can be produced at the lowest labour costs. Wages were and still are a major component of costs.

Automation efforts have been around since the 1980s. Technically, many things were already possible. The economic assessment, on the other hand, regularly turned out to be unfavourable in respect of investing in automation. There are a whole range of reasons for this, which have been addressed by the Innovation Initiative Wire Harness IIWH (see ‘Reasons for automation’ on page 75).

To make sure that no false impression is created: the progress in productivity that has been achieved in spite of these framework conditions over the past decades is impressive: almost every wire harness is different. Production in the so-called ‘best cost countries’ is very reliable and generates a practically error-free result despite the high manual costs involved.

If one looks at the highly dynamic development of automation and Industry 4.0 approaches in automobile production, but also in mechanical and plant engineering for the past 10 years, the wire harness appears as a phenomenon. Batch size 1, sometimes extreme change dynamics, drastically increased complexity – all these are actually criteria that would lead you to expect that, even today, the degree of maturity of automation is already close to the maximum possible state of the art.

The fact that the industry is still a long way from this and yet is still able to meet the requirements shows how far the optimisation of structures, organisation and processes has progressed beyond automation.

Nevertheless, it is becoming apparent that developments such as e-mobility and autonomous driving – but also comfort and entertainment – will further increase the demands on the wire harness. Complexity, functional safety and revision capability of all process steps including service, miniaturisation and

The automation of the wiring harness

many more are pushing today's heavily manual production paradigm to the limits of what is feasible and, in the longer term, beyond.

In view of the growing importance of this key component, the time is ripe for the development, production and assembly of the wire harness to work out possibilities for increased automation.

The IIWH partners believe that these challenges must be solved not only internally, but also across different companies.

Companies from various stages of the value chain are participating in the Innovation Initiative Wire Harness: from OEM's (as wire harness developers) and harness assemblers (as wire harness manufacturers) to machine and component manufacturers and also research institutions and software suppliers.

The partners are thus looking to develop neutral solution pathways for automatising development, production and assembly on a precompetitive basis. To this end, promising technologies and their added value for the wire harness (in this brochure the term cable harness is used as a synonym) are sounded out and methods and processes are developed. This is one of the key aims of the cooperation within IIWH.

1.2 The IIWH under the umbrella of ARENA2036

ARENA2036 is the chief coordinator of the IIWH.

ARENA2036 stands for **Active Research Environment for the Next Generation of Automobiles in 2036.** The name says it all: ARENA2036 is one of 9 research campuses founded

Figure 1: The ARENA2036 research campus on the campus of the University of Stuttgart

by the BMBF as a follow-up to the Federal Government's high-tech strategy. This is about nothing less than ensuring technological supremacy in certain key areas. ARENA2036 is the research campus that carries this mandate for the automotive sector and Industry 4.0.

With this in mind, the BMBF is funding several major projects to promote cooperation between companies and researchers in these areas.

The automation of the wiring harness

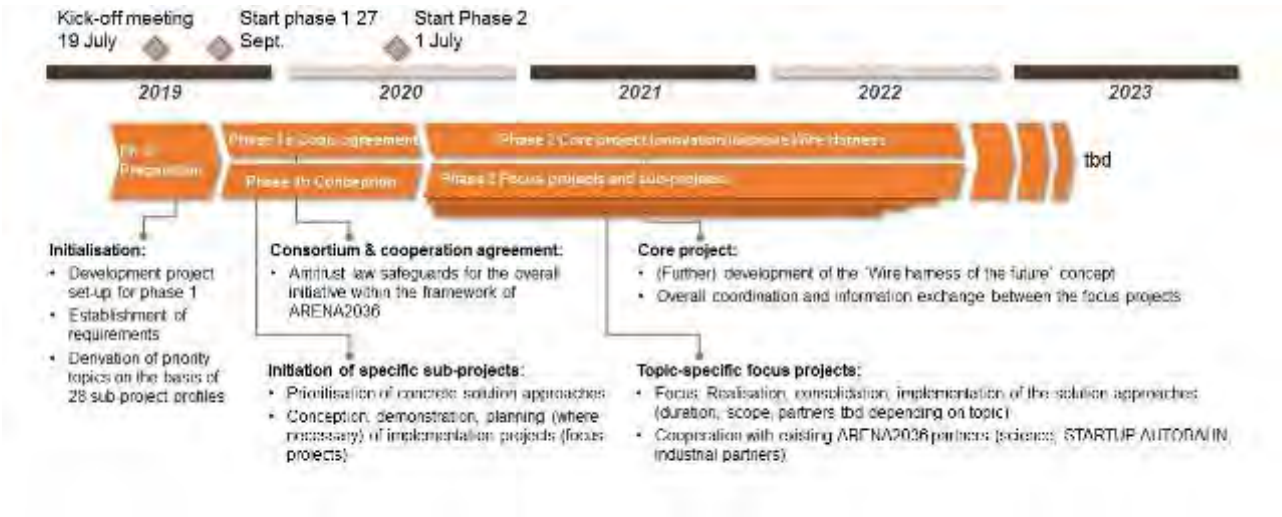


Figure 2: The overall roadmap of the Innovation Initiative Wire Harness

The partners at ARENA2036 know: these are the 'tough nuts' that will be cracked at ARENA2036. The automation of the wire harness is one such tough nut! There have already been a number of incentives and initiatives in the past, which have worked on guidelines, design and automation. First and foremost, the 'Bayern Innovativ' at its annual congress 'Bordnetzforum'. Their results have formed an important basis, especially for design rules.

Phase 0: Setting up the IIWH

The impetus for the Innovation Initiative Wire Harness itself came about in connection with the 2019 Bordnetze Kongress. Mercedes-Benz, one of the founding members of ARENA2036, took the initiative and invited people to an event at ARENA2036. 19/07/2019 marked the birth of the IIWH.

This was followed by a survey conducted by ARENA2036 among all partners regarding the most important aspects of automation. The result was 28 individual issues, the contents of which were each described in a profile. The spectrum ranged from visionary aspects such as the digital twin, Industry 4.0 interfaces and new production processes to more pragmatic topics such as design rules for automation, evaluation, maturity levels, component libraries, quality testing, wire harness architecture and in-vehicle assembly.

The results were presented at the first milestone meeting on 27/09/2019 and prioritised by the partners. This prepared the setting for phase 1: There were working plans, there were partners and there was ARENA2036. On this basis, almost all partners agreed to participate, so that the kick-off of Phase 1 was scheduled for 15/11/2019.

The automation of the wiring harness

This willingness to participate was accompanied by the establishment and commissioning of a project office for ARENA2036. The costs for this and other capacities were borne equally by all partners. Further resources were provided for the preparation of a cooperation agreement and legal support, as well as cooperation with the Institute of Human Factors and Technology Management IAT at the University of Stuttgart.

For ARENA2036, this meant accepting a group of 10 new partners as members of the ARENA2036Association in one go. In view of the fascinating subject matter, the ARENA2036 board was happy to agree.

Membership provides a framework for all collaborations, which essentially places cooperation at the heart of the association's statutes – an initial secure basis for cooperation.

One things that is noteworthy is that the necessary resources did not come from publicly funded tenders, but directly from the partners. This means that only 4 months passed from the kick-off meeting to the final set-up, including financing and staff participation – a good example of the possibilities that ARENA2036 offers as an R&D platform to work out synergies and transfer them into cooperation.

	SP 1 Design rules for Automation LS	SP 2 Design rules for plug connectors	SP 3 WH component library	SP 4 Quality seal for DFA components	SP 5 Automation of quality control	SP 6 WH architecture of the future	SP 7 Automatic WH assembly in the vehicle	SP 8 Reasons for automation
Aptiv	x	x		x		x		
BMW	x	x	Project Lead	Project Lead	x	Project Lead	Project Lead	
Daimler	Co-Project Lead	x	x	x	x	x	x	Project Lead
Dräxel-maier	x	x	x			Co-Project Lead	x	x
G&G	x	x		x		x		
Komax	Project Lead	x	x		Project Lead	x		
Kostal	x	Project Lead	x	x		x		x
Kroschu	x	x			x	x	x	Co-Project Lead
Nexans	x		x		x	x		
Rosenberger		Co-Project Lead		x	x	x		
Schäfer	x				x			
Siemens Mentor	x		x					
Yazaki	x	x	x	x		x		

Figure 3: Phase 1 organisation chart

The automation of the wiring harness

Phase 1: Concept development

The actual work started with the kick-off meeting for phase 1, where the prioritised topics were transferred into sub-projects together with teams and one or two sub-project leaders. This resulted in a project organisation chart with 8 sub-projects and about 50 people from 13 partner companies. The organisation chart shows an overview of the sub-projects and their staffing during phase 1.

What the structure does not show, however, is the dynamics of this cooperation. This can best be seen at the sub-project meetings. Four of the eight sub-projects were launched at the end of 2019, the other four from January 2020. From then on, things grew from strength to strength: there were meetings almost every day. The timing of the meetings also set the pace for the preparation, documentation and completion of ‘homework’.

This commitment of the teams over this short period – the net time frame of phase 1 was about four months – was impressive.

As a result of the corona situation, cooperation shifted to the virtual level, but was able to continue with undiminished intensity. Working this way, all sub-projects produced good results and presented them at the last milestone date of Phase 1 on 08/05/2020.

Antitrust protection

It is also worth mentioning that the entire Innovation Initiative Wire Harness was supported by antitrust law from the very beginning. For ARENA2036, this was the prerequisite for creating a legally sound basis for the precompetitive cooperation of the partners, some of whom are competitors with each other or have customer-supplier relationships.

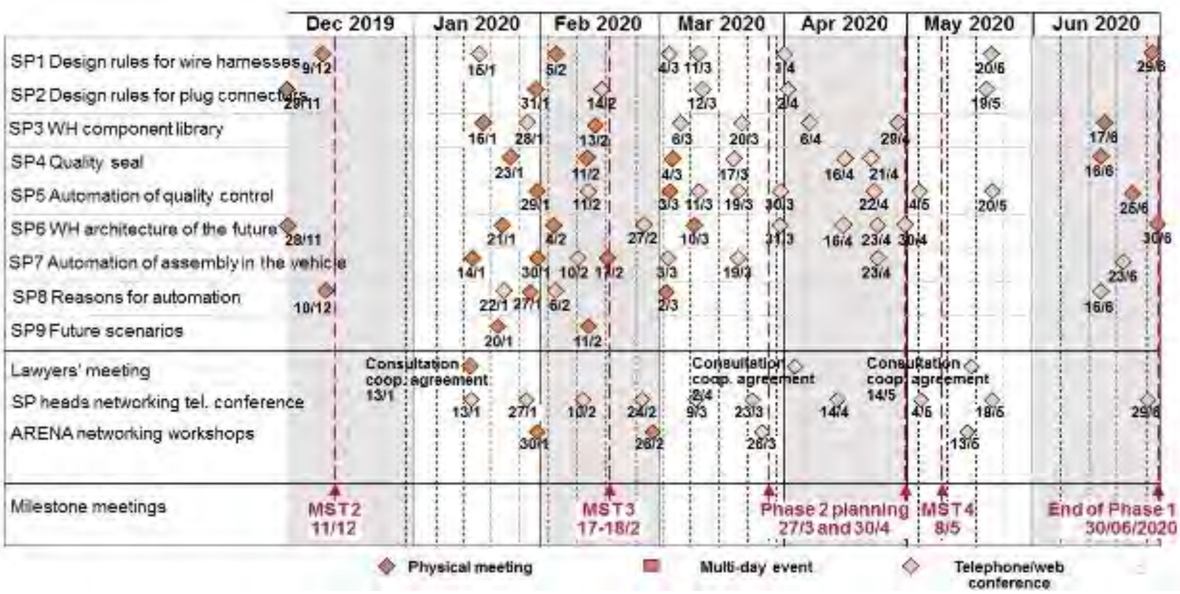


Figure 4: Schedule for Phase 1

The automation of the wiring harness

Thus, all of the physical and digital meetings were also attended by lawyers.

In addition, before the start of every sub-project task, each partner was presented with a guideline for compliance with antitrust requirements, which the partner then confirmed.

Moreover, a cooperation agreement was also drawn up during Phase 1 which regulates the cooperation as a whole.

To be on the safe side, the Innovation Initiative Wire Harness was also presented to the Federal Cartel Office. A constructive dialogue took place with the Federal Cartel Office: there were a number of queries which were then answered in consultation with the partners. During an on-site presentation at the 4th meeting of the decision-making department, the initiative was presented in detail by an IIWH delegation.

Milestones of the cooperation

The previous cooperation was structured into four milestone meetings at intervals of about 2 months. At these milestone meetings, interim results were exchanged and priorities were defined for the next phase of work. Together with the representatives of the partners and the sub-project managers, the milestone meetings act as a decision-making committee for the IIWH.

The Project Office prepared and documented the current status for these meetings. It goes without saying that all of the partners were able to store all documents relevant to project work in a protected archive and exchange them with each other – the ARENA2036 intranet was used actively for this purpose and has since established itself as a comprehensive knowledge base.

Figure 5: Participants of the third milestone meeting from left to right: Zimmermann, Grüner, Wortberg, Schnauffer, Rüter, Böhm, Pöschl, Steiler, Langhoff, Winter, Smedla, Weiß, Neubauer, Trommnau, Müller, Zebhauser, Haun, Hauptvogel, Doubek, Beinersdorf, Mittermeier, Fastabend, Kemeter, Riemenschneider, Rixen, Fahrnbauer, Wicki, Anantharaman, Akimoto, König, Infanger
Not in the picture: Pesch, Beck, Otte,Wienholz, Meseth, Neeser, Schäfer, Schmidt, Pacher

SUB-PROJECTS

Sub-projects
Brief overview of the SPs

2 sub-projects

Following the launch of the IIWH in July 2019 with a requirements analysis of the topics that are relevant for the automation of the wire harness from the point of view of the companies, 8 sub-projects were promptly developed and subsequently started in November 2019.

After the thematic cornerstones had been defined in profile papers, corresponding sub-project leaders were appointed from the ranks of the partners for each sub-project, who worked under the leadership of the partners involved in the project.

The start of the sub-projects also marked the beginning of 'Phase 1' of the IIWH. The purpose of this was to further specify the most urgent challenges of the industry in the context of the automation of the wire harness and to lay the foundation for phase 2. In this subsequent phase, from July 2020, more extensive work on content will take place with the overriding aim of creating standards that can lead to standardisation.

The following is an overview of the sub-projects of phase 1. The focus is not only on the motivation for the respective sub-project, but also on the approach and the results developed from it.

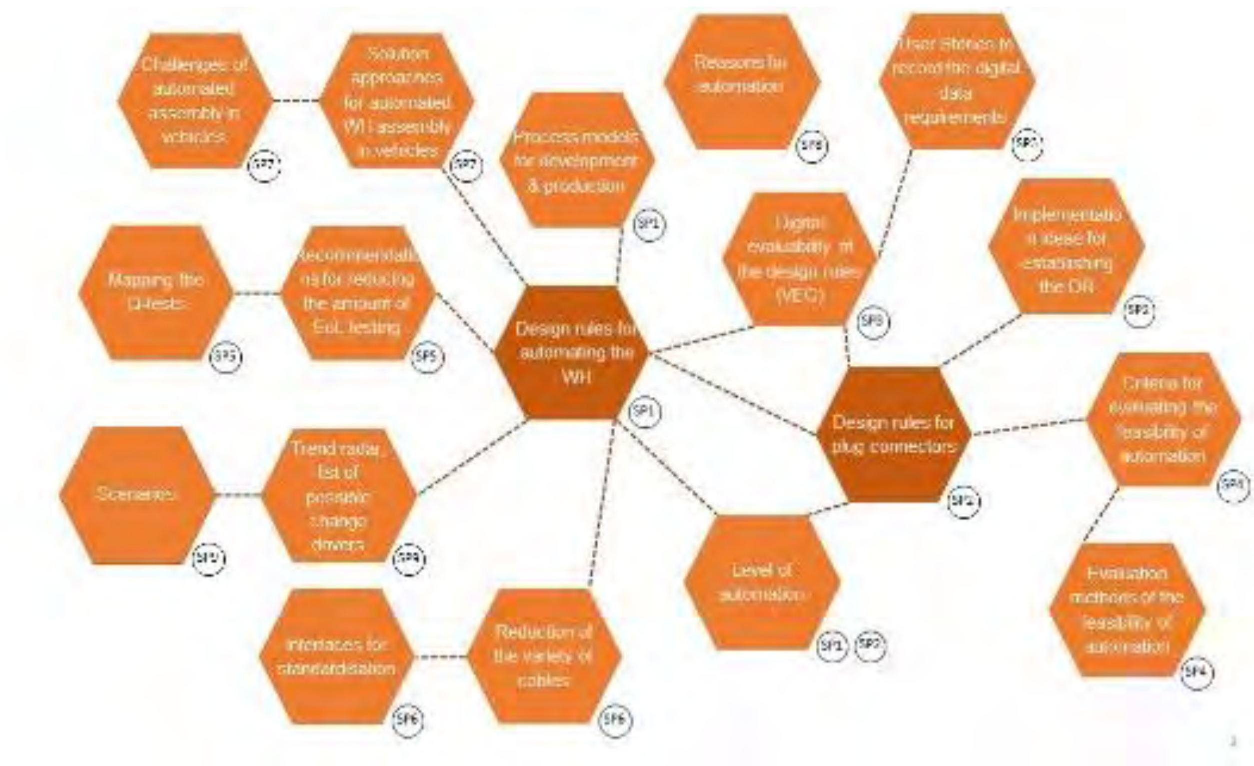


Figure 6: Results portfolio of Phase 1

Sub-projects
Brief overview of the SPs

Figure 6 shows the results portfolio of Phase 1, which represents the most relevant outputs from the individual sub-projects (SP). This illustration shows very clearly how the individual sub-projects build on each other and are linked to the design rules for the automation of the wire harness.

The results cover a broad spectrum with respect to the automation of the wire harness. Each sub-project produces results which, in the overall context, serve one aspect of wire harness automation. This shows that automation can only be achieved by tackling all of these facets holistically. This ranges from a summary of the reasons for automation to the formulation of design rules and an evaluation method of automatability. In the overall context of the IIWH, all of the results so far can be considered interim results, which will serve as a starting point for phase 2 and will be further developed as the project continues.

We also let the sub-project leaders who have been interviewed about the objectives of their sub-projects to have their say. In these discussions, they explain the background and necessities resulting from automation in more detail and point out the main stumbling blocks in the ongoing development of the topics.

In addition, an overview of the companies involved in the respective sub-projects, the duration and the coordination meetings held within the framework of the sub-projects is provided. These show how comprehensive discussions have taken place in all of the sub-projects, which have included very different aspects due to the participation of companies from all stages of the value chain.

The descriptions of the sub-projects are rounded off by a brief preview of phase 2 and the resulting ongoing thematic orientation in the development of the respective sub-projects.

Sub-project 1

Design rules for the automation of the wire harness

Sub-project 1
Design rules for the automation of the wire harness

2.1 Sub-project 1: Design rules for the automation of the wire harness

Participants

Christian Infanger (Sub-project Head)
Komax

Jerome Trommnau (Joint Sub-project Head)
Mercedes-Benz

Ulrich Döllinger
Nexans

Luis Echarri
Aptiv

Stephan Fahrnbauer
BMW

Kurt Herrmann
Gebauer & Griller

Michael Knödler
Kromberg & Schubert

Manfred Mittermeier
Rosenberger

Andreas Müller
KOSTAL

Stefan Neubauer
Schäfer

Thomas Plattetschläger
Kromberg & Schubert

Michael Richter
Siemens

Tobias Riemenschneider
Aptiv

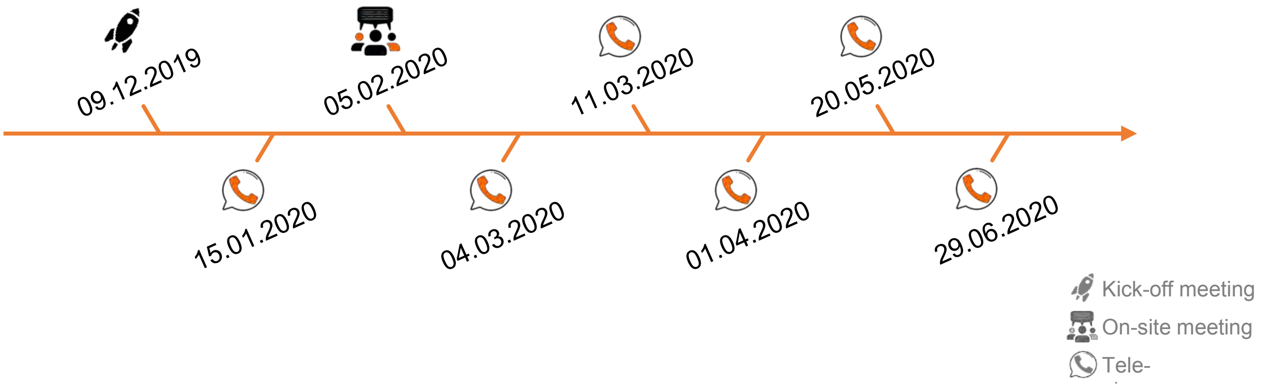
Karsten Rüter
Dräxlmaier

Michael Smedla
Nexans

Jörg Tillmann
Yazaki

Bernd Weiß
Mercedes-Benz

Projektzeitstrahl



Sub-project 1
Design rules for the automation of the wire harness

Starting point/Motivation

The development, production and assembly of a wire harness extends over various points of the value chain (OEM – Tier n – plant manufacturers). The process is optimised by each participant within their area of responsibility and according to their scope for action. However, an overall optimum cannot always be achieved in this way, as the consequences for subsequent phases cannot be fully assessed.

Nowadays, sophisticated automation solutions are sometimes used to solve problems in production which could possibly have been avoided or at least mitigated during development. However, this requires an understanding of the implications of activities such as component selection for subsequent processes. This is precisely where the design rules are intended to act most decisively.

Objective

The aim was to formulate design rules that will help to sensitise vehicle electrical system developers who will later be implementing the technology in practice to take the production viewpoint into account as early as the design phase.

The idea is that automation obstacles can be resolved at this stage more cost-effectively than later in the production process. To this end, a guideline with design guidelines was developed during the course of this sub-project, which favours economical automation solutions.

When defining the design rules, it is particularly important to take into account the main obstacles when automating the production of wire harnesses. Accordingly, it was necessary to focus on the following aspects in particular:

- Reduction of the variety of parts
- Enable the division into (sub-)modules
- Use of components suitable for automatic machines
- Restrict installation radii
- Selective use of add-on parts
- Threading sleeves, avoid hoses

Interdisciplinary cooperation and consistent implementation should significantly simplify the production of the physical wiring system.

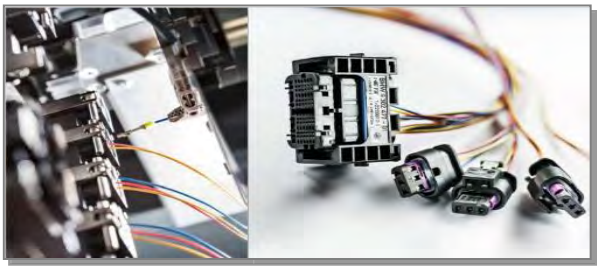


Figure 7: Automatic assembly of a connector housing

The main levers here are design adaptations, substitution of unsuitable components or use of technically more sophisticated automation solutions.

Sub-project 1
Design rules for the automation of the wire harness

Results of Project Phase 1

Phase 1 included the collection of existing guidelines from all stages of the value chain. On the basis of this, a guideline was drawn up with recommendations on how the wire harness design can facilitate automatic production. The implementation of this guide was accorded a high degree of prominence:

- A **schematic development process** was used to establish the addressee reference. This showed at which points the guide should be implemented in order to have the maximum effect later on.

- On the basis of a **schematic production process,** the project team checked whether the document covered all aspects of wire harness production and whether the individual fields of action were sufficiently taken into account.

In practice, it will only be possible to implement the contents of the guide in stages. With this in mind, **automation levels will be defined**, which will serve as anchor points over time. Using concrete metrics, the characteristics of sample wire harnesses can now be described for each level.

Prospects for project phase 2

Phase 2 focuses on the one hand on the content of this guide (general description, illustration and definition of target values).

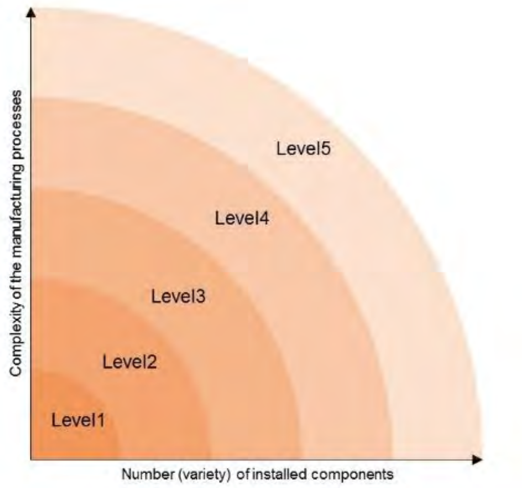


Figure 8: The automation level is defined along two dimensions and is continuously increased over time

On the other hand, it will need to be clarified how to ensure the effective application of this working product in practice. To achieve this, three approaches are being pursued:

1. A **plausibility check** is carried out on the basis of selected families of wire harnesses to examine the feasibility of the design guidelines in terms of time frame, costs, weight and installation space.
2. **Provision and maintenance** via standardisation bodies is being considered. This makes it possible to refer to these guidelines or this standard in the OEM's specifications.
3. The intention is to provide **tool support** so that the design guidelines are available to every wiring system developer in his customary environment and can automatically be applied to any drawing status.

Sub-project 1
Design rules for the automation of the wire harness

Interview with the sub-project head Christian Infanger (Komax)

ARENA2036: *The sub-project "Design Rules for the automation of the wire harness" has met with great interest from many IIWH partners. In your opinion, what is the motivation to become actively involved here?*

Infanger: The challenges we face when trying to increase the degree of automation in wire harness production are complex. I am convinced that only way we can make substantial improvements is by working together. Apparently, many other companies see it the same way.

ARENA2036: *What exactly are the main problems?*

Infanger: Exploiting technological potentials while keeping an eye on the economic efficiency of automation solutions. At the end of the day, it always comes down to the question of whether they achieve sufficient benefits to justify the level of costs involved.

ARENA2036: *How is sub-project 1 proceeding in this potential conflict area?*

Infanger: The aim is to draw attention to the topic of the automation of wire harnesses at an early stage of the project. Our aim is to provide every developer with a guideline that helps them to make decisions when designing the on-board electrical system for their vehicle.

ARENA2036: *Which levers are available?*

Infanger: The type and scope of the components used are certainly important. This is where we are seeing an enormous variety of parts today. Installation radii and possible interlinking in the wire harness also play a major role. Control units also define framework conditions that cannot simply be redesigned. In addition, there are the process steps on the cable production machines, the complexity of which is further increased by factors such as miniaturisation.

ARENA2036: *Do you think that the interests of all stakeholders can be reconciled to a common denominator?*

Infanger: Due to the increasing volume of new wire harness approaches, the previous strategy is reaching its limits. It may be possible to delay the change, but it cannot be prevented. For that reason, everyone is now being called upon to make a contribution to the extent of their capabilities. I think people are well aware of the situation, so I am confident that we will push for change now.

ARENA2036: *Mr Infanger, thank you very much for the interesting conversation.*

Infanger: Thank you, too.

Sub-project 2

Design rules for plug connectors

Sub-project 2
Design rules for plug connectors

2.2 Sub-project 2: Design rules for plug connectors

Participants

Dr Jens Haun (Sub-project Head)
KOSTAL

Manfred Mittermeier (Joint Sub-project Head)

Jörg Beinersdorf
BMW

Luis Echarri
Aptiv

Kurt Herrmann
Gebauer & Griller

Christian Infanger
Komax

Michael Knödler
Kromberg & Schubert

Andreas Müller
KOSTAL

Hans Nummer
Yazaki

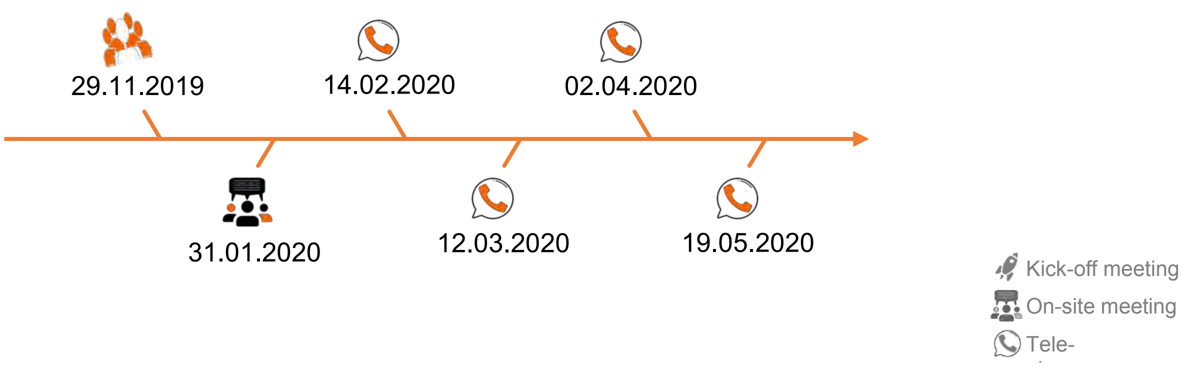
Franz Pacher
Aptiv

Andreas Pesch
KOSTAL

Marco Schweizer
Mercedes-Benz

Norbert Sickau
Dräxelmaier

Project timeline



Sub-project 2

Design rules for plug connectors

Starting point/Motivation

Today (2020), plug connectors are mainly assembled manually or semi-automatically. The crimping process is already automated. Process monitoring is implemented by means of crimp force monitoring.

Depending on the type of wire harness – low-voltage, data, high-voltage –

Figure 9: Standard plug

there are very different degrees of automation in production. The degree of automation is generally higher for low-voltage lines than for data or high-voltage line sets. However, the proportion of manual production is highest for customer-specific wire harnesses.

However, the fact remains that fully automated assembly of all existing connectors is currently not possible. There is no industry-wide design guideline for connectors that would facilitate automation.

Objective

The aim of this sub-project was to create a design guideline for connectors with a view to automated wire harness production. This design guideline should be applicable across the industry on a voluntary basis and take into account the existing knowledge about the automation of connector assembly.

Furthermore, it must be possible to map future design changes. The design guideline must also be consistent with the other sub-projects. The design guidelines for connectors are based on the structure from sub-project 1, into which they are also integrated.

The starting point of the work in this sub-project is to incorporate the insights from existing standards. These were first collected and then checked for their current validity. The first attempts at automation approaches, on which this SP is based, were discussed within the framework of the Bayern Innovativ around 10 years ago. Another important ongoing endeavour is the design guideline established by Komax which is already widely used in the industry, and was also taken into account here.

Sub-project 2
Design rules for plug connectors

Results of Project Phase 1

After initial meetings and the clarification of the task definition for the connector sector, the connector design guidelines, which had previously been publicly available and used in practice on the market, were compiled during an extensive research phase.

Figure 10: Event presentation at the 1st networking meeting

The design guidelines available in the individual companies are very similar and largely correspond to the design guidelines published by Komax, which can be used universally.

In 2010, the Bayern Innovativ already had a very similar approach. The working group 'Automation-compatible onboard electrical system design' has drawn up a list of requirements and design guidelines for the construction of a wire harness. Dr Böhm from Bayern Innovativ presented this project at ARENA2036 and explained and provided all the results they had developed thus far.

In this context, a list was compiled at the time, which contains requirements for the wire harness as a whole as well as for the individual wire harness components and thus also for the connectors. The list was screened, analysed and updated to the requirements for connectors as part of this sub-project. A prioritisation of topics was defined with regard to issues that can be implemented in the short term (quick wins) and in the longer term.

To ensure that all connector manufacturers could be included, an additional channel was opened up. With the help of KOSTAL's coordination, there was a dialogue with the German Electrical and Electronic Manufacturers' Association (ZVEI) working group 'Requirements for the validation and processing of contacts' so that the various design guidelines of the contact part manufacturers could be taken into account.

Another result is the definition of a level categorisation of automatability. Today, plug connectors are processed semi-automatically. In order to classify the design guidelines accordingly, a level categorisation had to be developed. After a first basic draft was drawn up within the framework of this sub-project, this level categorisation was handed over to sub-project 1, where the design guidelines were reformulated at a higher level, which is why this is the ideal situation for the further development of the level categorisation.

Sub-project 2

Design rules for plug connectors

The list of interdependencies of the individual sub-projects is a further result of project phase 1. The respective overlaps and the information that must flow from one sub-project into another sub-project were discussed at the joint project meetings.

The design guidelines found in project phase 1 have been incorporated into the design guidelines list from sub-project 1. This provides the prerequisite for creating a structurally uniform design guideline for both the wire harness and the components (here: plug connectors).

Finally, first approaches for an implementation roadmap were discussed. The team agrees that it is crucial to work towards an implementation roadmap at an early stage. Both the identified priorities on the one hand and the level categorisation on the other hand are being taken into account.

Prospects for project phase 2

The main task in phase 2 will be to formulate and detail a design guideline for connector automation. Structurally, this is will take place as part of the design guideline from sub-project 1.

KOSTAL will continue to perform the interface function with other contact part manufacturers who are not yet IIWH partners, working within the framework of the German Electrical and Electronic Manufacturers' Association (ZVEI).

In phase 2, the implementation timetable will be detailed and implementation will begin.

The key issues of implementation are as follows:

- What needs to be done so that the design rules can be used in practice?
- Where are roadblocks and how can they be removed?

Verantwortlich	Hauptgruppe	Untergruppe	Betrifft	Bereich	Prozessgruppe	Prozessschritt	Designrichtlinien	Zielwert
Daimler	Steckergehäuse		Rückverfolgbarkeit	Logistik	Lager-Logistik	Steckergehäuse identifizieren	Merkmal für Rückverfolgbarkeit am Gehäuse	Chargenreinheit
Komax	Steckergehäuse	einteilig	Pinbelegung	Vormontage		Bestücken	Die Bestückungsreihenfolge kann nicht beliebig gewählt werden.	von links unten nach rechts oben
Komax	Steckergehäuse	einteilig	Pinbelegung Twisted-pair	Vormontage		Bestücken	Verdrillte Adernpaare sollen je Stecker einheitlich ausgerichtet sein.	alle horizontal
Komax	Steckergehäuse	einteilig	Pinbelegung Twisted-pair	Vormontage		Bestücken	Verdrillte Adernpaare sollen je Stecker in direkt benachbarte Kammern gesteckt werden.	
Komax	Steckergehäuse	einteilig	Pinbelegung Twisted-pair	Vormontage		Bestücken	Verdrillte Adernpaare sollen je Stecker nicht schräg versetzt gepinnt werden.	
Komax	Steckergehäuse	einteilig	Pinbelegung Twisted-pair	Vormontage		Bestücken	Verdrillte Adernpaare sollen je Stecker in Kammern mit dem gleichen Kammerabstand gepinnt werden.	
Komax	Steckergehäuse	einteilig	Pinbelegung Twisted-pair	Vormontage		Bestücken	Verdrillte Adernpaare sollen je Stecker in Kammern mit der gleichen Orientierung gesteckt werden.	
Komax	Steckergehäuse	einteilig	Pinbelegung	Vormontage		Bestücken	Die Anzahl unterschiedlicher Leitungsquerschnitte je Stecker soll minimiert werden	3
Komax	Steckergehäuse	einteilig	Pinbelegung	Vormontage		Bestücken	Gleiche Leitungsquerschnitte sollen auf dem Steckerinterface in Gruppen zusammengefasst werden.	
Komax	Steckergehäuse	modular	Pinbelegung Twisted-pair	Vormontage		Bestücken	Verdrillte Adernpaare sollen nicht in verschiedene Moduleinsätze gesteckt werden.	
Nexans	Steckergehäuse	Ladedosen	aufzuklebende Dichtungen	Vormontage			Rollenware verwenden	Rollenware
Nexans	Terminal	Ringkabelschuhe	Kontaktierung	Vormontage		Crimpen (vollautomatisch)	Automatische Verarbeitung und Validierung ermöglichen	Crimp
Nexans	Terminal	Ringkabelschuhe	Kontaktierung	Vormontage		Crimpen (vollautomatisch)	Gegurtete Ware verwenden	gegurtet
Nexans	Terminal	Ringkabelschuhe	Kontaktierung	Vormontage		Crimpen (vollautomatisch)	Baukastensystem für Kontakt- und Crimpbereich soll eingehalten werden	5 Varianten
Nexans	Terminal	Ringkabelschuhe	Überwachbarkeit	Vormontage		Crimpen (vollautomatisch)	Headroom-fähige Crimpauslegung	Headroom >35%
Nexans	Terminal	Ringkabelschuhe	Anzahl Leitungen	Vormontage			Anzahl Leitungen ist einzuschränken	5
Nexans	Terminal	Ringkabelschuhe	Abdichten	Vormontage			ungedichtete Kabelschuhe verwenden	ungedichtet
Kostal	Steckergehäuse	mehrpolig	Kammerdesign	Schneidraum		Crimpen und Bestücken (vollau	Kammergeometrien und Kammervorraum müssen fehlerfrei automatisch bestückbar sein	> Fehlerrate <=0,5 %
Kostal	Steckergehäuse	mehrpolig	Steckerdesign	Schneidraum		Crimpen und Bestücken (vollau	Alle Kammern müssen leicht erreichbar und fehlerfrei automatisch bestückbar sein	> Fehlerrate <=0,5 % für alle Kammern
Kostal	Steckergehäuse	mehrpolig	Steckerdesign	Schneidraum		Crimpen und Bestücken (vollau	Integration von Doppelanschlägen in den automatisierten Steckprozess	Doppelanschläge möglich
Kostal	Steckergehäuse	mehrpolig	Abdeckkappen	Vormontage		Bestücken	Abdeckkappen sollen ohne Einfädeln aufgebracht werden können	Halbschalen
Kostal	Steckergehäuse	mehrpolig	Moduleinsätze	Vormontage		Bestücken	Moduleinsätze 2-Stufiges Konzept - Verdrillte od. Squipleitungen in Moduleinsätze gesteckt zum	Standardmodule
Kostal	Steckergehäuse	mehrpolig	Dichtmatten	Schneidraum		Bestücken	Manuelles Nachbestücken/Mehrfachstecken / Servicefall / Nacharbeit (0 km) ermöglichen	3 X Stecken und 2 X Entnehmen

Figure 11: Extract from the table of design guidelines for plug connectors (consolidated version)

Sub-project 2

Design rules for plug connectors

Level 3			Level 4			Level 5			Level 6		
aktuell - 2025			aktuell - 2025			2025 - 2030			ab 2030		
teilautomatische Produktion von kleinen Teilmodulen			**vollautomatische Produktion größerer Teilmodule mit Einschränkungen bzgl. Technologien und Anzahl unterschiedlicher Bauteilen**						**vollautomatische Produktion größerer Module**		
teilautomatische Produktion von kleinen Teilmodulen ohne Einschränkungen aber ohne komplexe Komponenten			vollautomatische Produktion größerer Teilmodule mit Einschränkungen im Routing und Zusatzteilen			vollautomatische Produktion größerer Teilmodule OHNE Einschränkungen im Routing und Zusatzteilen			Vollautomatische Produktion von Modulen ohne Einschränkungen		
Kleine Teilmodule können ohne wesentliche Einschränkungen hergestellt werden. Es sind keine Umfänge im Teilmodul wie Sicherungsdosen, Schäumtüllen, oder andere komplexe Umfänge enthalten.			Größere Teilmodule können vollautomatisch mit Einschränkungen bzgl. Technologien, Anzahl der zu verarbeitenden unterschiedlichen Bauteile, der Meterwaren, des Routings oder Zusatzteile wie Tüllen oder Befestigungslemente vorproduziert werden. Der Gesamtleitungssatz muss durch Zusatzarbeiten und Zusammenlegen von Teilmodulen erzeugt werden.			Größere Teilmodule können vollautomatisch mit Einschränkungen bzgl. Technologien, Anzahl der zu verarbeitenden unterschiedlichen Bauteile, aber ohne Einschränkungen bezüglich Meterwaren, Routing oder Zusatzteile wie Tüllen oder Befestigungslemente vorproduziert werden. Der Gesamtleitungssatz muss durch Zusatzarbeiten und Zusammenlegen von Teilmodulen erzeugt werden.			Größere Teilmodule können vollautomatisch ohne Einschränkungen vorproduziert werden; beschränkendes Kriterium ist die Größe des aufgespannten Raumes; Teilmodule müssen noch zu einem Komplettleitungssatz zusammengelegt werden und ggf. bewickelt oder in Kanäle eingelegt werden		
lfd. Nr.	**Kurzbeschreibung**	**Kategorie**	**lfd. Nr.**	**Kurzbeschreibung**	**Kategorie**	**lfd. Nr.**	**Kurzbeschreibung**	**Kategorie**	**lfd. Nr.**	**Kurzbeschreibung**	**Kategorie**
301	**Umspritzungen herstellen**	Abdichten	401	**Leitungsausb. ausrichtungsgenau**	Ausbindungen	501	**Routing nur in best. Richtungen**	Leitungsführung	601	**Umschäumungen herstellen**	Formteile
302	**Befestigungen positionsgenau**	Befestigungselemente	402	**Längenausgleich versch. Inhalten**	Ausbindungen	502	-	-	602	**Routing in beliebige Richtungen**	Leitungsführung
303	**Befestigungen ausrichtungsgenau**	Befestigungselemente	403	**Längsbew. Gew. Bänder bel. Länge**	Bewicklung	503	-	-	603	**Wellrohre auf bel. Leit.segm.**	Schläuche
304	**Steckhilfen in belieb. Position**	Kontaktgehäuse	404	**Längsbew. Längsverschl. bel. Länge**	Bewicklung	504	-	-	604	**Splice in beliebiger Technologie**	Splice

Figure 12: Extract from the level categorisation

- At what point can a national or international standardisation body be approached with the aim of establishing standards for these design rules?

In addition, the design rules are to be illustrated using real 3D patterns. The idea of using brief video tutorials to introduce the design rules has already been discussed.

Sub-project 2
Design rules for plug connectors

Interview with the sub-project head Dr Jens Haun (KOSTAL)

ARENA2036: *The topic 'Design rules for plug connectors' is nothing new in the industry. What is new in this project?*

Haun: Indeed, there are already design rules that have been drawn up by some connector manufacturers that allow automation to a certain degree. These design rules are written down in the design guidelines of the contact and connector manufacturers. They are based on the specifications of the machine manufacturers.

We should also mention the widely used Komax Design Guideline. Within the framework of Bayern Innovativ, there was already a project about 10 years ago with the aim of working out optimisations and also with an eye to drawing up design rules. The results achieved there, together with the guidelines established in the market, were analysed and updated as part of our sub-project.

One new addition is the definition of the level of automation. This makes it possible to better adjust the design rules to the practicable degree of automation and to stagger them over time. What is also new is that representatives of all parties involved in the development chain will participate in this sub-project. This will ensure the consistency of design rules at all development levels along the value chain, which is ultimately a crucial prerequisite for acceptance and feasibility.

ARENA2036: *Wouldn't general design rules lead to reluctance on the part of connector manufacturers, as their unique selling points could disappear?*

Haun: I do not see this as a danger. On the contrary, standardised design rules will lead to more participation in this topic. The unique selling points do not concern the automation of production, but rather other aspects of plug connectors.

Automation is and increasingly will be a kind of ticket to selling plug connectors. Requirements relating to the road safety of vehicles have not led to fewer car manufacturers on the market. Rather, road safety is merely a prerequisite for participation in road transport. The differences and unique selling points of the vehicles lie in completely different areas.

Continued on next page

Sub-project 2

Design rules for plug connectors

ARENA2036: *Plug connectors are part of the wire harness in the on-board electrical system. How can you ensure that the design rules for connectors fit in with the considerations and results from other sub-projects?*

Haun: At the sub-project manager meetings and teleconferences we regularly coordinate with all the IIWH partners (OEMs, wire harness manufacturers and plant manufacturers) on a cross-project basis about objectives, results and interdependencies in the sub-projects.

In addition, we discuss interdependencies between the sub-projects and elaborate these at milestone and networking meetings. We made a proposal to this effect at a very early stage, which has since been taken up by the other sub-projects.

In particular the coordination with sub-project 1 (Design rules for the automation of the wire harness) is very close. The plan is to produce a joint document with the same structure. The proposal for the level of automation also originates from our sub-project and was then taken over by sub-project 1 due to its general validity and relevance for several sub-projects.

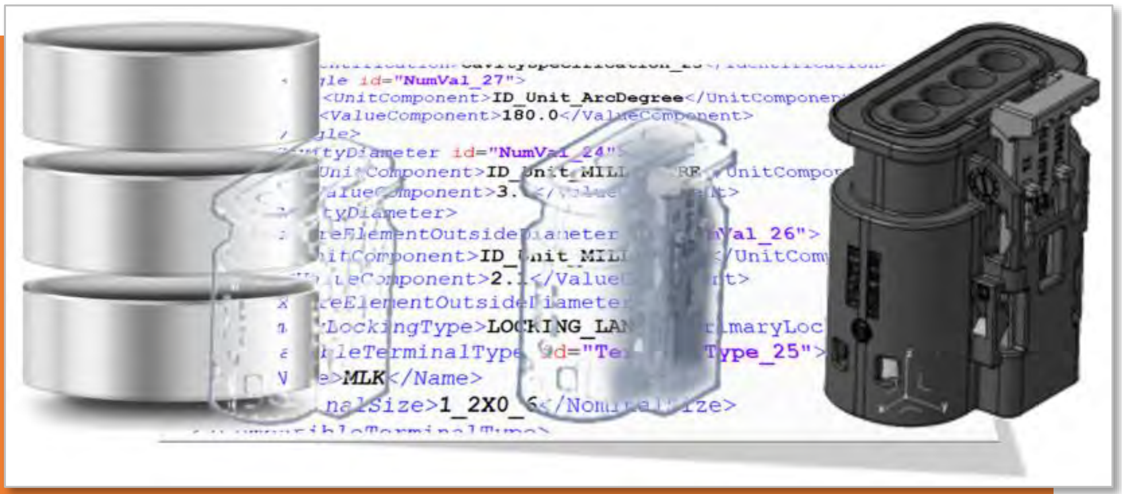
ARENA2036: *In the past, design rules could only be partially implemented. Are there any new ideas for implementation here?*

Haun: The implementation of the design rules is indeed a very important aspect. To this end, during project planning we have already considered how we can implement the design rules as quickly as possible. The level categorisation I mentioned earlier is a crucial basis here.

In addition, the design rules have already been classified according whether they are ‘easily implementable’ or ‘implementable in the long term’. This simplifies rapid implementation for the easily implementable design rules. Another idea is to use 3D sample parts to make the design rules more vividly clear and understandable. Demonstrations by means of short tutorial videos are also conceivable. In project phase 2 we will be firmly defining an implementation timetable.

ARENA2036: *Dr Haun, thank you very much for the interesting conversation.*

Haun: My pleasure.



Sub-project 3

Wire harness component library

Sub-project 3
Wire harness component library

2.3 Sub-project 3: Wire harness component library

Participants

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(Sub-project Head)

Martin Anantharaman
Yazaki

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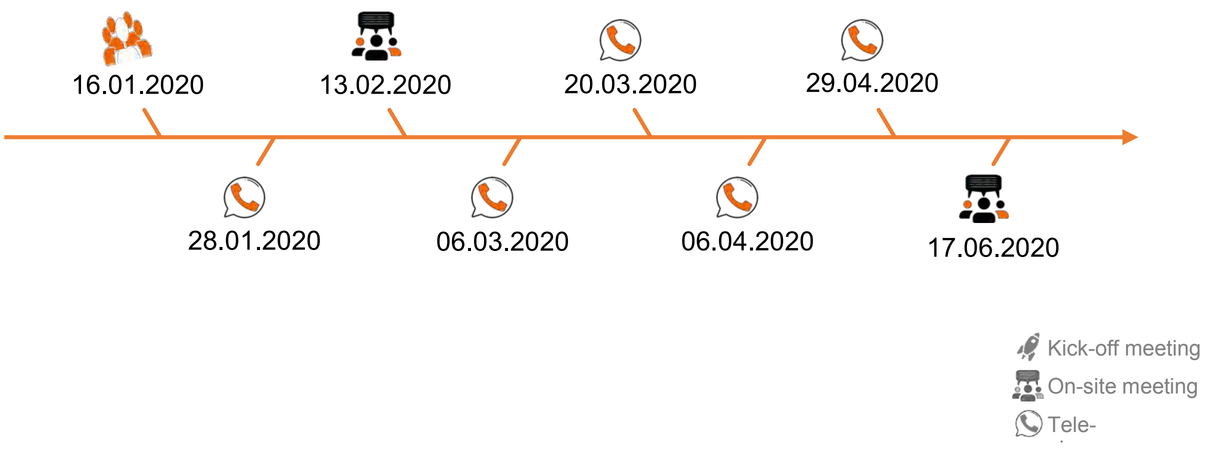
Project timeline



Sub-project 3
Wire harness component library

Starting point/Motivation

The companies in the process chain already possess extensive digitally evaluable data about the wire harness components. However, these data usually do not primarily focus on automated wire harness production, but rather on other issues, such as aspects related to the technical design of the construction. As a result, the data managed today is generally patchy in terms of an end-to-end process to promote automated manufacturing.

There are also breaks across the data. For example, the shape of a chamber contained in a connector geometry model cannot necessarily be digitally associated with other metadata describing the chamber. This further limits the usability of the data in the context of automated production, such as virtual validation or the simulation of a specific manufacturing step.

After all, the necessary exchange of digitally evaluable data is difficult in today's process chain. Most companies maintain their company-specific databases manually. One solution could be open data standards, such as the VEC (Vehicle Electric Container) format. However, these data formats were not created with a focus on automated production. The consequence is that there are also corresponding gaps here too.

Objective

In the light of the challenges described above, the aim of sub-project 3 was to pinpoint the existing gaps by way of example and to find a solution to the deficits identified. Using the concrete example of 'block loading', from the perspective of the various process partners, requirements for the necessary digitally evaluable data were collected and compared with the current status of their availability.

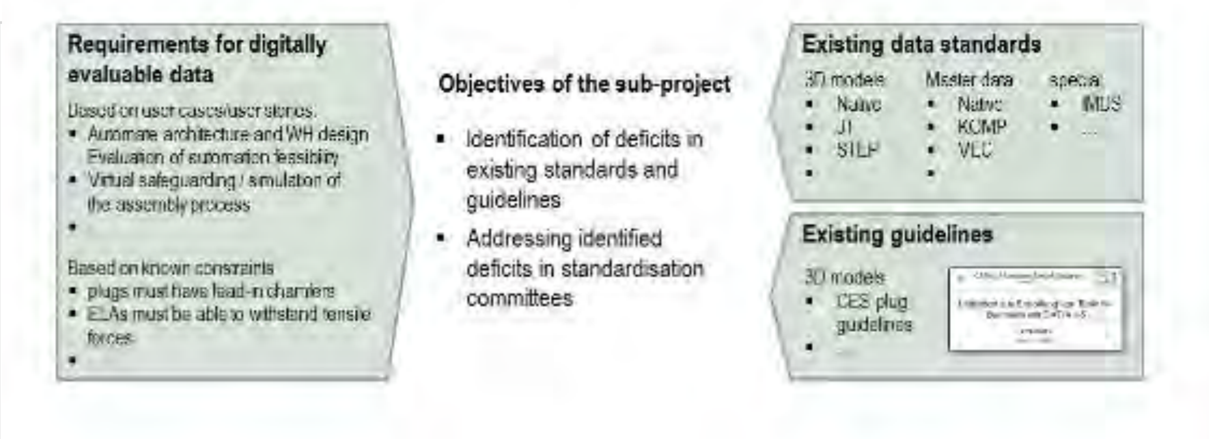


Figure 13: Objectives of the sub-project

Sub-project 3
Wire harness component library

Well-known, neutral and open data format standards such as VEC as well as standardised method descriptions such as the CES connector guide served as a reference.

Results of Project Phase 1

The overall result of the sub-project is essentially divided into two sub-sections, which were developed on the basis of each other. The first partial result comprises a user story analysis derived from existing automation solutions. The second partial result consists of an examination of the digital evaluability of design rules derived from the state of the art.

Both partial results were developed using the example of 'block loading' – the production step that describes the assembly of a connector with contacted leads.

The user stories were deliberately not restricted to this limited context. Rather, the user stories were compiled and considered holistically along the entire product creation process in order to also capture the upstream and downstream demand for digital data in the process chain, for example in the phases of product development and production planning. The following figure shows an extract from the result.

ID	User Story	Benefits
OEM 1.1	Within the architecture and series development I want to be able to target development towards automation. Input: E/E architecture, body shell concepts, wire harness design, digitally evaluable component data Output: Statement regarding feasibility of automated block loading	Promotes automation-friendly design
OEM 1.2	As an OEM, I want reliable quality in the production process Input: Flow diagrams, process capability analyses Output: Control plan, P-FMEA, risk analysis, in-process monitoring	Reduced complexity of final electrical inspections, less reworking and reworking costs
1st-1.9	As 1st tier, I want to be able to read in digitally evaluable component data directly from the manufacturer via a data set. The description should contain all relevant data for automation-friendly design. Input: Component attributes in digital form, which are required for automated processing. Output: Check and record whether automated processing possible; modular system for components that can be processed automatically.	Reduction of error sources in component management. Reduced complexity in the maintenance of component databases. Increased data quality and integrity.

Figure 14: User stories from the perspective of the process partners

Sub-project 3
Wire harness component library

As you can see, the user stories are sorted according to the actors involved (OEM, 1st tier, 2nd tier, automation solution provider). The list begins with the – admittedly unsurprising – user story that an OEM would like to be able to carry out a digital evaluation of the design for any existing automation obstacles at the time of architectural and series development. However, the list quickly became more extensive than originally expected. In the end, for example, we concluded that basically all process partners require meaningful component data that can be transferred to the company-specific part number ranges.

Another interesting result is the extent to which a 1st tier potentially wants to be able to design and change the (automated) production process itself. This ultimately defines the requirements for the necessary data flow between production planning and machinery.

The second partial result comprises the examination of the digital evaluability of the design rules defined in sub-projects 1 and 2 and which are relevant for block loading. All design rules relating to the relevant part types – connectors, cables, contacts and seals – have been considered. The figure shows an extract from the result.

Connector housing-related design rules

Design rule	Reference	Results	Relevant standards	Evaluation
Assembly must take place from the bottom left to the top right	See design rules, last updated 20/04/2020	(1) Definition of the geometric positions of the chambers on the basis of standardised KOOSY must be digitally evaluable (2) Orientation of the connector during production (3) The placement sequence must be defined in such a way that it can be digitally evaluated.	(1) VEC or a 3D convention (2) <unknown> (3) <unknown>	(1) **Need for action.** Simple cases writeable in VEC. No 3D convention known (2) **Need for action.** No standard known (3) **Need for action.** No standard known
Twisted pairs of wires should only be led into geometrically adjacent chambers.		see above: The geometric positions of the chambers must be digitally evaluable	VEC or a 3D convention	**Need for action** Simple cases writeable in VEC. No 3D convention known
For twists with more than 2 cores; the distance between adjacent cores must be the same and the orientation must be linear.		see above: The geometric positions of the chambers must be digitally evaluable	VEC or a 3D convention	**Need for action** Simple cases writeable in VEC. No 3D convention known

Contact part-related design rules

Design rule	Reference	Results	Relevant standards	Evaluation
The front-side contact surface should be minimal and contain insertion chamfers.	See design rules, last updated 20/04/2020	Geometric insertion direction of the contact part based on standardised KOOSY must be digitally evaluable.	3D convention	**Need for action** No conventions currently exist.
The spatial orientation of the contact part must be identifiable during production		It must be possible to describe the criterion for (optical) identification in a digitally analysable way.	<unknown>	**Need for action** No standard known

Sub-project 3

Wire harness component library

As can be seen, analogous to the definition of the design rules, care was taken to ensure that the requirements for digital component descriptions derived from the design rules differentiate between a digital description of the relevant product features (ideally a measurable physical quantity) and the target values (from today's perspective) that need to be met. This ensures that the digital component descriptions retain their value even while the technology of future automation solutions advances.

In conclusion, it can be stated that the VEC data standard already covers most of the requirements for a digital component description with regard to the examined process step 'block loading'. The greatest need for action was identified with regard to design rules that relate to the geometric design of the components. It turned out that the existing 3D models could not be automatically checked for compliance with the design rules without further methodological specifications. Among other things, this also requires some basic agreements, such as the location and orientation of the coordinate system. However, more extensive, digitally evaluable markings in the 3D model, such as the position and orientation of the respective entry points into the chambers of a connector, are also required for this.

Prospects for project phase 2

According to the current planning, project phase 2 aims to extend the approach described above to all manufacturing steps and design rules considered in the context of IIWH. However, the first step is to focus on the rules which can already be evaluated in the development phase.

Unlike in phase 1, the wire harness is to be considered from a holistic perspective. There is therefore no longer a focus on the individual components of the wire harness.

As a result, corresponding best practices are to be developed as well as a methodological guideline that addresses the need for action involving 3D models which was identified in phase 1. Furthermore, we plan to incorporate the documentation into a new standard to be developed within the framework of the overall IIWH project.

Sub-project 3

Wire harness component library

Interview with the sub-project head Dr Martin Pöschl (BMW)

ARENA2036: *The sub-project 'Wire harness component library' is the only sub-project in phase 1 of the IIWH that approaches the topic of automation of wire harness production and assembly with digital data. How important is the sub-project for you in this respect?*

Pöschl: The complexity of automotive wire harnesses has increased dramatically in recent years and this trend seems set to continue. This affects all partners in the process chain, from development to assembly. Without suitable tool support, this complexity cannot be mastered economically by human beings, if at all, at least in the long term. It is therefore only logical that a sub-project within the IIWH also deals with the provision of digital data and its evaluation.

ARENA2036: *Your sub-project places particular emphasis on being based on open data standards. What do you expect to gain from this approach?*

Pöschl: In my opinion, the data format itself, in which the process partners exchange data, but also on the basis of which tools and machines within the individual companies organise a continuous data flow, does not have a competitively differentiating character. You see, for a musician who releases a single, it's all about the song and not the data format. But imagine that there were no standardised data format like mp3 – we would still be using long-playing records and even there, various parameters were standardised. This is exactly what we need in the industry: a strong data standard with which we can exchange and evaluate content required in the course of development, production or assembly.

ARENA2036: *The long-playing record you refer is already going back a long way. Conversely, shouldn't we have long since had a corresponding data standard in the context of automotive wire harness production?*

Pöschl: Well, there has been. In Europe, at least, the KBL (harness description list) has been the relevant data standard for digital wire harness description for over 15 years. In the meantime, a gradual transition to the much more powerful data standard VEC (Vehicle Electric Container) is evident in the industry.

Continued on next page

Sub-project 3

Wire harness component library

I myself am an active member of the relevant group, which is responsible for standardisation at prostep ivip. However, it is a fact that 'automated production' has so far played only a minor role in the definition of the data formats mentioned. This is exactly the deficit that we are now addressing with the IIWH sub-project.

ARENA2036: *What has already been achieved in Phase 1 and by when will the process be completed?*

Pöschl: In phase 1 of the sub-project, our main goal was to define the contents and the working methodology for the upcoming phase 2 on the basis of an example that was as relevant as possible. We chose the example of 'block loading' and looked at the topic from the different perspectives of the process partners, i.e. deliberately not only from the point of view of production. It quickly became clear how multifaceted the topic is and where in the overall process digital data can contribute added value. It is not only the product definition phase where you want to be able to electronically evaluate whether a design considers all design rules. Another use case, for example, is the virtual assessment of a component under development, e.g. a connector, to identify automation obstacles. Yet another lies in the virtual analysis of the assembly process.

Nonetheless, for Phase 2 we decided to focus on the virtual evaluation of the design rules relevant to the development process. Within one year we want to establish best practices for all rules defined in the other sub-projects and develop a method guide for geometry models. One of the side effects of this, we believe, is that it can also have a positive influence on the definition of the rules themselves – in the end, only rules whose fulfilment can actually be measured make sense. And in our opinion, of course, this should be on a digital basis.

ARENA2036: *Dr Pöschl, many thanks for the interesting conversation.*

Pöschl: My pleasure.

Sub-project 4

Establishment of a quality seal for wire harness components optimised for automated machines

Sub-project 4

Establishment of a quality seal for wire harness components optimised for automated machines

2.4 Sub-project 4: Establishment of a quality seal for wire harness components optimised for automated machines

Participants

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Gebauer & Griller

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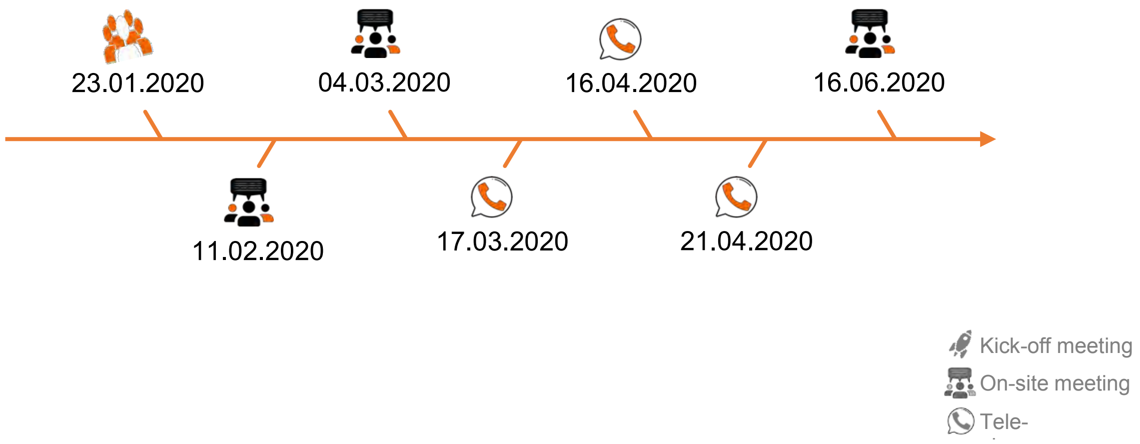
Project timeline



Sub-project 4

Establishment of a quality seal for wire harness components optimised for automated machines

Starting point/Motivation

The development and design of cable harness or wire harness components, such as connector systems for use in HV and LV wire harnesses, or add-on parts and protective elements, is primarily geared to the requirements for manual assembly of wire harnesses. In the technical documentation of wire harness components, requirements for the automatic assembly of connector systems are often only mentioned in passing. For a few components, reference is made to the basic possibility of automatic processing with special machine types commonly available on the market. No industry-wide implementation of the recommendations can be observed.

The basic problem in the development of wire harnesses is being able to recognise whether a wire harness component is suitable for automatic production or not. Even in the early stages of development, ignorance in the selection of wire harness components can make automatic production impossible, as it is not immediately apparent whether a component is suitable for the automated production of wire harnesses.

This is to be made possible with the help of a technical attribute, referred to here in the working title as a 'quality seal'. As the project progressed, this working title was renamed into a more descriptive term which clearly describes the meaning of the attribute. At the end of phase 1, the term 'automation index' was agreed upon as a further project designation.

Objective

In order to counter the challenges described above, the aim of sub-project 4 was to develop a type of identifier for the suitability of components for automatic machines in the form of an automation index that can be recognised throughout the automotive industry and has the potential to become a standard. The characteristic of the index should make every user, operator or processor immediately aware that this is a component that has been developed with a view to automatic wire harness production. In general, one could speak of a standard or a product label which, when awarded, takes into account the compliance of corresponding features for a wire harness component suitable for automatic machines.

The primary objective of sub-project 4 in phase 1 was therefore to define a method which, on the basis of evaluation criteria, makes the automation expenditure for components quantifiable and can depict it in the form of an automation index.

Sub-project 4

Establishment of a quality seal for wire harness components optimised for automated machines

Results of Project Phase 1

At the beginning of phase 1 of this sub-project, it very quickly became clear that it is not as easy as expected to assign an automation index to a component. As already mentioned at the beginning, the design guidelines known today describe characteristics and prerequisites for wire harness components that can be advantageous for process-reliable machining on a specific machine type. It is therefore not possible to state categorically that a particular characteristic is as important for a machine [A] as it is for a machine [B], or even that they can be mutually exclusive. There are also confirmed examples from actual practice, where various components were able to be processed automatically even without recommended features.

The aim of the project is to develop a solution-neutral evaluation method. From the very beginning, care was taken not to tailor the valuation method to a specific type of machine or machine manufacturer.

It was agreed that every production process could be automated with a correspondingly high technical and financial outlay. The result of the method must therefore be able to provide quantifiable information on the basis of evaluation criteria as to how high the automation expenditure of individual components is.

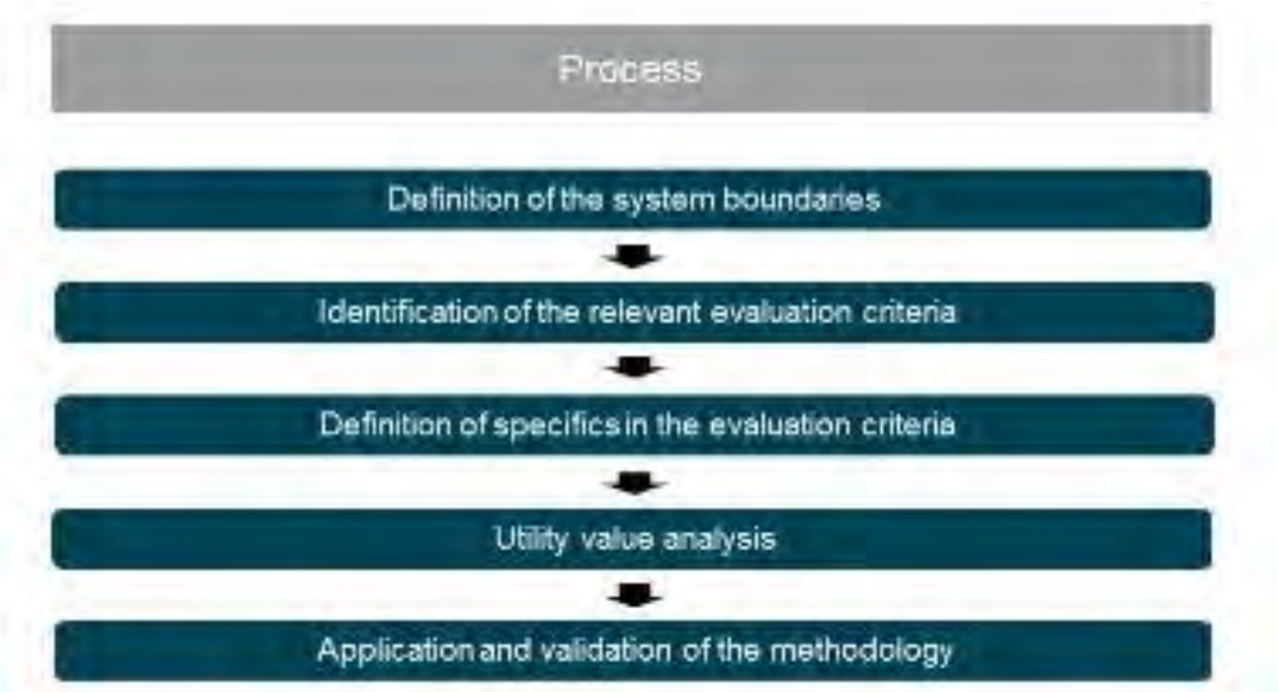


Figure 16: Sequence of the method for technical evaluation of the automation effort

Sub-project 4

Establishment of a quality seal for wire harness components optimised for automated machines

Furthermore, it was decided to build on a method that had been theoretically developed in a master's thesis, which deals with the technical evaluation of the automation effort in the assembly of HV wire harness connectors. The procedure for this method is shown below:

The method presented here was applied step by step both in the sub-project workshops and online in expert questionnaires. In the first analysis, this was done using various HV connector systems. The focus was therefore on HV connector systems because, in addition to the individual process steps of LV connector systems, they require several different individual process steps in their assembly. The individual processes of the LV systems are considered using the same approach in phase 2.

The method works at the process level of the individual components in order to ultimately obtain a quantitative evaluation. This means that the system limits for each individual process step, such as cutting, crimping, shielding, plugging and pushing on HV components, were considered and evaluation criteria were assessed in a utility value analysis. The entire plug-in system that the method refers to is seen as a complete system. It therefore does not provide an assessment of the degree of automation that can be achieved for the entire wire harness.

The first validation has finally taken place in phase 1. As the amount of data was too small, further results will be analysed in a deep dive in phase 2 to sufficiently confirm the method's functionality. But the general first impression is that the method will be highly suitable for the further continuation of the project.

Prospects for project phase 2

At the end of phase 2, it should be possible to provide user-friendly guidance in the form of a user manual for engineers. This manual describes the exact application of the method developed in this sub-project and the procedure for achieving the automation index. It should be possible for the manufacturer to voluntarily determine the automation index for his products autonomously.

Furthermore, the procedure is described in such a way that the documents can be converted into a standardisation process, for example.

Sub-project 4

Establishment of a quality seal for wire harness components optimised for automated machines

Interview with the sub-project head Stephan Fahrnbauer (BMW)

ARENA2036: *At the beginning of the IIWH, the sub-project 'quality seal' was voted 16th in the profile survey. Many probably weren't focusing on this topic. Why did you nevertheless take over the sub-project management and campaign for collaborators?*

Fahrnbauer: Because I think that this kind of technical attribute, after all, this is precisely what the quality seal and the automation index is all about, is a very important element that can take us a big step forward both in the development and in the automatic production of wire harnesses.

ARENA2036: *Why do you think that is?*

Fahrnbauer: We are repeatedly faced with the same problem when developing wire harnesses that are to be produced automatically. The decision as to which connector system is installed on the respective component is usually not made by the wire harness development department, but by the person responsible for the component, e.g. a control unit or sensor. Unfortunately, most of them, justifiably so, do not know what to look for when selecting their connectors so that the cable harness can be produced automatically. A quality seal could close this knowledge gap from the outset, as it would mark a wire harness component as 'suitable for automated machines'.

ARENA2036: *How should the quality seal be set up?*

Fahrnbauer: The seal should be open to all market participants on a voluntary basis. In particular, it is up to each manufacturer of wire harness components to decide whether or not to advertise products with a quality seal, just as the person responsible for the components is free to decide on their use.

ARENA2036: *What are you looking for in your sub-project once IIWH is completed?*

Fahrnbauer: I would hope that this sub-project has enabled us to lay a foundation stone which will lead to the quality seal being a standard in its own right and being recognised in the automotive industry as a means of marking the suitability of components for use in automatic machines.

ARENA2036: *Many thanks for your time and the interesting conversation.*

Fahrnbauer: Thank you very much.

ARENA2036

Sub-project 5

Automation of quality control

Sub-project 5
Automation of quality control

2.5 Sub-project 5: Automation of quality control

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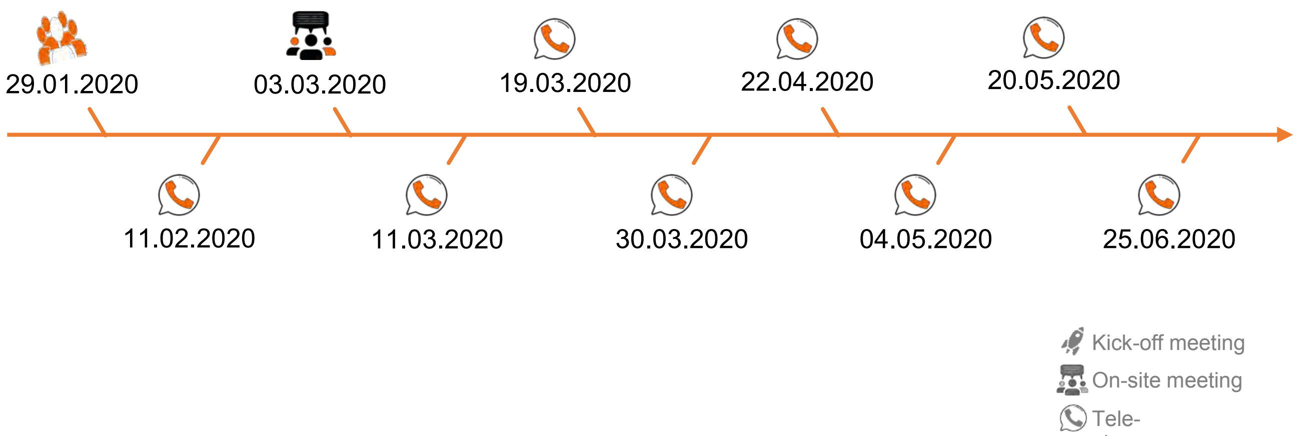
Project timeline



Sub-project 5

Automation of quality control

Starting point/Motivation

The 100% quality of a finished product is usually ensured in wire harness production by an end-of-line test (EOL) on an electrical test table (ETT).

In upstream sub-processes, such as cutting and crimping, state-of-the-art inline process monitoring is possible. The quality data determined here are usually documented in relation to batch sizes. However, any existing quality features, such as the assembly alignment and positioning of components, are checked again in the end-of-line test.

Increasing miniaturisation poses a great challenge for workers, both physically and mentally. Complex reworking due to possible sequential errors requires manual removal and repositioning during the end-of-line test, which places mechanical stress on the wire harness.

By shifting 100% consistently documented and automated test steps towards corresponding production steps, it is possible to create the technical basis for carrying out quality assurance in the intermediate steps of the ongoing production process.

Objective

The aim of the sub-project was to investigate the extent to which it is possible to move away from the requirement of a mandatory 100% end-of-line inspection in automated production and to what degree the desired automation of inspections can already be achieved during the production process. Possibilities were identified for seamless quality assurance through automatic monitoring and documentation of the individual production and testing steps.

This was accompanied by a quantification of the potentials arising from the elimination of quality assurance measures in manual production up to and including the elimination of final inspections.

In addition to the aspects of technical feasibility, it was equally important to consider and demonstrate the associated cost implications on an abstract basis.

Sub-project 5

Automation of quality control

Results of Project Phase 1

In order to further increase the degree of automation in production, it is necessary to first consider the entire process. During production steps, such as assembly and foaming, quality assurance measures are already being carried out in some cases, but the results do not always allow a clear conclusion to be

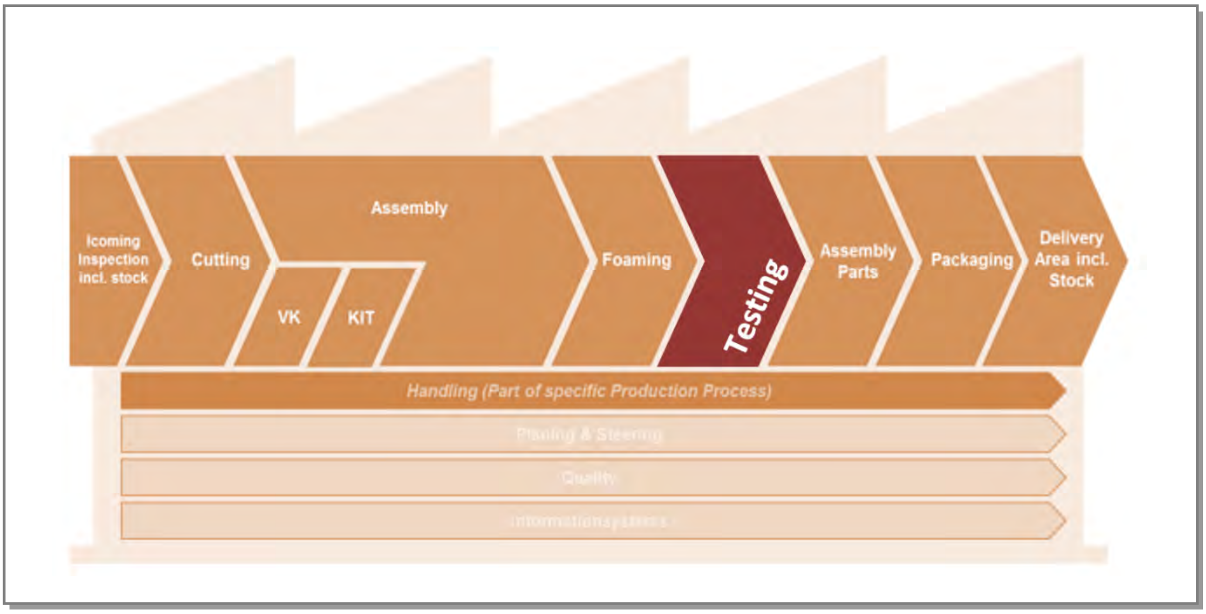


Figure 17: Location of the testing in the wire harness production process

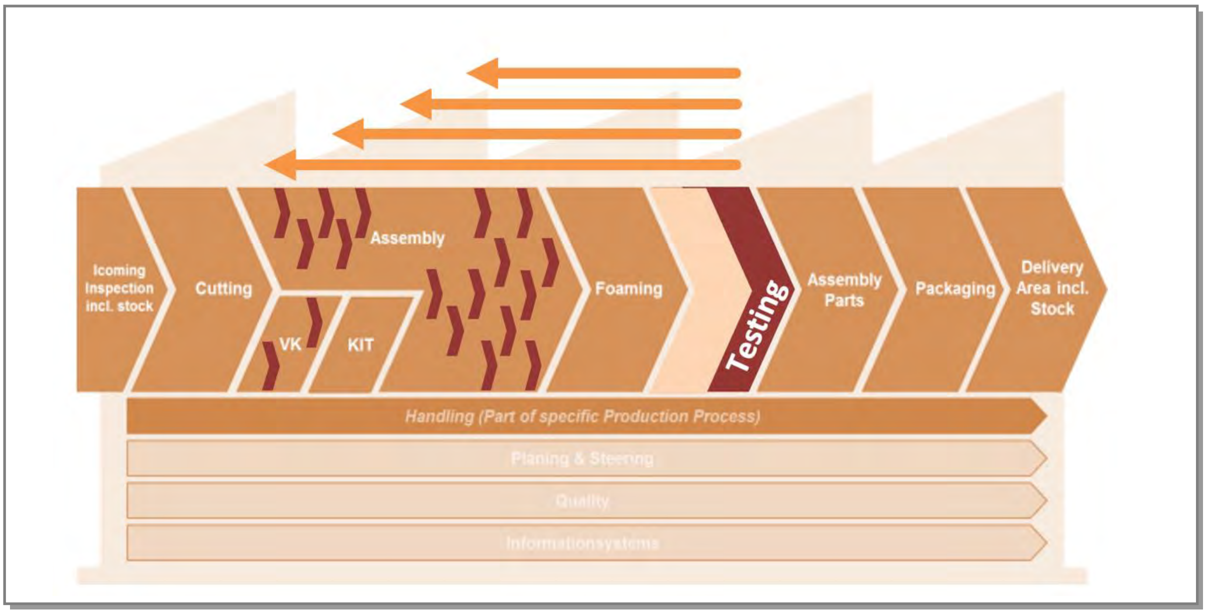


Figure 18: Shifting the testing in the wire harness production process

Sub-project 5

Automation of quality control

drawn about the specific wire harness (cf. Figure 17).

The aim is to shift the final quality assurance measure to the point of value creation in the production process (cf. Figure 18). Care must be taken to ensure that the documentation of the results is clearly linked to the overall set of guidelines.

To reduce the depth of testing in the end-of-line test, it is first necessary to categorise the individual tests. Three categories were developed and the corresponding tests were assigned.

The *module type* defines the basic function of the adaptation. Examples are electrical adaptation, body clip or grommet (cable bushing), ring terminal or USB.

Detections also check the properties of a connector housing, such as tightness, secondary locking, covers, coding, locks, clips, cable ties (see Figure 19).

The detections are typically implemented by switching pins or other sensors (cf. Figure 20).

Options describe separate versions, such as a mask for bent pins, housing colour, contour inserts, airbag short-circuit bridge.

On the basis of these principles, concrete recommendations for action were developed using a simplified wire harness, which are presented here in extracts (cf. Figure 21).

Figure 19: Typical detections on a connector housing

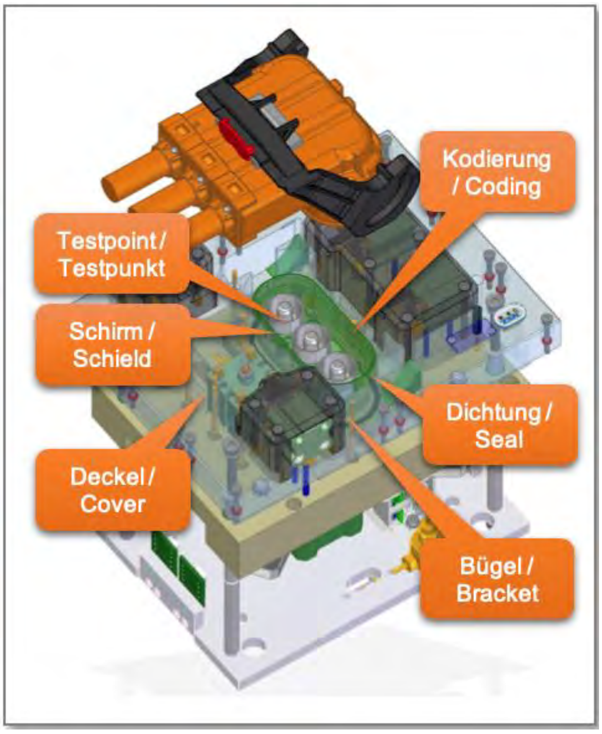


Figure 20: Sample set-up of a test module

Sub-project 5

Automation of quality control

EOL test	Where	Challenge
Coding	Automatic assembly	Reliable supply of components along the entire supply chain
Contour	Automatic assembly	Reliable supply of components along the entire supply chain
Snap-in test	Automatic assembly	Push – Pull – Push Force and travel monitoring
Secondary locking	Automatic assembly	Automatic closing before removal, checking the end position
Seals	Construction suitable for automated machines	Necessary structural changes so that leakage testing is no longer necessary Leak test in the interlinked production step
Electr. connection	Automatic assembly	Ensuring correct, non-destructive chamber assembly
Cross section	Automatic assembly	Reliable supply of components along the entire supply chain

Figure 21: Extract from recommendations for action

Prospects for project phase 2

The improvement potentials and options for action identified in phase 1 of the Innovation Initiative Wire Harness are to be used to compare the automation needs and possibilities in the process chain. To this end, further technology trends are to be identified and taken up, which are deliberately not limited to the automotive solution space. Concrete feasibility studies will be carried out in phase 2 to outline an automation roadmap that will lead to a paradigm shift in the process chain through innovative process design.

The core aspects of error avoidance through automation-compatible design, error handling safeguards through automation technology and error detection through automatic tests at the point of value creation are to be highlighted and presented in a generic target process in line with the precompetitive character of the innovation initiative.

Phase 2 thus provides normative and informative aspects for an integrative standardisation of the wire harness development, production and protection across sub-projects. This means that, on the one hand, the requirements for necessary preliminary development work (design rules, zonal E/E architecture, etc.) are more clearly emphasised and, on the other hand, the degree of automation is increased by changing from manual to automatic production processes.

In addition to the topic-specific sub-project ‘Automation of quality control’, the thematic extension of the focus project ‘Production’ by a ‘Structural model LS production process’ as well as the implementation of the digitisation of the process chain is desirable.

Due to the ever increasing demands on the complex functional range of vehicles, the pressure to innovate will also increase in respect of the industrialisation of wire harness production. While maintaining our zero-defect strategy, we must make cost efficiency and investment risks manageable and maintain both production flexibility and customer quality at a high level.

Sub-project 5

Automation of quality control

The generic target production process should make an effective contribution to this. The aim is to reduce the process-related quality assurance measures as much as possible or to optimally position automatic in-process inspections along the value chain (keyword: front-loading). Redundant tests should be avoided along the entire tier n chain. Traceability at component level must be ensured throughout.

At the end of phase 2, greater transparency is to be achieved by detailing and standardising the industrialisation process. The implementation requirements for the automation of the wire harness production are described. The automation roadmap shows the various possibilities and predicted trends.

Sub-project 5

Automation of quality control

Interview with the sub-project head Matthias Otte (Komax)

ARENA2036: *Mr Otte, you come from the testing division of the Komax Group. When you were asked to lead the sub-project 'Automation of quality control', what was it that tipped the scales for you?*

Otte: Ensuring the quality of wire harnesses has made up a significant part of my professional career for some time. In my view, conceptual changes are already long overdue here. When I heard about the IIWH, I was quickly convinced that active participation in the project made a great deal of sense.

ARENA2036: *From today's perspective, what particular challenges do you see in the production of wire harnesses?*

Otte: Even today, the production of wire harnesses is still characterised by a high proportion of manual work in the area of cable routing and assembly. In addition, miniaturisation is progressing with increasing complexity. This means ever higher demands on workers with an accompanying possible increase in error rates. Errors are often not recognised and corrected until the 'end-of-line testing'. This cost-intensive approach must be eliminated.

ARENA2036: *What expectations do you have of this task?*

Otte: We have made it our mission to first analyse the process of wire harness assembly and the associated end-of-line testing and to develop proposals and methods that will shift quality testing to the point of added value in such a way that the end-of-line testing effort can be reduced.

ARENA2036: *What are your hopes for your sub-project?*

Otte: In phase 1 we had a diverse and powerful team that took up the challenge. This is also what I would like to see for phase 2. In phase 1, it became apparent that a paradigm shift is necessary to achieve the necessary automation needs and possibilities in the process chain. I expect an analysis of technology trends and feasibility studies during phase 2. It is also necessary to work out aspects which aim at a cross-sub-project automation-optimised standardisation of the wire harness development.

ARENA2036: *Mr Otte, thank you very much for the interesting conversation.*

Otte: Thank you very much.

Sub-project 6

Wire harness architecture of the future

Sub-project 6
Wire harness architecture of the future

2.6 Sub-project 6: Wire harness architecture of the future

Participants

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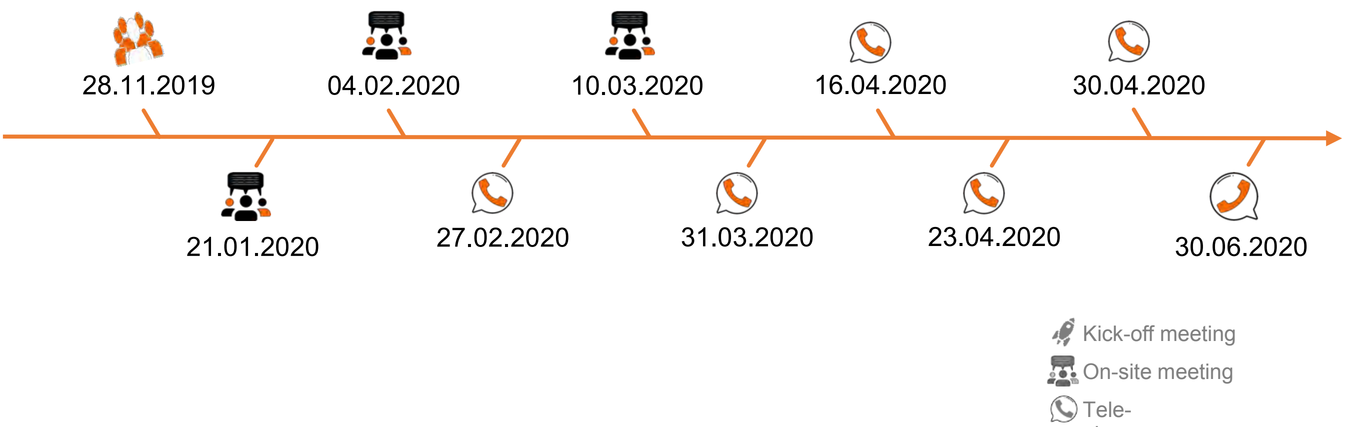
Project timeline



Sub-project 6

Wire harness architecture of the future

Objective

The sub-project 'Wire harness architecture of the future' has the general aim of developing proposals on how wire harness architectures can be produced as fully automated as possible in the future. The wire harness architecture should thus support the automation of wire harness production. A standard for all wire harnesses should be helpful in this respect.

Three sub-goals were identified for this path:

- Drastic reduction of the variety of parts.
- Sector comparison and comparison with other industries.
- Development of a baseline as to which interfaces need to be standardised.

The work in this sub-project is based on a green field approach in order to be as free as possible from backward compatibility constraints. The year 2030 was envisaged as the time frame (quasi SOP).

Results of Project Phase 1

Reduction of the variety of parts

The focus was on cable types and their uncontrolled 'growth'. To start with, the generic properties, such as structural and functional requirements and their characteristics, such as current-carrying capacities or temperature ranges of single and multi-core cables, were worked out.

As the objective of the Innovation Initiative Wire Harness is a standard and such a standard always means a restriction, the Pareto principle was applied and in the following only cable types were considered which account for at least 90% of the cables used.

Datentransport (Busse)

Signaltransport (diskret)

Sinn	Anforderungen	Ausprägungen	Detaillierungen / Beispiele	Einflussgrößen
Energietransport	Funktional	Verbindung zur energetischen Versorgung herstellen		
		Eigensicherheit gewährleisten		
		Interferenzfreiheit / Rückwirkungsfreiheit sicherstellen		
		Optional: Masserückführung darstellen		
	Strukturell	Schnittstelle zu Systemumgebung		
		- feste Verbindung	?	
		- lösbare Verbindung	USB-, Fzg.-Laden	
		Verteilungsstruktur darstellen	unterschiedliche Topologien	Schalter, Verteiler, Messung sonstige Funktionen & Deployment
	System-umgebung	Masserückführung über Karosserie		
		Werkstatt & Upgrade (z.B. Leasing-Rückläufer)		
	Zukunft	Innovationen		

Figure 22: Result of generic requirements analysis for cable types

Sub-project 6

Wire harness architecture of the future

Provided that new (green field) paths are taken, such as marking cables by printing instead of using colours or significantly reducing the diversity of cross-sections, the number of cable types can be reduced to under 100. This would be equivalent to a reduction in cable diversity by an order of magnitude of 10 or more (depending on the vehicle derivative and equipment).

Special cables outside the Pareto scope, such as high-voltage cables, would not be covered by the envisaged standard initially, but this would still bring us a significant step closer to automated wire harness production, ideally on a single machine.

Sector comparison and comparison with other industries

For the industry comparison, it is best to use an automotive company whose product development is as free as possible from inherited problems. This allows interesting ideas to be integrated into products more quickly. It was precisely this idea that needed to be addressed. Our choice went to the Californian company Tesla.

For example, a patent disclosure was analysed in which rigid conductors are registered as the 'backbone' for the wire harness. Although this approach would be tantamount to a minor revolution in the assembly of wire harnesses, the patent itself was 'demystified' in large pieces by the sub-project staff, because similar ideas have already been patented by other OEMs.

The comparison with the electronics industry, especially the 'surface-mounted devices' (SMD), was more worthwhile: Here, too, there is an immense variety of components which could be managed by standards.

The example also shows that the introduction and use of established standards have not harmed the innovative strength of this industry. The recommendation is therefore to use this as a basis for standards or norms for the production of wire harnesses.

Discussion basis for the standard

Based on the model of the SMD industry (cf. Figure 23), the individual components of the value chain and their interrelationships were worked out for the wire harness.

In a subsequent step, participating/necessary sub-projects or results of the IIWH were integrated into the overview.

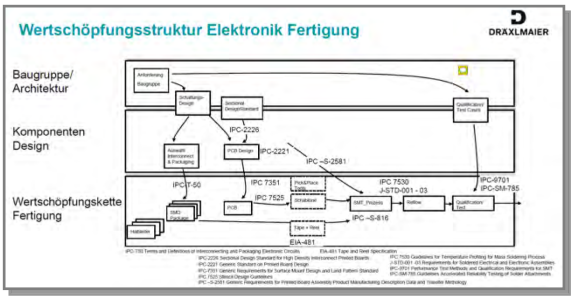


Figure 23: Added value in SMD production

Sub-project 6
Wire harness architecture of the future

Finally, all transitions and interfaces were highlighted for which the participants consider standardisation necessary (cf. Figure 24).

Prospects for project phase 2

The work carried out so far can be regarded as preparatory work for the later standard. Enhancements and possibly corrections will be necessary.

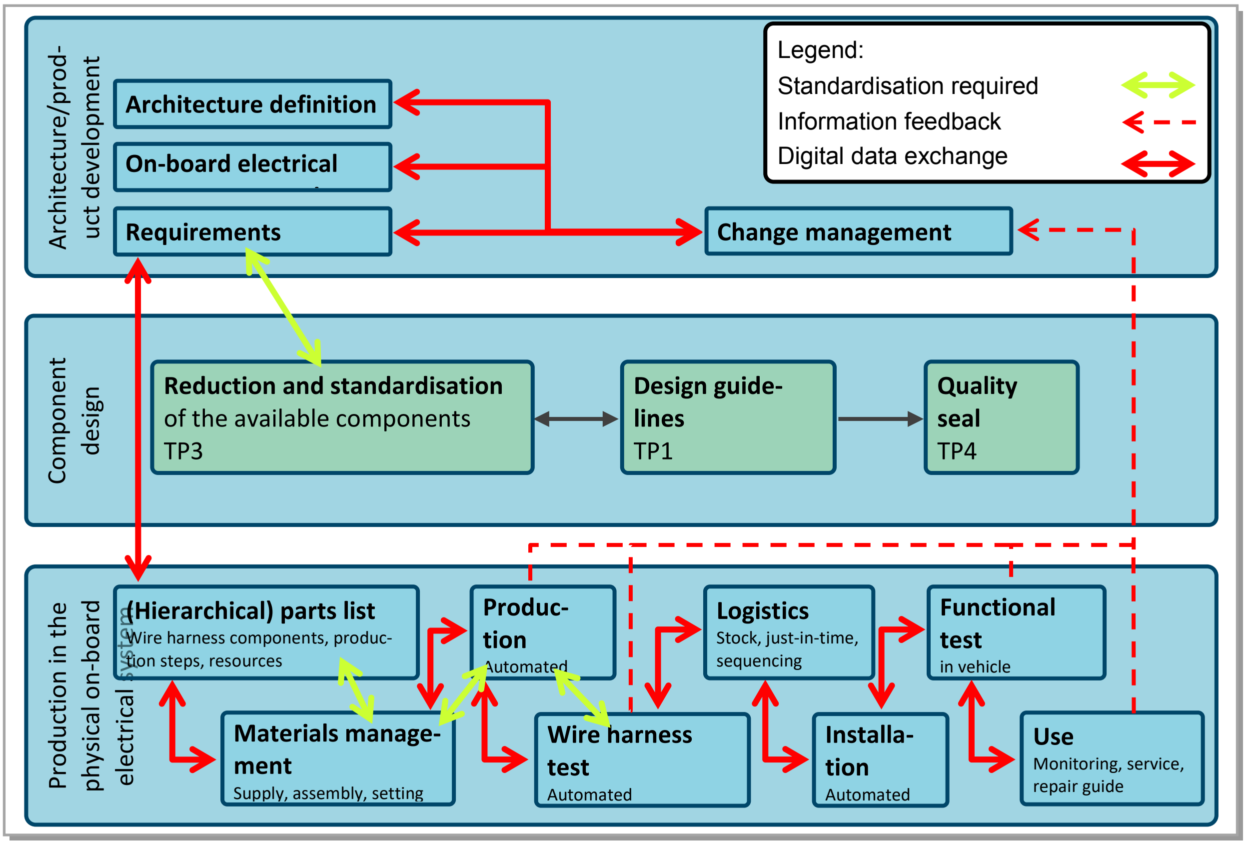


Fig. 24: Value creation in WH production

Sub-project 6

Wire harness architecture of the future

Interview with the sub-project head Dr Martin Meseth (BMW)

ARENA2036: *Dr Meseth, how far into the future are you looking in your sub-project?*

Meseth: We agreed on a time frame for the sub-project of 2030, i.e. about 10 years in the future.

ARENA2036: *Are you developing an actual wire harness architecture?*

Meseth: No. It was never the aim to develop a wire harness architecture that could be, more or less, used as a blueprint for everyone. Even in the future, all companies should be free to choose their own architecture. The sub-project rather focuses on generic questions, such as the maximum number of different cable types required.

ARENA2036: *What is this reduction in the variety of parts good for?*

Meseth: The aim of IIWH is to produce wire harnesses automatically – i.e. by machines – in the future. The number of 'add-on possibilities' will be limited on such machines. Ergo, the variety of parts should be significantly reduced (compared to today's customer-specific wire harnesses).

ARENA2036: *What was achieved in Phase 1?*

Meseth: I consider our greatest achievement in this sub-project to be the proposal we developed for reducing the number of cable types. This can make a significant contribution to automation.

The discussion framework aimed at developing a standard is also an important result.

Sub-project 7

Automated assembly of the wire harness in the vehicle

Sub-project 7
Automated assembly of the wire harness in the vehicle

2.7 Sub-project 7: Automated assembly of the wire harness in the vehicle

Participants

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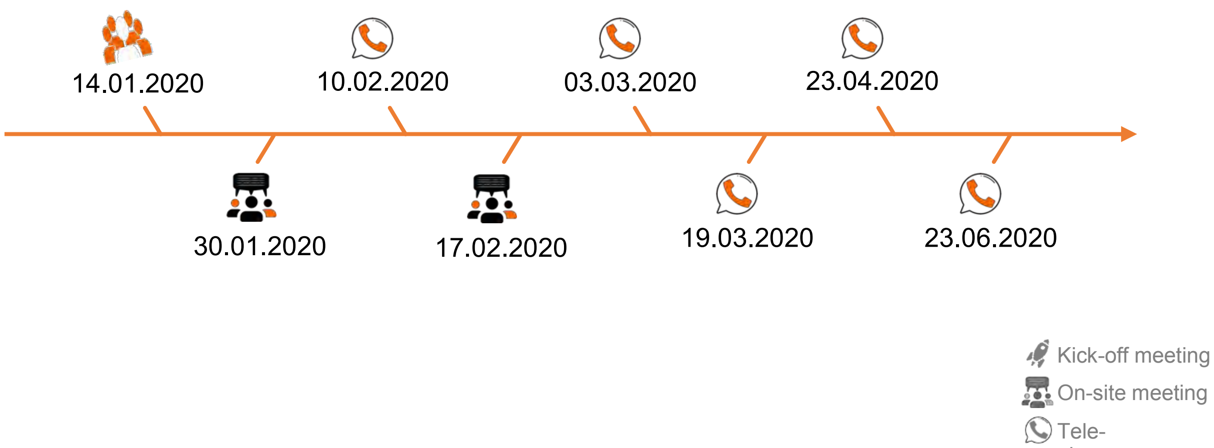
Uwe Hessler
Kromberg & Schubert

Michael Wortberg
Dräxlmaier

Jerome Trommnau
Mercedes-Benz

Bernd Weiß
Mercedes-Benz

Project timeline



Sub-project 7
Automated assembly of the wire harness in the vehicle

Starting point/Motivation

The assembly of wire harnesses in vehicles is a labour-intensive manual activity today. Due to the size and weight of the wire harness, it can easily be damaged. Manual installation also leads to scattering during the exact laying of cables as well as to possible errors in the correct connection of the wire harness.

Last but not least, the great complexity of the wire harness leads to the binding of many cycles (time factor) in manual assembly, because the plugging of the large number of cable ends or plugs and fastenings, such as clips, is very labour- and time-intensive.

Since the wire harness is one of the first components to be installed in the vehicle, error correction at a later stage is very costly.

Objective

The assembly of the wire harness in the vehicle represents a relevant field of application for automation from an OEM perspective. This does not mean eliminating human labour from assembly per se. Rather, the aim is to identify possible applications for modern man-machine collaboration models in order to minimise the potential for error. Furthermore, the aim is also to determine the assembly parameters, so that continuous quality recording, traceability and, if necessary, early reworking are made possible.

The assembly of the wire harness should therefore not necessarily become faster and more efficient; the aim is rather an increase in quality in the assembly process.

Procedure

In this sub-project, the first step is to work out technical possibilities that will enable (partial) automation of the assembly process. Particularly in light of the flexible components of the wire harness, the question of mechanical support for humans arises.

In order to gain an overall picture, a generic process step analysis of the wire harness assembly was first carried out on the status quo (cf. Figure 25). This was used to identify the obstacles and challenges for automating the assembly of the wire harness. In this way, it was possible to define the relevant fields of action and topics that can be considered across OEMs.

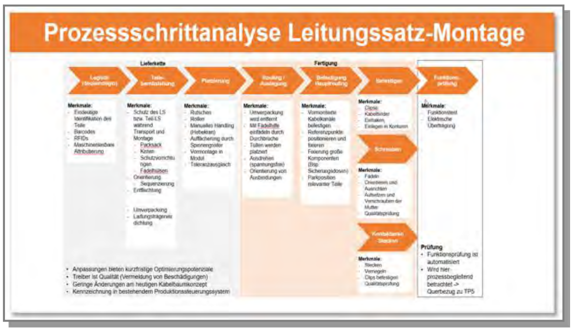


Figure 25: Process step analysis of the wire harness assembly

Sub-project 7

Automated assembly of the wire harness in the vehicle

Positioning of the wire harness in the vehicle, routing and design, as well as the attachment and contacting of the wire harness in the vehicle were the areas that emerged as the scope of the sub-project.

All upstream and downstream steps of the assembly process are largely the responsibility of the OEM or supplier.

Far-reaching insights into the overall wire harness have been gained through extensive research into numerous patents and benchmark studies in the field of wire harnesses (including Tesla Model 3, cf. Figure 26). This knowledge was the basic prerequisite to successfully start phase 2 of IIWH with the current state of knowledge.

Figure 26: Hardware benchmark analysis of the Tesla Model 3 wire harness

In order to gain insights into projects already carried out in the field of robotics in wire harness assembly, the Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW) at the University of Stuttgart was invited to present the current state of the art in a lecture. This resulted in points of contact regarding the handling of flexible parts for robots, which suggest a possible integration of the ISW into the project during phase 2.

Results of Project Phase 1

The entire spectrum of the installation of the wire harness in the vehicle was considered and analysed. The perspective was extended from the planning and production of the wire harness to the final inspection of the finished vehicle in an example vehicle production plant. All connections and dependencies of the wire harness assembly process were recorded in a general process step analysis.

The fields of action that will be continued in the sub-project were identified as a result of this process step analysis. The individual process steps were underpinned with obstacles and efforts, so that a clear view of the challenges emerged. Based on these findings, the main field of action was selected as the area from inserting the wire harness into the vehicle to contacting the plug to the component.

Sub-project 7
Automated assembly of the wire harness in the vehicle

For phase 2, the project outlines were derived and prepared on the basis of the study results. Two main areas were developed. One area will deal with the scope ‘Automatic rough positioning of the WH in the vehicle’ in Phase 2. Another area will deal with the ‘Construction of a demonstrator for the automated installation of a partial wire harness into a body shell with the aid of a robot’.

A comprehensive patent and benchmark search has been completed and the knowledge gained will be used in project Phase 2.

A further result of Phase 1 was the generation of project outlines for Phase 2 and the associated considerations as to which technologies and methods can be used for the automated installation of a partial wire harness in the vehicle. To this end, two sub-projects were defined and their contents described.

Focus 1: Concept development: Automatic rough positioning of the WH in the vehicle

There are different approaches as to how the wire harness can be installed in the body shell and placed in its approximate final position. One variant is the insertion of the WH into the body shell by means of a transport and mounting plate (cf. figure 27).

For a defined area (interior right side, area A-pillar to B-pillar and floor panel)

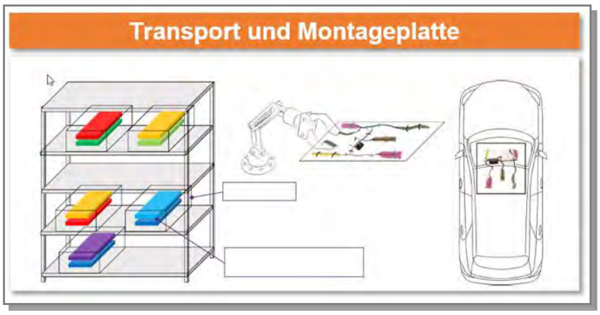


Figure 27: Transport and mounting plate

Another possibility would be a ‘rotary wire harness’. Rolled onto a workpiece carrier, the wire harness is automatically unrolled again in a predefined position in the vehicle (see Figure 28).

Furthermore, there are considerations and attempts to roughly position the wire harness in the vehicle using compressed air assistance.

Focus 2: Construction of a demonstrator for the automated installation of a wire harness into a body shell with the aid of a robot

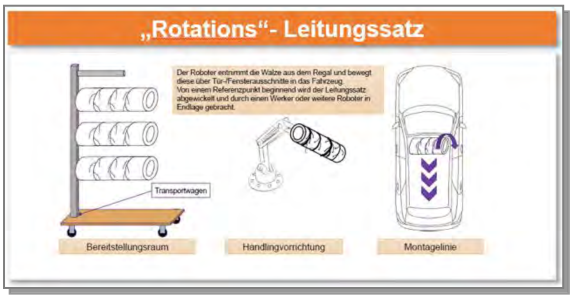


Figure 28: ‘Rotary’ wire harness

Sub-project 7

Automated assembly of the wire harness in the vehicle

of the type-neutral body shell, a partial wire harness is designed and manufactured by the supplier. The scope of the wire harness was defined with four different plugs, different windings, as well as different cable cross-sections and fastening elements. Among other things, the demonstrator also serves to define mounting points and areas for robots. Finally, the robot should automatically grip the wire harness, bring it into its final installation position and then fully automatically install and plug it in.

Prospects for project phase 2

The detailed planning for the construction of the demonstrators will take place at the beginning of project Phase 2. New partners from the fields of robotics and material supply are required for this.

Various small-scale hardware tests are planned to determine, among other things, suitable materials and component properties, which will provide new findings in the field of automated wire harness production. The experience gained will be incorporated in the construction of the demonstrator.

In the second half of Phase 2, intensive work will be done on the implementation and construction of the demonstrators.

The **aim** here is to install a partial wire harness automatically in the vehicle using modern man-machine collaboration. Application cases are to be worked out, as to how an automated assembly of the increasingly extensive wire harness in the vehicle can take place in future. The construction of the demonstrators serves, among other things, to gain insights and illustrate the planned application examples.

Sub-project 7

Automated assembly of the wire harness in the vehicle

Interview with the sub-project head Christian Steiler (BMW)

ARENA2036: *Mr Steiler, your background at BMW is in the area of production. What made you decide to lead a sub-project at IIWH?*

Steiler: I have been working on the assembly of wire harnesses for a long time. When I first heard about the IIWH, I found it very exciting and at the same time I was convinced that it was high time to automate the assembly of the wire harness as well. Up to now it has largely been purely manual work to install a wire harness in the vehicle.

ARENA2036: *Your sub-project deals with the automation of wire harness assembly. What expectations do you have of this task?*

Steiler: We have made it our task to work out proposals and methods as to how machine-supported or fully automatic wire harness assembly will look in the future.

ARENA2036: *Do you see any real chance of automating the assembly of the wire harness?*

Steiler: I definitely see this as a possibility. Installation work on wire harnesses is currently very time-consuming and there is great scope for errors. For this reason alone it is necessary to think about modern production methods. In addition, we all naturally want to achieve a progressive improvement in quality, which I believe can only be realised through automation.

ARENA2036: *What are your hopes for your sub-project?*

Steiler: I hope that in phase 2 we will continue to be such a powerful group of people from very different companies with a great team spirit and that we will continue to strengthen ourselves by specifically recruiting new members from the fields of robotics and materials science. Together, we can make a significant contribution to the automation of wire harness assembly.

Sub-project 8

Reasons for automation in wire harness production and assembly

Sub-project 8
Reasons for automation in wiring harness production and assembly

2.8 Sub-project 8: Reasons for automation in wire harness production and assembly

Participants

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Mercedes-Benz

Till Beck (Joint Sub-project Head)

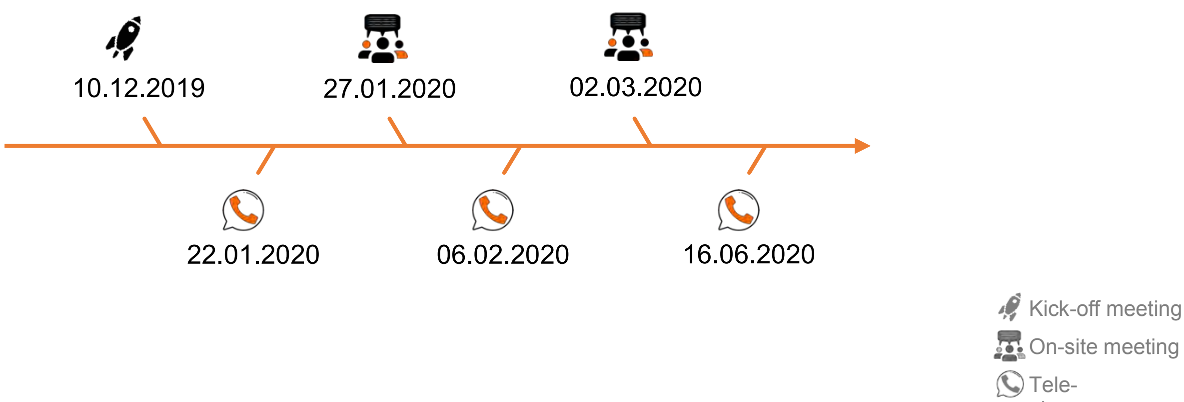
Andreas Müller
KOSTAL

Andreas Pesch
KOSTAL

Karsten Rüter
Dräxlmaier

Bernd Weiß
Mercedes-Benz

Project timeline



Sub-project 8

Reasons for automation in wiring harness production and assembly

Starting point/Motivation

The production of automotive wire harnesses is still characterised by a very high proportion of manual production steps. So far, automation solutions can only be found in the field of prefabrication. The assembly steps on the classic building board are usually carried out manually. It is worth mentioning that the wire harnesses of different cable laying areas also differ with regard to their share of automated production steps. Here, only the engine block wire harness has a comparatively high proportion of automated production steps. This shows that there is great potential for automation in the field of wire harnesses.

OEMs, wire harness suppliers, component manufacturers and plant manufacturers are making efforts to increase the degree of automation in the production and assembly of wire harnesses.

The reasons for this are manifold and often complex. In order to gain a precise understanding of the motivational factors of the individual participants in the overall process, it is imperative that the reasons for automation are reviewed. Furthermore, a holistic overview with specifically detailed starting points can be developed to make the complexity manageable.

Objective

For a complete overview of the reasons for automation in wire harness production and assembly, all of the relevant reasons had to be recorded, discussed and presented in detail. The reasons were then clustered into thematic fields. Furthermore, it was necessary to include a division of the subject areas with regard to their time frames.

The reasons for automation that have been worked out now form the basis and motivation for the Innovation Initiative Wire Harness itself and the individual specific sub-projects.

Results of Project Phase 1

An overall document with all relevant reasons for automation in the production and assembly of wire harnesses was prepared for the refurbishment.

In addition, topic area clusters have been developed for the respective reasons for automation. The time scale was differentiated between ‘already relevant today’ and ‘relevant in the future’.

Sub-project 8

Reasons for automation in wiring harness production and assembly

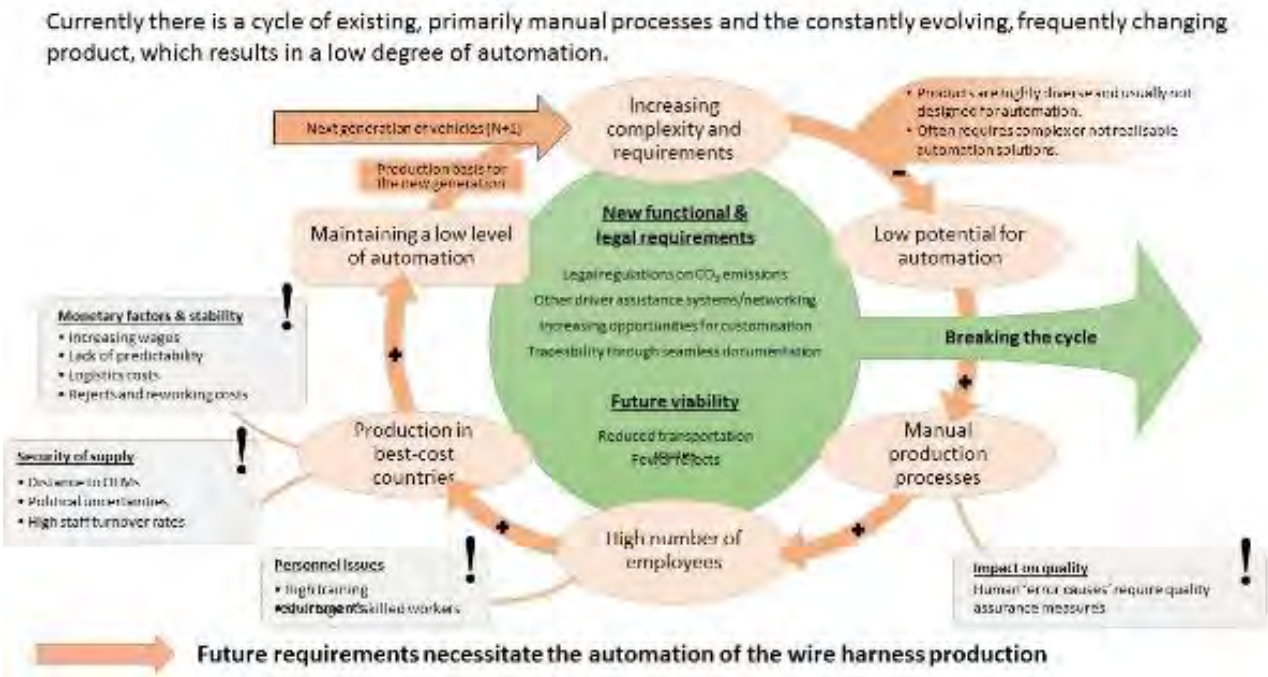


Figure 29: Causal loop diagram of today's wire harness development process

In order to describe the individual reasons for automation, an explanation of the respective initial situation and the specific benefit of increasing the degree of automation was given.

In addition, a 'big picture' was designed, which shows the interrelationship of the wire harness development process in relation to the increase in the degree of automation (cf. Figure 29).

To continue to maintain an overall view of the advantages of automation in the production and assembly of wire harnesses, an overview was also prepared for this purpose.

The reasons for automation can be divided into the following subject areas:

1. Personnel issues
2. Monetary factors/stability
3. Impact on quality
4. Flexibility
5. Ensuring security of supply
6. Timing
7. Functional safety/new legal requirements
8. Sustainability/future viability
9. Increasing complexity of the wire harness

Sub-project 8

Reasons for automation in wiring harness production and assembly

A targeted appraisal of the reasons for automation in the production and assembly of wire harnesses makes it clear that today's influencing factors, such as a shortage of skilled workers at production sites, high fluctuation rates, the demand for miniaturisation and the constant demand to improve quality are positively influenced by an increase in the degree of automation. In addition, future milestones, such as autonomous driving and related legal regulations will require new and different types of process control. Replacing existing manual processes with automated solutions is a suitable means of meeting these requirements.

However, the complexity of the wire harness makes it difficult to achieve these objectives. Furthermore, an exclusively gradual substitution of manual assembly operations does not lead to the desired and necessary future scenario. Only a holistic approach along the entire product development chain makes it possible to achieve this vision of the future.

Prospects for project phase 2

From this list of reasons in combination with the focus projects in Phase 2, higher-level road maps can be developed in the future. Furthermore, the overall document is regularly supplemented with relevant content from the individual sub-projects.

Sub-project 8

Reasons for automation in wiring harness production and assembly

Interview with the sub-project head Jerome Trommnau (Mercedes-Benz)

ARENA2036: *Mr. Trommnau, all of the sub-projects at IIWH have the basic aim of creating a future practical applicability. Yours is different in this respect. What was the motivation to start this sub-project?*

Trommnau: A brief look at the different sub-projects shows how different the topics are within the IIWH. However, the treatment of each topic requires legitimation. Accordingly, we agreed on one point from the outset: We need a common vision of why the step towards automation is necessary and right. Due to the diversity of the individual reasons, we have decided to work on this task in a separate sub-project.

ARENA2036: *What significance do you assign to the sub-project 'Reasons for automation in wire harness production and assembly' within the overall project structure of the Innovation Initiative Wire Harness?*

Trommnau: For any project, it is essential to know the motivational factors as well as the desired target states in order to be able to pursue them consistently. This is particularly important in a project like IIWH, which has several sub-projects. The sub-project 'Reasons for automation' enables us to create a holistic overview of motivational factors and target states. This lays the foundation for the justification of each individual sub-project as well as the overall project. It enables each sub-project to find its within the context of the larger whole and serves as an aid to critical discussion.

ARENA2036: *Which approaches did you take within your sub-project to deal with the scope of the various different factors?*

Trommnau: Our team is interdisciplinary and comprises representatives from along the entire value chain. This made it possible to shed light on the whole process and discuss the various challenges. Input from the other sub-projects was also very helpful for us. To start with, we had gathered a broad base of information through a series of brainstorming sessions, which was then clustered according to different topics during the following meetings, before finally being worked through in detail.

ARENA2036: *How will this sub-project continue in the future?*

Continued on next page

Sub-project 8
Reasons for automation in wiring harness production and assembly

Trommnau: Our sub-project can be useful for a variety of purposes. This includes, for example, the development of an overall roadmap, especially for Phase 2. Also, the Innovation Initiative Wire Harness and the individual sub-projects will continue to make progress in the future. For this reason, it is necessary to keep comparing the contents of the individual sub-projects with the contents of this sub-project and to supplement these with new material at regular intervals

ARENA2036: *Mr Trommnau, thank you very much for the interesting conversation.*

Trommnau: Thank you very much.

IIWH

Outlook for Phase 2

OUTLOOK PHASE 2

3 Outlook for Phase 2

The launch of the Innovation Initiative Wire Harness in July 2019 saw the development of an overall roadmap that envisages working on the various issues in successive phases. In Phase 1, the main aim was to initiate specific sub-projects in which the relevant topics of the various partners were taken into account. In addition to this content aspect, it was necessary to set up the organisational structure of the initiative.

Starting with a survey of the partners' requirements for the topics to be anchored in the IIWH, priority topics were derived on the basis of profiles. These formed the basis for the specific problem-solving approaches from which the project set-up for Phase 1 was finally developed. In addition, antitrust protection played a major role in Phase 1, as the broad range of partners in the initiative had to ensure that the topics were positioned at a precompetitive level right from the start. This and other requirements were safeguarded by involving the Cartel Office at an early stage and by providing seamless legal support and documented throughout the entire phase.

Phase 2 will build on this basic content and organisational set-up. While the partners had relatively little time to work on the content of the sub-projects in Phase 1 (half a year), Phase 2 has been conceived to extend over a number of years. The transition takes place on 1.7.2020 and introduces Phase 2.1, which includes the first annual slice.

One main focus here was the continuation of the sub-projects already started in Phase 1. Of the nine sub-projects, seven will continue directly and two indirectly. In this way, the approaches developed in Phase 1 can be taken to the next level. To this end, the individual sub-projects will consolidate the material with the aim of achieving the first implementations and realisations of their solution approaches.

At the same time, another five sub-projects will be set up on the basis of a white-spot analysis, covering topics that are important for the IIWH partners, but were not yet addressed in Phase 1. A total of twelve sub-projects will thus be processed in Phase 2.

The sub-projects will be classified into topic-specific focus projects. On the physical level, these are:

- Focus Project Development
- Focus Project Production
- Focus Project Assembly

At the digital level, there is also the Focus Project Continuous Digitisation.

OUTLOOK PHASE 2

As far as the higher-level control with regard to the strategic orientation of the topics in IIWH and the integration of topics from the individual sub-projects into a holistic context is concerned, the core project will be supplemented and staffed chiefly by the sub-project leaders. The project structure of Phase 2 is shown in Figure 30.

and strategically implemented in the IIWH by selecting appropriate topics.

Focus Project Development

The focus project Development will develop and formulate the ‘Design rules for the automation of the wire harness’. This includes concept development for digital and automated applicability and its provision and tool integration. Closely related to this is the development of an ‘automation index’, which is intended to represent a recognised method of designating the suitability of components for automatic machines and is to be converted into a standard in the long term. A further sub-project is ‘Concepts for the wire harness’. This involves scouting new technologies in order to derive innovation drivers from them.

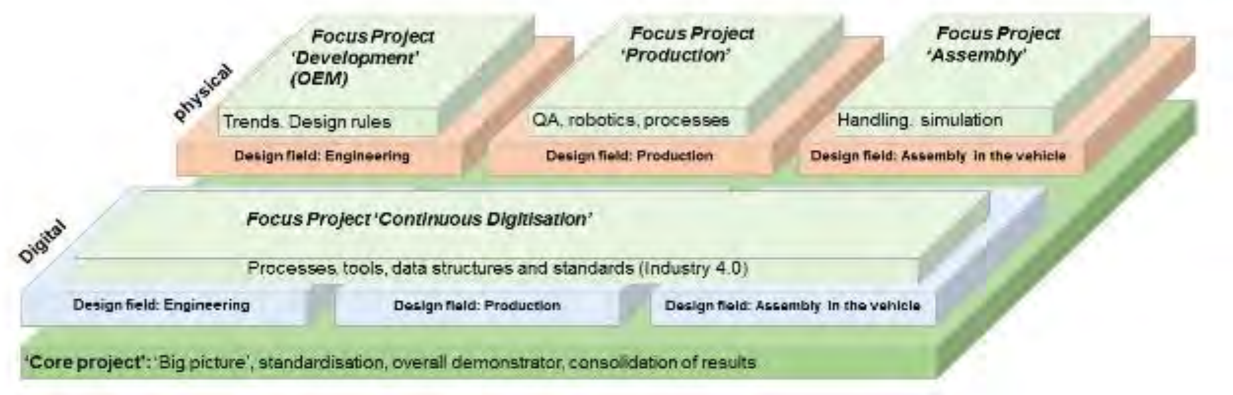


Figure 30: Project structure of Phase 2

Core project

The objective of the core project is to continuously review the strategic orientation of IIWH throughout the overall transformation of the industry towards automation. To this end, all standardisation work will be merged and synchronised to further develop the IIWH standardisation strategy. Secondly, the sub-project results will be tested on a joint demonstrator. This enables overlaps from the sub-projects to become apparent. Thirdly, it will further deepen the ‘big picture’ of automation. On the basis of the reasons for automation, the inherent potentials will be elaborated

OUTLOOK PHASE 2

Focus Project Production

The aim of the Focus Project Production is the optimisation and automation of the production process. To this end, the sub-project ‘Automation of quality control’ will investigate the extent to which costly end-of-line testing can be streamlined by front-loading test steps into upstream production steps.

In the sub-project ‘Wire harness production equipment for automation’, standardisation requirements and further solution approaches such as alternative components or variants, reduction of variant diversity will be derived on the basis of a generic analysis of automation constraints. The results flow into the formulation of the design rules. The focus project is rounded off by the sub-project ‘Automation of the wire harness production process’. This involves the development of generic solutions for intra- and interlogistics and the digitisation of the production process. The alternative process models are to be analysed by means of testing or simulation within the framework of potential assessments.

Focus Project Assembly

The focus project Assembly focuses on the ‘Automation of assembly in the vehicle’. To this end, new concepts to simplify assembly are being developed and evaluated. Approaches such as pop-up wire harness, transport and mounting plate or even the rotary wire harness will be examined. These approaches are flanked by the construction of a demonstrator for the automated installation of a wire harness in a body shell with the aid of a robot that masters the handling of flexible parts. At the same time, the sub-project ‘Automation of indirect assembly processes’ is investigating how intra- and interlogistics can be geared to the new assembly approaches while simultaneously optimising the processes.

Focus Project Continuous Digitisation

The focus project ‘Continuous Digitisation’ brings the wire harness into Industry 4.0 and creates digital continuity along the process model. To this end, the sub-project ‘Digital product description’ will first derive all the necessary contents of a digital repository of WH components. This also involves the examination and testing of possible standards (management shell) and development of a standard proposal for the WH component description. The sub-project ‘Digital Process Chain’ includes the elaboration of the generic process model of development, production and assembly with regard to digital consistency and also for change management. Finally, the sub-project ‘Digital Changes’ will work on the derivation of a generic target change process with digital consistency across the entire value chain using common and consistent databases. To achieve this, concrete starting points will be derived (interfaces, data volumes, uniform basic semantics for standard change volumes, etc.).

OUTLOOK PHASE 2

All topics in the focus projects represent relevant building blocks on the way to the automation of wire harness production. There are extensive mutual dependencies that are addressed in the projects. In this way, the development of solution approaches in all the areas described above can create the basic conditions for future automation.

Innovation Initiative Wire Harness partners in Phase 1

4 Innovation Initiative Wire Harness partners in Phase 1

1. Aptiv Services Germany GmbH, Am Technologiepark 1, 42119 Wuppertal, Germany
2. Bayerische Motoren Werke Aktiengesellschaft, Petuelring 130, 80809 Munich, Germany
3. DRÄXLMAIER Group, Landshuter Str. 100, 84137 Vilsbiburg, Germany
4. Gebauer & Griller Kabelwerke Gesellschaft mbH, Muthgasse 36, 1190 Vienna, Austria
5. Komax AG, Industriestr. 6, 6036 Dierikon, Switzerland
6. KOSTAL Kontakt Systeme GmbH, An der Bellmerei 10, 58513 Lüdenscheid, Germany
7. Kromberg & Schubert Automotive GmbH & Co. KG, Raitestr. 8, 71272 Renningen, Germany
8. Mercedes-Benz AG, Mercedesstr. 120, 70372 Stuttgart, Germany
9. Nexans autoelectric GmbH, Vohenstraußer Straße 20, 92685 Floss, Germany
10. Rosenberger Hochfrequenztechnik GmbH & Co. KG, Hauptstr. 1, 83413 Fridolfing, Germany
11. Schäfer Werkzeug- und Sondermaschinenbau GmbH, Dr.-Alfred-Weckesser-Strasse 6, 76669 Bad Schönborn, Germany
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