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ARENA2036: a Collaborative Space for the Future of Mobility and Production

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Abstract:

The disruptive impact of digital technologies opens the opportunity to redefine the innovation ecosystems across (and between) several industries. To respond to this challenge, several initiatives were funded all over Germany. The Research Campus ARENA2036 at the University of Stuttgart oversees the platform for research and innovation on the topic of mobility and production of the future. This article describes the creation of ARENA2036, its organizing mechanisms, and its function as a catalyst for collaborative innovation. The article ends with a summary of the lessons learned in its first years of operation and an outlook on the future challenges.

Keywords: Collaboration, Mobility Industry, Smart Production, Innovation Spaces

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1. Introduction

The evolution of the automotive industry has been driven by constant improvements in production technologies and systems. The region of Baden-Württemberg has been home of leading automakers for decades, creating a rich and complex supply chain network of SMEs in the region. As a result, the region accumulated advanced technological knowledge and production capabilities that sets it apart from any other region in Europe. However, the accelerated transition to the new electric mobility paradigm and the omnipresent digitalization created an urge to accelerate innovation across the whole ecosystem.

To respond to this challenge, ARENA2036 was founded in 2013. The Active Research Environment for the Next generation of Automobiles (ARENA2036) is a highly flexible platform for research and innovation on mobility and production. It is a Federal Ministry of Education and Research (BMBF)-supported Research Campus that brings together partners from science and industry in a co-creative and open research environment. The building itself (see Figure 1) received support from the European Fund for Regional Development (EFRE) and the University of Stuttgart. To ensure that it successfully connects science and industry research, ARENA2036 is built as an association with members from both communities. To add to the co-creative mindset on site, ARENA2036, the University of Stuttgart, and Daimler AG co-founded the open innovation platform STARTUP AUTOBAHN in 2015.



Figure 1: ARENA2036 interior (authors)

We take three perspectives to explain how ARENA2036 is contributing to the digitalization of SMEs and accelerating the response of the whole innovation ecosystem to the ongoing challenges in mobility and production.

First, we take the innovation organization perspective to describe the distinct types of projects that have structured the activities in the ARENA2036. We then describe the key projects that defined ARENA2036 and how they have contributed to what the collaborative space is currently.

As second perspective, we describe the profiles of the different partners and active members that engaged in the initial set up and the further evolution of the ARENA2036 collaborative space. We explain the motivations and roles that start-ups, SMEs, large companies, and university/research institutes have taken. We take advantage of the five years perspective to reflect on how the network of partners has co-evolved and matured.

Finally, we take the technology perspective to explain how the projects and partners have been organized around the production and mobility challenges. We go in-depth with the technology perspective to explain how the innovation ecosystem has been integrated in ARENA2036, deciphering how the projects have covered aspects related to building the future digital platforms and their integration with existing mobility and production infrastructures and technologies.

We conclude by sharing the four lessons learned in these first two phases of ARENA2036 and the upcoming challenges to keep driving innovation across the automotive supply chain and the broad innovation ecosystem.

2. Organizing for innovation in mobility and production

The ARENA2036 defines itself as a space to co-create innovations and it has a strong focus on the automotive industry. The 2036 suffix in the name is the year that the automobile industry will celebrate its 150th anniversary. Given the ongoing transformation in the automotive industry (Llopis-Albert et al. 2021), the innovation focus includes aspects related to electrification, modern production, and interconnectivity. It resembles other similar international initiatives like the research campus of the Manufacturing Technology Center (MTC) in Coventry, UK, effectively bridging industry and academic research on the future of manufacturing.

To better understand how ARENA2036 works, we first describe the rules and institutional values of the space, to then go in detail on the different projects that agglomerate the different innovation activities.

2.1 The core values of the collaboration space

An essential aspect of ARENA2036 is that it is defined as an active research environment. In this context, active means that research is done by exploring and testing solutions that can be easily transferred to the industrial production context. For this to happen, a core value of the space is that industry (large companies, SMEs, and startups) and academia work on an equal footing, under the same roof. This means that when engaged in a research project, both sides have an equal role in the generation and experimentation of viable solutions addressing the research challenge.

This core value is translated in the legal form used to organize projects, ARENA2036 promotes the activation of bilateral agreements that involve academic and industry partners. The ambition is to establish an initial framework that reduces the distance between the industry and academia researchers, making it more likely to trigger cross-boundary innovations where ideas coming from science and technologies in a specific research field can be adapted and translated for an industrial research challenge and vice versa.

A second core value of the space aims to strengthen the expected benefits of physical proximity. Besides ensuring proximity by placing industry and academic research units close, in the same space, special attention is given to foster cognitive proximity. This is done by promoting trust within the partners of ARENA2036, by facilitating informal exchanges in the space (workshops, thematic events, open seminars), but even more importantly by putting in place a mandatory non-disclosure agreement (NDA) that every partner's member must sign. Interestingly this NDA mimics an established corporate formality to protect knowledge and secrecy, however ARENA2036 drafted this NDA to create a different effect. It is an open-ended NDA where partners commit to exchange and protect each other's interest in the scope of the innovation projects that are being developed in the space. This NDA contributes to reinforce the core value of trust among partners, it offers a legal space to work together and explore without being constrained by the operational – and intellectual property – boundaries of each organization.

2.2 An innovation-oriented project-based space

To drive active research collaborations, ARENA2036 established that it will run its activity around innovation projects. For this, it established three distinct types of projects that would also reflect the scope and resources of the challenge being tackled. The first category is the publicly funded joint projects, these have a duration of 5 years and each of them defines a collaboration pillar inside the ARENA2036 (see Table 1). Over the course of 5 years, the listed projects receive aggregated funding of 10m€ from the German Federal Ministry (BMBF). In addition to the beforementioned projects, 17 projects were initiated in 2021. These are supported by 261m€ in total, with a share of 19m€ for research conducted at the ARENA2036 facilities.

Table 1. Description of the publicly funded joint projects at ARENA2036

Project Name	Project objective
Agile Innovation Hub	Understand and further develop the cooperation and innovation process of collaborative research spaces.
Digital Fingerprint	Develop and visualize the structure for an intelligent value chain.

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FlexCAR	Develop and promote an open vehicle platform for the mobility of the future.
Fluid Production	Develop and implement a human-centered cyber-physical production concept.

At a second level, the focus projects have an equally ambitious goal but in a shorter time horizon (see Table 2). They are 3-years projects that complement the larger joint projects and help to bring the future visions to solutions that can be implemented by the industry. This category opens additional options to SMEs and startups to collaborate with larger players that usually work with longer time horizons.

Table 2. Exemplary description of some focus projects at ARENA2036

Project Name	Project objective
Catena-X	Promotion and implementation of a secure and standardized data exchange for the automotive industry.
DIRECT	Development of a digitally reconfigurable, sensory-supported production environment for high-performance fiber composite components.
GrantSLAM	Interdisciplinary optimization of the SLM process, from the original component concept to the intelligent material composition, and to the desired process result.
SynergieRegion	Development and testing of 5G applications for modern production systems in the urban area of Stuttgart.
Management shell for the line set	Development of shared digital twins along the value chain to improve the management overview.

Finally, there is a third level for projects that have a duration below one year. These projects are built around very narrow and clear challenges. They are directly funded by the industrial partners, particularly fitting for SMEs needs and capacities. Those projects are meant to also work as pilots that provide some initial evidence to support a larger focus project or joint-project type.

The distinct project types are established to facilitate that ARENA2036’s partners can get involved in multiple ongoing projects, as well as join new projects as they complete them. The ARENA2036 management actively seeks to re-engage existing partners in future projects, as well as to bring in new partners into the research campus.

2.3 Managing a diversity of collaborative projects

To understand the approach that ARENA2036 has followed to organize the collaborative innovation projects it is imperative to describe how it is formally established. It is a business association, meaning that each member (currently over 50 organizations) pays an annual fee to be part of ARENA2036. The members’ fees help to cover the project management and other running costs of the association.

Consequently, the function of the management of ARENA2036 is not only to look after the physical space – the building – but also to activate, facilitate, and guide the interactions between active partners in the projects and the rest of members in the association. Its function goes beyond the building management role to then become an innovation intermediary that can broker between members to trigger and expand the impact of their activities.

These responsibilities that the management takes, also become visible at project level, where ARENA2036 introduces key performance indicators for each publicly funded project to monitor its respective progress. These indicators are then used to learn and report externally, how the space is operating and how it is contributing to transform the mobility and production ecosystem.

3. Partners and ecosystem development

The ecosystem concept has emerged as a popular topic among management scholars in strategy, innovation, and entrepreneurship and is gaining increased attention in practice and policy (Dedehayir et al. 2018; Gomes et al. 2018; Scaringella and Radziwon 2018; Tsujimoto et al. 2018). Digitalization is the major trend driving business model innovations, open innovation, and ecosystems (Thomas & Autio, 2020). Experts frequently refer to today’s world as the VUCA world, characterized by volatility, uncertainty, complexity, and ambiguity. Ecosystems are formed when organizations collaborate to create a value proposition that would be impossible for a single firm to create on its own (Adner 2017). Ecosystems are characterized by participant heterogeneity (large companies, SMEs and other actors), ecosystem outputs, partner interdependence and non-contractual governance (Thomas & Autio, 2020).

To further understand how ARENA2036 works, in this section we examine the partner ecosystem and its evolution over time. We have included profiles of the various partners and active members that

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contributed to its initial setup. We use a longitudinal lens to examine how the network of partners has co-evolved and matured.

3.1 The Ecosystem Blueprint at ARENA2036

ARENA2036 partners join the ecosystem for different reasons. In some cases, they aim to influence the future vision of manufacturing, in others (e.g., SMEs), they try to learn and gain insights on how the industry can evolve. To get a better picture of these different aspects we take the perspective of Lingens et al. (2021) on what constitutes an Ecosystem blueprint and how to design it based on surrounding conditions. We will analyze the ARENA2036 Partner ecosystem and its development and how ARENA2036 defines the architecture of its ecosystem focused on mobility and production using this approach. Ecosystem design entails defining an ecosystem's structure and activities (Lingens et al. 2021). Orchestration is critical for the ecosystem's effective governance and performance, and it encompasses activities at four distinct layers: technological, economic, institutional, and behavioral (Autio 2021).

In this case, ARENA2036 plays a critical role as the ecosystem orchestrator to bring together all the partners around the shared value proposition. The orchestrator in an innovation ecosystem does not have to be the largest firm with the most resources; it can also be an organization capable of bringing the ecosystem's partners together around a value proposition (Lingens et al. 2021). Thus, we define ARENA2036 as a unique innovation ecosystem in which the orchestrator is not a large corporation but a neutral organization that connects science and industry and is backed by policy and government.

3.2 Ecosystem Partners and Evolution

Now, let us take a closer look at how ARENA2036 has evolved over time. We explore how the network of partners has co-evolved and matured over time using a longitudinal perspective. Among the ecosystem's partners are large enterprises, small and medium-sized businesses, start-ups, research institutes, universities, and accelerators. In 2013, ARENA2036 was founded with the objective of engaging with research and industry in an atmosphere that fosters innovation and creativity. In 2014, the founding partners included large companies such as Bosch, Daimler, and BASF, as well as the University of Stuttgart and research institutes such as Fraunhofer, DLR and Deutsche Institute für Textil und Faserforschung (DITF). A little later, SME's such as BÄR, developing AGVs and automation technologies, as well as FARO, specialized in 3D measurement and imaging technologies, joined the ARENA2036.

We can observe that the ARENA2036 has been successful in drawing new partners over the years, with 54 members today representing large businesses, small and medium-sized enterprises, research institutes, universities, start-ups, and accelerators. Most ecosystem's partners joined to capitalize on opportunities for collaborative work with other ecosystem partners established through projects, benefiting from shared knowledge, and contributing to new innovations by examining problems that no single organization or entity can solve alone. From the standpoint of research institutes and universities, it is an excellent opportunity to market their technology research and contribute critical inputs, as seen by the formation of new spin-off start-ups from universities and research institutes. This way, all ecosystem players benefit from one another, making the entire mobility and production ecosystem more resilient to disruptions caused by digitalization and increased collaboration.

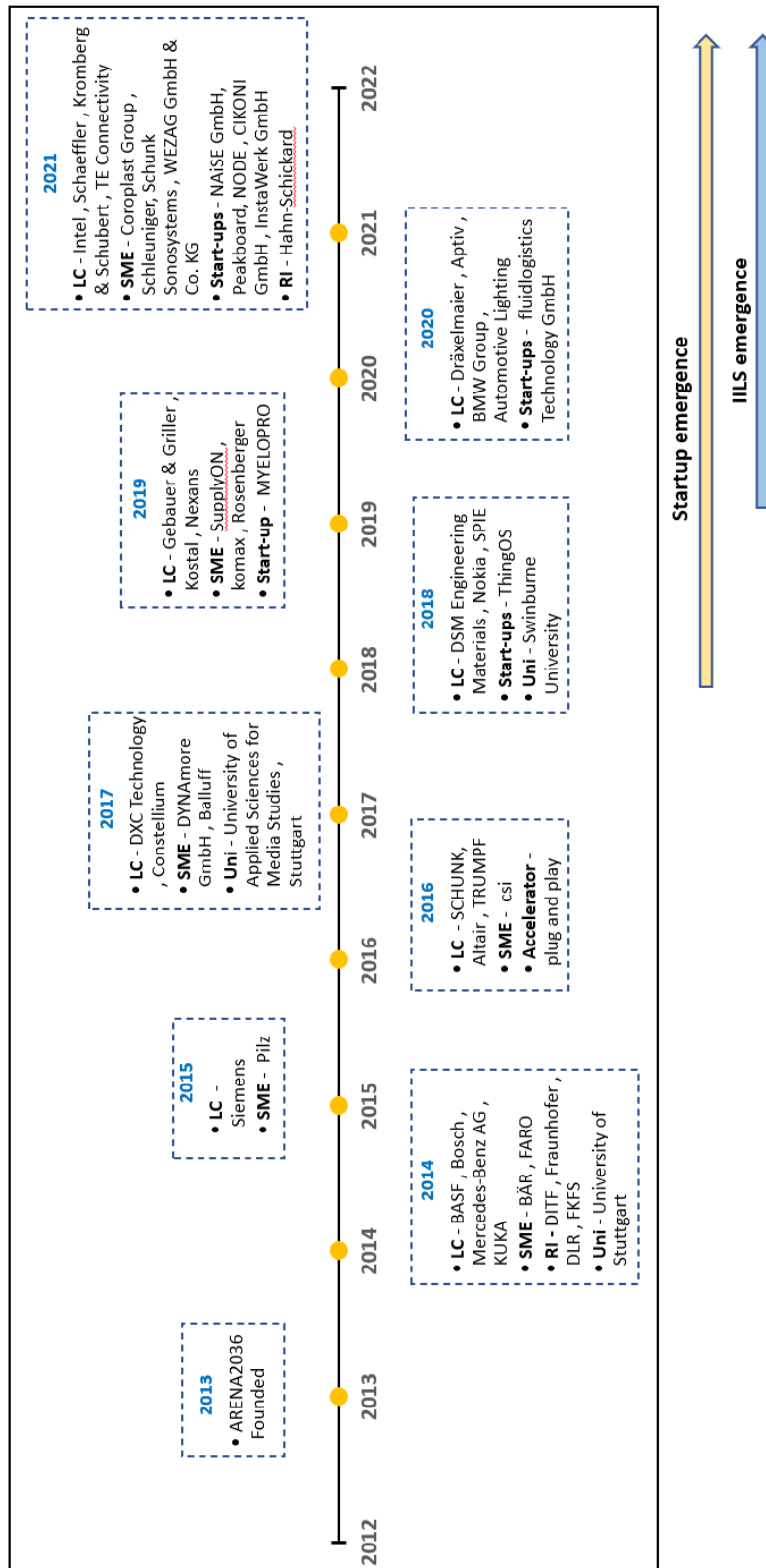


Figure 2: Evolution of ARENA2036 partners Large Companies (LC), SMEs, Start-ups, Academic Partners (Uni) and Research Institutions (RI)

The timeline in **Error! Reference source not found.** summarizes ARENA2036's evolution from 2013 to 2021, as well as that of its numerous partners. The collaborative projects began to bear fruit in 2018, when the ecosystem's first startup, ThingOS, emerged. Due to ARENA2036's unique position in the ecosystem, which enables it to have a bird's eye view, initiatives such as the Innovation Initiative Wiring Harness (IILS), a first-of-its-kind project to digitalize the wiring harness in the automotive sector, began

to emerge in 2019. This has resulted in the addition of new partners to ARENA2036, as stakeholders in ecosystems recognize the value of bringing all parties together to address specific digitalization challenges. The year 2021 saw the highest number of partners join ARENA2036, with 14 organizations.

ARENA2036 has shaped its ecosystem over the years around the future of mobility and production. Additionally, it emphasizes the value of a collaborative innovation space that enables all partners to collaborate on a common value proposition while also developing capabilities for small and medium-sized businesses and start-ups. The current partner ecosystem of ARENA2036 is depicted in Figure 3, which showcases the diversity of stakeholders that are active actors. ARENA2036 has successfully orchestrated the ecosystem to work collaboratively thus far and is still navigating the various orchestration mechanisms as the ecosystem evolves further.

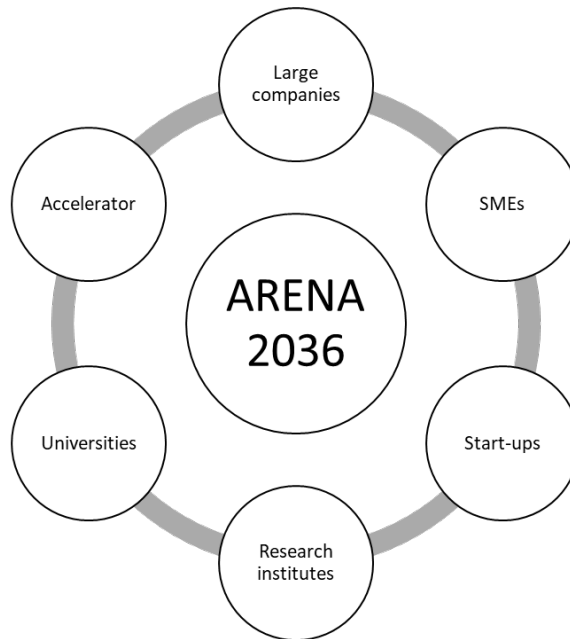


Figure 3: ARENA2036 Partner Ecosystem

4. Technology view development

Given the weight of the car manufacturing industry in the regional economy, it is no surprise that the ARENA2036 project defined the transformation of mobility and production as their core goal. This overarching topic defines the central motivation of individual projects carried out within the ARENA2036 framework. Understandably, this goal is too broad and intangible to allow all members to contribute constructively. As a result, “*tech areas*” were introduced, which each portray an underlying, enabling technology. Each *tech area* represents an umbrella for ongoing, crossdisciplinarity and project independent work around a given technology. All *tech areas* are led by one or more experts in the field, who supervise the projects and serve as the main contact person.

The ARENA2036 project is closely related to the concept of Industry 4.0. To visualize how ARENA2036’s activities relate to the technologies of Industry 4.0, we bring in Zhong’s (2017) framework to map the research topics of the *tech areas*. Their proposed framework allows categorization of intelligent manufacturing systems research topics into five distinct categories: Smart design, smart machines, smart monitoring, smart control, and smart scheduling (see Figure 4).

- **Smart design** covers all attempts to rethink traditional design processes by introducing cyber physical systems into the process. Especially technologies like augmented reality and virtual reality have the potential to better connect traditional digital design processes such as computer aided design to the real world.
- **Smart machines** describe all efforts to elevate robots and manufacturing machines from passive devices to sensing, fully connected and collaborative equipment. This lays the foundation for digital twins.

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- **Smart monitoring** summarizes all research related to obtaining relevant data from individual processes. Those range from process related to generic information surrounding the process. Based on this the operation, scheduling and maintenance of the production site can be optimized.
- **Smart control** deals with the controlling mechanisms of cyber physical production-control systems.
- **Smart scheduling** builds on top of the data obtained from the smart monitoring, building data driven advanced modelling and scheduling algorithms for decision making processes.

In the diagram we can see the positioning of all the *tech areas* defined. Production specific areas have been placed within the framework, while accompanying areas have been placed alongside.

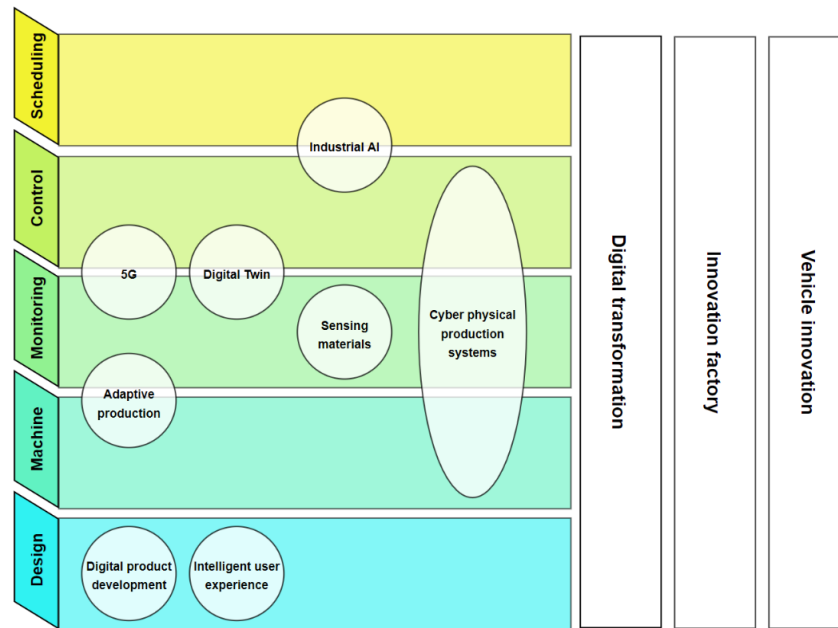


Figure 4: Categorization of the different tech areas of the ARENA2036 project following Zhong et al.'s (2017) dimensions

Looking at the *tech areas* and their positioning, it becomes apparent, that a wide variety of production related topics are covered by the research conducted at ARENA2036. However, given the strong emphasis on the car manufacturing sector, it is not surprising that the focus lies on optimizing and rethinking production processes. Especially the smart scheduling category has not received as much attention as other categories. Improving the supply chain management will without a doubt be as relevant as the production itself in the future.

In addition to production related areas, three more topics complement the research at ARENA2036. These intend to foster innovation surrounding vehicles of the future and business model innovation through digital transformation. While these topics do not directly contribute to the production itself, continuously questioning current products and business models means that the research does not only focus on doing things right but is also concerned with doing the right things.

Overall, it can be concluded, that the research consortium covers all relevant aspects of the industry 4.0 technologies, while not losing sight of more impactful changes to the car manufacturing industry. The subdivision of the core goal into smaller areas with autonomous projects and leadership results in the projects being more agile and focused, while at the same time allowing greater specificity of the individual projects. However, effective communication between the different areas becomes imperative, since most if not all areas are interconnected and should benefit from the learnings of others.

5. Lessons learned on orchestrating a production and mobility innovation ecosystem

Having started out in 2013, ARENA2036 is now looking back at nine years of precompetitive, collaborative research. The BMBF has set the scene for the Research Campus initiative with a headline that shape the every-day work of everyone involved: 1) it is an industry on campus scheme that enables, 2) science and industry to, 3) work together on an equal footing in, 4) a precompetitive environment.

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Beyond these guidelines, the actual implementation of the cooperation varies amongst the nine Research Campuses in Germany. Hence, this is also an interesting opportunity for companies, and in particular SMEs, to gain more insights into the different interpretations of these guidelines.

As for ARENA2036, there are numerous learnings that show us how to enable collaborative innovation. At the same time, there is still quite some room for improvement when it comes to systematizing the serendipitous nature of cooperative ideation.

First, we will discuss those experiences that we still pursue and that we plan to further develop for the years to come. After that, we will turn to those areas, where we still see room for improvement. The backbone of everything that follows is always the goal to speed up the process from idea to project to transfer. Finally, we close with concrete suggestions for practice.

ARENA2036 is conceived as an ecosystem platform, i.e., management serves as platform operator and simultaneously functions as a catalyst, whilst the partners on the platform are the ones involved in the actual research projects. In other words, one partner that joins the platform benefits from the experience and expertise of 50+ other partners, instead of having to repeatedly seek individual partners for bilateral research relationships. This is especially valuable for SMEs and Start-ups, since ARENA2036 offers them an ecosystem that guarantees immediate access to large corporates as well as research institutes that they would otherwise not be able to approach. Knowing this, ARENA2036 – secondly – puts an emphasis on projects that have a similar platform character. This means that the larger ARENA2036-projects are conceived in a way that they are architecturally open to enable other partners to join into a discussion with the project owners and to potentially add to the project with their respective expertise. This is in line with earlier research highlighting the role of innovation ecosystems orchestrators, the value of common standards, and the strategic approach which is necessary to develop ecosystems further (Brem et al. 2016). For this, it is also important to consider at which levels different projects operate. Utilizing the Technology Readiness Level (TRL) helps to assess the different stages projects are in. Here, the challenge emerges that projects at early levels (TRL 1-3) must be combined with projects at applied levels (TRL 4-6) up to industrial projects (TRL more than 7), ideally in combination with other readiness levels such as demand, regulatory, etc. (Hjorth and Brem, 2016; Vik et al. 2021). The experience in the ARENA2036 context, indicates that a mix of such TRLs fosters collaborations to a certain extent, but also hinders project evolution, requiring for ARENA2036 interventions to realign the collaboration between projects. Otherwise, this creates problems when project partners' expectations do not match or have not been explicitly discussed before. For instance, if you get a 5G network installed in the factory floor, but the accuracy of the network is not as assumed by the project partners, this requires revision and redeployments of expensive technical equipment in the collaborative area of the research campus. In conclusion, there is high potential, yet it is necessary to have management interventions to make sure that it is exploited.

That said, there are still vast, partly untapped potentials. Over the past eight years, we were able to observe that chance plays a crucial role in the ideation and innovation process. Turning mere chance into serendipity is one of the management-tasks that needs further attention. For example, ARENA2036 offers an open research environment that enables researchers and developers from diverse backgrounds to move around freely and without structural barriers between the different companies of institutes. This openness creates chances for random meetups, for inspiration, and an exchange of ideas. However, increasing the frequency of these meetups, hiding inspiring prototypes in plain sight, and creating more spots for productive exchanges of ideas is a challenge that shall be tackled soon. To do so, we plan to redesign the entire shopfloor in such a way that the researchers and developers are forced to take detours on their way from a to b, to increase the number of accidental meetups, inspiring moments, and insightful conversations. In other words, we aim at finding a way to structurally help with the transformation from mere chance to serendipity. This highlights the role of formal and informal communities of practice, which typically undergo several phases in their development (Brem and Maier 2014). The first phases are like the one of startups, where the focus lies on building up structures, bringing in partners and acquisition of customers, with the overall aim to have a solid foundation for growth. Later, the focus shifts towards managerial issues since the growth of an organization is generally higher than the adaption of related processes (Picken 2017). These dynamics can also be seen in the ARENA2036 setup. Here the challenge remains to develop the setup further, including new partners and ending projects which are beyond their project deadline and scope. Such renewal processes come also with a kind of pain, since established routines are always difficult to break in any organization with new configurations and business models (Volberda et al., 2021).

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In this context, the COVID-19 pandemic with all the related restrictions in 2020 and 2021, and beyond, showcases how critical personal interactions are. Even though there were digital technologies available as alternatives, this could not substitute human interaction one would have meeting in person. Especially when it comes to new projects and project execution in these years, the negative effect of the pandemic is apparent.

Lastly, management has a privileged teichoscopic position that allows for a bird's eye view on the entire portfolio of partners. This enables management on the one hand to take on a seismographic role, which informs the general strategic process, thus allowing for the improvement of the ARENA2036 platform. Simultaneously, however, it offers a chance to formulate future topics at the intersection of interests of a variety of partners that we are only now beginning to turn into high profile projects such as the Innovation Initiative Wiring Harness (IILS) or Catena-X, that will create common standardized platforms for the automotive industry. Going forward, formulating, implementing, and proactively managing such lighthouse projects, is an area that we have only begun to explore. ARENA2036 partners such as the STARTUP AUTOBAHN can provide an international platform for collaboration with startups, while partners within the University of Stuttgart can potentially increase the range of fields covered. Finally, growth of such ecosystems naturally leads to more competitive situations. To overcome such challenges, a mindset of coopetition might help in the future (Luo, 2007).

In conclusion, what are the learnings of this research campus setup, framed as implication for managers? In a nutshell:

- Bring both companies (industry) and research (academia) institutions together in a joint, managed open space.
- Assemble multiple companies (and include SMEs and startups) with distinct knowledge and specialty areas within the same physical space
- Start only projects that have a common interest and a clearly defined goal, duration, and end
- Create a culture of “give and take” beyond cultural and disciplinary borders
- Take your project partners serious, stick to deadlines, and deliver as per the made commitments.
- Enforce promised commitments from the partners

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