GIO WHITE PAPER: INDUSTRY-SPECIFIC ECOSYSTEMS

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GLOBAL INDUSTRY ORGANIZATIONS

This document has been produced by the Global Industry Organizations Roundtable initiative which has been formed as an environment for discussion and open exchange amongst global industry organizations involved in digital transformation and/or ICT across multiple vertical industries. This whitepaper is the result of a collaborative effort between multiple industry organizations. It is intended for general informational purposes only and does not take into account the reader's specific circumstances, and only reflects a current view of the industry developments.

For more information on GIO, please go to http://www.gio.zone/#/Index.

1 Contents

2 Introduction

A McKinsey Global Survey[1] found that in traditional industries, only between 4% and 11% of Digital Transformation projects were deemed successful. In many cases, a number of projects suffered from lack of appropriate skills and effective partners to help the organization to implement change effectively. It is clear that Digital Transformation requires a broad set of skills and technologies to be brought to bear, something that is difficult for the individual company to achieve alone. Whilst an enterprise generally has very deep knowledge of its own vertical industry, it often will not have in-house skills in the technologies and approaches required to implement digital transformation. Equally, the suppliers and providers of disruptive technologies (such as 5G, AI, Cloud, Edge, etc.) may have great expertise with their chosen technology, but generally do not have deep knowledge of the vertical industries they are helping to transform.

The most successful transformation projects seem to be those which bring together domain expertise specific to the industry vertical, alongside strong technology and implementation skills from experienced partners. But bringing together these ecosystems of partners - and governing them successfully - is a complex challenge!

This white paper investigates some of the different aspects of how ecosystems can be used to more effectively support Digital Transformation opportunities:

- Section 3 introduces some models and frameworks that offer an approach for how to think about ecosystems and how to understand the various stages in developing a new ecosystem or engage with an existing ecosystem. This section goes on to describe a methodology for selecting which ecosystems might be suitable to engage with for specific use cases.

*1. https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Organization/Our%20Insights/Unlocking%20success%20in%20digital%20transformations/Unlocking-success-in-digital-transformations.ashx

- Section 4 explores the challenges of sharing data across ecosystems and the trust infrastructures that are emerging to support this sort of data sharing. It discusses initiatives like International Data Spaces (IDS) and GAIA-X. All of these suggest IT architectures and collaboration frameworks that help with safeguarding data sovereignty.
- Section 5 examines the role of platforms and platform business models in making ecosystems practical, and proposes the concept of industry specific platforms as a way of bringing vertical industry ecosystems to life.
- Sections 6, 7 & 8 highlight how to think about transformation in the manufacturing, healthcare and automotive verticals and shares a range of transformative case studies that are emerging in these industries. Other verticals will be explored in future editions of this whitepaper.

3 Key Challenges in Ecosystem Modelling

3.1 How to think about Ecosystems

One of the promises of the combination of the major transformational technologies (e.g. 5G, Cloud, AI and IoT), is the potential to streamline the operations of vertical industries to reduce costs and improve overall efficiency. However, the reality today is that vertical industries are often limited by having multiple 1:1 relationships with each of the key providers of these transformational technologies – with little synergy between their various supporting technologies. By adopting an ecosystem approach, vertical industry enterprises can leverage the skills, knowledge and market position of transformation technology partners, achieving a more efficient approach and improving their opportunity for a successful and timely digital transformation.

Building a successful multi-partner business ecosystem requires the participants to innovate both business models and technology. Furthermore, not all transactions between inter-dependent companies are best achieved by trying to create a business ecosystem. Think of this along two axes: one representing the level of coordination needed between the various parties that are cooperating in a transaction; and the other axis representing the level of 'modularity' present in the disparate elements that go to make up a complete transaction. Professor Michael Jacobides of London Business School has written extensively about this, and he uses this approach to represent four distinct types of interdependent company relationships (see Figure 1).

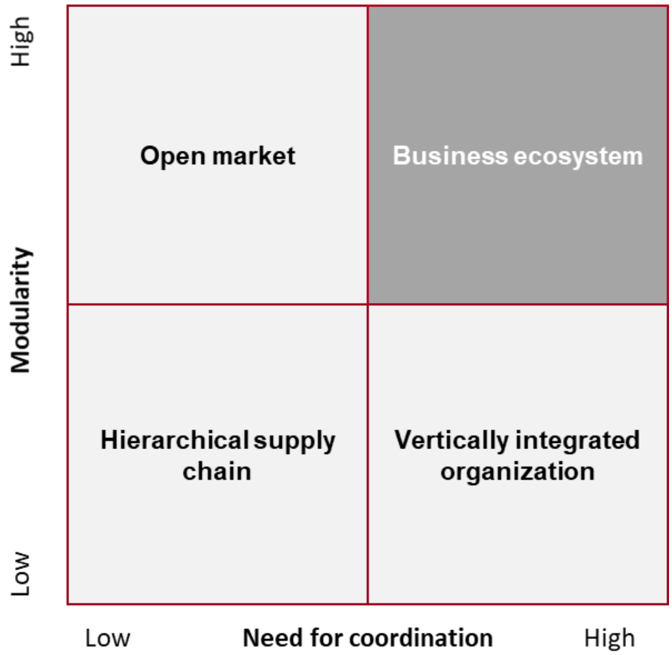


Figure 1: Mapping Interdependent Company Relationships

(Source: Jacobides et al (2018))

- **Vertically Integrated Organization:** If a high level of coordination is needed between the disparate elements in a transaction, and there is a corresponding low level of modularity in those elements then the most appropriate structure to adopt would be a vertically integrated organization. In the early days of the telco industry (right up to the 1980's) the telco world adopted this approach, choosing to be vertically integrated and in many cases even going so far as to manufacture their own phones, fax machines, cables, etc..
- **Hierarchical Supply Chain:** In the scenario where the modularity of the disparate elements in a transaction or value chain is low, and the need for coordination between the various partners is also low, a hierarchical supply chain makes most sense, often controlled by one or more dominant producers or manufacturers. Many would argue that the strength of the major telco suppliers (Huawei, Ericsson, and Nokia) still relies on the relatively poor level of modularity in the telco world, where it is safer for the telco to buy from a one-stop-shop rather than risk the challenges of integrating multiple disparate components.

- **Open Market:** The open market scenario becomes possible when there is a high degree of modularity between the disparate components in a transaction\value chain (in the high tech world think of this modularity in terms of clearly defined and open interface standards), and this is matched with no real need for coordination between the various parties. Manufacturers of commodity laptops or servers sit in this open market world.

- **Business Ecosystem:** Finally, there is the scenario where the components display high levels of modularity, and where there is also a need for a high degree of coordination between the parties. This is where business ecosystems come into their own.

There are 4 common types of business ecosystems and 3 roles that companies can play within them.

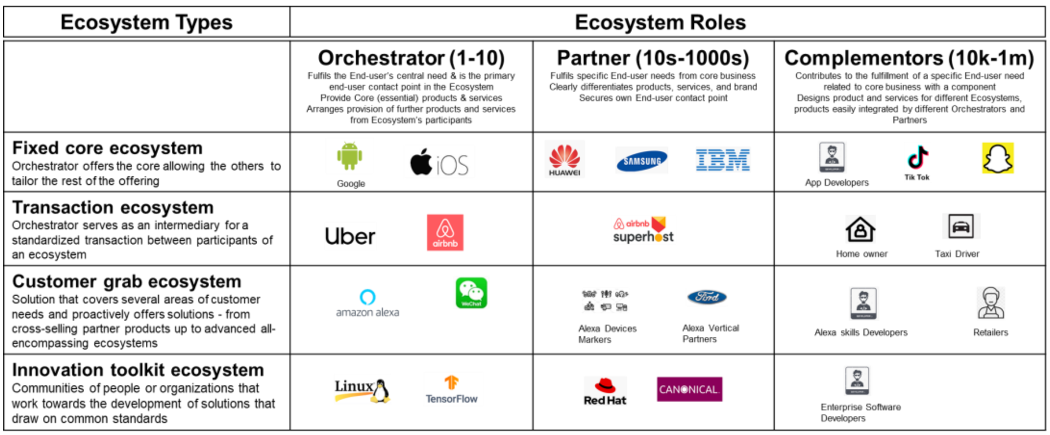


Figure 2: Business Ecosystem Types

3.1.1 Business Ecosystems are not yet in operation in most vertical industries

As mentioned previously, the transformation which vertical industries have been trying to achieve through the use of disruptive technologies such as cloud, edge, AI, etc., is in most cases, an ad hoc process facilitated by systems integrators. This can probably best be described as sitting in the bottom left-hand quadrant of the 2x2 matrix - in the hierarchical supply chain position. The level of modularity of the various cloud, communications and specialist components is patchy at best, and the level of coordination between the various parties in the ecosystem is low. In this scenario, the systems integrators play the crucial role in extracting some level of cohesion between the various components - which ultimately proves to be both costly and time-consuming.

An important element of the work of the standards bodies and industry associations that are involved with GIO is to try to get various parties to converge on agreed standards (de facto or de jure). This allows the emergence of greater levels of modularity of the various component parts, and allows us to move up the vertical axis towards more of an open market model – allowing the vertical industry buyers to select best of breed components from a modularized market, and significantly reducing both the cost and time to market of creating solutions from disruptive components (see Figure 3).

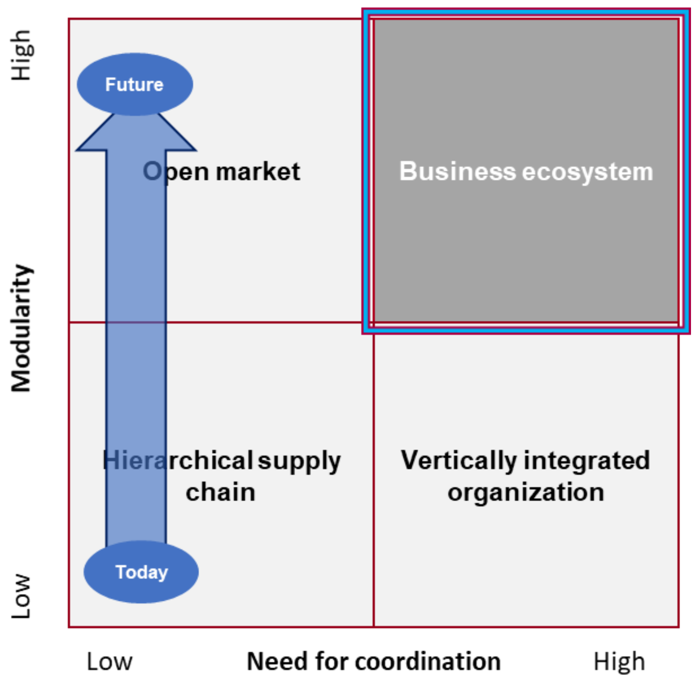


Figure 3: How standards can impact market structure

In many cases these standards are slowly emerging. In the cloud world, de facto standards dominate, driven by the hyperscalers (although with limited effective modularity between the different advanced PaaS offerings). In the communications world a mix of de facto standards and de jure standards driven by the various established standards organizations allow good modularity at the infrastructure level, but weak modularity at the management systems level. But this still does not by itself enable the creation of really effective **business ecosystems**.

The real power of the disruptive technologies to transform vertical industries will only be realized when the various different players within the ecosystem can coordinate their capabilities to maximize value as part of a **business ecosystem**. Much of this coordination will be around data/knowledge and how it is transferred and shared in a trusted fashion to iteratively maximize the economic effectiveness of each of the constituents within the ecosystem. For this to happen it will require the emergence of shared knowledge bases and data-trust frameworks such as IDSA, as well as appropriate economic models that make it sensible for the various parties to collaborate. This topic will be discussed later in this paper.

3.1.2 A Framework to de-risk the innovation stages for new telco business opportunities

While most enterprises have developed an understanding of the need to work within wider business ecosystems, they are often only peripherally aware of how difficult it is going to be to select, develop and govern these ecosystems in a profitable fashion.

In 2022 the TM Forum created an Ecosystem Modeling working group to tackle these challenges for the Telco industry. This created an industry platform to help develop a framework that provides a blueprint to accelerate and de-risk the innovation stages of concept to design for new telco business opportunities beyond connectivity.

The framework provides a library of templates as a practical guide the different stages of ecosystem design. The expectation here is that initial feasibility assessments will be more light weight, while those later in the cycle will be more in depth.

The framework covers the following stages:

1. Explore whether an ecosystem system opportunity is worth pursuing from a market, strategic, customer, value viability perspective.
2. For an opportunity that seems viable based on a high-level evaluation, what is the ecosystem strategy to deliver the value proposition by identifying and acquiring the right partners, capabilities, monetization models.
3. How to build a business case for approval?
4. How to plan, design for a scalable implementation?

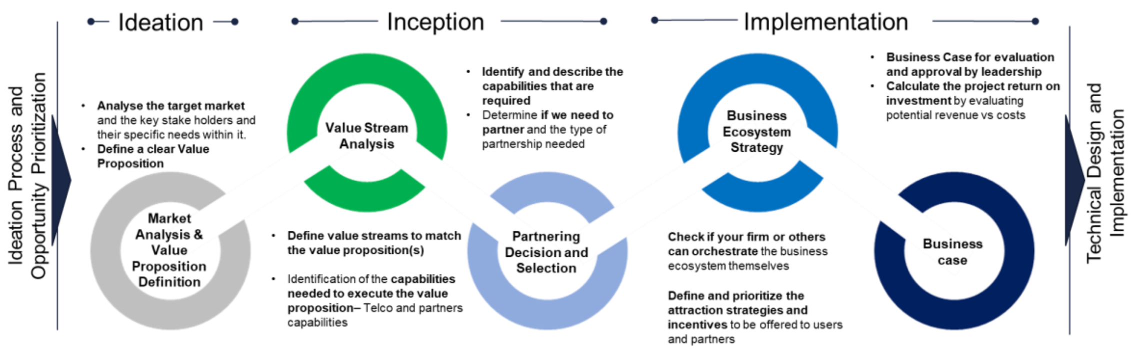


Figure 4: TM Forum Concept to Design Framework (TM Forum)

The different stages of the Concept to Design Framework can be described as follows:

Market and Value Proposition Analysis

- Define the market need to be addressed
- Define the primary user and the key stakeholders surrounding them
- Profile user, jobs to be done, pains and gains and stakeholder interaction
- Define a value proposition offering and list the best candidates
- Evaluate each value proposition and select the top candidates
- Perform high level ROI analysis on each candidate and select the most promising
- Perform a competitive study of each candidate and select the most promising

Value Mapping and Capability Assessment

- Define Value Network & Associated Key Value Trees
- Identify Key Value Streams & specific Value Propositions
- Identify Associated Serving Capabilities & Create Capability Impact Assessment
- Normalize Capabilities
- Overlay with relevant Capability Heatmap Dimensions
- Identify Outsourcing/Partnering Opportunities
- Create one or more Scenario specific Capability Maps based on Value Network Options
- Iterate above as appropriate until desired clarity is achieved

Partnering Decision and Selection

- Identify and describe the capabilities that are required
- Identify current match for that capability and the level of difficult needed to acquire it
- Determine if we need to partner and the type of partnership needed
- Shortlist potential partners and select the best matches using the criteria for guidance
- Use the TMF Zero Touch partnering guide to streamline the onboarding and management of Partners

Business Ecosystem Strategy

- Check if your firm or others can orchestrate the business ecosystem themselves
- Assess if partners would want to work with you
- Define the pricing and monetization strategies to be offered to users and partners
- Define and prioritize the attraction strategies and incentives to be offered to users and partners
- Validate the capabilities needed to orchestrate the ecosystem
- Survey the trust and confidence level of partners and decide the correct governance strategy to manage the ecosystem
- Monitor the health of the business ecosystem as it moves through its growth stages by monitoring KPIs

Business Case for Leadership Approval

- Answer key questions from business stakeholders
- Calculate the project return on investment by evaluating potential revenue vs costs

3.2 Identifying New Opportunities and designing their Ecosystems in Practice

The Digital Transformation journey for any organization involves commitment to significant change across the business, while using new technologies to drive new business models across customers and suppliers. Identification and implementation of new business & innovation opportunities is an important element of any digital transformation, and it is important to have a clear and consistent methodology to identify the priority opportunities and their associated business models.

To this end Huawei SPO Lab has proposed a 'Digital Service Innovation Framework' (DSIF) which provides a methodology to explore new digital opportunities and associated business models. This was initially constructed to explore digital services opportunities within the telco industry but has been applied more broadly to digital transformation opportunities within other industries.

Following an initial pre-study phase to assess at a very high level whether this business opportunity is potentially interesting, there are a number of important steps within the DSIF that are briefly described below:

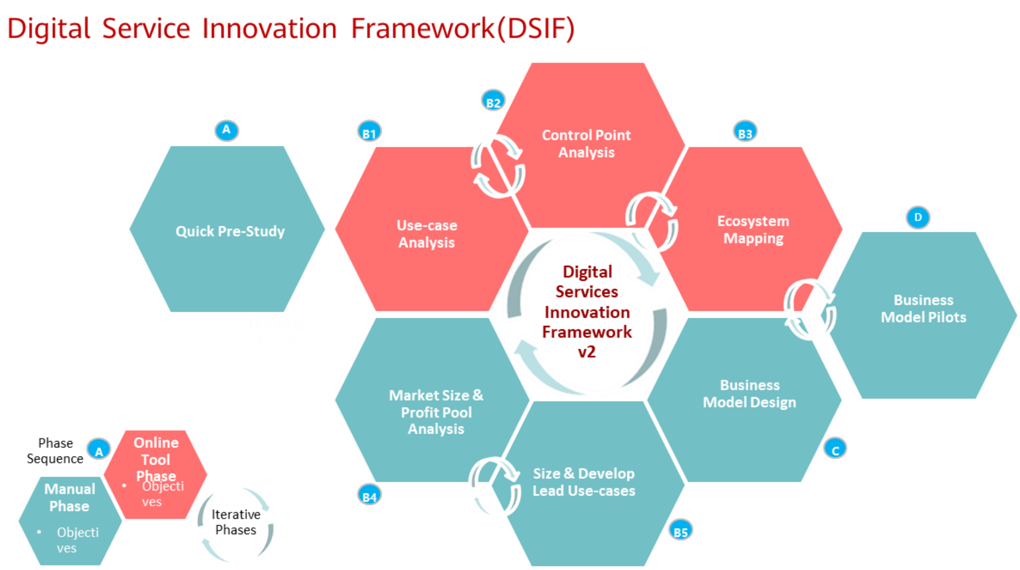


Figure 5: The various stages of the DISF methodology

3.2.1 Market Opportunity Analysis

The aim of market opportunity analysis is to gain an understanding of the structure of the ecosystem and competitive landscape. Then the most promising use case solution opportunities can be investigated further and sized to address the customer needs identified in the ideation phase.

- **Use-Case Analysis (B1)**

  Building on the ecosystem mapping phase the use case analysis phase aims to build a comprehensive use-case solution repository for the target market and to provide a categorization of use-cases. Use case solutions researched can be linked to real world partners within the ecosystem or they can be theorized based on inputs from technical and marketing experts.

- **Control Point Analysis (B2)**

  This phase identifies lead use-cases for business model exploration. Use cases are assessed on a set of higher- and lower-level criteria including market opportunity attractiveness, enterprise business fit and market timing risk. The aforementioned higher-level criteria are factored from lower-level criteria such as market size and growth, market control points and market adoption. The above figure shows a sample set of criteria which can be used.

- **Ecosystem Mapping (B3)**

  A comprehensive framework for mapping and understanding ecosystem structure has been developed as mentioned in section 3.1.1.

Market Opportunity Attractiveness			Telco Business Fit			Market Timing Risk		
Market Size & Growth Rate	Value Creation & Capture	Market Adjacency	Core Capabilities – Business	Core Capabilities – Technical	Market Control Points	Market Adoption	Competitive Threats	Environmental Constraints

Figure 6: Example Control Point Analysis Criteria when applied to Telco industry

- **Market Size & Profit Pool Analysis (B4)**

  This phase identifies key underlying market trends and sizes the market opportunity. This work may also include estimating the size of the overall market, percentage profit pool for each value-stack component and the key assumptions for growth. This analysis helps to inform decisions on which opportunities are perused and the level of investment that is need.

- **Size & Develop Lead Use-cases (B5)**

  This part of the process develops a deeper understanding of the needs of customers for the lead use cases selected in the control point analysis phase. It should also analyze the assumptions made by the market hypotheses. This phase also includes lead use case market sizing, where the return on investment is assessed versus costs from the perspective of the solution developer, partner and customer. Research can be primary and/or secondary, but primary research in the form of feedback from potential customers and partners is more important in this phase.

3.2.2 Business Model Design

Business model exploration validates the business feasibility of the lead use case, firstly by exploring possible business model approaches for the lead use cases and then validating them in a stakeholder workshop or a pilot project.

- **Business Model Design (C)**

  This phase explores the lead business model scenarios for the lead use case identifying the characteristics of the model e.g. how value is created and captured, go-to-market approaches, sources of revenue and costs and finally it identifies and examines the assumptions that are made. This may also incorporate one or more workshops to explore the value proposition of the leading use cases, these can be useful to gain direct insights and test assumptions before progressing to a business pilot.

- **Business Model Pilot (D)**

  This is a prototype that is developed to test the feasibility of a use case within a market segment, prior to committing resources to a full product offering. The aim should be to practically test use case challenges, these could be things such as the core value proposition, technical obstacles, ecosystem orchestration challenges, or business model approach.

- **Exploring new opportunities in Practice**

  The Digital Services Innovation Framework can help pick the opportunities with the best fit for the Telco, and the Concept to Design Framework can help to build out this concept.

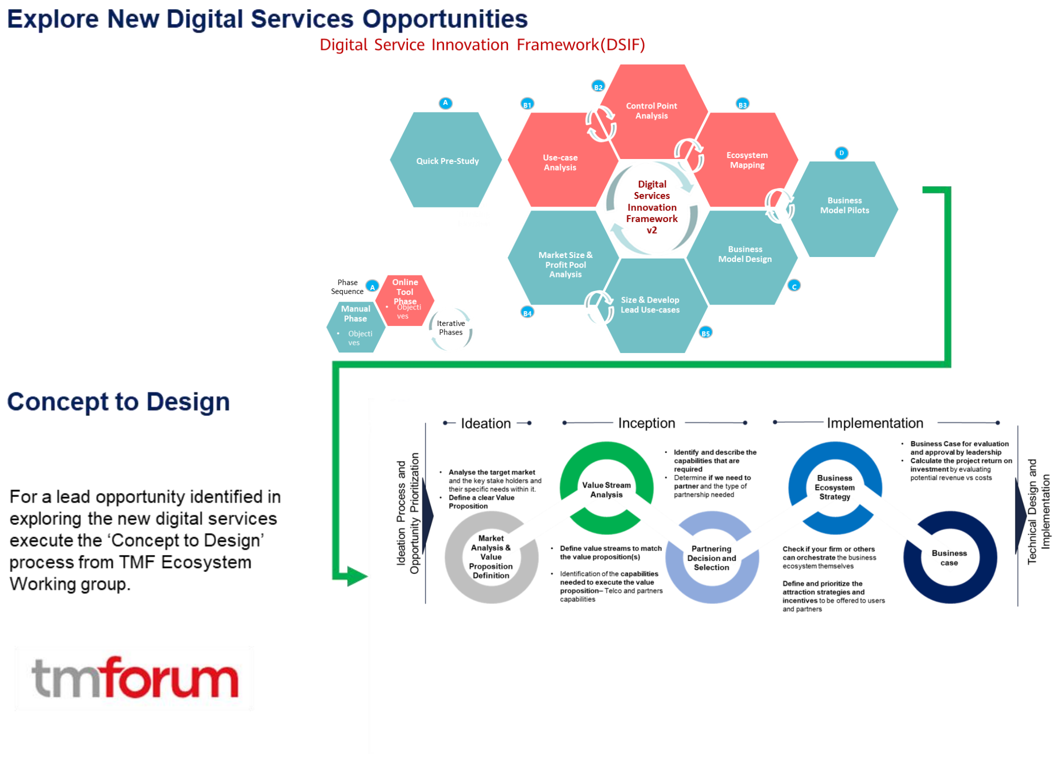


Figure 7: Exploring new opportunities in practice

3.3 Example: EV Charging Infrastructure

In this section we explore an example of the application of the 'Concept to Design Framework' to the EV Charging market.

The Electric Vehicle and ancillary services market will be very large and grow strongly over the next 20 years. To support the global ramp up of EV cars, there will need to be significant investment in EV charging networks to ensure charging stations are available where needed.

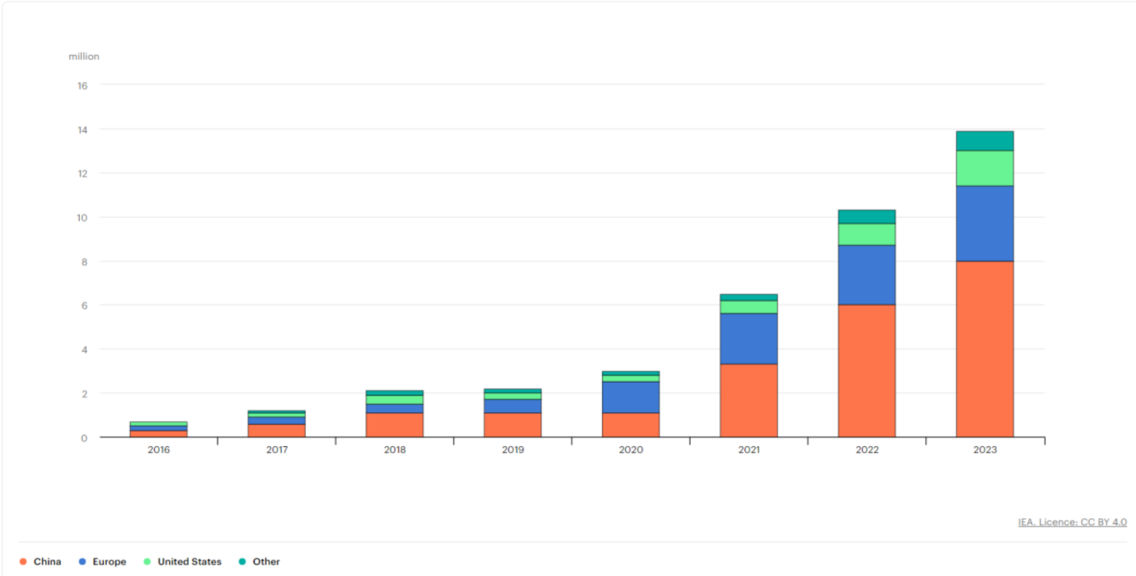


Figure 8: Electric car sales 2016-2023 (IEA)

The Telco industry has assets it can leverage in support of EV charging infrastructure. Telco's can leverage their distributed network assets (road side cabinets and infrastructure, many with fibre and power already) locations to deploy EV charging stations. This provides a solid advantage to the Telco in the development of a business case for public EV charging network.

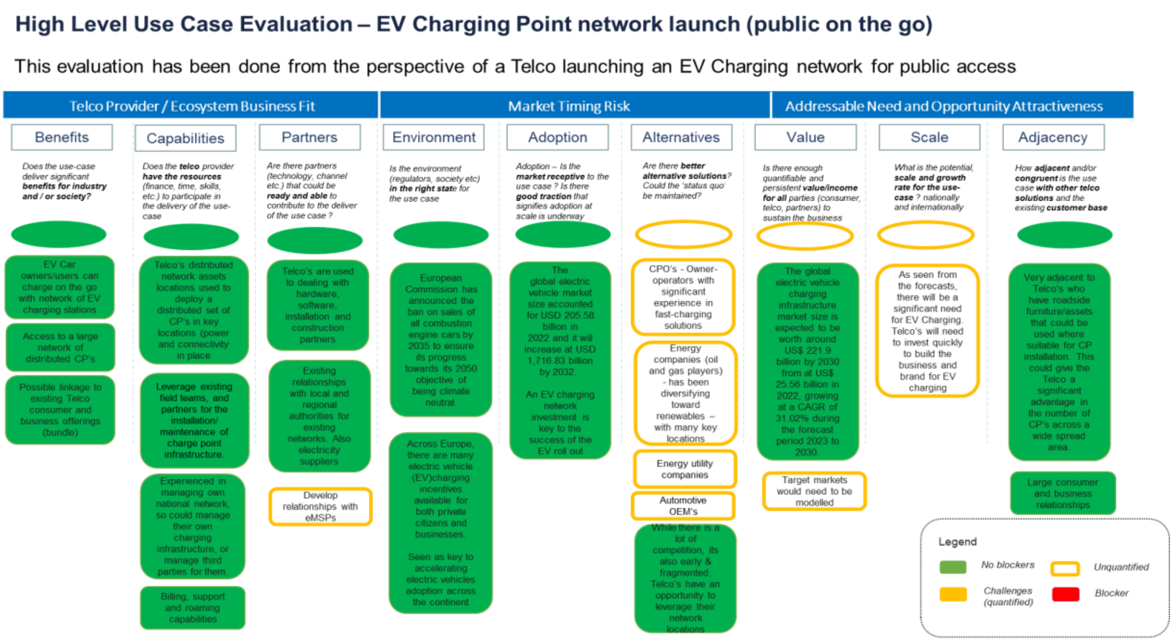


Figure 9: High Level Use Case Evaluation – EV Charging Point network launch (public on the go)

The High Level use case evaluation shows that EV Charging Point network infrastructure is a good fit for a Telco to consider as a lead value proposition. The Telco has some key assets that they can leverage, for example:

- Telco's distributed network assets locations used to deploy a distributed set of charging points in key locations (power and connectivity in place, many in prime locations.
- Leverage existing field teams, and partners for the installation/ maintenance of charge point infrastructure.
- Experienced in managing own national network, so could manage their own charging infrastructure, or manage third parties infrastructure for them.
- Billing, customer support and roaming capabilities.

While there is a lot of competition, it's also early with fragmentation in many markets. Telco's have an opportunity to leverage their network locations, and back end capabilities. But they need to move early, or any advantages will be lost.

The value network below shows that the Telco can target a number of roles in the delivery of EV Charging infrastructure:

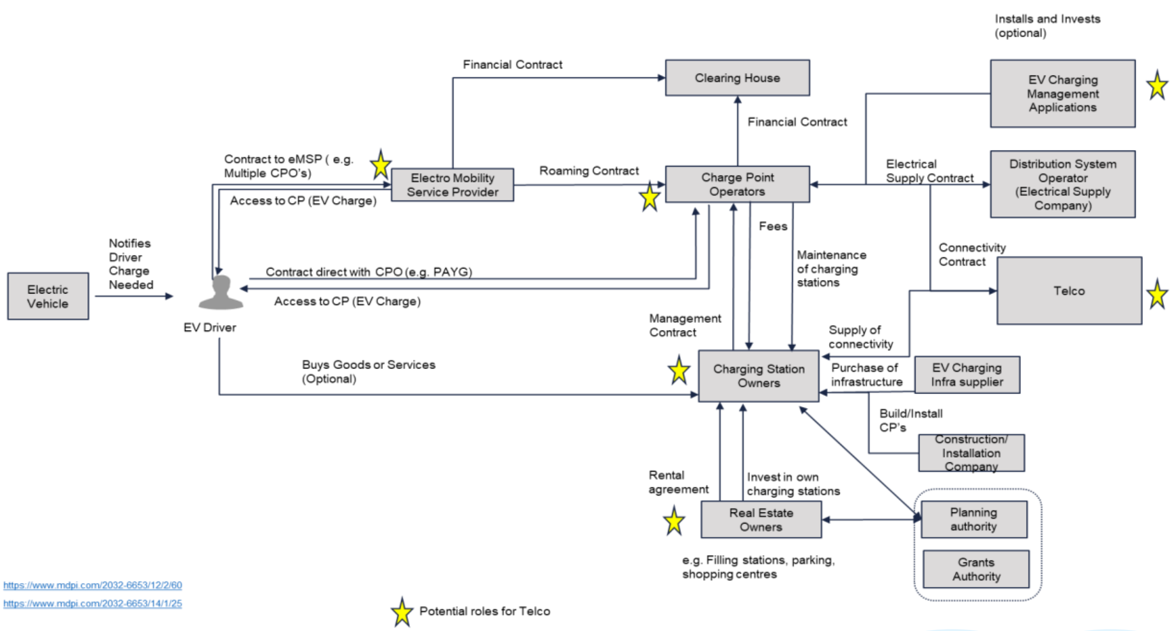


Figure 10: EV Driver Stakeholder Interaction map (Recharge Outside Home) (TM Forum Ecosystem Working Group - EV Charging)

In the second stage of the Concept to Design Framework, we decompose the value proposition for EV Charging to a number of value streams.

In the case of EV Charging this is made up of six value streams as we see below:

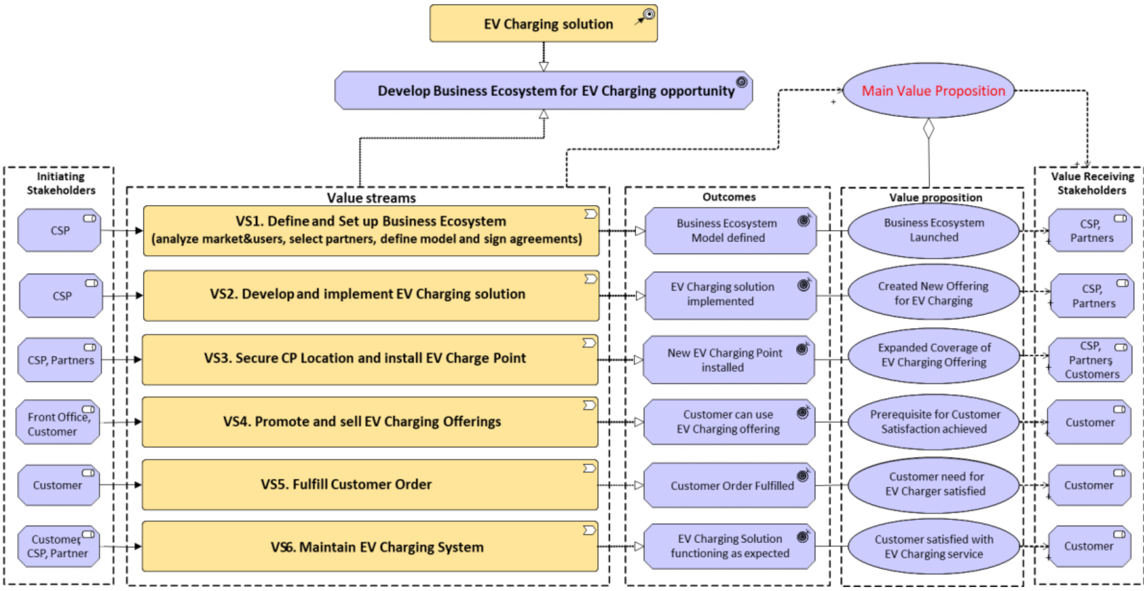
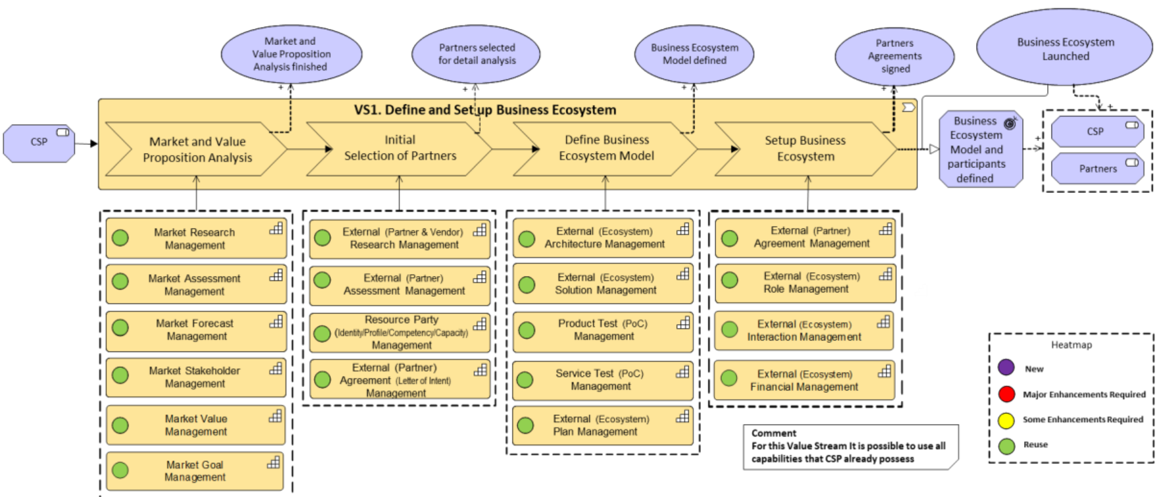


Figure 11: EV Charging Business Ecosystem Key Value Streams (TM Forum Ecosystem Working Group - EV Charging)

If we take the first values stream (VS1 – Define and Setup Business Ecosystem), we can them map each stage of the value stream to the TM Forum Capability Map which has all Telco capabilities mapped. This gives us the ability to use these capabilities to realise the specific value stream.



Example from TMF Ecosystem Working Group: IG1328 Concept to Design Framework – EV Charging Example v1.0.0 | TM Forum

Figure 12: Define and Set up Business Ecosystem - Value Streams cross-mapping with Capabilities (TM Forum Ecosystem Working Group - EV Charging)

This approach by the TM Forum helps to drive a repeatable approach to ecosystem design and Implementation.

4 Knowledge and Data Sharing within Industry Ecosystems

In a digitalized and deeply interconnected business ecosystem it is of paramount importance to devise schemes that enable trusted sharing of data between parties. This trusted sharing needs to seamlessly guarantee standardization and verifiability, interoperability, transparency and trustworthiness of the sharing process. Initiatives like International Data Spaces (IDS) and GAIA-X initiatives are designed to facilitate industry knowledge sharing, pave the way to a framework for collaboration for the use of secure and trusted data services safeguarding digital sovereignty.

4.1 European Data Regulators Chief Concerns and Actions

In this context, the European Strategy for Data primarily aims at creating a single market for data that will ensure Europe's global competitiveness and data sovereignty. It further aims to create a strong legal framework covering data protection, data sharing, fundamental rights, safety and cybersecurity. Europe's Strategy for Data is the plan to address these and other systemic problems, and it has a number of aims that are outlined below.

A	**DSA clarifying resp. for digital services**	• Update to eCommerce Directive clarifies online platform responsibilities; e.g. notice and take-down of illegal content. Right to redress. Single EU body to coordinate enforcement of DSA & DMA
B	**DMA: Ex ante regulation for gate-keepers**	• Ex-ante regulation with lists of prohibited practices; e.g. ban on self-preferencing. List of banned practices and gatekeeper definition can be amended
C	**Market Definition Digital Economy Update**	• Current Market Definition outdated. Update will consider inter alia value of data in M&A and for sector anti-trust investigations. It will strengthen existing Competition Law under TFEU 101/102
D	**e-Privacy Regulation**	• Particularises GDPR for datacomms replacing ePrivacy Directive. Provides data protection for personal metadata. Would negatively impact digital ads industry. 14th Draft proposed by Portuguese Presidency
E	**eIDAS (EUid)**	• Current eIDAS introduced in 2014 not widely adopted. Proposal to extend use to private sector and to increase EU-wide uptake
F	**EU Digital Services Tax**	• Ensures tax paid where value is generated. Applies to digital platforms that use tax jurisdiction arbitrage
G	**EU Data Governance Act & Data Strategy initiatives (GAIA-X and EU Data Spaces)**	• Data Governance Act will establish trusted intermediaries for data sharing with data processing localised to EU. Data (sharing) Spaces will be created in nine sectors with the Health Data Space prioritised. GAIA-X creates federated EU data infrastructure standard
H	**AI Strategy & Regulation**	• AI regulation will provide an appropriate ethical and legal framework. It is expected to cover many aspects of product liability with a focus on high risk AI; e.g. autonomous vehicles, biometric identification, surveillance and healthcare. Policy options outlined in AI whitepaper
I	**P2B regulation**	• Ensures fair P2B business terms; e.g. KYC, fair business terms, rights of arbitration. It came into force in July 2020 and will be reviewed in July 2023

Figure 13: Synoptic Table of the EU legislation actions for DSA, DMA and Data Governance2

The EU Strategy for Data[2] sees several issues holding Europe back from realizing its potential in the data economy including:

- **Availability of data:** It aims to increase the use of public sector information by business (G2B – data sharing), sharing and use of privately-held data by other companies (B2B – data-sharing). Use of privately-held data by government authorities (B2G – data sharing).
- **Imbalances in market power:** Small numbers of players may accumulate large amounts of data, gathering important insights and competitive advantages from the richness and variety of the data they hold. The 'data advantage' can enable large players to set the rules on the platform and unilaterally impose conditions for access and use of data.
- **Data interoperability and quality:** Application of standard and shared compatible formats and protocols for gathering and processing data in an interoperable manner across sectors and vertical markets should be encouraged through the rolling plan for ICT standardization.
- **Data governance:** Enforcement of data governance in society and the economy.
- **Skills and data literacy:** General data literacy in the workforce and across the population is relatively low and participation gaps exist.

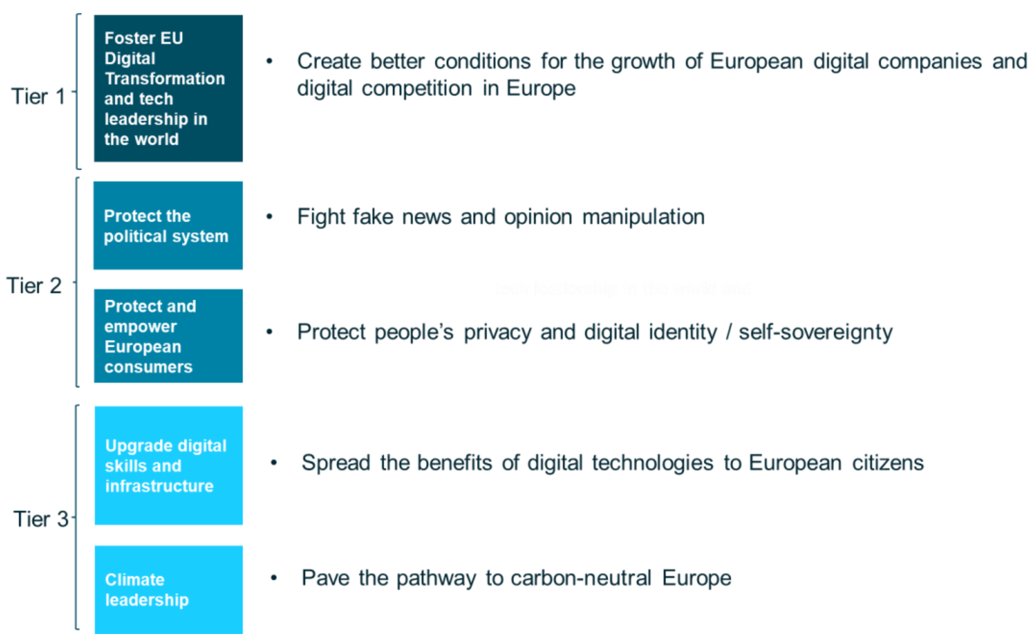


Figure 14: Europe's Strategy for Data [2]

*2. A European strategy for data (2020), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0066

Europe hopes to accomplish these aims through:

- A cross-sectoral governance framework for data access and use.
- Investments in data and strengthening Europe's capabilities and infrastructures for hosting, processing and using data, interoperability.
- Investment in a High Impact Project on European data spaces and federated Cloud infrastructures.
- Empowering individuals, investing in skills and in SMEs.
- Creating common European data spaces in strategic sectors and domains of public interest.
- An open, but proactive international approach.

4.2 Laws, regulations, and national standards in China on data protection

China has also been moving swiftly in this respect and in recent years the cadence of laws, regulations and national standards in China on data protection has been especially intense. Examples include:

PIPL: Submitted on 26th April 2021 China's (PIPL) applies to the country's citizens and to companies and individuals handling their data. It contains 70 articles and shares many of the same principles and values of GDPR including transparency, fairness, purpose limitation, data minimization, limited retention, data accuracy and accountability.[3,4,5,6] PIPL will apply extra-territorially to protect the interest of Chinese data subjects.

GDSI: Additionally, to address data security risks and enhance dialogue and cooperation in cyberspace governance, China has also issued the Global Data Security Initiative (GDSI)[7], which proposes three principles and eight initiatives for global data security governance. These principles include agreeing global data security rules through consultation and co-operation, balancing security and development, and adhering to the principles of fairness and justice. These principles provide a feasible path for the healthy development of data protection and cyberspace.

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*3. Shek, H., et ak., KPMG Cybersecurity, Overview of Draft Personal Information Protection Law in China (2019), https://assets.kpmg/content/dam/kpmg/cn/pdf/en/2020/11/overview-of-draft-personal-information-protection-law-in-china.pdf

*4. Zhang, G., Yin, K. (2020). A look at China's draft of Personal Information Protection Law, https://iapp.org/news/a/a-look-at-chinas-draft-of-personal-data-protection-law/

*5. Leung, H. T. (2020). The Mainland unveils new draft data privacy law, http://csj.hkics.org.hk/site/2020/12/28/the-mainland-unveils-new-draft-data-privacy-law/

*6. Rogier Creemers, R. (2020). China's Draft 'Personal Information Protection Law' (Full Translation), https://www.newamerica.org/cybersecurity-initiative/digichina/blog/chinas-draft-personal-information-protection-law-full-translation/

*7. Ministry of Foreign Affairs of People's Republic of China (2020). Global Initiative on Data Security, https://www.fmprc.gov.cn/mfa_eng/zxxx_662805/t1812951.shtml

4.3 Why Trust Infrastructure is Important in many Vertical Industries

Ecosystem cooperation between industry players is difficult with many companies fearing data sharing as they feel it will result in ceding too much sovereignty to competitors or platform orchestrators in vital areas like market access, standards setting, price, licensing and enforcement.[8]

Many sectors of the economy deal with sensitive data that depends on trust and security such as Manufacturing, Health, Energy, Telecoms, and Government Services to name a few. Often in these sectors, data remains fragmented and in heterogeneous formats. Trust and interoperability is key, and these sectors and will not reach their full potential unless a trust infrastructure is in place that ensures data can be shared accurately and securely, facilitating interoperability and data portability.

Trust infrastructure can become the trusted regulator for industry platforms in the data economy, orchestrating value creation, setting standards, offering federated platform services and incentivizing and encouraging the exchange of data through data portability and interoperability. This will reduce switching costs and also reduce co-dependencies.

The benefits are numerous, Jacques Cremer outlined them as[9]:

- Direct benefits from the data - for example the ability to create sophisticated AI models used on a host of applications through data partnerships.
- Reduced ecosystem transaction costs between business ecosystem participants of all types leading to more efficient supply chains.
- Prevention of captured and siloed data markets.

IDS and GAIA-X can provide this trust infrastructure and foundation of industry data ecosystems.

*8. Tirole, J. (2015), "A few remarks on the role of intermediaries in the Digital Economy", July 9th 2015 Lecture, Boston.

*9. Cremer J., "The world with GAIA-X", November 18th 2020 GAIA-X Summit, https://events.talque.com/gaia-x-summit/en/6iq6yI5LPSxaIRA6cmnq

4.4 International Data Spaces

International Data Spaces: European Commission has decided to invest in common European Data Spaces in strategic economic sectors and domains of public interest. As of 2022 there are 12 data spaces proposed and additional data spaces could follow in order to ultimately create a full European Data Space and a genuine single market for data (European Commission, 2022).

Figure 15: Data Spaces being considered

It is hoped that making data available to be exchanged in a trustworthy and secure manner will enhance the development of new data-driven products and services in the EU and thereby create the backbone of an interconnected and competitive European data economy. Role of Industry Specific Platforms.

5 Creating a Platform for Industry Digital Transformation

Across many industries, the use of platform business models has proven to be extraordinarily successful. As described in the work of Marshall Van Allstyne[10] and many other academics, platform models open up new opportunities for many different stakeholders, mediated through a platform which allows consumers and providers to transact freely. This approach has powered the success of massive organizations such as Amazon and eBay, but has also been effectively used to create opportunity within much narrower market niches.

The power of a platform approach is partly in the way that it encourages an ecosystem of cooperating partners to grow organically, with every new participant making the platform more valuable to all the participants. By bringing service providers and consumers together and making it easy for them to offer and transact services, a platform removes barriers and allows the platform owner to benefit without having to be directly involved in the delivery of services.

Innovation-oriented platforms are an excellent way for innovative smaller companies to quickly and cheaply bootstrap their solutions to market. Sophisticated platform capabilities can be integrated directly into the solution, so the innovator can concentrate on their domain expertise. This approach has been leveraged to great effect by the public Cloud platforms such as Amazon Web Services, with hundreds of platform services on offer, from basic compute, databases, charging and billing, to leading-edge AI capabilities.

In this section the potential for use of platform business models to accelerate industry-specific ecosystems is examined.

5.1 Creating Industry-Specific Platforms

One of the promises of the combination of next generation of transformational technologies (specifically 5G, Cloud, AI & IoT), is the potential to streamline the operations of industries to reduce costs and improve overall efficiency. However, the reality today is that vertical industries are limited by having multiple 1:1 relationships with each of the key providers of these transformational technologies – with little synergy between their various supporting technologies.

*10. https://www.bu.edu/questrom/profile/marshall-van-alstyne/

For example, an enterprises use of centralized and edge Cloud capabilities – purchased from major hyperscalers - is often independent of their decision process to adopt advanced 5G low latency, network slices and mobile private networks. Similarly, their implementations of niche vertical solutions in areas such as remote healthcare, predictive maintenance or digital twin, is often isolated from the implementation roadmaps of the communications and Cloud platforms. And this complexity often means that vertical industries need to rely very heavily on specialist systems integrators who are the only ones who can plumb together all of this disparate technology functionality - making it all very expensive, both in terms of dollars and time, and often yielding lowest common denominator functionality. A critical next stage of the transformation of these vertical industries is to radically simplify how they engage with, and make use of, the communications, Cloud and digital services ecosystem through the use of industry specific platforms.

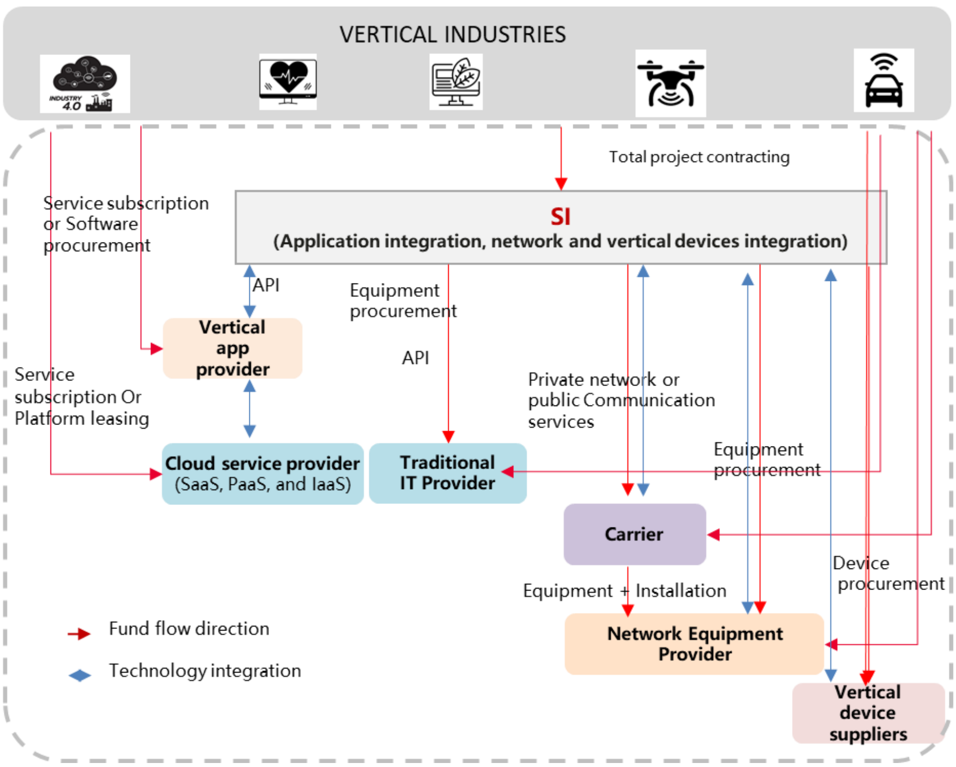

Figure 16: Traditional Relationships within Vertical Industry

There are lots of people looking to create the platforms that will drive the transformation of vertical industries! For example, in the manufacturing world, the powerful vertical industry players, are trying to develop their own dominant platforms that will try to capture the value for that enterprise, rather than surrendering it to a 3rd party/hyperscaler. To a certain extent this is already happening with companies like GE, Schneider, Dassault Systems and others all having launched industry platforms to meet their own business needs. Of course, the hyperscalers are well positioned to offer industry specific platforms to each of the vertical industries they already serve with basic cloud & platform offerings – e.g. Microsoft's Azure for Healthcare. Similarly, multiple telcos (and their suppliers) have been busy developing their own platforms with the ambition to use these to drive overall 'beyond connectivity' business. Over the coming years this will result in massive platform duplication, diverting investment away from true innovation in the short to medium term. Ultimately, one of more of these industry platforms (most likely the hyperscaler variants) will outlast the rest, and will reap significant long-term value capture, while the investment in the rest of the platforms will be written off. The net result will be financial losses for many and substantial delay in innovation for all!

The above scenario may be the most likely outcome, but there is another possible outcome, one where a number of the key industry players (vertical industry leaders, systems integrators, vertical solution specialists and communications & cloud players) cooperate to create a small number of shared platforms that enable rapid innovation and monetization, avoiding the expensive duplication & delay that would otherwise occur.

If such industry platforms are to occur, they are likely to include some of the elements below:

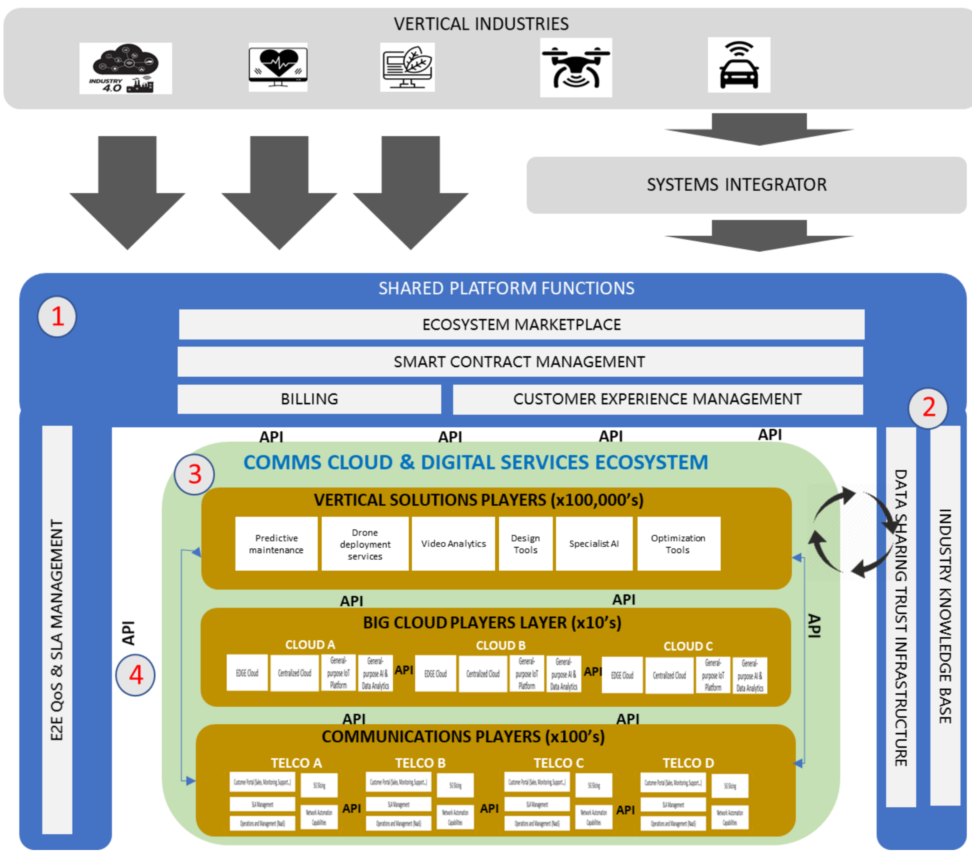

Figure 17: Vertical Industry Ecosystem Shared Platform

1. A number of **shared platform functions**, such as a marketplace to facilitate the efficient matching of sellers with buyers, as well as back-end functions, such as billing and E2E Customer Experience Management & SLA/QoS management. It will also contain functionality to maximize key platform business model characteristics (such as network effects), as well as facilitating capabilities such as smart contract management to enable efficient interaction between the participants.

2. Key to such a shared industry platform will be some form of shared **industry knowledge base**. This will be the platform's repository of shared learning that the various platform stakeholders can use, and which they agree to contribute to. Without a shared form of learning to create additional value-add over the marketplace aspects of the platform, the stickiness of the platform will be poor and the value that it delivers in terms of improved overall efficiency to the industry will be lessened. The 'exhaust data' from this knowledge base can potentially generate a future monetization opportunity increasing the overall value of the shared platform. Alongside this knowledge base they must be some **trusted mechanism for sharing data** so that the various parties are comfortable sharing information without exposing information they wish to keep private. Industry initiative such as GAIA-X and International Data Spaces (IDS) are trying to achieve this sort of industry common benefit.

3. The **communications, cloud and digital services ecosystem** that the platform engages with, will comprise the disruptive technologies that will underpin the transformation of all vertical industries. This will certainly include:

- 5G public and private network offerings
- Easy to use network slicing capabilities
- Centralized and edge cloud offerings
- Flexible IoT platforms suitable for different industry challenges

In addition, tens (if not hundreds) of thousands of niche vertical solution players will emerge who have a specific expertise targeted at one or more verticals, and operating in one or more geographical regions. For example, in the case of smart manufacturing these vertical solutions could surround data sharing and optimization of specific manufacturing equipment, or come from a 3rd party AI or digital twin specialists.

4. All layers of this platform will need to be underpinned by clear and open API's between the different services and capabilities, such that the platform users can procure and instantiate simple capabilities without much technical expertise, while continuing to work with SI's for more complex requirements.

Ultimately, the success of these industry specific platforms will depend on a combination of the ease of use of the platform and how well they integrate the various communications, cloud and vertical solutions being offered, the breadth of solutions being offered, and the ability of the shared knowledge base to continually grow and offer trustworthy added-value to each of the platform participants and users.

5.2 How do Platforms influence Ecosystem Modelling?

It's worth thinking about the role of these platforms in the context of how they will affect ecosystems. Referring back to Section 3.1, without such platforms the industry will either remain in the bottom left-hand quadrant of the Figure (worst-case scenario) - where all the various individual disruptive technologies will exist independently and where systems integrators play the crucial role in extracting some level of cohesion between the various components (costly & time-consuming). Or industries will converge on agreed standards (de facto or de jure) which will improve the level of modularity of the various disruptive component parts and allow us to move more of an open market model – allowing the buyers to select best of breed and significantly reducing both the cost and time to market of creating solutions from disruptive components.

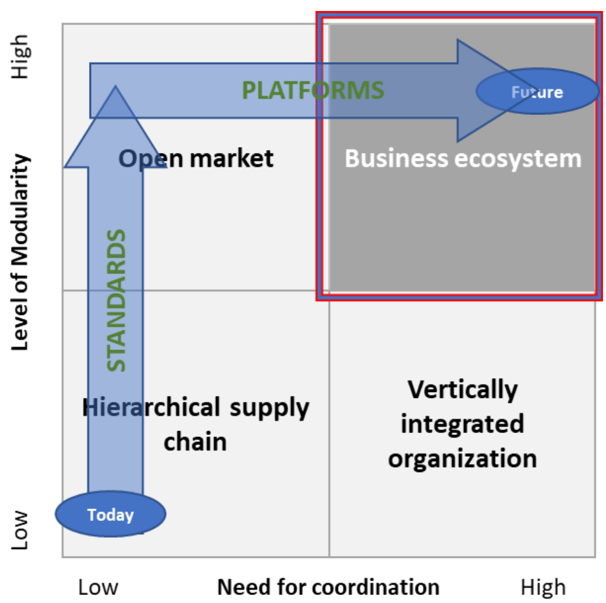

Figure 18: Mapping Interdependent Company Relationships

The real power of the disruptive technologies to transform vertical industries will only be realized when the various different players within the ecosystem can coordinate their capabilities to maximize value. Platforms are one key mechanism for enabling this required level of coordination.

6 Digital Transformation & Ecosystems in the Manufacturing Industry

6.1 Introduction

In this section we look at the specific challenges the manufacturing industry faces in using disruptive technologies and techniques in order to digitally transform. We compare and contrast the manufacturing industry perspective and challenges, with the perspective of the ICT industry. We also share some noteworthy case studies of transformative projects across this industry.increased due to a greater attention to patient engagement and empowerment. Researchers, industries, policymakers, health authorities, as well as many other health-data consumers and sources, have to be considered today to all intents and purposes health actors.

6.2 ICT vs. manufacturing industries

6.2.1 Difference in digitalization focus

Many of the technologies and opportunities in industrial IoT have been postulated by the ICT industry. The rapid advancements of the Internet, cloud computing, and correspondingly, computing-as-a-service business model have led to the assumption that such concepts can be transferred to other industries, particularly manufacturing.

When discussing digitalization, ICT, media, and finance industries are seen as the forerunners, with the ‘producing’ industries to follow. Such an analysis falls short in one key aspect of digitalization: in the aforementioned leading industries, the product has been the subject of the digitalization. Software and data are digital per definition, in media, CDs and newspaper no longer carry the information but it’s consumed directly from the internet, and in finance, large money transactions are just moving bits between banks. However, in the ‘producing’ industries, most of the product will remain physical. It will be extended by more and more digital services, but the key concerns of the producing industries is producing product that is delivered physically to customers.

This reveals a key difference between the corresponding industries: ICT industries have the transfer, storage, manipulation, and retrieval of information as their key business focus. The ‘producing’ industries transform material into valuable products that are stored and shipped. The key technologies in the producing industries are those that are involved in material transformation. Digitalization therefore only plays a supporting role. Furthermore, since the 'product' of ICT companies (i.e. information) has fully transformed to be digital and therefore intangible, their business model is typically a service business model.

6.2.2 Manufacturing customers' concerns

A large part of a manufacturers' concerns are no different from those in any other industries – i.e. top line growth through having an attractive offering and bottom line maximization through cost optimization. But if you were to identify one differentiating concern that is possibly unique to manufacturing, it would be the focus on Operational Equipment Effectiveness (OEE) - the ability to maximize the produced quantities on the given equipment.

OEE is affected by the following aspects:

- Performance (P): production capacity of the line, how quickly can products be produced in normal operation. Performance is affected by the speed of the machines, reduction of intermediate buffers, parallel operations, etc.
- Availability (A): how much of the time is the line producing. Availability is reduced by planned outages (re-configuration, planned maintenance), and unplanned outages (failures, repair). Those can be positively affected by improved planning, optimized maintenance, and fast time to repair.
- Quality (Q): what percentage of the production meets the quality requirements to be sold.

OEE is calculated by multiplying the three percentages P*A*Q. In an optimal set-up, the plant is operating at 100% performance (peak speed and utilization), 100% availability (uninterrupted operation), and 100% quality (no scrap parts). In all three aspects of OEE, digitalization can play a major role in maximizing those variables. Optimized scheduling, predictive maintenance, or in-process quality control are all contributing to the increase of OEE, among others.

6.2.3 Information technology requirements

Since we concluded that the business concerns of manufacturing customers are similar to other verticals, IT requirements for manufacturing industries don't differ either. Business processes are similar, and business management systems can easily be adapted to accommodate these. In the end, companies have to follow the same financial reporting rules, HR processes follow the same local laws, and there are no differences in storing documents and other information or exchanging electronic communication.

Today still, humans are involved in most of the steps, and most data is generated by humans originally, and then passed on and further analysed and aggregated.

The IT department of a manufacturing company takes care of these systems, and adapts them to the specific business processes of an organization. In recent years, the evolution of cloud computing has shifted the IT departments' focus from running computers and software, to only concentrate on the installation, adaptation and maintenance of software, since the execution is on an infrastructure that operates as a service. If IT systems fail (by accident or as a result of a cyber security incident), hardly any company today can continue its operations, a failure results in a business interruption, and consequential losses.

6.2.4 Operational technologies requirements

Even though the manufacturing industries rely on machinery for production, those machines have been incorporating computing capabilities for decades. PLCs or other embedded electronics control the manufacturing process within a machine, and also across machines in production cells or lines. These components, as well as the software they run, are an integral part of the functionality of the equipment. Today, machine builders have the choice to design functionality into mechanics, software, or a combination thereof. The software is an integral part of the machine. Software and hardware are jointly designed and are optimized against each other. The computing systems and the corresponding software is typically referred to as 'Operational Technologies', OT – in contrast to IT, 'Information Technology'.

Authors who discuss the differences between IT and OT very often focus on the technologies they consist of: Data centers and servers as examples for IT, and PLCs (Programmable Logic Controller) and SCADA systems (Supervisory Control And Data Acquisition) for OT. However, there are fundamental differences in the requirements that are driving these technologies; it is these differences that distinguish the resulting technologies most. When having these in focus, it can even be concluded that there is no convergence between IT and OT, it's just IT components that over time fulfil the OT requirements, and therefore become OT components.

Depending on a particular vertical's requirement or customer's market position and business model, a number of OT related requirements may differ, and may therefore allow for a variety of architectural approaches when it comes to the implementation of the IT/OT stack:

- Safety: since some OT components have a direct impact on critical parts of the physical process, they may cause outages, failures, or even damages or injuries. Such components require careful design and very high reliability.
- Security: A breach in the system's security may result in a safety breach, and have a damaging effect on the production.
- Privacy: Similar to IT security, some data from production is more sensitive. Even though it's mostly not personal data, machine data contains intellectual property (e.g. pharma recipes, production secrets) that must not be exposed externally.
- Timing requirements: the reaction time requirements (sensor to actuator) are defined by the physics of the production process. These timing requirements have to be met quite precisely to achieve safe and accurate production.
- Need for data: Some architectural decisions are impacted by the availability of data: if only data from one single machine is required, the functionality can execute on the in-machine computing component. If a vast amount of data from different sites is needed (e.g. statistical analysis), the place to go for is probably the cloud.
- Computing power: The complexity of the algorithms that is needed to solve an analytics or control problem defines the required computing power. More and more power is added to the equipment at the edge, but some capacities require cloud support (e.g. AI training).
- Scope of delivery: A machine builder needs to be able to assemble and test a machine to be sure that it works properly when delivered on site. To secure the accountability on the performance of the machine, 3rd party dependencies have to be minimized, and specified as precisely as possible. A machine would most probably have defined interfaces to the infrastructure and adjacent equipment, while it contains all the functionality required to operate.

It is to be noted, that within a manufacturing operation, these aspects may be reviewed by use case. What works in one case (e.g. due to relaxed timing requirements) may not work in another (due to safety concerns). An overall solution will therefore mostly have components that are distributed along the IT/OT stack.

These, and possibly more, aspects need to be taken into consideration when discussing a solution architecture and corresponding business models with a manufacturing customer.

6.2.5 Life cycle aspects: from engineering to end-of-life

Industrial manufacturing requirements not only cover the plant in operation, but throughout its lifecycle: from design and engineering through end-of-life. As mentioned initially, many of the OT components are part of machine functionality. They not only execute part of the functionality, they are also designed as part of the functionality.

The design of OT systems follows the design of the production process, and design limitations are imposed by the hardware of the equipment. To ease the design process, a tight integration into the tool landscape that is commonly used to design production lines is beneficial. Data formats typically supported (e.g. OPC UA semantics) support a seamless exchange of information in the engineering process.

As the investment costs for a production line or machine is very high, the planned lifetime of the machine is often decades. New products are produced on old lines by retrofitting or extending components, in software or hardware. Customer expectations are such that the system as a whole is supported throughout its lifetime. It is not accepted, that a production machine can no longer be supported due to the inability to upgrade the software. End-of-support announcements are expected to be 5-10 years to allow for proper re-planning of the plant. Even after support of the supplier is phased out, some customers continue operation with the help of 3rd party service organizations.

It is in the machine supplier's interest to never force the customer to replace the complete machine, but to gradually upgrade components over a long period of time to extend its lifecycle.

Any technology that is supporting high investment equipment has to make sure that it will need to be supported / migrated over the lifecycle of the machine.

6.2.6 Twin Transition – Green and digital design for sustainable manufacturing[11]

No discussion on manufacturing and ICT can be complete without mentioning the sustainability challenges that are faced regionally and globally. The European Green

*11. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/industry-and-green-deal_en

https://new.siemens.com/global/en/company/stories/research-technologies/energytransition/product-carbon-footprint.html

https://orgalim.eu/sites/default/fles/2021-07/PPT%20-%20Orgalim%20Policy%20exchange%20on%20SPI%20and%20DPP%2C%2029%20June%20202

Deal is the EU’s new growth strategy, aiming to transform the EU into a fairer and more prosperous society, with a modern, resource-efficient and competitive economy, with no net emissions of greenhouse gases by mid-century. The main goal is to harness the significant potential in global markets for low-emission technologies, sustainable products and services in order to achieve climate neutrality by 2050. All industrial value chains, including energy-intensive sectors, will have to be addressed.

Because the supply chain accounts for the largest share of the ecological footprint of products, the decarbonization of industry is a challenge which must be solved by all the stakeholders together. Under the umbrella of ZVEI an industry consortium named “estainium” has been founded. The target of “Estainium” is to make the exchange of emission data possible and feasible along the supply chain and to combine it with data from a company’s own value creation in order to obtain a product’s true carbon footprint. The open, cross-industry Estainium network has been established in 2021 with the aim of enabling manufacturers, suppliers, customers and partners to exchange trustworthy PCF data.

Additionally, the digital product passport will cover CO2 management - already foreseen in the engineering phase of products and highly integrated systems - thus supporting companies on their way towards carbon neutral production and helping them to transform sustainability into a decisive competitive edge. The digital product passport is evolving as a standard to enable manufacturers to create digital twins, embedding all the information required either by manufacturers or by customers in B2B transactions. The life story of a product can be tracked, enabling services related to its remanufacturing, reparability, second-life, recyclability and new business models. More information on these and other initiatives is available in the links below.

https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/industry-and-green-deal_en

https://new.siemens.com/global/en/company/stories/research-technologies/energytransition/product-carbon-footprint.html

https://orgalim.eu/sites/default/files/2021-07/PPT%20-%20Orgalim%20Policy%20exchange%20on%20SPI%20and%20DPP%2C%2029%20June%202021.pdf.

6.3 Manufacturing Case Studies

This section describes some real-world case studies contributed by GIO member companies, as a way to illustrate the breadth of digital transformation activity already taking place within the manufacturing ecosystem.

6.3.1 Case Study: Collaborative Condition Monitoring

The Use Case "Collaborative Condition Monitoring" (CCM for short) deals with the collection and use of operating data to optimize the reliability and service life of machines and their components during operation. This use case relates to Manufacturing and targets how cross-company collaboration can generate added value, resulting in reduced costs.

Keywords:

data sharing | value add in supply chain | maintenance | service models | kiReallabor

6.3.1.1 Submitted by

Michael Jochem, ZVEI, German Platform WG1

6.3.1.2 Context

This Use Case addresses the following key questions:

1. How can data be monetized (including shared data)?
2. Who receives what share of the benefits generated by collective data provision?
3. How does the use of AI expand the application options?
4. How is flexible communication made possible between all partners across all instances?
5. How are security and trust in data usage and access guaranteed?
6. How can we achieve legal use of the data?
7. How do we ensure usability in the application by people down to the shop floor?

- **Current barriers in industry and restrictions of existing business models:** Nowadays, cooperation is primarily bilateral, for example when the factory operator and the machine supplier exchange operating data. The machine data generated during operation are used, for example, to analyze operational disruptions or to organize maintenance work. This cooperation usually takes place between two partners and is initiated and enforced via the customer / supplier relationship (including market power).
- **Issues with Scaling:** Only large amounts of data provide a meaningful basis that is necessary to analyze the service life and reliability of machines and components more precisely. However, due to the primarily bilateral cooperation, these data are only available to two partners.
- **Lack of trust:** In order for actors to share their data, secure data transmission, storage and access rights are required to protect data from competitors or from the theft of know-how (sensitive production data).
- **Missing business model:** By providing and using data from the various actors in the CCM, added value can be generated, which can have a positive effect on the total cost of ownership, for example in a longer service life of the machine.
- **Lack of framework for digital intra- and entrepreneurship:** The development of the added value potential of industrial data will largely determine the future competitiveness of Germany and Europe as a business location.

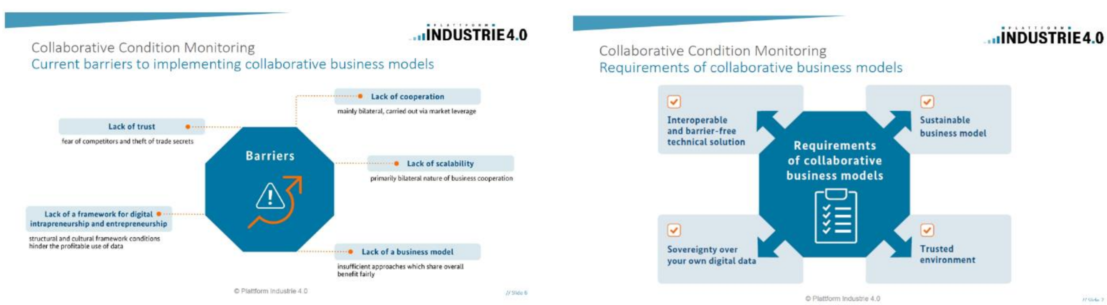

Figure 19: Collaborative Condition Monitoring – barriers and requirements

6.3.1.3 Business Benefits

The hypothesis is that an economic advantage can be generated within the digital ecosystem ("digital business model") by increasing the reliability and service life of components and machines. This requires collaboration between all those involved in the value chain from sensor supplier, machine integrator and factory owner which in turn requires access to data.

Because the CCM use case is a blueprint for many evolving use cases, the first business benefits are evaluated in the kiReallabor, e.g. temperature management in machine for maintenance planning.

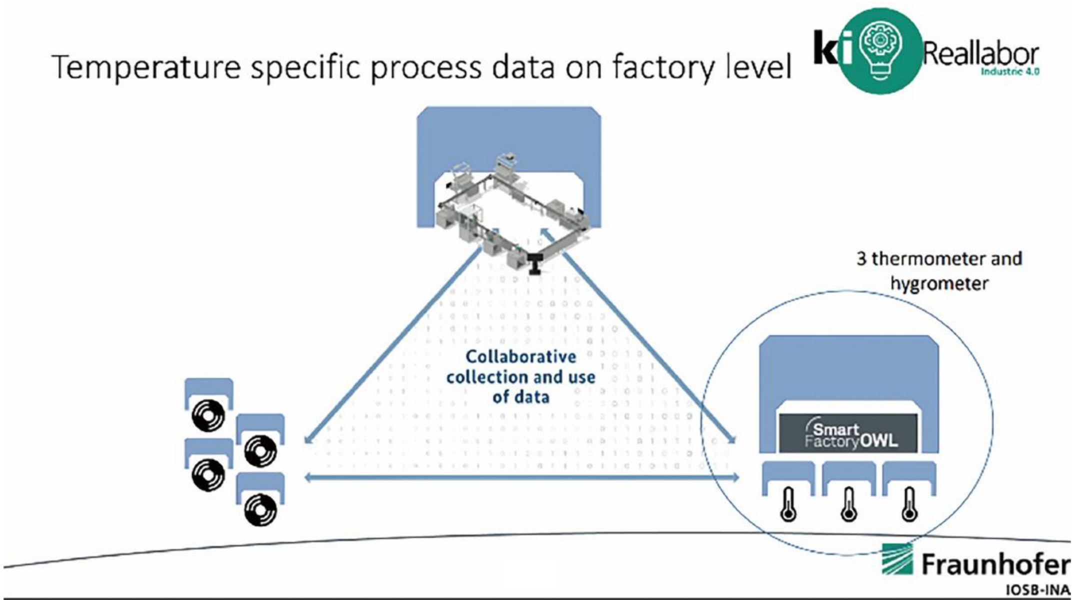

Figure 20: Temperature specific process data on factory level

6.3.1.4 Solution or Innovation Detail

- Digital Standards:
  - Use of AAS, semantically interoperable in terms of content and access rights.
  - Sub model of AAS for asset-specific data on reliability and service life.
  - Secure access, authorization and communication.
- Implementation:
  - The component supplier provides a component with an AAS that contains data fields for data relevant to service life and reliability.
  - The machine supplier delivers his machine with its own AAS which also contains data fields for service life and reliability-related data.
  - The AAS of the machine will be upgraded to be able to forward the data of the machine and the components accumulated over the service life of the machine to a neutral platform.
  - The factory operator supplements the data with relevant machine usage data (e.g. operating temperatures, maintenance intervals) based on the data fields in the administration shell.

6.3.1.5 Ecosystem

This use case defines a different kind of value chain with a high scalability.

- Value chain: A three-stage value chain with various actors is considered as an exemplary, simplified process of an operational ecosystem.
- Value triangle (three-point fractal): The smallest possible fractal of a multilateral structure.

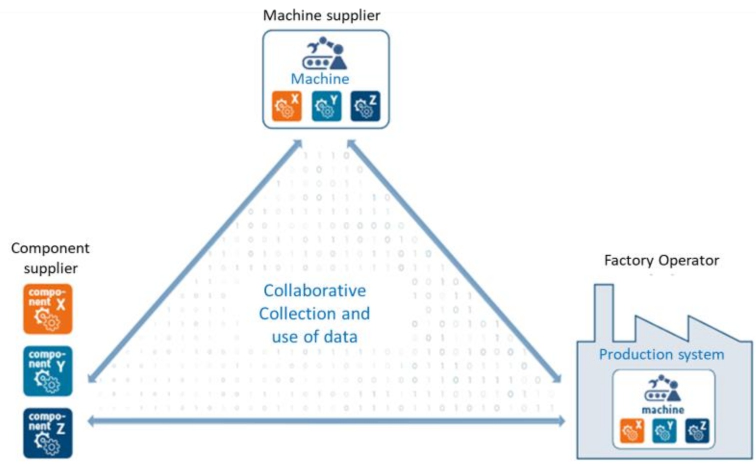

Figure 21: Value triangle (three-point fractal)

This triangle is the smallest ecosystem spanning different actors in the value chain. It therefore can be considered as smallest building block or fractal of larger ecosystems.

The fractal can be used to discuss the challenges and requirements of a multilaterally collaboration regarding:

- Technical aspects, e.g. Identity, Trust and Data Sovereignty
- Compliance
- Legal aspects
- Mindset, courage for data entrepreneurship
- Usability aspects
- Knowledge gained can be transferred to larger fractal networks

6.3.1.6 Business Model

An economic advantage can be generated within the digital ecosystem ("digital business model") by increasing the reliability and service life of components and machines. This requires collaboration between all those involved in the value chain and access to data depending on authorization.

6.3.1.7 Further Information and References

https://www.plattform-i40.de/PI40/Redaktion/EN/Downloads/Publikation/collaborative-data-driven-business-models.html

https://www.plattform-i40.de/PI40/Redaktion/EN/News/Actual/2020/2020-10-15-CCM-Web-Seminar.html

https://www.iosb-ina.fraunhofer.de/de/geschaeftsbereiche/maschinelles-lernen/next-level-ml/ki-reallabor.html

6.3.2 Case Study: E2W Full-Lifecycle Management Based on Industrial Internet Platforms

This case study focuses on a solution for two-wheeled EVs (E2W) full-lifecycle management based on industrial Internet platforms. This solution integrates China Telecom's 5G+MEC network reconstruction capabilities and uses big data and IoT technologies to empower the SaaS model. In addition to providing high-bandwidth and ultra-low latency networks for industrial devices, this solution creates a trustworthy and automated execution environment and provides value-added services of product full-lifecycle optimization based on industrial Internet platforms.

#industrial Internet platform #5G+MEC

6.3.2.1 Submitted by

Jiangsu Xinri E-Vehicle Co., Ltd. ("SUNRA"), Alliance of Industrial Internet, China

6.3.2.2 Context

Jiangsu Xinri E-Vehicle Co., Ltd. ("SUNRA") is a leading E2W company based in Wuxi, China. The company is regarded as "a global leader of intelligent two-wheeled EVs", with products sold in more than 70 countries and regions, such as America, Europe, and Southeast Asia. It plans to build its cloud-based industrial Internet platform, with one centre (visualized data monitoring centre) and six applications (product line capacity statistics, equipment management, energy management, MES dashboard, Andon visualization, and warehousing management) at the core. As workshops are digitized, the existing information systems will be integrated to link information silos and realize a strategic transformation of intelligent manufacturing. This aims to improve the company's flexibility, automation and intelligent level, and helps the company develop sustainably in the future.

The project adopts an approach of "phased implementation and step-by-step fast deployment". The solution features integration of China Telecom's 5G+MEC network reconstruction capabilities and close collaboration between SUNRA's cloud-based industrial Internet platform and Huawei's FusionPlant industrial Internet platform. It uses big data and IoT technologies to empower the SaaS model. In addition to providing high-bandwidth and ultra-low latency networks for industrial devices, this solution creates a trustworthy and automated execution environment and provides value-added services of product full-lifecycle optimization based on industrial Internet platforms. The three phases of implementation are "building an industrial Internet basic application platform", "integrating systems, synchronizing logistics, and synchronizing manufacturing", and "adopting more applications and building 5G smart workshops".

6.3.2.3 Business Benefits

The project is being centrally planned and implemented through three phases.

01 Phase I

Core infrastructure will be built in this phase, including the basic engineering of the SUNRA E2W industrial Internet platform for data collection, network reconstruction, and equipment connectivity. This phase will address related pain points to enable the visualization of production capacity, efficiency and energy consumption, and improve cyber security. Project Phase I will:

(1) increase equipment lifecycle by 30%,

(2) cut electricity costs by 10%,

(3) reduce the equipment failure rate by 90%,

(4) increase data real-time transmission speed by 85%,

(5) cut management costs by 20%,

(6) improve network stability by 80%,

(7) improve network reliability by 99%.

02 Phase II

Phase II construction is carried out on the basis of phase I. The existing SAP, SRM, and OA systems will be linked to the industrial Internet platform, so data can be shared between the systems and the platform. This phase will visualize the Andon system, enable smart warehousing management, and bridging information silos. Project Phase II will:

(1) cut warehousing management costs by 70%,

(2) improve inventory counts efficiency by 200%,

(3) cut product line management costs by 30%.

03 Phase III

Phase III construction is carried out on the basis of the previous two phases. This phase will witness the building of a 5G+AGV intelligent warehousing system to realize unmanned warehousing management and the building of an enterprise-level private industrial Internet platform. Project Phase III will:

(1) enable each AGV vehicle to replace 2.6 labours,

(2) improve pickup efficiency by 200%,

(3) reduce the logistics damage rate by 90%,

(4) improve goods movement accuracy by 90%.

6.3.2.4 Industry Values

There are more than 400 E2W manufacturers in Xishan District, Wuxi, including more than 100 OEMs and more than 300 vendors providing components. As the home to many industry leaders such as SUNRA, Yadea and AIMA, Xishan now has a relatively mature and complete industry value chain. According to statistics, 6 out of the top 10 E2W companies in China are located in Xishan. For every four two-wheeled EVs sold in China, one comes from Xishan.

SUNRA is a leading E2W company based in Wuxi, China. To meet the company's development needs, SUNRA expects to develop an in-depth restructuring solution to address issues of low-efficiency and high-cost operations through digital transformation and upgrade of its supply chain. Based on HUAWEI CLOUD's FusionPlant industrial Internet platform, SUNRA will build its cloud-based E2W industrial Internet platform. This platform will enable transparent supply chain management, activate suppliers' enthusiasm, and make collaborative operations between suppliers possible, helping the company maximize their production capacity.

FusionPlant's industrial aPaaS capabilities and ROMA's capabilities as an integration platform will help break the data barrier across SUNRA's supply chain, achieving data sharing and interoperability between SUNRA and its suppliers. This will effectively improve the collaboration across its supply chain, and greatly reduce the control and procurement costs. The project plan, progress, and quality of suppliers can be monitored remotely, and no SUNRA personnel are required to take a business trip to suppliers' factories. As a result, this will reduce the labour cost by more than 90%, and improve the efficiency and supply delivery accuracy by more than 80% and 20% respectively.

6.3.2.5 Solution or Innovation Details

01 Network reconstruction

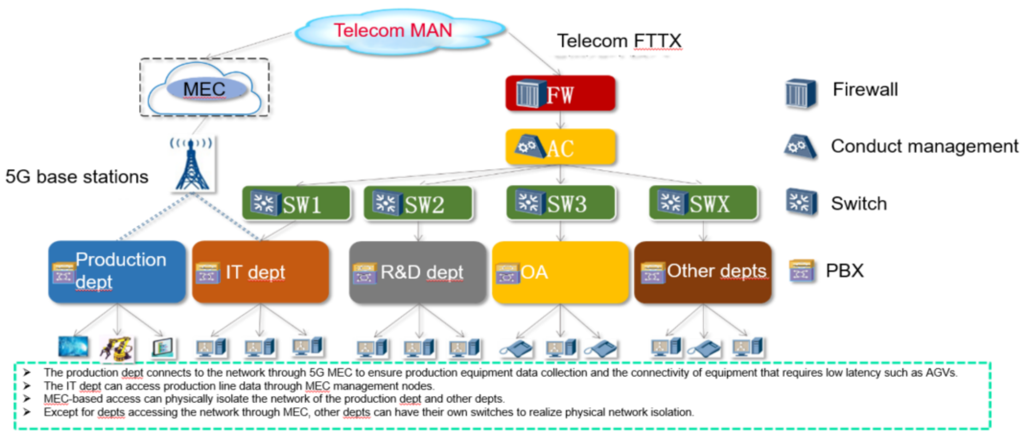

Figure 22: Solution architecture

02 Data integration and convergence across multiple platforms

ROMA platform + SRM system + four cloud-based systems + data warehouse + BI system: Application systems are migrated to the cloud and integrated by the ROMA platform. Upstream suppliers can access end-to-end service management systems at one stop to obtain customer data. The business systems and data of customers and suppliers are connected through the cloud-based platform to accurately link sales orders with production plans, enabling real-time feedback on production progress. In addition, production data can be obtained in real time to monitor production quality and provide effective insights for product quality improvement. Through building an industry-level industrial Internet platform, the data and information of upstream and downstream suppliers and their branches (subsidiaries) are streamlined to analyse and utilize big data of manufacturing, equipment, quality, and operations to realize smart factories featuring autonomous decision-making, autonomous adjustment of process parameters, proactive warning of manufacturing quality issues, and autonomous diagnosis of equipment operations.

6.3.2.6 Ecosystem

Through the intensive and collaborative management and operations on the platform, the upstream and downstream enterprises of the supply chain can form a strategic alliance. The competition between enterprises will be transformed into a cooperative relationship based on supply chain standardization, which is beneficial to reducing the total cost of the industry value chain and promotes the standardization of the industry process management. A value network example is shown below.

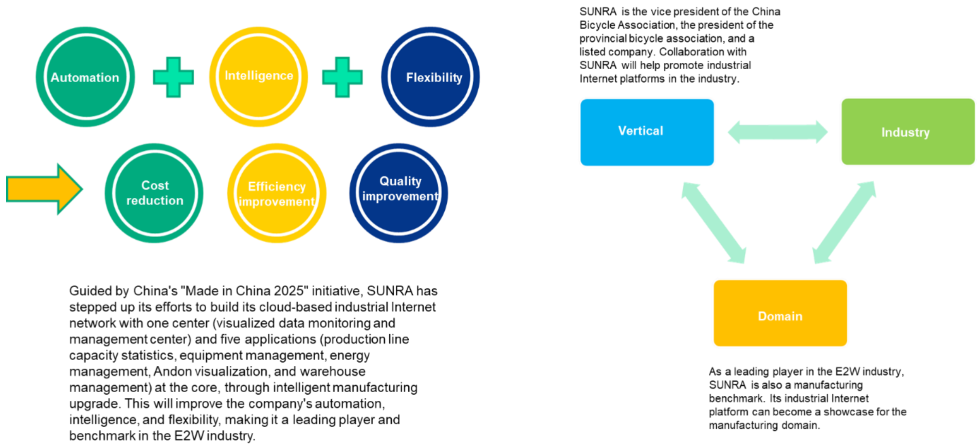

Figure 23: Example of a value network

6.3.3 Case Study: AI-based service ecosystem for services in the age of Industry 4.0

This project encompasses a cluster of different save costs due to delivering services utilizing an AI-based service platform . The project deliverables enable small and medium enterprises (SMEs) to save costs due to delivering services utilizing an AI-based service platform.

Keywords:

service AI platform AI for SME service models servicemeister AI Service Platform

6.3.3.1 Submitted by

Hauke Timmermann, Service-Meister Project, eco Association of the Internet Industry (https://international.eco.de/)

6.3.3.2 Context

New service tasks and business models lead to an increased need for service staff to maintain or improve mechanical operations, reducing costly downtime of machines. Especially in the environment of Industry 4.0, many machine suppliers and plant manufacturers no longer simply sell their machines, but offer them as part of so-called MaaS (Manufacturing-as-a-Service) or subscription models. Up to now service is being offered and billed on the basis of operating hours – restricting transparency in the service process.

27% of German companies are already using AI in services and customer support - but in 5 years this is expected to rise to 69 %. Networked sensors allow remote access to machine and environmental status data, leading to an optimized management of transparent service and maintenance operations.

6.3.3.3 Business Benefits

Business benefits are due to the transparency gained in the service process. Networked sensors (wired or wireless) allow remote data access that enable the creation of forecasting models to deliver targeted services leading to overall cost reduction and efficient service delivery.

The expectation is that economic advantage can be generated for SMEs by using Reference Architectures and AI-as-a-Service platforms, made available via the open service master platform. This will create a low-threshold access to AI technology and a service ecosystem leading to reduced overall costs for service suppliers and at customer sites.

6.3.3.4 Solution or Innovation Detail

Two important goals in the project are:

a) to create leapfrog innovations from which other companies can learn and which they can then also use for themselves,

b) to also achieve platform innovations in Germany and Europe.

Actually, Germany has been leading AI development and research for 50 years, but so far no large-scale AI Platform implementations have been developed.

The platform is designed to support the needs of SMEs offering services also to their customers. A broad scope of different service demands in industry is incorporated in the project by “speed boats”, representing different use cases in different industries. Some other these are shown below.

- **Krone**

Environment Screening: Keeping an eye on water levels from a distance, determining discharge rates, and identifying problems

> IoT services like this are increasingly popular as climate change demands smart water management solutions. If more rain falls in winter and there is only occasional heavy precipitation in summer, this can push wastewater pipes to their limits. The consequence of extreme weather conditions: flooding and high water.

- **Wuerth**

Material Supply in Industry: Accelerate service processes

Condition Monitoring and Surveillance: detect faults remotely

> These use cases focus on predictive maintenance – based on data supplied by networked tools. AI procedures analyse the devices’ service reports and IoT data.

- **OGE**

Service Management: Detect anomalies in gas pipe lines, forecast service requirements

> Open Grid Europe operates its own Competence Center, which is tasked with detecting anomalies in the data streams of all 850 gas leakage sensors.

- **Trumpf**

Efficient planning of service calls, automatic diagnosis of machine data

> Machines get enabled to independently diagnose and analyse problems, transfer results to a cloud platform where they get evaluated. Maintenance tickets can be automated and information can be used in a continuous learning and improvement process. This increases system availability and reduces maintenance costs.

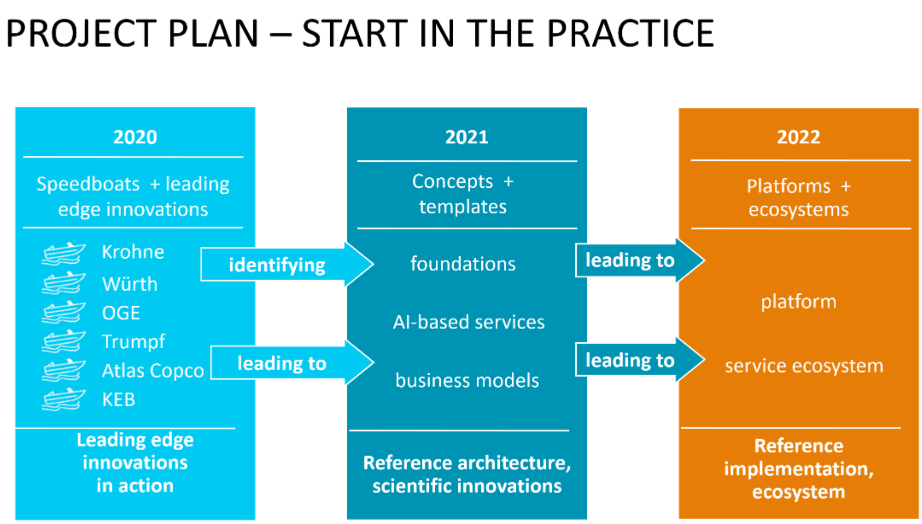

Figure 24: Project Roadmap for creating the AI support platform and reference implementation

A standardised 100% digital service lifecycle serves as the basis for extending the various functionalities from the speedboats to the platform.

This process creates generic services, modules and blueprints that can be made available to SMEs and ensures the scalability of the solution.

The platform can be operated as a Gaia-X compliant federation and ensures that digitally sovereign partners can exchange and share their data and create new business models.

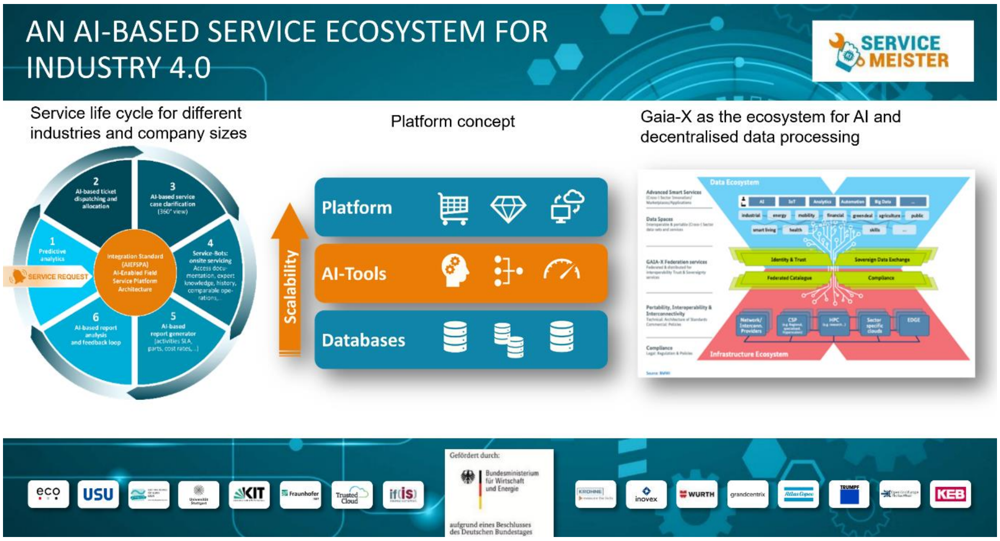

Figure 25: An AI-based service ecosystem for Industry 4.0

6.3.3.5 Ecosystem

The Service Meister platform is designed to provide AI systems and components that cover the entire service process – in a 360-degree view. Service technicians must be able to access the information in various working conditions to ensure a good user experience and barrier-free access to the relevant information and solutions.

The ecosystem of Service-Meister Use Cases encompasses:

- Service staff
- AI service platform operator
- Terminal Provider for service operators
- AI solution support centers
- Machine & equipment supplier needing maintenance
- The end user: factory operator

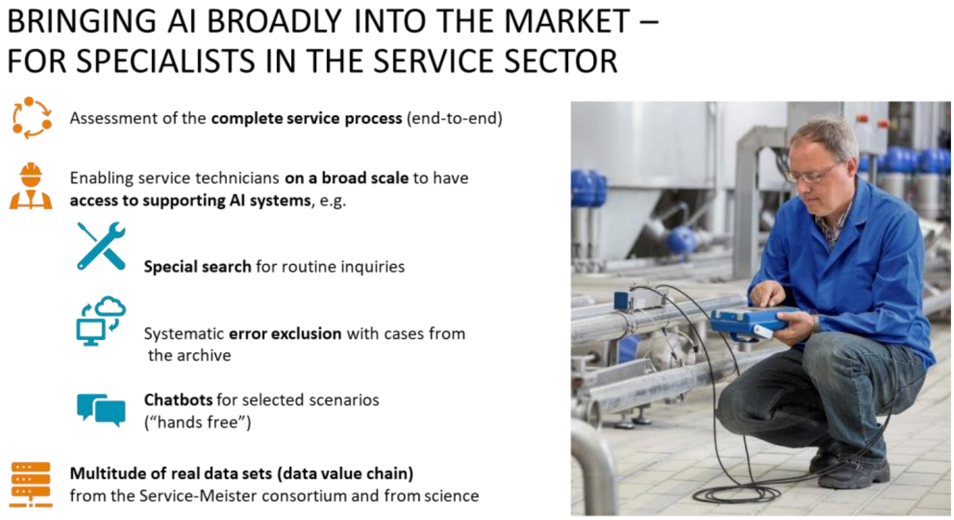

Figure 26: Service-Meister ecosystem

6.3.3.6 Business Model

New business models are being developed to monetize targeted services based on reduced downtime of machinery, reduced risks of environmental hazards and total cost of ownership in the supply chain engaged.

Public available deliverables can be downloaded from the project web page after the project end, in 2023.

6.3.3.7 Further Information and references

https://www.servicemeister.org/das-konsortium/

Abendroth, J., Riefle, L., & Benz, C. (2021). Opening the Black Box of Digital B2B Co-Creation Platforms: A Taxonomy. In Proceedings of the 16th International Conference on Wirtschaftsinformatik(WI).

https://www.researchgate.net/publication/348326720_Opening_the_Black_Box_of_Digital_B2B_Co-Creation_Platforms_A_Taxonomy.

Riefle, L., Eisold, M. & Benz, C. (2021). Industrial Corporation's Transformation into a Digital Platform Provider: A Case Study on Enablers. In Proceedings of the 23rd IEEE Conference on Business Informatics(CBI).

https://www.researchgate.net/publication/354339339_Industrial_Corporation's_Transformation_into_a_Digital_Platform_Provider_A_Case_Study_on_Enablers

6.3.4 Case Study: Predictive Manufacturing Process Control

This use case relates to the control of manufacturing processes using Artificial Intelligence predictive algorithms.

Keywords:

predictive control predictive maintenance AI Control

6.3.4.1 Submitted by

Huawei SPO Lab / September 2021

6.3.4.2 Context

A major focus for Digital Transformation in manufacturing has been increases in productivity through improving the efficiency of industrial processes of every sort. One example of how efficiency can be improved is through better control of the process, ensuring less waste in the form of imperfect product or reduced use of energy and raw materials.

In general, optimization involves collection of data from all stages of the process, and using that to understand how to improve the process as a whole. As the sophistication of optimization increases, an increasing quantity of data must be collected, processed in shorter and shorter timeframes, and used to make faster interventions to control the process.

These developments imply the need for more and more sensors within the manufacturing environment, collecting more data at higher rates and utilizing more computing capacity. This places increasing demands on the connectivity services used in manufacturing – needs which must be met by innovative services provided by the telecoms industry.

In order to explore the requirements and opportunities for connectivity services in process control, a consortium of stakeholders developed a technology demonstrator that was delivered as a Catalyst project at TM Forum Digital Transformation World in 2019.

In this project, the process to be controlled and optimized was provided by TWI, world-leading experts in materials jointing and additive manufacturing techniques (www.theweldinginstitute.com). The process of Selective Laser Melting (SLM) uses a laser to melt metal powder and thus create solid shapes as a series of individual layers – a bit like 3D printing but using metals like titanium to create sophisticated and expensive manufactured products for the aerospace and medical industries.

The SLM process is complex and requires very precise control of the laser power in order to prevent overheating and damage to the piece being manufactured. It takes many hours to build up pieces, so the cost in terms of machine time and raw materials can be significant if a build fails. Overheating can occur rapidly and unless the laser power is reduced immediately, irreparable damage can be inflicted on the work piece. The laser power must be reduced within the order of 100 milliseconds.

6.3.4.3 Business Benefits

The immediate business case for improving the control of the SLM process is based on a reduction in wastage through failed builds, thereby saving money, improving the overall efficiency of the process and improving customer satisfaction through reduced delays and uncertainty.

Below shows the costs that could be experienced by a large additive manufacturing site using 50 SLM machines, which shows that the costs can be significant. If the rate of failures can be significantly reduced by applying predictive control to the process, then there is a clear case for investment.

SLM Predictive Control: Business Case

Each build is 12 hours including setup time - so a machine can complete 14 in a week of continuous operation

Assume up to 20% of builds can fail, so each machine can have up to 3 failures per week

Failed Build: Direct Costs	Annualised Direct Costs per Machine
0.5kg materials @ \$400/kg = \$200 3hr technician time @ \$150/hr = \$450 8hr machine time @ \$50/hr = \$400 **Total failed build cost = \$1050**	3 builds per week x 52 weeks = 156 failures 156 failures @ \$1050 = \$163,800 **Total cost = \$164K per machine per annum**

A large manufacturing site with 50 machines could experience costs of **over \$8M** due to failed builds

Figure 27: Control Example Business Case

6.3.4.4 Solution or Innovation Detail

The project made use of a high-speed infra-red camera to monitor the piece at the laser spot, and an Artificial Intelligence algorithm running in a Cloud service to determine how and when to change the laser input power. The AI algorithm was trained on hundreds of good and failed builds, in order to learn when a build would fail based on the real-time characteristics of the laser melting spot.

The use of computer vision to retro-fit data collection to existing manufacturing machines is non-disruptive, since generally the camera can be located outside the machine, and does not require the machinery to be dismantled or even stopped for fitting. Below shows a block diagram of the overall system, which delivers the video imagery to an AI algorithm running in edge Cloud to perform the predictive analysis, before returning control signals to the machine.

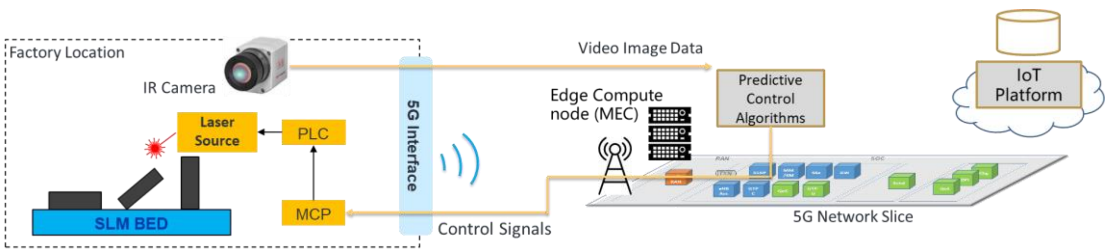

Figure 28: Predictive Control Demonstration System

In this case, the high-speed camera is required to facilitate very fast response times. This results in a need for high-bandwidth low-latency connectivity from the camera to the Cloud, an ideal use case for 5G cellular technology.

The prototype project was a success, with the AI algorithm able to predict with reasonable accuracy when a build would fail due to overheating or burning, in time to intervene and reduce the laser power. Further information about the project can be found on the TM Forum website[12].

6.3.4.5 Ecosystem

The figure below shows a possible Value Network for the predictive control service. This diagram shows how many of the players within the ecosystem collaborate and provide different aspects of the overall solution in order to create value for the ultimate consumer, the manufacturer.

*12. https://www.tmforum.org/manufacturing-predictive-maintenance-using-5g/

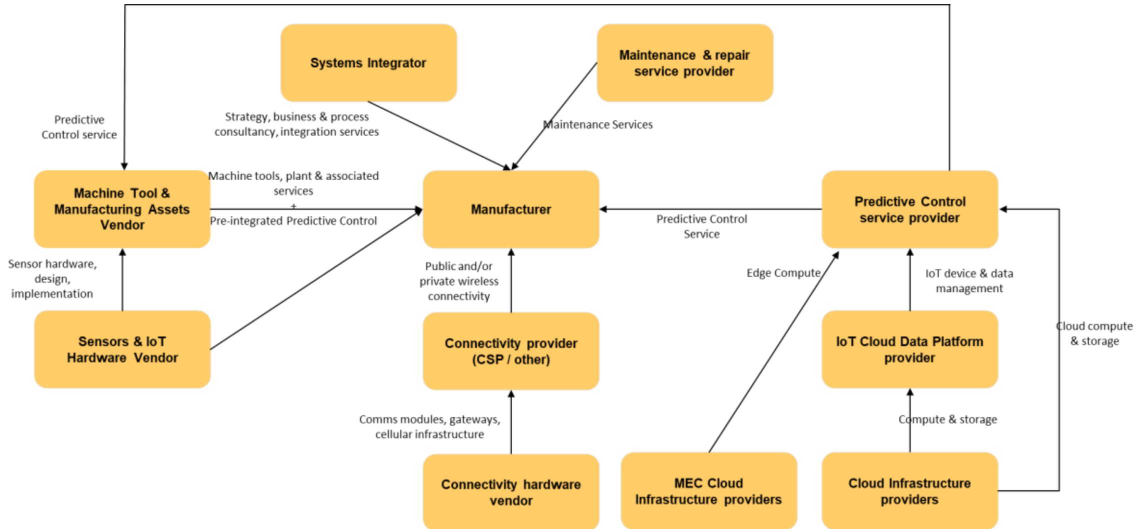

Figure 29: Predictive Control Value Network

In this model, the predictive control service provider composes an offering by bundling their software-based service with Cloud and IoT services, and brings that to the manufacturer either directly or by pre-integrating their services with production equipment provided by a machine tool vendor. The manufacturer may require other associated services such as systems integration to integrate the predictive control service into existing processes and systems. The manufacturer will also require high-quality network connectivity to facilitate data gathering from the production machinery to the Cloud, provided by a communications service provider.

Referring back to the work of Professor Jacobides, this use case requires a high level of coordination between multiple parties within the ecosystem in order to deliver the overall value, but each of the separate offerings (Cloud, predictive control software, connectivity, machine tools, etc.) are quite modular in nature. So the need for a business ecosystem approach is clear in this case.

6.3.4.6 Business Model

A number of different business models are possible for this kind of service, which involve the ecosystem participants playing different roles. In order to understand how an industry ecosystem can be facilitated it is necessary to think through the different roles that each stakeholder can play within the ecosystem. Below redraws the value network to show three possible business models for this service.

These business models differ primarily in terms of which stakeholder takes the lead role in bringing the overall service to market.

— **Option 1:** the telco bundles their own connectivity offering with the Cloud and Predictive Control capabilities required to offer a complete service to the manufacturer. This has the advantage of having a single provider to deal with who offers the complete service.

— **Option 2:** the machine tool OEM bundles cellular connectivity and the Cloud-hosted Predictive Control service with their production equipment, allowing them to offer an enhanced whole-life service to the manufacturer. These connected production machines can offer better efficiency and lower cost of ownership because they incorporate connectivity and Cloud-based control.

— **Option 3:** the manufacturer uses the domain expertise of a systems integrator to bring together all the elements of a predictive control service and implement it for themselves, instrumenting existing equipment and acquiring the predictive control software capabilities directly from the provider. This gives the manufacturer the greatest degree of control, but is likely to involve a much greater up-front investment.

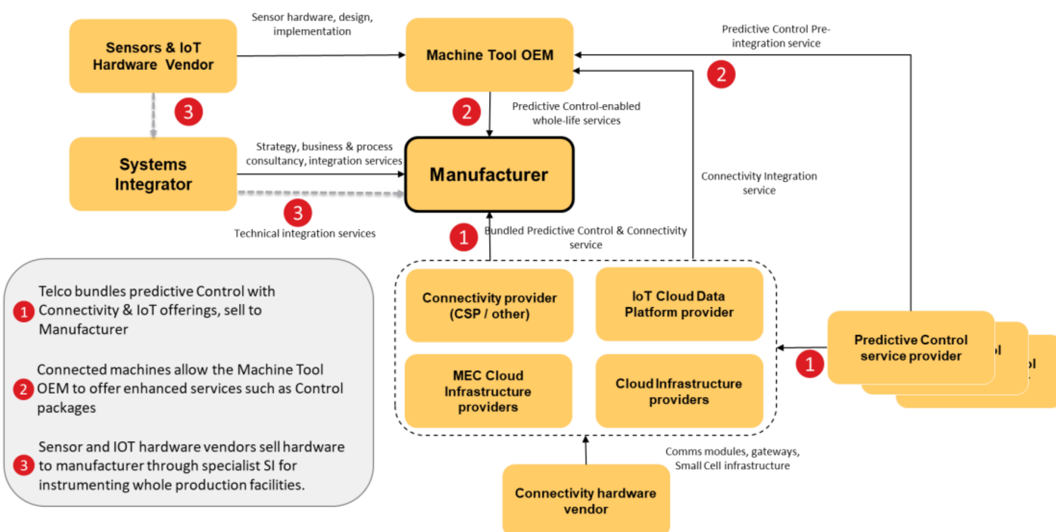

Figure 30: Predictive Control Service Business Model Options

This use case illustrates the complex ways in which ecosystem players can interact to deliver value to consumers within the ecosystem. It is clear that as the ecosystem becomes richer with more diverse participants, the opportunities for all the players increases and the overall value delivered is much greater than if the individual players went to market completely in isolation.

6.3.5 Case Study: Connected Industries Open Framework for manufacturing industry, application with Edge-AI

"Connected Industry Open Framework" (CIOF) is a data sharing platform developed by Industrial Value Chain Initiative, Japan (IVI), for manufacturing industry, covering data transactions and contracting. This stamping factory use case achieves real time trouble detection and predictive maintenance utilizing Edge-AI based inference, under controlled data sharing through CIOF.

Keywords:

CIOF Data sharing Edge Artificial intelligence trouble detection

predictive maintenance stamping

6.3.5.1 Submitted by

Industrial Value Chain Initiative, Japan

Yasuyuki Nishioka: President, Industrial Value Chain Initiative
Yasuo Matsuoka: Steering committee member, leader of advanced study group for sensor data utilization technology for data distribution.
Nobuyuki Ogura: Convenor for IVI Reference Architecture Task Force

6.3.5.2 Context

In digital transformation and ecosystems, the necessity to connect different entities to share information over different enterprises are often mentioned. But in reality, this is extremely difficult because it will require various legal, commercial agreements and adjustments among stakeholders involved, let alone solving many technical issues, such as connecting the correct information between the entities.

Industrial Value Chain Initiative (IVI), with the support of Ministry of Economics, Trade and Industry (METI) Japan, has developed CIOF: Connected Industries Open Framework to cater these requirements for manufacturing in mind. Through couple of years of successful use case projects, in April 2022, IVI and CIOF partners will launch commercial service of this CIOF.

The concept of CIOF is something like delivery-certified mailing system as illustrated below.

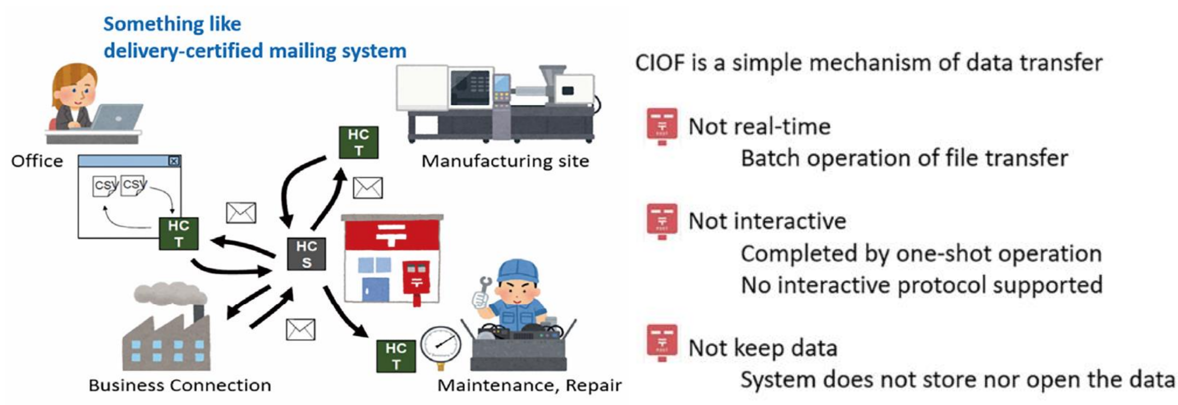

Figure 31: Concept of CIOF

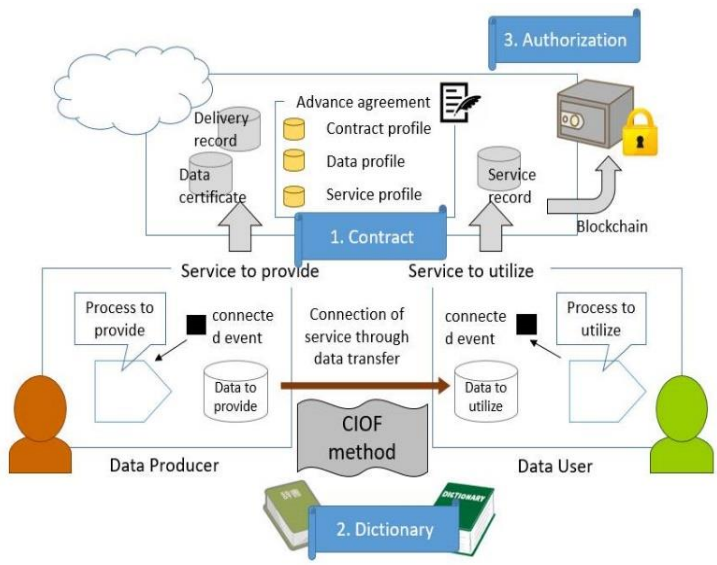

Figure 32: Distinctive features of CIOF

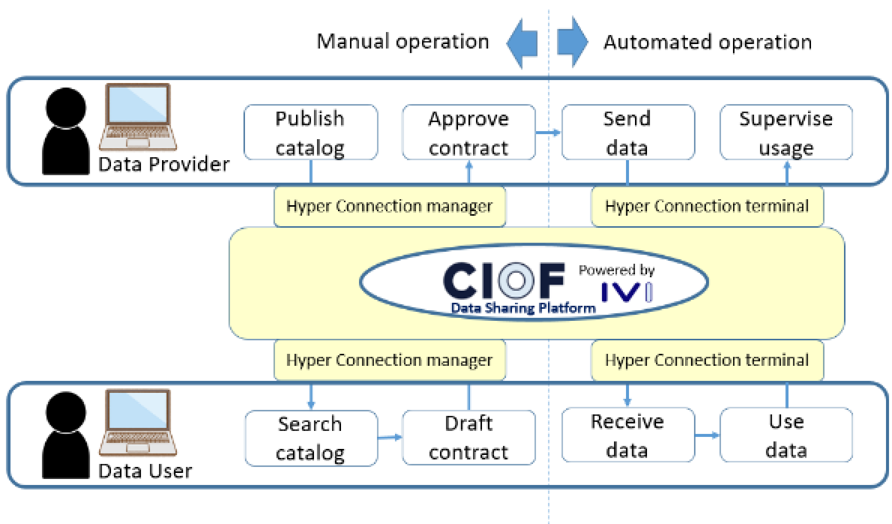

Figure 33: Flow of contract-based data distribution

CIOF has three distinctive features illustrated above:

1. **Contract based data distribution**: Usage of data must be defined by contract in advance. CIOF system can trace the usage of data (event-based monitor or record based inquiry, according to contract) and the status of data (kept, modified, deleted) when necessary.
2. **Encoding/decoding by dictionary:** Multiple dictionaries (Specific dictionary and Actual dictionaries) are used for metadata conversion so that independence of implementation on site is guaranteed.
3. **Security and data authorization:** Data itself and related assets on site are managed by CIOF system to prevent data falsification. Data is encrypted and transferred on demand, not stored on cloud. Blockchain technology will guarantee the communication security.

6.3.5.3 Business Benefits

CIOF facilitates easy and flexible creation of new value chain and innovative business model.

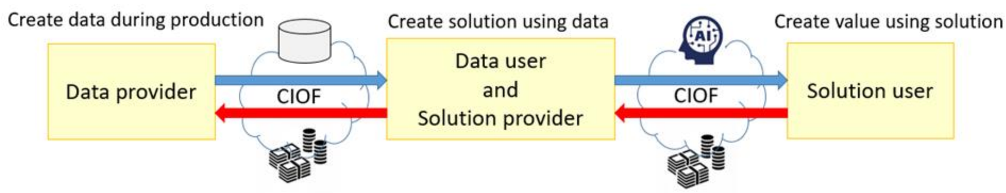

Figure 34: Business benefits of CIOF

CIOF is a platform on which users can create a system for purchase ordering, inventory/production/delivery control, trouble detection, efficiency improvement, quality control, digitalization of craftsman's' skills or whatever else. In the next section we will introduce some implementation examples for stamping industry.

6.3.5.4 Solution or Innovation Detail

So far IVI has three examples of implementation in stamping factories. (Misuzu, KS-tech, Nichidai)

Generalized outline of the full solution applied to three use cases of stamping industry is as follows:

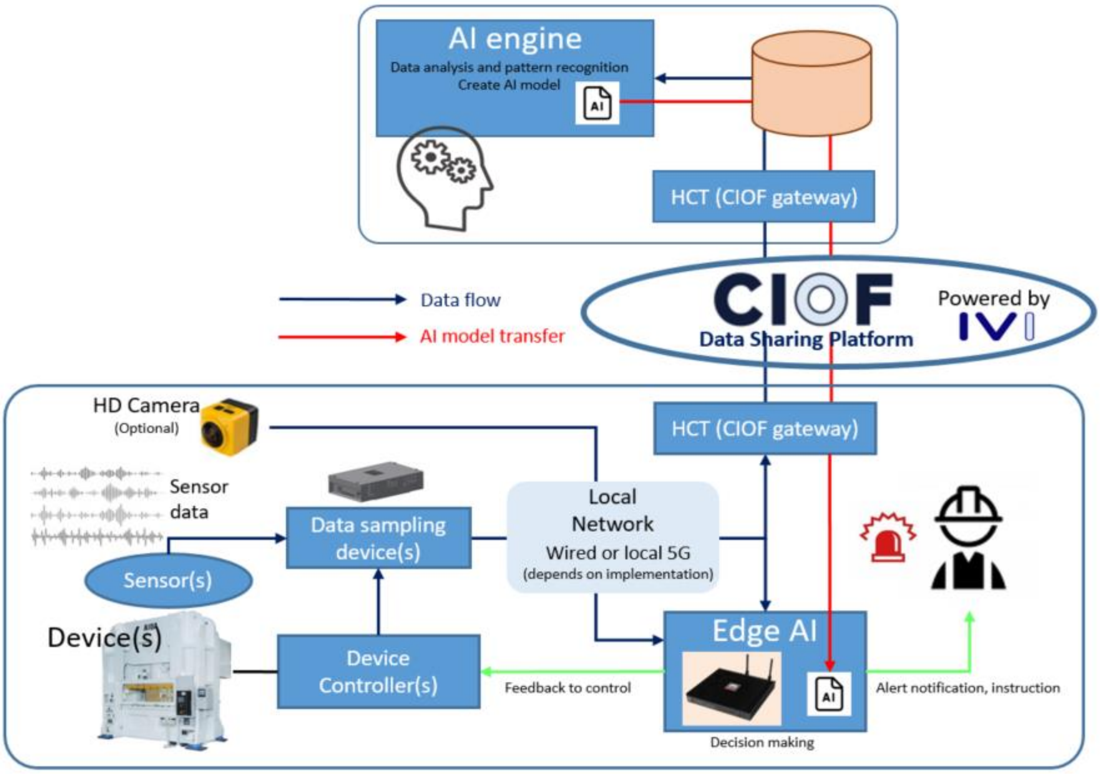

Figure 35: Generalized outline of CIOF applied to three use cases

On these systems, two ways of data distribution were verified:

1. Sensor data transferred from Factory to AI vendor through CIOF platform. AI vendor analyses the sensor data and creates the AI model.
2. AI model transferred from AI vendor to Factory through CIOF platform. Factory implement AI model and use it for trouble detection and predictive operation.

Optional camera usage was also verified in some cases using edge AI:

1. Product inspection (Misuzu).
2. Surveillance of human entrance to dangerous or restricted area (KS-tech) .

6.3.5.5 Ecosystem

The goal of above solution in Section 1.4 is to grow the following ecosystem. Main players are of course a manufacturer and an AI vendor, but the commitments of others are needed to make this solution functional.

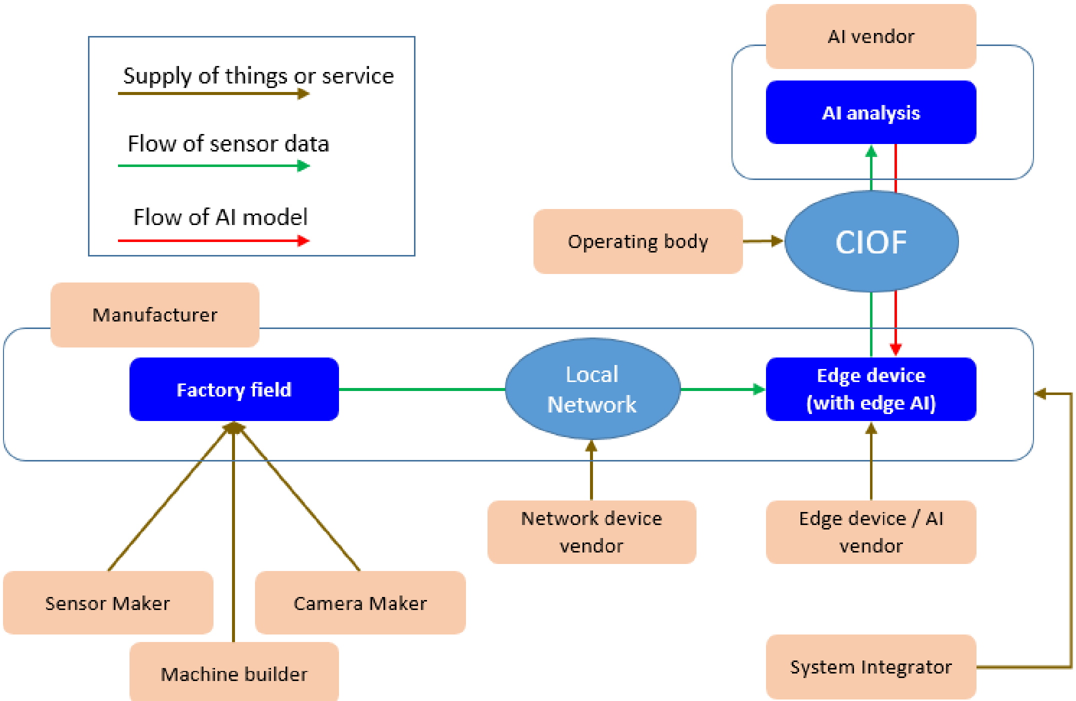

Figure 36: Ecosystem of all players

In these use cases main players are the companies from stamping industries and total 52 companies and 5 consortiums joined to jointly carry out this project.

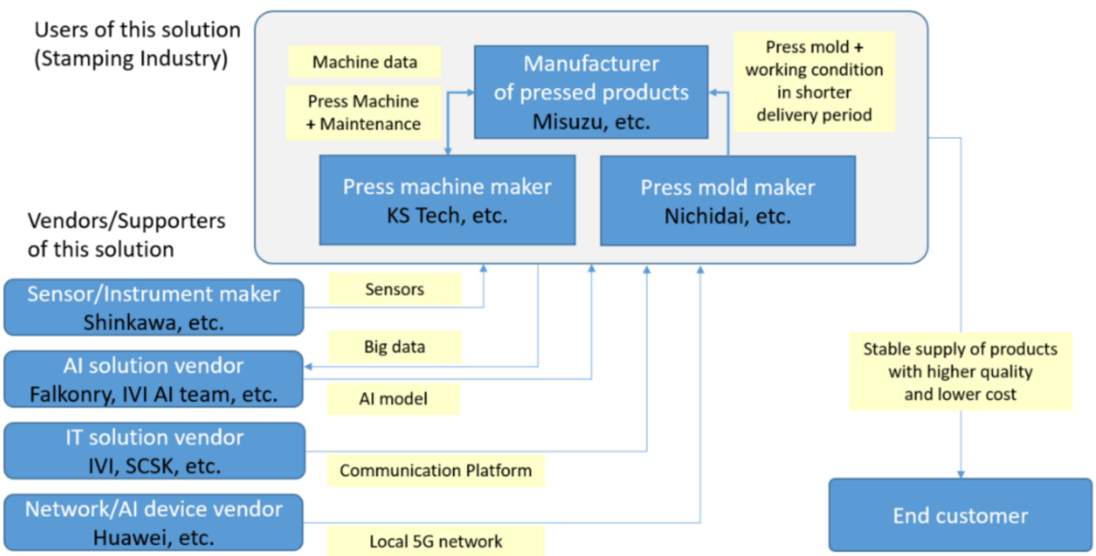

Figure 37: Project jointly carried out

Most important points of this ecosystem are:

- Manufacturers can provide data from their daily activities and make money by providing their data.
- AI vendors can analyze big data from manufacturers and create and provide AI models to make money.
- Manufacturers can use AI models to improve efficiency and quality, that eventually save money.
- The other participants can sell their own products to help this cycle works.
- End customers get product with higher quality and lower cost.
- All of which means a win-win relationship between all participants is expected.

6.3.5.6 Business Model

As already mentioned above, CIOF is designed to facilitate creation of new value chain and innovative business model. A number of different business models with various applications are possible. One example of planned model is a joint order acceptance system for a cooperative of SMEs to secure big orders from e.g. global enterprises.

Sometimes SMEs have high skills of design or are good at manufacturing in specific areas which global enterprise wants to use. However, the order from the global enterprise is usually too big for SMEs to handle considering their resources. So IVI is proposing a business model illustrated below to stamping industry. In this scenario Misuzu or other highly skilled company becomes a hub which accepts a big order, shares the burden of the big order with cooperative member companies and secures the order, sharing design drawing, manufacturing know-how, progress status, quality data, etc. through CIOF.

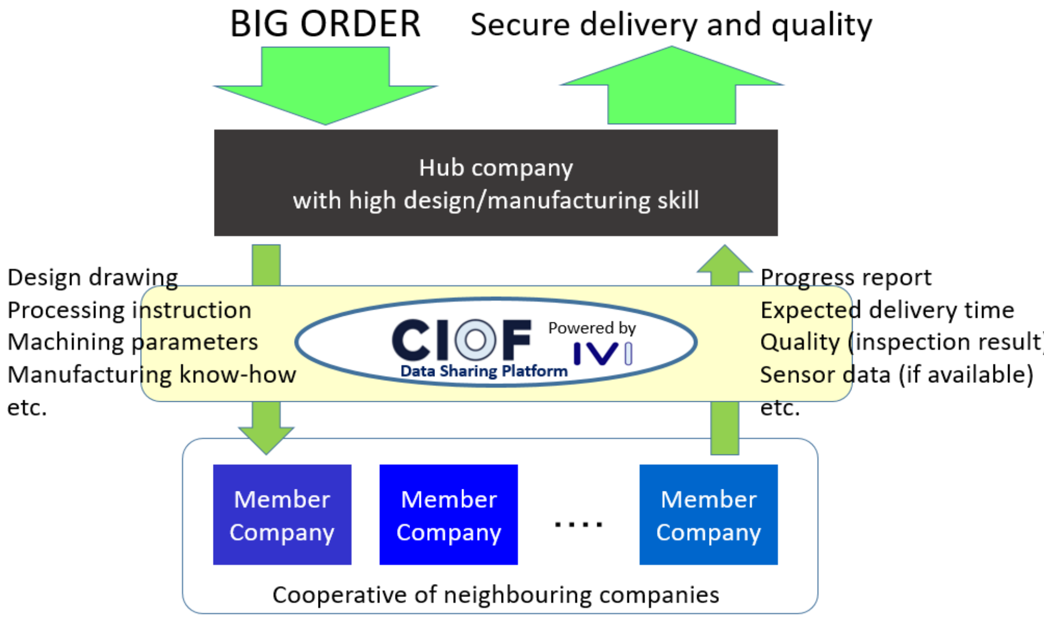

Figure 38: CIOF implemented via company as a hub

6.3.5.7 Further Information and References

CIOF as a Basic OS for Data Distribution Among Companies

https://iv-i.org/wp-content/uploads/2021/02/CIOF-Practical-Seminar-2020-Part1_EN_20201001.pdf

CIOF Architecture Overview and System Implementation Procedure

https://iv-i.org/wp-content/uploads/2021/02/CIOF-Practical-Seminar-2020-Part2_EN_20201001.pdf

7 Digital Transformation and Ecosystems in Healthcare

7.1 Introduction

Recent decades have been characterized by large transformations in healthcare affecting several dimensions, where advances in technology[13] have been a strong enabling factor, but not necessarily the only or the main driver.

During these years a progressive shift of focus from organizations, process-based approach, to individuals, personalized or P5[14] , data-driven, medicine occurred. A progressive enlargement of the jurisdictional scope also happened: the initial focus on departments (e.g., imaging department) and units, was expanded to acute care settings (e.g., hospitals); and then multi-organizations; integrated communities-hospitals; up to regions, countries and nowadays to cross-borders (e.g., MyHealth@EU[15] or global (e.g., GDHP[16]) contexts. In parallel to this, and reflecting the increasing role of patients, a transition from the canonical health provider to individual settings[17] has also been experienced.

Expectations on data usage and reusage are also changing. If in the past, the sharing of data realizing a part of a care process (e.g., order management) was already considered a good result; nowadays, even comprehensive support to primary care may not be deemed sufficient, looking for unlocking data for health research, innovation, policy-making, regulatory purposes, monitoring, support to learning systems, etc. In this context, the secondary use of data should not be any more seen as a separated, independent process; but as a by-product of the primary care provision, therefore a process totally connected and integrated.

All this leads also to a revolution of who “health actors” are. If initially Healthcare Providers and Professionals were the main, and probably the only actors, with patients acting as subject; gradually, patient’s role increased due to a greater attention to patient engagement and empowerment. Researchers, industries, policymakers, health authorities, as well as many other health-data consumers and sources, have to be considered today to all intents and purposes health actors.

*13. E.g. From web technologies, to mobiles and then wearables, AR/VR, IoT, Sensors, DTx, AI/ML, 3D-printing, Drones, Robotics, Learning Systems, etc.

*14. Predictive, personalized, preventive, participatory, and psychocognitive.

*15. https://health.ec.europa.eu/ehealth-digital-health-and-care/electronic-cross-border-health-services_en

*16. The Global Digital Health Partnership (gdhp.health)

*17. For example the body area (e.g. wearables/body sensors), home, vehicles, etc.

Moreover, like no other area, healthcare is becoming more and more multi-disciplinary and multi-source by nature. The cooperative usage of multi sourced data is no more an exceptional practice. This means, for example, a combined use of typical health provider-generated data (e.g., conditions, medications, allergies), together with patient-generated information, including Patient Report Outcome (PRO) captured through personal mobiles; wellbeing or lifestyle data from personal devices and/or environmental measures (e.g., room temperature and humidity, air quality) and several other-sourced information.

This new way to see health - taken in consideration by the new regulation proposal for the European Health Data Space[18] - also brings questions about the actual boundaries between regulated and non-regulated health products to be further explored.

7.2 Understanding Transformation Priorities in Healthcare Industry

7.2.1 Multi-dimensional approach

From the few and brief considerations reported in the previous section it is evident how Healthcare is by nature complex, multidisciplinary, characterized by potentially distributed care settings and realized by multiple stakeholder communities from different policy domains. Typically, a **system of ecosystems.**

In consideration of this, for a more comprehensive approach, multiple factors, from different viewpoints, at different levels of granularity should have to be taken in account[19], but for the purposes this section the simplified model of the Refined eHealth European Interoperability Framework[20] is here reported.

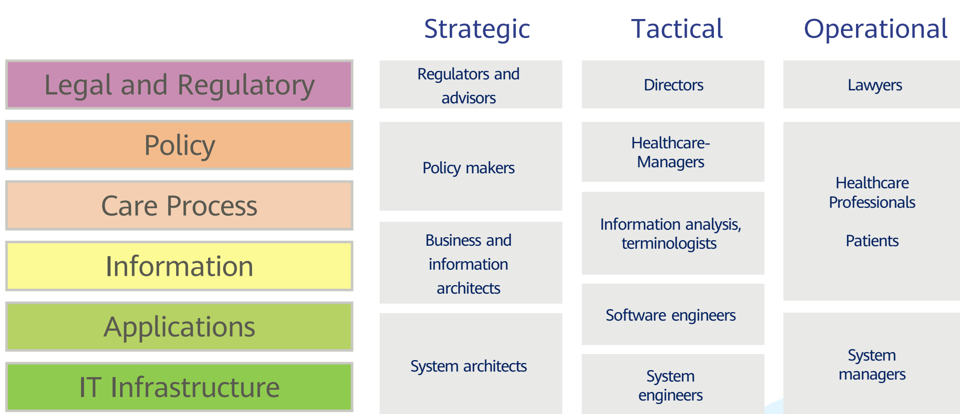

Figure 39: Refined eHealth European Interoperability Framework

*18. https://health.ec.europa.eu/ehealth-digital-health-and-care/european-health-data-space_en

*19. See e.g. the multidimensional cube of the "generic component model" as specified in ISO 23903 Interoperability and integration reference architecture-Model and framework

*20. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5b56dffdc&appId=PPGMS

This model – developed mainly for decision makers in support of European eHealth services - highlights some of the interrelated aspects that should be addressed to enable interoperability and explains how this requires "cooperation and effort on different organisational levels and requires different levels of expertise". It is recognized that to scale up to regional or global solutions, and therefore to realize regional/global marketplaces, **compatible legislation and regulatory guidelines** are needed. Within a compatible legal and regulatory framework organizations have to formalize **trust** and **responsibilities** between the organisations on the Policy level; then make care / business **processes** comparable and compatible; agree on **common** functional information **models and** semantic; and on the physical representation of shared data. Finally, settle **IT infrastructural solutions** that can support the sharing of data, fulfilling the privacy and security requirements. This framework might be further sliced, over different architectural layers, as the application or the security layer; or by abstracting the information models in the conceptual, logical and implementable layers.

7.2.1.1 Multi-stakeholders' engagement

Sharing health data at intra- and cross-borders[21] levels, requires a serious **commitment from all actors** (e.g., Governments, National Authorities, Healthcare Providers (HCP), Information Solution Providers (ISP), Industry, professionals, patients and managers) to collaborate around common ways to exchange health data. An **ecosystem of users, developers and adopters is then needed to foster Digital Health innovation**.

Therefore, if Government(s) engagement is required for coordinating the ecosystem and assuring common legal and regulatory frameworks, **both supply and demand sides** of healthcare provision have to be engaged, assuring **Industry involvement and co-creation spaces**.

7.2.1.2 Trust

Trust is a key factor for enabling data usage and reusage. This concept however underpins several correlated aspects as **security**, **data quality**, **provenance** information, data, product, and processes **labeling** and certifications, **compliance with regulations, ethical and social implications** and many others aspects requiring, each of them, to be addressed at different levels (e.g. legal; policy, IT infrastructure; content,) engaging different competences.

Concerning ethical and social implications, there is a recognized need to pursue evaluating their implications on patient data, AI and its growing use in the field of healthcare. Accordingly. the European eHealth Network under the French Presidency agreed on a set of Ethical principles for digital health as a tool for improving mutual understanding to facilitate discussions on the future European regulation on the European Health Data Space[22].

*21. In this case "border" can refer not only to countries, but also to organizations, or even usage context.

*22. https://presidence-francaise.consilium.europa.eu/en/news/the-european-union-sets-out-a-framework-of-trust-as-a-basis-for-digital-health/

7.2.1.3 Privacy and Security

Health data are by nature personal and sensitive data. Assuring the compliance with privacy and security regulations (e.g., GDPR[23] for Europe) is a minimal pre-requisite for any solution dealing with the health space both for primary and secondary usage.

Sometimes, however, the way these rules are interpreted and applied locally prevents an effective provision of digital health. Agreements among the involved stakeholders to assure both the inalienable individual rights and the effectiveness of the services is a key factor for the realization of Ecosystems in Healthcare.

7.2.1.4 Legal and regulatory framework

The lack of compatible legislation and regulatory guidelines, and/or common interpretations and applications of these rules, can be inhibiting factors for Ecosystems in Healthcare towards regional or global digital health markets.

Cooperation activities to reduce these gaps are envisioned; as well as deeper investigations about the regulatory implications of more comprehensive, multi-disciplinary, multisource digital health ecosystems combining health and non-health data; medical (regulated) and non-medical devices (e.g., wearables, home sensors,..) and so on...

The harmonization of legislation and regulatory guidelines is a recognized need across jurisdictions, but it may apply also within a single jurisdiction as the case of the European AI Act proposal[24] and the current Medical Device Regulation[25] has shown.

7.2.1.5 Semantic interoperability

Another critical factor to enable the usage and the reusage of health data is the semantic interoperability. This implies the capability of agreeing on the meaning of the used concepts, the sharing of common functional and implementable models, the selection of common terminologies to identify or classify these concepts; the definition of concepts maps supporting the harmonization of data coming from different domains or designed for different scopes; the availability of terminology services to support them; and so on..

Most of these aspects are related to the availability of an Ecosystem of Health standards that will be analyzed below.

*23. General Data Protection Regulation
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R0679&qid=1662541467071

*24. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0206

*25. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R0746&qid=1662545727674

7.2.2 The goal: multi-disciplinary and distributed ecosystem

As mentioned in the introduction, a more holistic and systemic approach to the “health” should be taken in account: that is “health” not limited to the individual disease diagnosis anxd treatment, but considering also prevention (individual and social), wellbeing, public and industrial research, innovation, social determinants, and many other aspects, including environment, food and animal ‘health’. This holistic view has been initially captured by the One Health concept, adopted by World Health Organization (WHO)[26] ; and further developed by the One Digital Health conceptual framework summarized in below.[27]

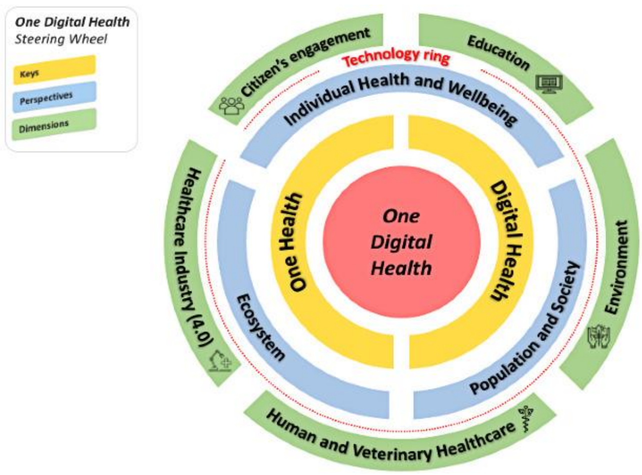

Figure 40: The One Digital Health Steering Wheel conceptual framework.[28]

Without entering the details, it is easy to recognize how this framework necessitates a multi-disciplinary and distributed ecosystem, or in other words a system of ecosystems, able to share, manage, select, analyze and correlate data made available by different kind of organizations, entities and systems. This requires:

1. enhanced automation and connectivity of systems
2. increased technology adoption and performance
3. traceability, flexibility, adaptability, and efficiency
4. improved technology safety, quality, effectiveness;
5. capillary collection of data (e.g., wearable devices, environmental sensors, telemonitoring systems)
6. standardization and interoperability

Concepts now new for the Industry 4.0 to be adopted and adapted for the Healthcare Industry 4.0.

*26. Gostin LO, Friedman EA. The sustainable development goals: One-Health in the world's development agenda. JAMA 2015 Dec;314(24):2621-2622. https://dx.doi.org/10.1001/jama.2015.16281

*27. Benis A, Tamburis O, Chronaki C, Moen A One Digital Health: A Unified Framework for Future Health Ecosystems J Med Internet Res 2021;23(2):e22189 URL: https://www.jmir.org/2021/2/e22189 DOI: 10.2196/22189 (CC BY 4.0)

*28. ©Arriel Benis, Oscar Tamburis, Catherine Chronaki, Anne Moen. Originally published in the Journal of Medical Internet Research (http://www.jmir.org), 05.02.2021.

7.2.3 Ecosystem of Health standards

Sharing, managing, selecting, analyzing and correlating data made available by different kind of organizations, entities and systems **requires the agreement on a set of coherent and cooperating standards** serving the different needs and actors contributing this multi-disciplinary and distributed ecosystem, where HL7 FHIR[29] (Fast Healthcare Interoperability Resource) may play a central role as endorsed by several subject matter experts and big tech companies and shown by several worldwide project and initiatives (see e.g. [30,31,32]).

This ecosystem may for example include reference terminologies, used to identify concepts, correlated with coherent classification systems used for research or monitoring purposes; transmission standards optimized for each context of use; data exchange standards easily mappable to common models adopted in the health data space; and so on. The following figure provides an example of distinct real time monitoring systems using ISO/IEEE 11073[33] standard over the Bluetooth Health Device Profile[34] to capture real-time data from body sensors; and SAREF[35] (Smart Applications REFerence Ontology) over Web of Things[36] for smart applications; that share their relevant data into a common health data space through a HL7 FHIR API. In this case the consistency between the captured Personal Health Data (PHD) and the HL7 FHIR based data space is assured by the PHD FHIR Implementation Guide result of a Joint effort of HL7 Health Care Devices WG, Integrating the Healthcare Enterprise (IHE), and Continua/Personal Connected Health Alliance (PCHAlliance).

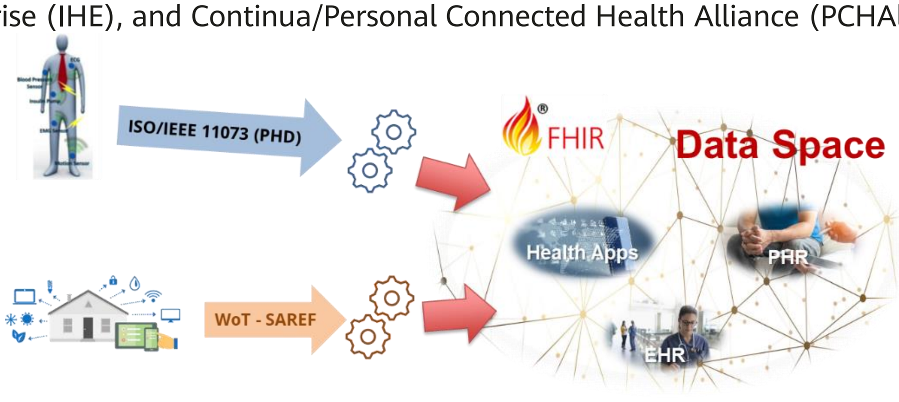

Figure 41: Sharing data through an agreed standards ecosystem

*29. https://www.hl7.org/fhir/

*30. https://www.healthcareitnews.com/news/amazon-google-ibm-microsoft-oracle-salesforce-reup-interoperability-promise

*31. https://gdhp.health/

*32. https://www.who.int/teams/digital-health-and-innovation/smart-guidelines/fhir-based-smart-guidelines

*33. https://www.iso.org/standard/77338.html

*34. https://www.bluetooth.com/bluetooth-resources/health-device-profile-implementation-guidance/

*35. https://saref.etsi.org/

*36. https://www.w3.org/WoT/

7.2.4 Manage the transition

If digital transformation trends in healthcare are almost clear, there are still several gaps to be filled to get that target, including but not limited to:

- lack of legislations, guidelines and their application: compatibility across jurisdictions; alignment with technology and architectural state of the art; unlocking the potentiality of data, still protecting personal rights and allowing for fair and ethic access; etc.
- maturity of the systems in use: too many data silos; project based on old-fashion conception and technologies;
- actors' awareness: empower citizen, to enable a true control on their data; prepare decision makers for digital transformation; etc.

Overcoming these gaps requires the cooperation and the commitment from all the actors involved including, but not limited to, governments or care providers. Industry may play a relevant role in driving open innovation in the Ecosystems in Healthcare.

7.3 Healthcare Case Studies

This section describes some real-world case studies, mainly contributed by GIO member companies, as a way to illustrate the breadth of digital transformation activity already taking place within the healthcare ecosystem.

7.3.1 Case Study: Smart Inhaler

This use case relates to the application of Smart Inhalers for the treatment of asthma as a common chronic disease.

7.3.1.1 Submitted by

Huawei SPO Lab / June 2022

7.3.1.2 Context

Asthma is a major non-communicable disease (NCD), affecting both children and adults, affecting an estimated 262 million globally people in 2019 and causing 461,000 deaths. Asthma is the most common chronic disease among children.

According to the World Health Organization (WHO): "Asthma is a long-term condition affecting children and adults. The air passages in the lungs become narrow due to inflammation and tightening of the muscles around the small airways. This causes asthma symptoms: cough, wheeze, shortness of breath and chest tightness. These symptoms are intermittent and are often worse at night or during exercise. Other common "triggers" can make asthma symptoms worse. Triggers vary from person to person, but can include viral infections (colds), dust, smoke, fumes, changes in the weather, grass and tree pollen, animal fur and feathers, strong soaps, and perfume."

Asthma cannot be cured, but good management is essential. Inhaled medications can control the disease and enable people with asthma to enjoy a normal and active life.

But there are challenges with the traditional model, including the scale of incorrect inhaler use. This has been well documented; with less than one-half of the patients used their inhaler correctly.

7.3.1.3 Benefits

Smart inhalers have the potential to improve adherence, providing more information on their patterns of usage. Smart Inhalers and their supporting platforms can help digitize a parts of the asthma management value chain, to open up significant value to the stakeholders within this ecosystem.

Some of these smart inhaler benefits include:

- Improved patient outcomes
- Provide accurate and detailed insight of inhaler usage for practitioners
- Adherence to prescribed medicine
- Reductions in doctor visits / emergency admissions
- Capture additional data items to predicts asthma attacks
- Management of long-term conditions at scale
- Data at scale in line with regulations can drive further breakthroughs

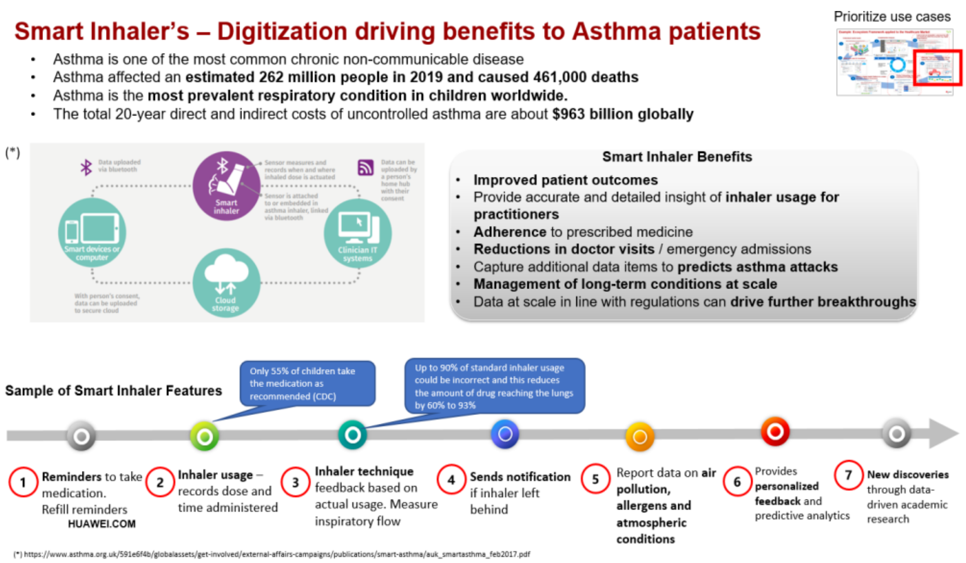

Figure 42: Benefits of digitization for a Smart Inhaler

7.3.1.4 Solution or Innovation Detail

A smart inhaler is an inhaler that integrates connectivity with a mobile app. These devices have sensor technology (inbuilt in some cases or sensors can be connected externally in others) that helps record data about the time and date of use, and the location of the patient.

This then opens up capabilities such as reminders to take your medication, reminders to bring the inhaler with you when leaving home, refill reminders and proactive recommendations on when you should take the inhaler based on your personal data. With the patient's permission the data can be shared with health practitioners, so enabling healthcare providers to react when needed based on data from the device. Also combining the data with third party data such as weather, pollution levels, allergens etc. enables highly personalized recommendations to the specific patients.

The Telecoms industry can leverage their technology capabilities (e.g. connectivity, edge, Cloud…) to enable a Digital Health Platform combining their capabilities with a rich partner ecosystem. Increasing number of connected devices enabling remote monitoring and service delivery assisting global initiatives to deliver health care outside the hospital.

An example of the technology stack, where a number of services could be deployed is shown in the figure below.

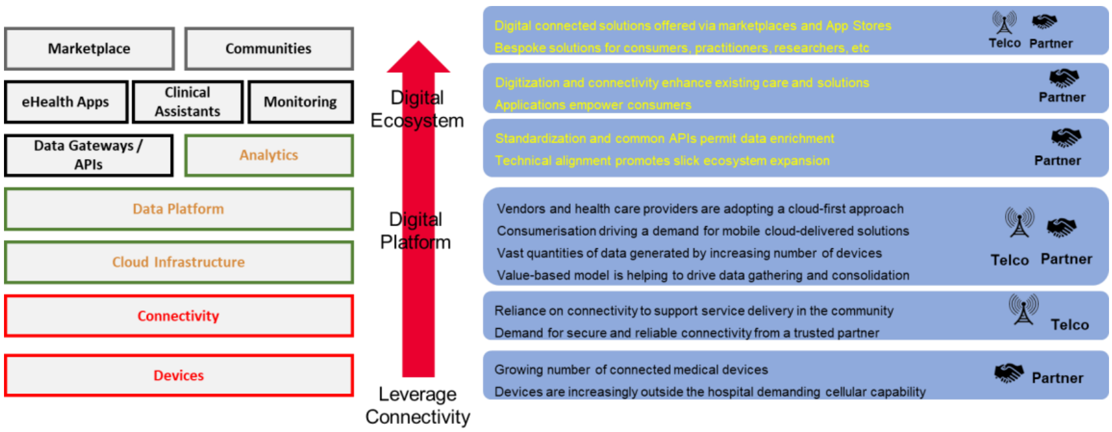

Figure 43: Where can the Telco Play in a Digital Health Platform

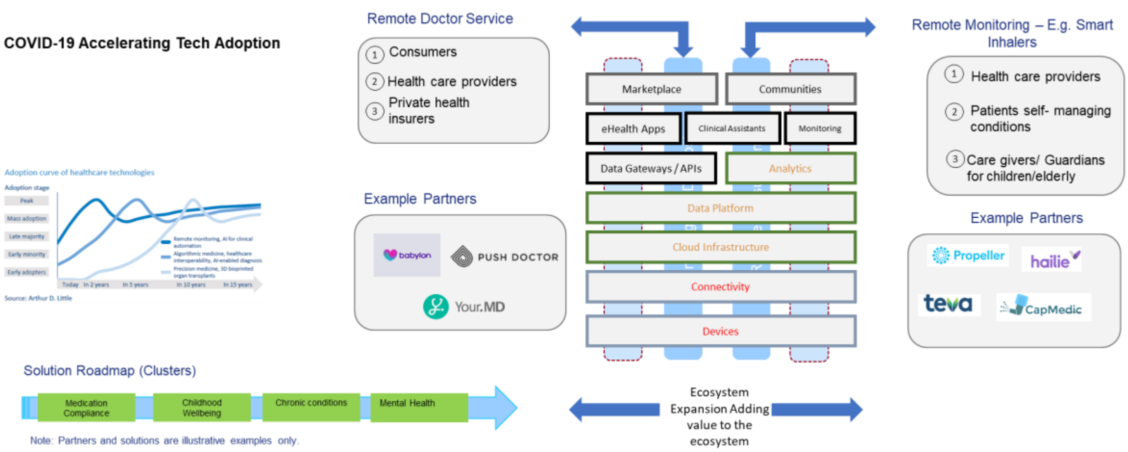

Figure 44: Development of a Digital Health Platform Ecosystem

7.3.1.5 Ecosystem

Healthcare ecosystems will vary in different geographies, for example there are different regulatory and funding models in different countries. The value network below shows one example, where the delivery of the smart inhaler solution is fulfilled via a pharmacy network.

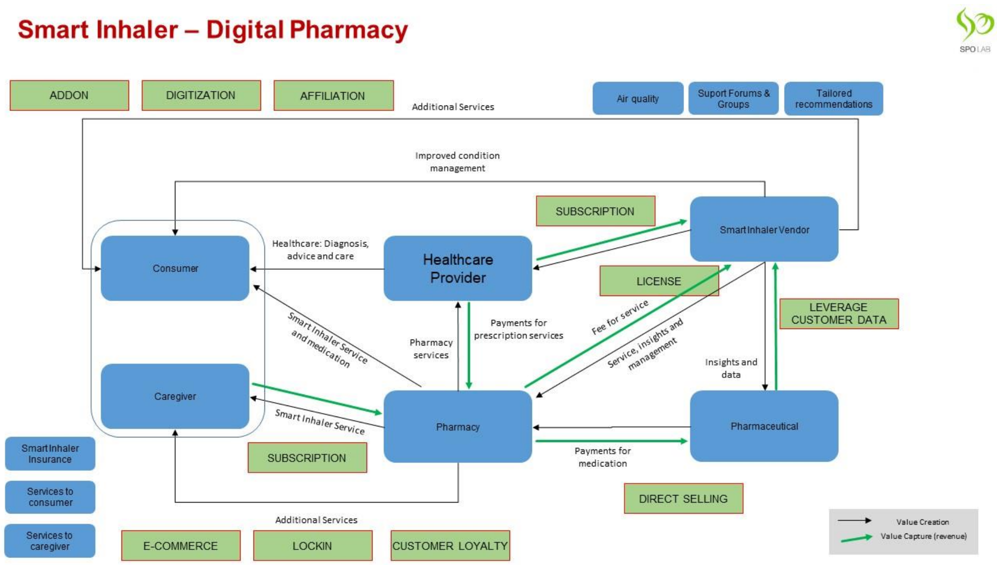

Figure 45: Smart Inhaler – Value flow and value capture

7.3.1.6 Business Model

A number of different business models are possible for this kind of service, which involve the ecosystem participants playing different roles. In order to understand how an industry ecosystem can be facilitated it is necessary to think through the different roles that each stakeholder can play within the ecosystem.

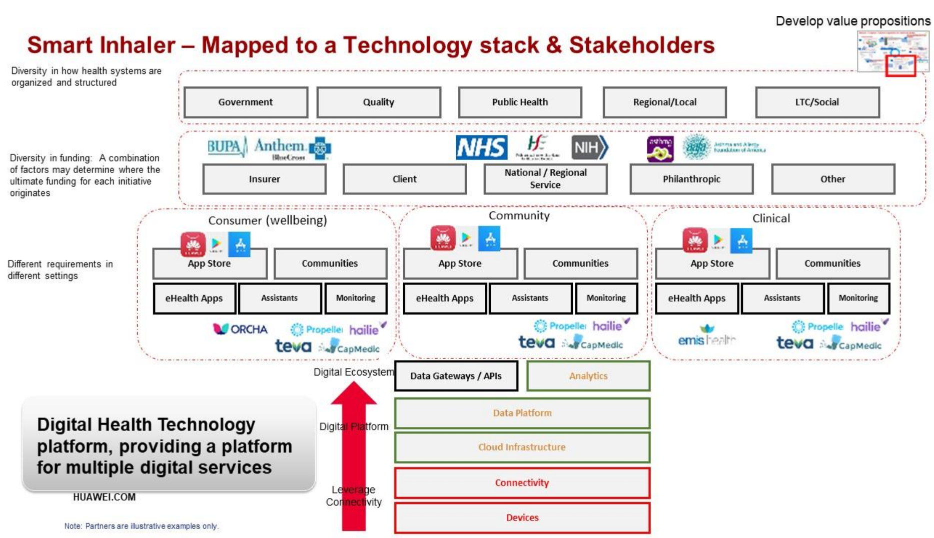

Figure 46: Digital Health Technology platform, providing a platform for multiple digital services

These business models differ primarily in terms of which stakeholder takes the lead role in bringing the overall service to market.

- **Option 1:** Telco resells Smart Inhaler product from third party direct to customer (where permitted) – many markets will allow fulfillment of these services through designated Health Providers.
- **Option 2:** Telco works with the Health Provider as a partner for Smart Connected Health products (e.g. asthma, diabetes) in a specific market.
- **Option 3:** Telco offers Smart Inhaler via its Digital Health platform as a part of a wider Health Ecosystem, including integration to national health providers, insurers, device manufacturers, solution providers.

7.3.2 Case Study: Intelligent Cognitive Behavioral Therapy for Insomnia

This project aims to develop an intelligent cognitive behavioral therapy for insomnia (CBT-i) on mobile devices for insomnia disorder patients. This project aims to develop a solution that, combined with smart wearables, provides dynamic quantitative monitoring and personalized intervention of sleep, cognitive functions, and behavior.

7.3.2.1 Submitted by

Digital Health Team, Institute of Science and Technology for Brain-Inspired Intelligence, Fudan University on September 2, 2022

7.3.2.2 Context

According to a report published by the China Sleep Research Society in 2022, more than 300 million people in Chinese have insomnia. This disorder has become an important physical and mental health issue affecting large numbers of people across many age groups. 80% of brain diseases, such as Parkinson's disease, dementia, and depression, are associated with sleep quality, duration, and changes in sleep duration and circadian rhythms. Cardiovascular and cerebrovascular health and immunity are also associated with the aforementioned factors.

CBT-i is an intervention method for insomnia recommended by international experts (Espie et al., 2019). CBT-i includes cognitive interventions, behavioral interventions, sleep hygiene education, and relaxation training. It can generate lasting impacts but is slow to take effect. Patients find it difficult to adhere to it, and the therapy compliance is low. Currently, CBT-i is usually carried out through outpatient interviews and inpatient treatment, which have time and space constraints that hinder treatment for large numbers of patients.

In recent years, as Internet technologies develop, digital CBT-i on intelligent mobile devices has garnered more attention. This type of digital therapy is built on traditional CBT-i. Video courses, online consultations, and electronic sleep logs are used to provide digital CBT-i. This assists doctors by making remote intervention and remote patient management possible. However, digital CBT-i, which lasts 6–8 weeks, has a fairly high dropout rate (about 36% in 4 weeks and more than 50% in 8 weeks), because the therapy is long, takes effect slowly, and there is no offline intervention. In addition, digital CBT-i intelligently adjusts the traditional 6–8 week therapies according to the doctor's prescription, but it cannot trace dynamic cognitive behavioral data such as that related to an individual's circadian rhythm, nor can it be effectively combined with quantitative assessment methods of cognitive functions, psychology, and behavior. Therefore, digital CBT-i cannot be provided to large-scale populations in a personalized manner. The key to overcoming the constraints of remote treatment of insomnia is to develop intelligent CBT-i based on individual digital profiles and personalized insomnia interventions suitable for large-scale populations.

7.3.2.3 Benefits

According to an epidemiological survey by the Ministry of Health in 2018, 38% of China's population suffers from sleep disorders, higher than the world average of 27%. More than 500 million people in China have sleep problems such as difficulty falling asleep, poor sleep quality, and sleep rhythm disorders. Sleep disorders have a serious impact on public health and quality of life, and threaten workplace safety.

Sleep disorders affect 45.5% of people over 60 and 56.7% of people over 80. In recent years, sleep problems have also become increasingly prevalent in younger populations. Young people's sleep disorders result from mood fluctuations such as anxiety and irritability caused by stress from work and life. According to the 2020 China Sleep Index Report and the 2021 Exercise and Sleep White Paper released recently by the China Sleep Research Association, 69.3% of young people have sleep problems such as difficulty falling asleep and sleep procrastination. The number of people with insomnia increases year by year. This figure increased from 24.9% in 2018 to 36.1% in 2019. Less than 25.8% of people born in the 1970s and 1980s have deep sleep.

According to the China Sleep-health Market Analysis and Investment Prospect Research Report 2018–2023, the sleep-health industry in China was valued at about CNY279.7 billion in 2017, of which sleep supplements was valued at CNY12.8 billion, sleep medications CNY13.4 billion, sleep devices and supplies CNY250 billion, and sleep services CNY3.5 billion. At present, beddings, supplements, and intelligent wristbands account for the majority of China's sleep aids market. Sleep and circadian rhythms are directly controlled by the brain, and there is a huge gap in the market regarding solutions leveraging the brain's neural regulation of sleep. This project aims to develop a method that integrates cognitive, behavioral, and emotional regulation based on monitoring data collected from intelligent wristbands on sleep states, behavior, cognitive changes, and physiological indicators in real-time, in order to create a personalized intelligent therapy which is quantitative, long-term stable, and suitable for large numbers of people.

7.3.2.4 Solution & Innovation Details

This project aims to develop the intelligent CBT-i. The R&D is built on a comprehensive method for evaluating circadian rhythm based on customized and dynamic monitoring by intelligent wristbands on behavior, cognition, and emotions. Using the multi-dimensional data, we aim to develop sleep profiles and personalized digital intervention solutions, realizing intelligent, quantitative, and stable sleep management and interventions.

(1) On top of traditional cognitive-behavioural therapies, we strive to develop a hierarchical intervention theory covering cognition, behaviour, and emotions for circadian rhythm regulation, and accumulate sleep-related quantitative data of physiological signals, motion signals, cognition, and behaviour to lay a theoretical and data foundation for the development of personalized intelligent intervention solutions.

(2) Based on the behavioral and physiological data during long sleep monitored by wearables, and the clinical cognitive evaluation data, we are developing artificial intelligence algorithms to create digital profiles for individuals that can describe the interactions between sleep abnormalities and cognitive, behavioral, and emotional functions. Based on these profiles, we are developing intelligent intervention solutions.

With the previous research efforts, the project team had completed the R&D of the following aspects.

a) The theory and solution covering cognitive, behavioral, and emotional intervention;

b) A digital therapy application that can be used together with intelligent wearables;

c) A randomized controlled trial, which collected more than 350 subjects' sleep-related cognitive, behavioral, and emotional data over five weeks.

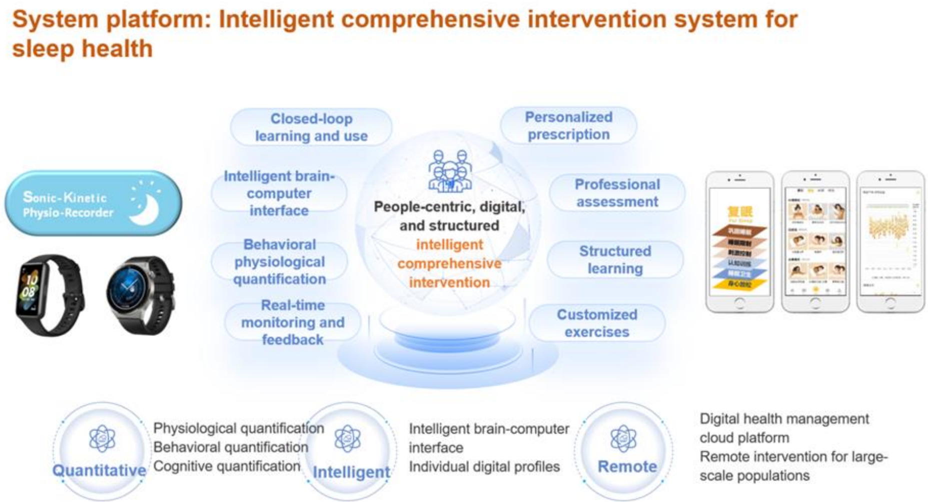

Figure 47: Intelligent comprehensive intervention system

7.3.2.5 Ecosystem

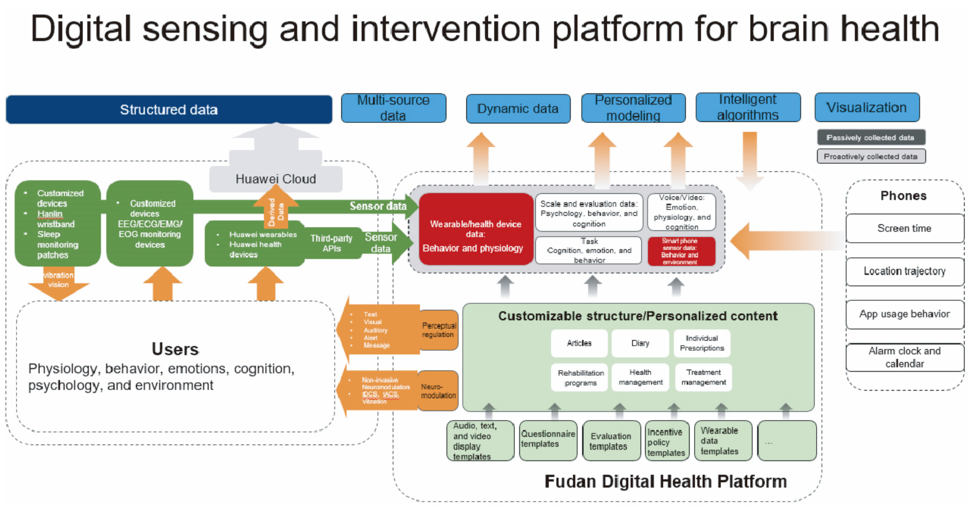

Figure 48: Digital sensing and intervention platform

This project focuses on a digital system for brain health supported by digital intervention, intelligent brain regulation, wearable-based quantitative monitoring, and big data modeling technologies. The project starts with the application of the digital CBT-i, and builds theory- and data-driven digital solutions for brain health to address functional brain disorders such as depression, cognitive impairment, and Parkinson's disease. Following that, we aim to develop solutions for remote intelligent management, diagnosis, and treatment for brain health for large-scale populations.

7.3.3 Case Study: Fully-Automated Peripheral Blood Cell Morphology Analyzer

This digital health industry case study introduces the application of fully-automated peripheral blood cell morphology analyzers in the fast diagnosis of hematological diseases.

7.3.3.1 Submitted by

Tencent Miying, Tencent AI Lab, and Mindray on August 8, 2022

7.3.3.2 Context

During blood cell analyses, such as complete blood count (CBC) tests, automated blood cell analyzers provide count and classification results that show changes in the number of peripheral blood cells, while morphological examinations primarily look at changes in blood-cell quality. During the diagnosis of many diseases, changes in the quality of blood cells are more important than changes in quantity, as blood-cell quality serves as a reference for the diagnosis, classification, and staging of hematopoietic and lymphoid tumors, anemia, infectious diseases, hemorrhagic diseases, and other similar diseases. Blood-cell quality also provides a direct and objective basis for monitoring curative effects and prognoses.

In the case of leukemia, for example, data shows that the incidence rate of the disease in China is about 2.76 per 100,000. Leukemia is the sixth most common tumor in China, and the most common amongst children and adolescents. It is highly malignant and progresses rapidly. If childhood leukemia is detected early and properly treated, more than half of patients can go on to live long lives or be cured completely.

CBC tests are generally used first to screen the disease, in which morphological examinations play a key role in assisting clinical diagnoses. Morphological analyses then show changes in blood-cell quality, and are crucial for the clinical screening of hematological diseases, especially leukemia and other malignant hematological diseases.

Currently, about 20% of the samples collected during CBC tests at hospitals require morphological re-examination. Traditionally, the observation of cell morphology is mostly done manually under a microscope. In China, about 0–15% of all morphological examination is conducted through microscopic examination, which is lower than in countries that are more advanced in this regard. In addition, the number of physicians in China does not match current clinical demand. A tertiary hospital in China, for example, may have only 1 or 2 morphological physicians, meaning there are too few to fulfill the demand for microscopic examination. When it comes to hospitals in prefectures, this shortage is even greater.

Many companies in China and abroad have developed numerous automated morphological analyzers to meet actual demand. Analyzers imported to China are expensive, and, similar to those currently available on the Chinese market, they have low recognition accuracy. This means manual examination is still necessary, and the clinical challenge of a lack of doctors remains unresolved.

7.3.3.3 Benefits

Mindray and Tencent Healthcare jointly developed a fully-automated peripheral blood cell morphology analyzer (AI image reader). The reader can analyze 60 blood smears per hour, making it twice as efficient as similar products currently available. The recognition rate of AI-supported analysis, regarding pre-classification, exceeds 98%, while traditional methods' only achieve 70%–80%. This reduces required manpower and cuts analysis time by 90%, filling the gap found in China.

This analyzer is also contributing to a high-quality cell database that is supporting China's decision making related to relevant disease prevention and treatment.

The fully-automated peripheral blood cell morphology analyzer has passed the special examination and publication for innovative medical devices and entered the innovation pipeline of the National Medical Products Administration (NMPA). It is the first ever AI-supported in vitro diagnostic product to enter the special examination procedure for Class III innovative medical devices.

The fully-automated peripheral blood cell morphology analyzer can:

- Help improve the clinical capabilities of blood cell analyses
- Greatly relieve the workload on clinical microscopy physicians
- Reduce the risk of failing to detect hematological malignancies such as leukemia
- Provide a more stronger basis for the early diagnosis and treatment of hematological diseases
- Help junior physicians improve their professional competences
- Be widely applied in primary hospitals, acting as an intelligent, high-quality blood cell analyzer
- Help China make decisions on hematological disease prevention and treatment

7.3.3.4 Solution & Innovation Details

The fully-automated peripheral blood cell morphology analyzer allows doctors to capture high-definition images, and perform intelligent blood cell analyses, intelligent re-examinations, and intelligent image reading, all while offering intelligent decision-making assistance.

The fully-automated peripheral blood cell morphology analyzer adopts unique, multi-DoF fusion technology that simulates manual adjustments to focus when capturing medical images. This technology can capture 20 images at different depths of field for each cell and then superimpose the sharpest parts of each image to create high-quality planar images of stereoscopic cell morphology.

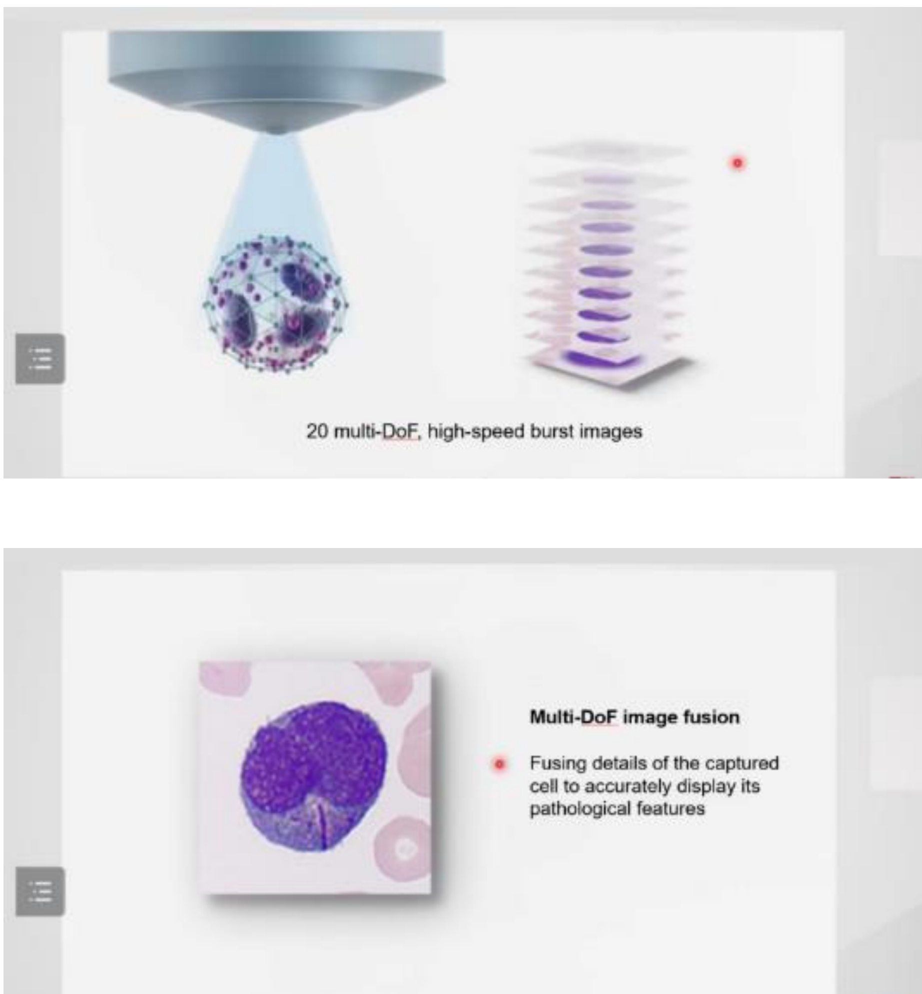

Figure 49: Intelligent blood cell analysis - Multi-DoF image fusion for quick generation of HD images

In terms of image reading and decision-making assistance, Tencent Healthcare's proprietary advanced AI computing solutions can enable efficient training and development when systems are dealing with millions of pieces of data. This enhances the overall performance of cell morphology analyses, meaning no abnormal or malignant cells are missed and highlighting suspected cells.

Photography technology and AI computing solutions are used to: (1) allow new aerospace materials to be applied to the analyzer, guaranteeing the stiffness and toughness required to counter small system jitters when it is moving at high speed; (2) enable stable structures and advanced high-frequency exposure algorithms, addressing weak jitters during horizontal and vertical movements.

These enable the image reader to work at high-speeds without stopping, taking 20 pictures in 0.1 seconds, and examining 60 blood smears per hour. In addition, flexible monolithic injection ensures the quick generation of results in emergency situations.

7.3.3.5 Ecosystem

A three-level labeling system for professional physicians is used to generate a high-quality cell database and develop a data ecosystem. This improves the quality of image reading and accuracy of diagnoses, while enabling the construction of a hematological disease prevention and treatment system in China for more service possibilities.

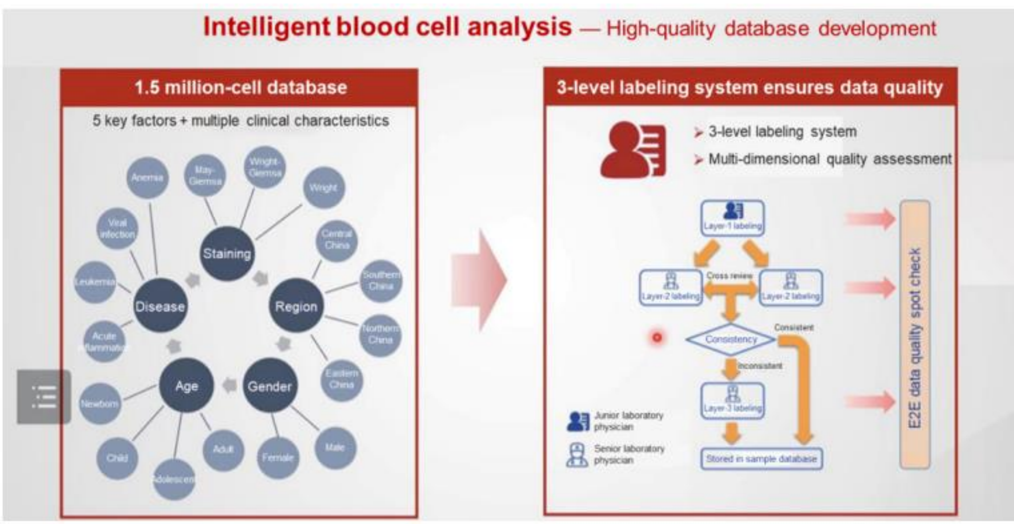

Figure 50: Intelligent blood cell analysis - High-quality database development

Sources

What's the Next Big Deal between Tencent and Mindray?
https://baijiahao.baidu.com/s?id=1690559657145844352&wfr=spider&for=pc

Mindray and Tencent: Delivered the First Innovation Pipeline Product in this Field
https://baijiahao.baidu.com/s?id=1727994655319304629&wfr=spider&for=pc

Mindray and Tencent Explore "Healthcare + AI"
http://www.sznews.com/news/content/mb/2022-05/16/content_25128700.htm

Mindray and Tencent Explore Cutting-edge Healthcare Technology AI Image Reader, Receiving Clinical Recognition
https://baijiahao.baidu.com/s?id=1732968553776356388&wfr=spider&for=pc

Mindray and Tencent Explore the Microcosm on the Image Reader
http://duchuang.sznews.com/content/2022-05/16/content_25128959.html

7.3.4 Case Study: GATEKEEPER project

The GATEKEEPER project goal is to ensure healthier independent lives for the ageing populations by providing a trustable, privacy preserving and secure platform to foster large-scale deployment of interoperable AI solutions for Chronic Disease Management.

7.3.4.1 Context

The goal of the GATEKEEPER project is to offer both, technological and trading platforms for ***early detection and intervention and support the risk stratification models*** aimed at ensuring healthier independent lives for the ageing populations.

In particular, a set of reference scenarios are piloted across Europe to demonstrate the effect, benefit, value and scalability of the proposed solutions:

- Lifestyle-related early detection and interventions
- COPD exacerbations management
- Diabetes: predictive modelling of glycaemic status
- Parkinson's disease treatment Decision Support System
- Predictive readmissions and decompensations in Heart Failure
- Primary and secondary stroke prevention
- Multi-chronic elderly patient management including polimedication

These results are planned to be achieved by enabling the collection of heterogeneous data (diagnostic; medications; lifestyle/wellbeing data; environmental data; questionnaires, etc) from different sources ranging from EHR, medical devices, personal devices (wearables, mobile), home sensors and even robots.

7.3.4.2 Benefits

- Heath Care institutions from Europe to access to digital data-driven services produced by European companies and medical software, medical devices and consumer devices that are being consolidated in the sector market.

- Consumer (citizen) from Europe to access to certified digital services, consumer devices and applications for self-care management, wellbeing and life style, and a secure, private Personal Health Record space.

- Industry, SMEs and technology startups to access to federated data resources and platform tools to design and develop data driven services for health care institutions and consumers.

7.3.4.3 Solution or Innovation Detail

GATEKEEPER is a European Multi Centric Large-Scale Pilot on Smart Living Environments. The main objective is enabling the creation of a platform that connects healthcare providers, businesses, entrepreneurs, and elderly citizens and the communities they live in, to originate an open, trust-based arena for matching ideas, technologies, user needs and processes, aimed at ensuring healthier independent lives for the ageing populations.

This general objective is explored through a set of sub use cases hereafter summarized:

- **Lifestyle-related early detection and interventions**: this case addresses risk stratification and early detection, based on *lifestyles analysis* including pattern recognition for the improvement of public health surveillance and for the early detection of cognitive decline and frailty.

- **COPD exacerbations management**: machine learning methods based on Dynamic Bayesian Networks are used to support apps that *predict exacerbations and avoid hospitalizations*.

- **Diabetes: predictive modelling of glycaemic status:** clinical data at home such as bio- and physiological signals (i.e. blood glucose concentration data or continuous glucose monitoring data, galvanic skin response, heart rate variability), combined with adaptive machine-learning regression models, are used to *prevent hypoglycaemic events*.

- **Parkinson's disease treatment Decision Support System:** motor symptoms information from wearable sensors and non-motor symptoms from digital applications are used to alert clinicians about the need of revising the treatment.

- **Predictive readmissions and decompensations in Heart Failure:** Telemonitoring services and machine learning with Dynamic Bayes Networks, taking comorbidities into account, are used for predicting acute HF decompensations.
- **Primary and secondary stroke prevention:** Image recognition algorithms are used to detect stroke signs from images recorded at home, for example on the basis of pathological facial weakness detection and activate early warning alarms, particularly for subjects affected by recurrent strokes.
- **Multi-chronic elderly patient management including polimedication** Several sensing technologies leveraged and integrated in an unobtrusive mobile data collection platform (e.g. based on smartphones, smart-trackers, smart-textiles, etc.), are used to monitor the multiple parameters required in Chronic Care Models (CCM) for multi-morbid subjects.

Pilots are currently on-going: the level of maturity, as well as the systems used as data source, varies depending on the site and the case piloted. In the following figures, just as example, a high-level schema of the Puglia[37] pilot in Italy, including Medical and non-Medical devices.

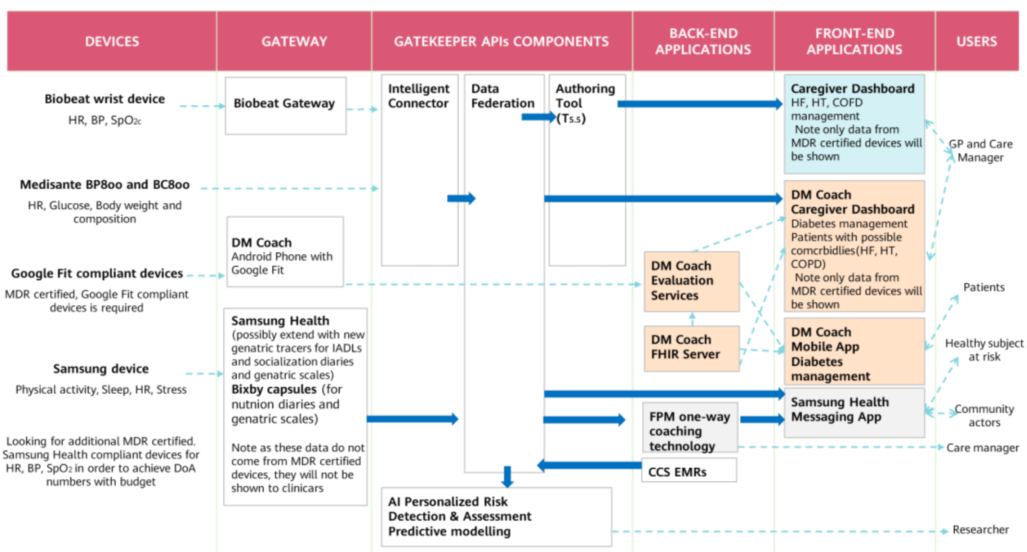

Figure 51: High-level schema of the Puglia pilot

*37. https://www.gatekeeper-project.eu/region/puglia-italy/

The following picture provides a logical view of the GATEKEEPER Platform acquiring data from heterogeneous Data Sources through its Data Connectors. These services allow the platform to receive data decoupling the protocol used for the collection or the details on the interaction from the single vendors and communication standards and allow the rest of the platform to rely on a well-defined REST-HTTP FHIR based communication.

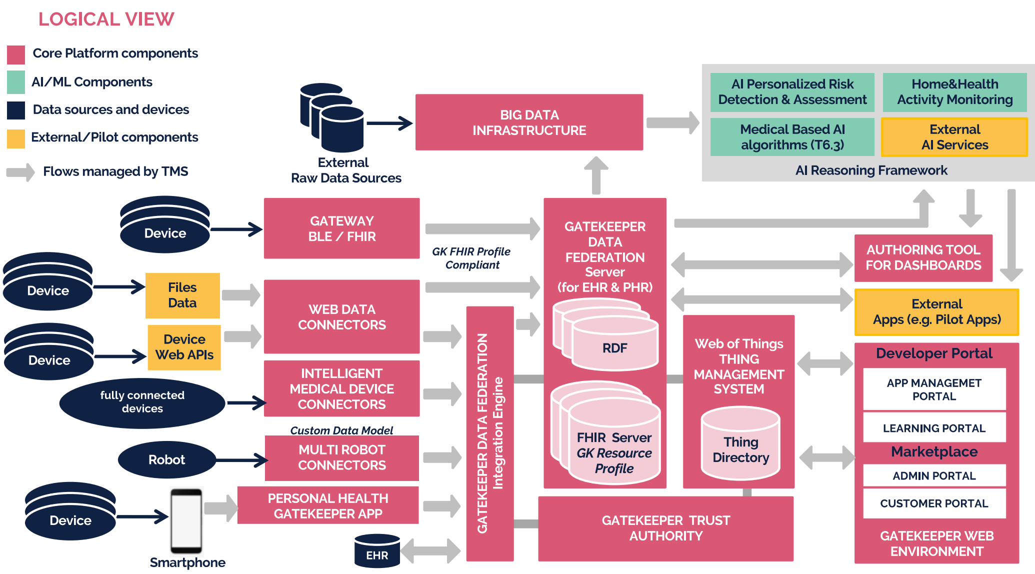

Figure 52: Logical view of the GATEKEEPER Platform

The platform offers a set of connectors used to integrate a large variety of *Devices*:

- *Web Data Connectors, to interact with Device vendors cloud services;*
- *Gateway BLE / FHIR,* that can collect measurements from devices following the BLE Continua standard;
- *Personal Health GATEKEEPER App*, a customization of Samsung Health mobile app, tailored to collect data for the GATEKEEPER Platform;

The Platform supports also the input of data from *Multi Robot Connectors*, a connector that allows collecting data coming from *Robots*.

Data sources able to communicate directly with the platform can do so, provided they are certified in the platform and their requests to the platform secured.

The key of this solution is the **HL7 FHIR-based Federated Data**: all data sources certified with the platform, have to provide data that can be harmonized with a common model formalized by the GATEKEEPER FHIR Profiles. Federated Data are then stored in the *Data Federation FHIR Servers.* The Platform is also able to directly poll data from preconfigured data sources, such as *EHRs,* to retrieve related historical data.

Data integrated in the Data Federation integration engine are also pushed to the *Big Data Infrastructure*, where they can be further processed and merged with further external data sources. This infrastructure provides also services to perform Data Analysis and AI/ML software and libraries that can be exploited from the *AI Reasoning Framework*. The results of the AI Reasoning Framework, together with the data stored in the Data Federation Servers, can be then presented to the end users though their proprietary External Services or using the dashboards built with the *Authoring Tool for Dashboards.*

7.3.4.4 Ecosystem

The stakeholders of the GATEKEEPER ecosystem according to their Space are:

- **Healthcare**: where intuitive and self-configuring dashboards, intelligent services for early risk detection and care plans, and a federated data infrastructure are provided to healthcare professionals and patients. It enables to build Business-to-Business (B2B) solutions and services from companies to healthcare providers.
- **Consumer**: where certified solutions, services and devices are provided to citizens for the management and prevention of health and social risks. It allows to build Business-to-Consumer (B2C) solutions and services to be used by end-users for health or life-style monitoring, as well as integrated with solutions from the Healthcare Space to combine services and provide a holistic health view and monitoring in return.
- **Business**: where certified companies are able to develop solutions, services and devices alone or in partnership, in order to reach end-users (Consumer Space) or health providers (Healthcare Space) following a set of standards in order to reach and boost the Digital Single Market.
- **Ecosystem Transaction**: where a large selection of applications and devices leveraging AI, Big Data, machine learning and IoT technologies; coupled with a variety of smart objects (e.g. wearables, sensors, robots) currently available in the market to support Data Sharing and Value-based healthcare are provided.

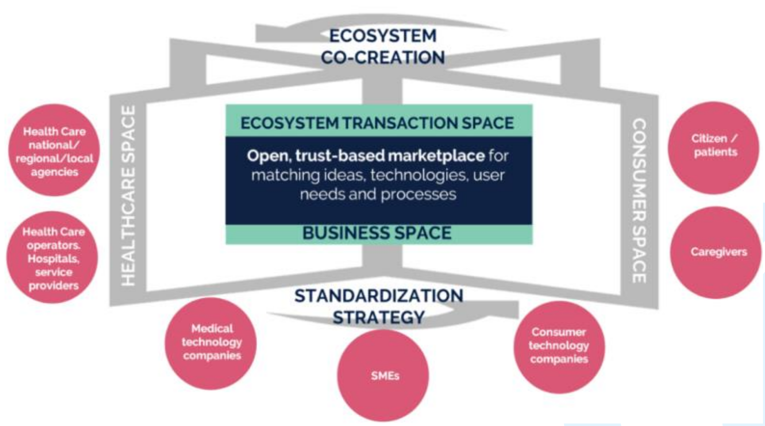

Figure 53: The GATEKEEPER concept

Table1 summarizes for each of actor identified in GATEKEEPER, the Space(s) they belong to and their most indicative user stories per space.

Table 1 - Actors and user types in GATEKEEPER platform

Actors	Space	User story
Patient	Healthcare	A user receiving or registered to receive medical treatment, in this way being the owner of personal health and wellbeing data
	Consumer	A user that is using the Key Enabling Technologies (KETs) suggested/provided by Healthcare professionals
Caregiver	Healthcare	A user providing formal or informal care to one or more patients
	Consumer	A user that is using the KETs suggested/ provided by Healthcare professionals or supports a Patient in using the applications
Healthcare Professional	Healthcare	A user that wants to visualise data collected from integrated KETs and make decisions
	Consumer	A user that wants to use an application/service from the GATEKEEPER Marketplace
Health Service Provider	Healthcare	A user that provides primary healthcare services at local/regional scope, in some cases coordinating healthcare professionals
	Consumer	A user that wants to use an application/service from the GATEKEEPER Marketplace
Technology Developer	Business	A user that develops KETs which exploit the existing GATEKEEPER services.
Company	Business	A user that produces and markets technology health and wellbeing KETs.
Integrator	Business	A user that provides local support and deploys services such as maintenance and system integrations, supporting Consumer Space actors.
Policy Maker	Ecosystem Transaction	A user that wants to interpret case-specific data in order to manage governance policy decision-making and acts and as an administrator of the GK Platform and also as a promoter

LINKS TO WEBSITES AND OTHER SOURCES OF INFORMATION

https://www.gatekeeper-project.eu/

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The GATEKEEPER has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 857223.

7.4 Use case assessment

The SPO Lab has developed a process allowing use case analysts performing a structured and repeatable evaluation and prioritization of a group of use cases. The results of this assessment for a set of exemplary use cases is here reported.

7.4.1 Process overview

This simple process directs the analyst to think about the opportunity in the context of these criteria:

- Health Provider Strategic Business Fit
  - Evaluate on: Benefits, Capabilities and Partners
- Healthcare Market Timing Risk
  - Evaluate on: Environment, Adoption and Alternatives
- Addressable Need and opportunity Attractiveness
  - Evaluate on: Business Models, Scale, Adjacency

For each criteria the analyst can assign the appropriate color coded ranking from the legend below:

No Blockers: Challenges: Unquantified: Blockers:

Justification of a score or ranking is critical. For example, has the analyst found a regulatory issue that severely hampers the viability of the use case when looking at the market or the environment criteria? If so this needs to be detailed as a contributing factor.

This is catered for in the tool by a notes section which allows for short explanations and a brief summary of the reasoning under the criteria. This can be color-coded to give an immediate visual indication of whether it has positively or negatively impacted the ranking.

7.4.2 The Benefits

A major benefit of this evaluation methodology is that it encourages and guides the analyst to research and evaluate the key factors that could contribute to the success of the use-case.

Of all information transmitted to the brain 90% is visual, and the graphical output from a completed use case evaluation is immediately engaging and intuitive, while the logical part of the brain can digest the reasoning contained within the written notes.

From a collaboration point of view the color coding of the logic behind the analysts ranking makes it straightforward for multiple analysts to share ideas and contribute to the analysis either sequentially or in a workshop.

7.4.3 Smart inhaler

This use case relates to the application of Smart Inhalers for the treatment of asthma as a common chronic disease. This is an eHealth application where a physical smart inhaler and environmental data combine to helps patients and their doctors to manage chronic respitory conditions. Smart inhalers have a digital component with woreless connectivity built in, and capable of linking to a smart phone or tablet. They alert patients to missed or duplicate doses, and remind patients to take their doses on time.

Smart Inhaler for Asthma / COPD Care

Health Provider Strategic Business Fit

BENEFITS

Does the use-case deliver significant measurable benefits for the patient, clinician, healthcare provider and/or society?

No Blockers

Proven benefits

Randomised trial results indciate that electronic adherence monitoring with feedback is likely to be of significant benefit in the routine management of poorly controlled asthmatic subjects.

Enables pat. self-management

Patients are empowered to manage their own condition via feedback provided by a mobile app

9 in 10 patients interested

early 9 in 10 people with asthma would be interested in using a smart inhaler if they were available through the NHS. https://www.asthma.org.uk/advice/inhalers-medicines-treatments/inhalers-and-spacers/smart-inhalers/

Summary: Difficult to control asthma reduces fm ~17% to ~3.7% if patients take their medicines. Smart inhalers enable this

CAPABILITIES

Does the healthcare provider have the organisational capacity, capabilities and resources to deliver the full benefits of the usecase?

Challenges

Good fit for health providers

Smart inhalers fit well into existing healthcare provider approaches

Patient data security concern

Patients are concerned about their medical data security for always connected devices reducing adoption. Healthcare provider may have poor track-record in data security

Summary: Patient concern about data security may reduce solution uptake

PARTNERS

Are market leading business partners identified, on-boarded and ready to deliver the solution?

No Blockers

Many good suppliers

There are many good suppliers of smart inhalers, some of whom have been awarded large contracts

Commodity S.I. chipsets & sw

Infineon supply commodity smart inhaler chipsets & toolkits - https://www.infineon.com/cms/en/applications/industrial/medical-healthcare/smart-inhaler/

Summary: Multiple vendors include: Sensirion, RYAH, Teva, Propeller Health, adherium, AstraZeneca

Healthcare Market Timing Risk

ENVIRONMENT

Are government, regulations and societal constraints major hinderances to adoption?

Challenges

Medical device approval reqd.

Medical device (quality system) approval is required for smart inhalers. This is a time-consuming but well known process.

Summary: Medical device approval required for each jurisdiction. This standard process can be time-consuming & costly.

ADOPTION

Is there market traction? Is the solution/solution provider ready for deployment at scale?

No Blockers

Strong market traction

Smart inhalers have been available since 2017. There is now strong market traction

Mkt growth 7%-21%p.a. forecast

DelveInsight forecast 21.3% market growth 2022-27 (https://www.delveinsight.com/report-store/smart-inhalers-market)

Mkt. size USD2.1B in 2028

Market size >USD 1.2 B in 2028 with 7% CAGR 2022 to 2028 - https://www.gminsights.com/industry-analysis/smart-inhalers-market

Summary: Good market traction in multiple markets with multiple suppliers

ALTERNATIVES

Is there a better alternative solution? Could the 'status quo' be maintained?

No Blockers

Non digital works for some

Asthma medication without a smart inhaler works well for organised and disciplined patients

Summary: Smart inhaler should be provided only to patients that need it. Not everyone does

Addressable Need and opportunity Attractiveness

BUS. MODEL

Are both the business and operating models resilient and sustainable for all parties as the solution scales?

No Blockers

Proven business models

Summary: Patient data can be exchanged for free smart inhaler. Long term patient relationship important: repeat sale of consumables

SCALE

What is the realistic potential to scale rapidly (within 3yrs) at a national or international level?

No Blockers

Already available at scale

Summary: USD500M mkt in 2021 in Europe with 30% share. Strong potential to grow

ADJACENCY

Are there significant synergies or challenges with related existing healthcare solutions?

No Blockers

Complements existing treatment

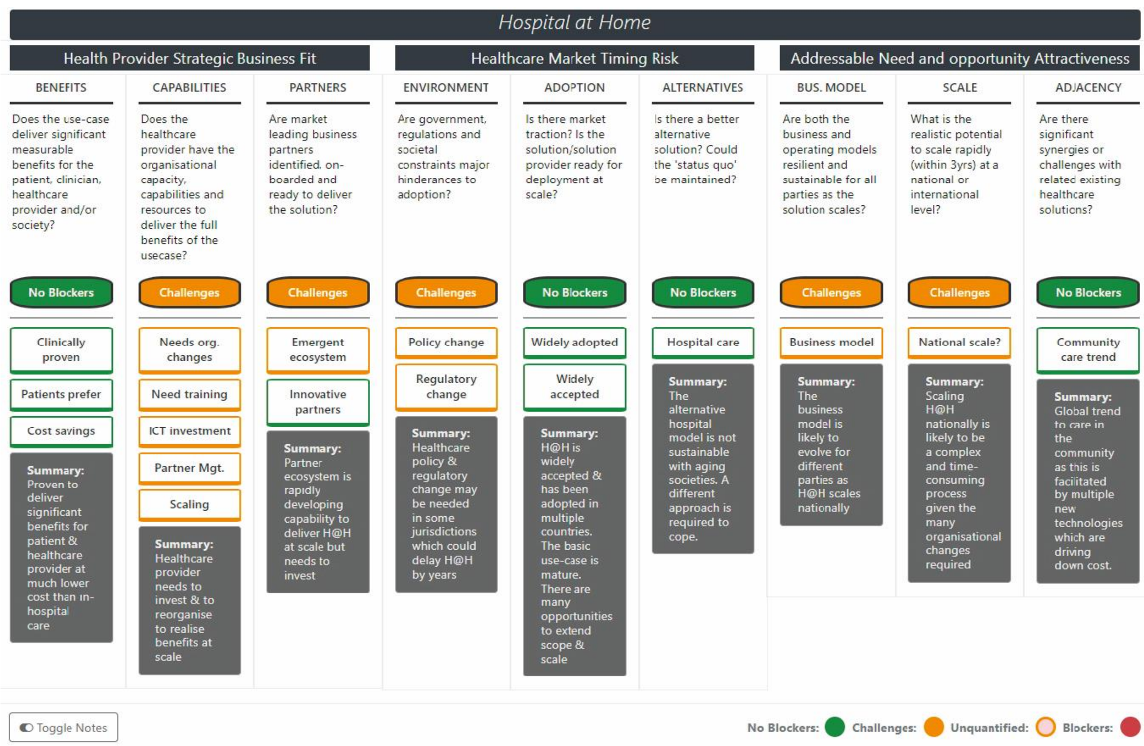
Summary: Straight-forward extension of existing care pathways for asthma & COPD

Toggle Notes

No Blockers: Challenges: Unquantified: Blockers:

7.4.4 Hospital at Home

Hospital at home provides intensive hospital level care for acute complex conditions that would normally require an acute hospital bed. This is delivered in a patients home or in a care home, typically for a period of less than 2 weeks. Patients are treated as though admitted to hospital under clinical governance, but managed within their own home. Typical patients are elderly and frail and suffer comorbidities and experience revolving door hospital stays.



7.4.5 Remote respiratory monitoring

Remote monitoring of a patients respiratory rate (shortness of breath and breathing difficulties) allows medical professionals to develop more accurate early warning scores, whilst protecting hospital staff from infection risk, allowing minimal contact and saving on PPE and time. Monitoring is suitable for patients at risk of Respitatory Compromise and can affect patients with Asthma and COPD. It can be used across multiple indications such as pneumonia, sepsis, heart failure, COVID19, etc..

Remote continuous respiratory monitoring for patient deterioration prediction

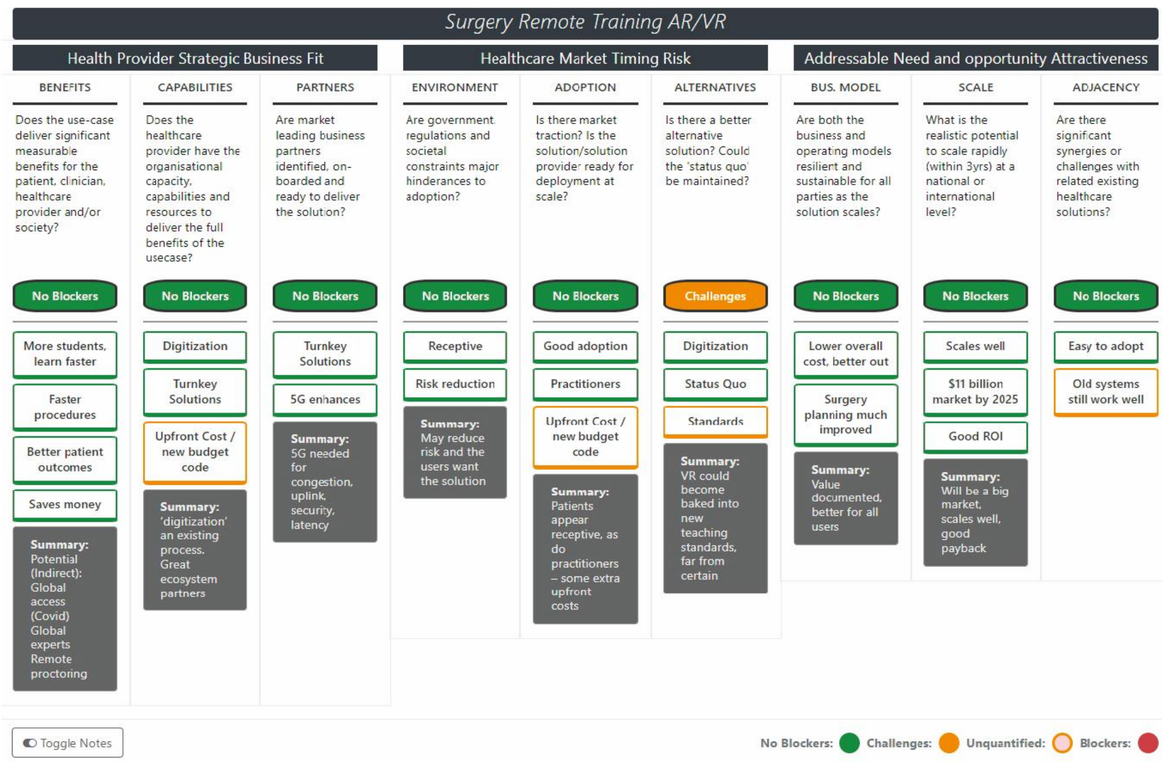
Group	Criterion	Question	Status	Factors	Summary
Health Provider Strategic Business Fit	BENEFITS	Does the use-case deliver significant measurable benefits for the patient. clinician healthcare provider and/or society?	No Blockers	Proven benefits with Covid	**Summary :** Use with multiple indications : pneumonia , sepsis , COPD , heart failure & Covid19
Health Provider Strategic Business Fit	CAPABILITIES	Does the healthcare provider have the organisational capacity, capabilities and resources to deliver the full benefits of the usecase?	Challenges	Wards need IT infrastructure	**Summary :** Roll - out requires hospital server and iPads in every ward (these may already be standard kit?)
Health Provider Strategic Business Fit	PARTNERS	Are market leading business partners identified. on-boarded and ready to deliver the solution?	No Blockers	RespiraSense is market leading	**Summary :** RespiraSense monitors patient movements & breaths . Avoids false readings due to patient movements
Healthcare Market Timing Risk	ENVIRONMENT	Are government, regulations and societal constraints major hinderances to adoption?	Challenges	Medical device approval reqd. Need medical trials as proof Covid accelerates adoption	Summary : Covid accelerated adoption of RespiraSense in Ireland & UK . Small trials were sufficient
Healthcare Market Timing Risk	ADOPTION	Is there market traction? Is the solution/solution provider ready for deployment at scale?	No Blockers	Reasonable cost NICE (NHS) promoted HSE national rollout	Summary : Promoted by national public sector health systems in UK & Ireland
Healthcare Market Timing Risk	ALTERNATIVES	Is there a better alternative solution? Could the 'status quo' be maintained?	No Blockers	Capnography rare use in wards	Summary : Capnography gold standard is rarely used in wards and is not scalable at reasonable cost for large patient cohorts
Addressable Need and opportunity Attractiveness	BUS.MODEL	Are both the business and operating models resilient and sustainable for all parties as the solution scales?	No Blockers	One off + recurring	Summary : Proven business model for both supplier & healthcare provider. No issues.
Addressable Need and opportunity Attractiveness	SCALE	What is the realistic potential to scale rapidly (within 3yrs) at a national or international level?	No Blockers	Deployed nationally in Ireland Scales affordably Training slows scaling	Summary : Proven scalability
Addressable Need and opportunity Attractiveness	ADJACENCY	Are there significant synergies or challenges with related existing healthcare solutions?	No Blockers	Helps manage acute Covid	Summary : Respiratory care has been given additional prominance & support due to Covid

Toggle Notes

No Blockers: Challenges: Unquantified: Blockers:

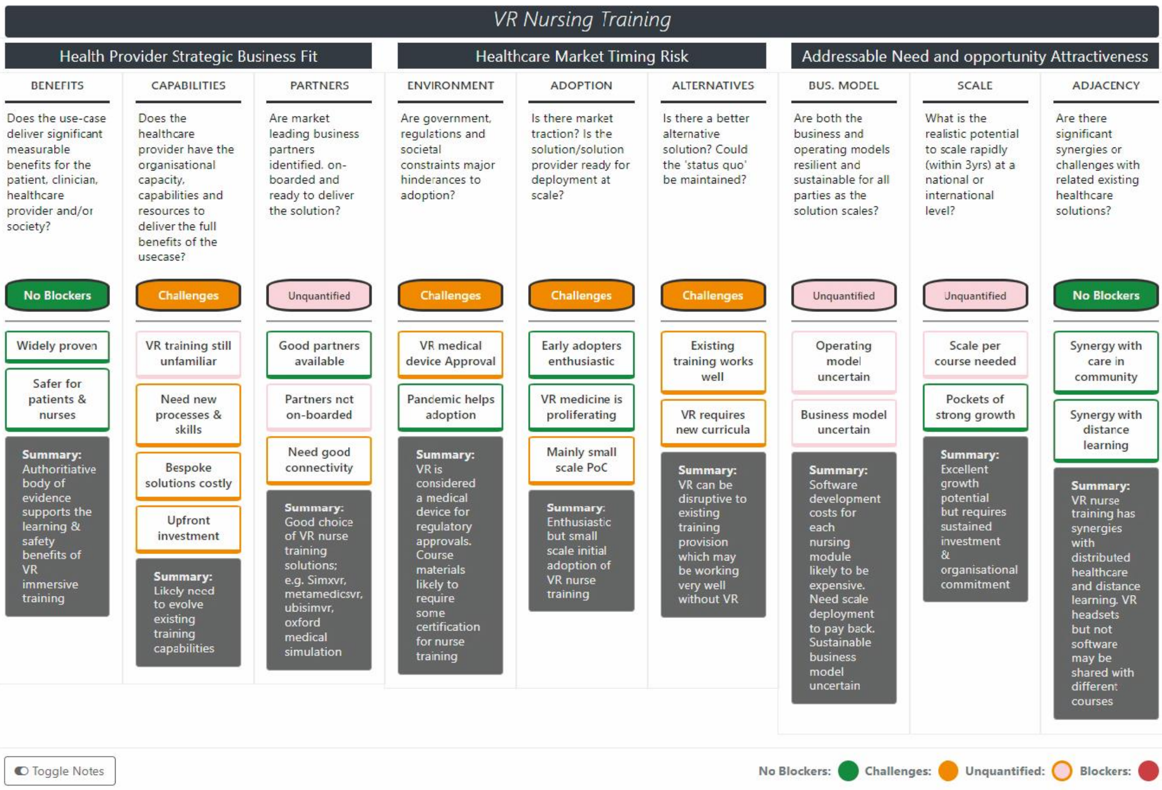
7.4.6 Surgery remote training

Traditional surgical training requires hands-on practice using cadavars and manikins in specialist centers. An alternative is to use AR VR headsets and Haptic feedback devices to simulate surgery and to provide students with real time feedback. The solution also allows the student to try the procedures as many times as they like, which represents a significant advantage over traditional methods.



7.4.7 Virtual Reality nursing training

This relates to training nurses using AR VR solutions to complement their traditional training methods. When combined with traditional training, AR/VR students can demonstrate significantly higher knowledge gain.



8 Digital Transformation & Ecosystems in the Automotive Industry

8.1 Introduction

In this section we look at the specific challenges the automotive industry faces in using disruptive technologies and techniques in order to digitally transform. We also share some noteworthy case studies of transformative projects across this industry.

The automotive industry is experiencing a paradigm shift driven by technological advancements, changing consumer expectations, and the imperative for sustainable practices. This digital transformation encompasses various megatrends, each contributing to a more connected, efficient, and innovative automotive ecosystem as outlined below by KPMG[38].

8.2 Automotive Ecosystem Evolution

The automotive, transport and wider mobility market is undergoing a transformational social, technological and economic shift, fundamentally changing the way people and products are moved. Many sectors, beyond automotive and transport, are being disrupted, with new markets emerging, existing ones converging, and others declining and possibly vanishing. New entrants and startups are challenging incumbents, who in turn look to leverage their experience and resources to build sustainable market positions[39].

As companies adjust to the changing landscape, mobility players especially automotive OEMs and suppliers, above face some pressing challenges. The automotive industry tends to have a weaker financial performance than other sectors because of structural disadvantages. Traditionally, it has underperformed the S&P 500 in terms of total return to shareholders and P/E multiples. On average, traditional auto OEMs are expected to trade at seven times P/E multiples versus the S&P 500's 21 times earnings multiples. This has, in part, been driven by a high capital expenditure (CAPEX) industry structure combined with historical overcapacities. The automotive industry's financial performance is continuing to decline, and current valuations reflect expected profit margins of below 3 percent.

*38. https://assets.kpmg.com/content/dam/kpmg/uk/pdf/2019/08/mobility-2030-transforming-the-mobility-landscape.pdf
*39. https://assets.kpmg.com/content/dam/kpmg/uk/pdf/2019/08/mobility-2030-transforming-the-mobility-landscape.pdf

Due to the market dynamics, new organised ecosystems are developing that will help companies respond to financial pressures and increase collaboration. These ecosystems[40] should allow each member to improve financial performance and increase collaboration and strengthen the entire sector in three key areas[41].

- Core business revenue streams- ecosystem can help players access new customers, improve operations and meet end users needs more effectively;
- New revenue streams – ecosystem drives adjacent or incremental revenue;
- New business models – ecosystem enables new models such as platform usage fees, pay per kilometre and data monetization.

New mobility ecosystems are forming around the needs and preferences of end users and digital ecosystems that bring together a variety of players within a cohesive structure. These ecosystems also offer economic incentives and benefits for all players involved.

For traditional players - Ecosystems allow traditional players to share CAPEX, especially when financing large-scale infrastructure projects. Traditional players can use the existing platforms of their "competitors turned collaborators" for new technologies, enabling joint R&D investments that reduce risks and accelerate development when pursuing important trends. Traditional supplier's category benefit from ecosystems because they gain access to both new customers and new technology-driven innovations. These arrangements also help suppliers to collaborate within R&D to share investment risk and accelerate development. Ecosystems also allow suppliers to consolidate, thereby enabling scale-up and improving performance.

Emerging mobility players view ecosystems as a tool that will deepen their customer relationships, give them greater control and allow them to harvest data from customer interactions. Many players in this group are still fighting to achieve tangible returns and hope that collaborations, involving both investment and knowledge, will optimize their performance. Industry analyst KPMG[42] forecasts a multitude of new entrants as outlined in diagram below to take a share of this new mobility ecosystem market, with unprecedented levels of partnership and collaboration in the search for new solutions.

*40. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/defining-and-seizing-the-mobility-ecosystem-opportunity

*41. Miklos Dietz, Hamza Khan, and Istvan Rab, "How do companies create value from digital ecosystems?," August 7, 2020, McKinsey.com.

*42. KPMG - Staking a place in the new mobility ecosystem

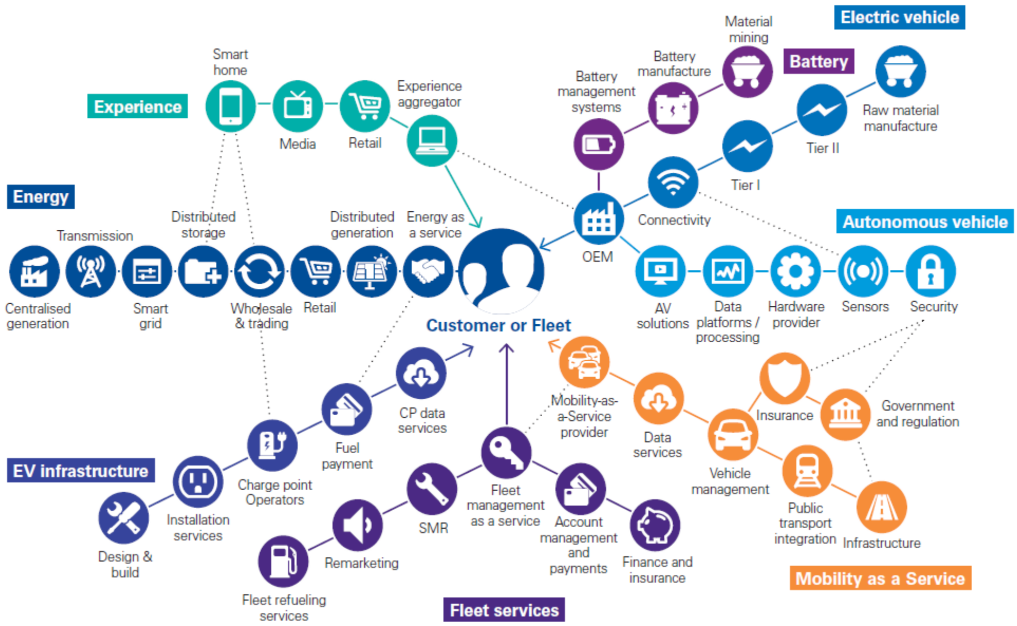


Figure 54: Automotive Ecosystem (KPMG)

We expect a multitude of new entrants to take a share of this new market, with unprecedented levels of partnership and collaboration in the search for new solutions. At the same time, sources of value will fundamentally shift both within value chains and across the ecosystem. The value derived from today's personal car is fairly equally split between upstream (raw materials to finished vehicles) and downstream (all other parts of the value chain). For example, customers typically directly buy services such as fuelling, insurance and service, maintenance and repair. Downstream revenues associated with personally owned vehicles are estimated at US$45,000 over a car's lifetime (KPMG Mobility 2030 analysis). However, by 2030, in a new ecosystem that is electric, connected, autonomous and Mobility as a Service, KPMG believes the downstream value could be multiple times larger, driven by new, digitally-enabled revenue streams.

An holistic ecosystem approach beyond core business is key to future success. All players will need to be clear about their own ecosystem role – whether orchestrator, realizer or enabler. Key players such as OEMs will need to build an offering portfolio and allocate resources accordingly. Thereafter, They will need to actively manage the portfolio and prioritize clearly according to a coherent, consistent and multi-layered ecosystem logic.

8.3 Digital Transformation Automotive Megatrends

Digital transformation is characterized by several key trends and shifts that demand attention and strategic flexibility of mobility players as described in this chapter below.

8.3.1 Manufacturing Revolution

Digital technologies are revolutionizing the manufacturing processes within the automotive sector. Industry 4.0 principles, including IoT integration, data analytics, and automation, are enhancing efficiency, reducing costs, and facilitating real-time decision-making on the factory floor. Insights on manufacturing digital transformation are covered elsewhere in this white paper and underscore the importance of embracing these technologies to stay competitive in the evolving market.

8.3.2 Connected Vehicles and Customer Experience

The advent of connected vehicles is reshaping the relationship between cars and their users. From advanced infotainment systems to over-the-air updates, vehicles are becoming sophisticated platforms for personalized experiences. connectivity can enhance the safety through features like Collision Avoidance Systems and enabling new in-car services, pointing to a future where vehicles are integral to the digital lives of their occupants.

The most important connected services reported in Strategy&[43] consumer attitudes survey in 2023 were:

1. Navigation
2. Safety
3. On demand car functions
4. Mirror smart phone
5. Infotainment

Among on-demand car functions - **Air condition activation, advanced headlight functions and seat heating activation** are viewed as the top three important on-demand car function. Automated driving features such as traffic jam pilot and parking pilot are listed next on demand priority.

*43. https://www.strategyand.pwc.com/fr/fr/assets/pdf/2022/02/en-strategyand-digital-auto-report-2021.pdf

As regards smart phone mirroring, consumer state they would prefer to enjoy connected services and media/entertainment in the car via screen mirroring from a smartphone in the vehicle rather than Auto OEM app for service access which are less popular.

The willingness to pay for connected services is around 20€/month in Germany and the USA but twice as much in China (40€). There is a high spread of willingness to pay in China which indicates strong polarisation of luxury vs. budget customers which implies that differentiated service packaging is needed.

The relevant market for automotive players is expanding beyond the car itself – delivering new services and maintaining user access is crucial. Digital transformation is key to maintaining a compelling connected services digital portfolio and different value levers of digital services need to be considered to unlock value beyond direct user monetization such as:

- Service monetisation
- Post purchase activity
- Brand loyalty
- 3rd party platform access & data sales

The simultaneous rise of on-board connectivity and mobility-as-a-service is driving the L3 and L4 autonomous vehicle market globally:

- By 2030, revenues from mobility services are projected to increase ~€1.2 trillion (US$ 1.37 trillion)—with profits reaching ~€220 bn (US$ 251.8 bn)

Advanced features of safety, autonomy and connectivity are expected to create traction for L3/ L4 autonomy in cars. OEMs are planning significant investments around safety including, intelligent speed adaption, lane keep assist and collision avoidance. OEMs are currently investing in connectivity and autonomy features such as V2V communication and highway autopilot.

Industry organisation such as 5G Automotive Association (5GAA) which is a global, cross-industry organisation of companies from the automotive, technology, and telecommunications industries (ICT), working together to develop end-to-end solutions for future mobility and transportation services. Cellular Vehicle-to-Everything, or C-V2X, is a connected mobility platform that allows vehicles to interact with their surroundings, such as other vehicles, cyclists, pedestrians, road infrastructure, or mobile networks. The start of in-vehicle commercial deployment (i.e. type-approved vehicles) began in 2020-2021. A significant testing schedule is already underway for 5G-V2X, the next generation for cellular technology-based communications solutions, with more than 20 trials and early deployments globally.

Vehicle experience increasingly depends on digital technologies that only work at scale. As OEMs go digital, the technology partner portfolio will have to balance the fast go-to-market benefits with the long-term dependencies. Today, OEMs are focused on their experience differentiators and are placing significant emphasis on the source technology capabilities (e.g. machine learning, operating systems or cloud storage) via ecosystem partnerships. The digital user experience trends and challenges are outlined below:

Table 2 - Digital User Experience Trends and Challenges

Digital User Experience Trends and Challenges		
Trends	Impact	Challenges
ChatGPT	Not only commands but actual conversations with ChatGPT technology in car voice interfaces	A more immersive voice assistants compromise the driver's concentration. The end to end systems require user trust and cyber security systems to handle personal data
Smart Surfaces	Smart materials allow physical surfaces to understand and react	Usability of Surface-embedded smart controls require special design attention to ensure that users can locate and operate the interface
Ultrawide display	The touchscreen is taking over the dashboard and are becoming wide entertainment systems	Bigger and more powerful infotainment system also requires more electricity, affecting the car range in EVs especially and issues of driver distraction remain
Augmented Reality	Augmented reality is becoming more mature and advanced with guidance projected on road ahead	The cost of AR technology in cars is still significantly more expensive than traditional displays

The importance of delivering a winning digital experience especially in China, can be seen in the latest according to the J.D. Power China New-Vehicle Intender Study (NVIS). Among consumers in China who intend to buy a new vehicle, nearly one-quarter (24%) consider their experience with vehicle intelligence features to be the decisive purchase factor. The lack of technology features is among the top three concerns when considering a vehicle purchase in China.[44]

8.3.3 ADAS & Autonomous Driving

"Intelligence" and "connectivity" are the basis of improved safety and future autonomous driving which is introduced in this section.

Figure 55: Intelligence and Connectivity advances to AD

*44. JD Power https://china.jdpower.com/press-release/2021-NVIS

Today, most new cars include basic advanced-driver-assistance (ADAS) features, but major advancements in Autonomous Driving (AD) capabilities are on the horizon. Vehicles will ultimately achieve Society of Automotive Engineers Level 4 (SAE L4), or driverless control under certain conditions as shown below. Consumers want access to AD features and are willing to pay for them according to many industry analysts.

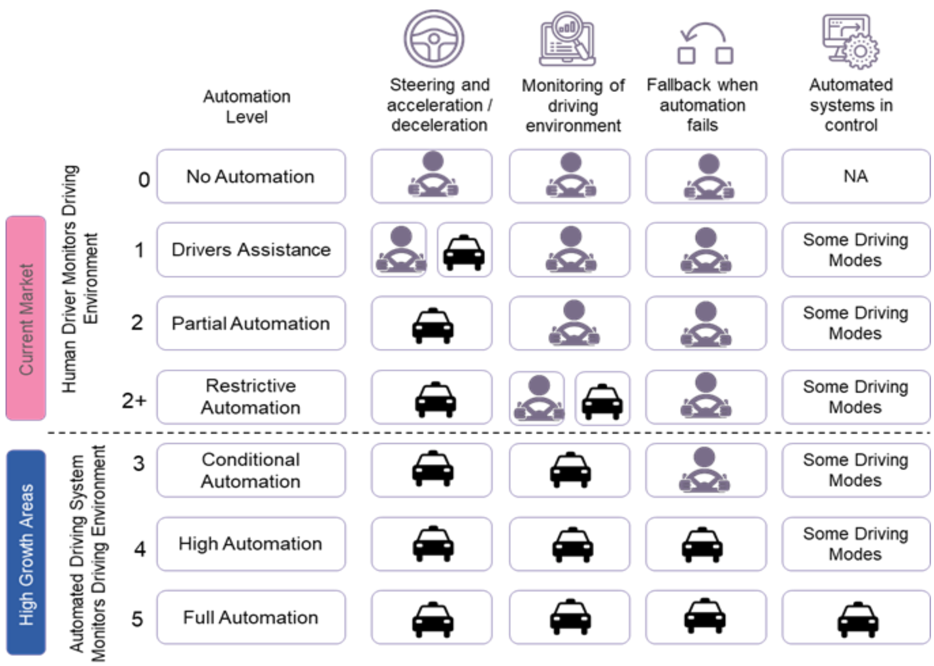


Figure 56: Levels of AD

AD is gradually moving beyond experimental stages towards commercial viability in private and shared vehicles. For example, in 2023 Mercedes-Benz became the first automaker to get permission from California regulators[45] to sell or lease vehicles with Level 3 (hands-off and eyes-off) self driving tech on designated roads. Drive Pilot will allow Mercedes-Benz drivers to takes their eyes off the road and hands off the wheel, then do other non-driving activities like watching videos and texting. If the rules for use are followed, Mercedes (and not the driver) will be legally responsible for any accident that happens. Waymo and Cruise received with first licenses in San Francisco, albeit with some negative press around the initial robotaxi service launches in 2023[46].

Adoption forecast of highly automated driving (L4/5) have recently become more conservative than in pre-2020 forecast due to both the technology challenge and regulatory clearance. China tends to be more optimistic, driven by very ambitious government plans (36% of new sales in 2035)[47].

*45. https://www.engadget.com/mercedes-becomes-the-first-automaker-to-sell-level-3-self-driving-vehicles-in-california-103504319.html

*46. https://www.forbes.com/sites/bradtempleton/2023/12/28/robocar-2023-in-review-the-fall-of-cruise/

*47. https://www.strategyand.pwc.com/de/en/industries/automotive/digital-auto-report/volume2.htm

Reduction in costs, regulations aiming for high safety and increased use of ride hailing services will drive growth of L4/5 through 2030 and beyond.

The penetration of advanced driver assistance and active safety features in new cars is increasing at a fast rate. In the past, carmakers used ADAS and level 2 autonomy as differentiators in new cars, now they are seen as must-have features. But there is still a huge ADAS opportunity as many local popular vehicle types do not yet include level 2 functionality, or it is still a niche feature.

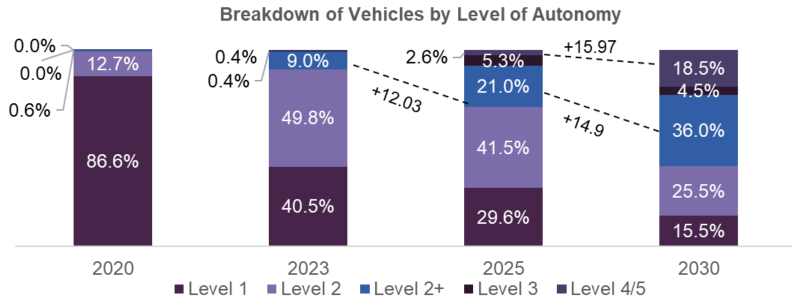


Figure 57: Breakdown of Vehicles sales forecast by level of Autonomy

Most of the players present in the AV ecosystem recognize regulation as a major bottleneck for AV adoption. In Europe specifically, 70% of the players listed strict regulations as a major hindrance to the AV tech adoption in the region. Notably, several European countries have launched independent efforts to create regulations, rather than coordinating with one another. For instance, Germany has adopted legislation that allows robotaxis on certain roads by 2025.

8.3.4 Mobility as a Service (MaaS)

Digital transformation extends beyond the traditional ownership model, with the emergence of Mobility as a Service (MaaS).

Connected and automated vehicles hold great potential to transform economies and societies. The transformation underlines the need for automotive players to adapt to changing customer references, emphasizing the shift towards shared mobility solutions. The industry is witnessing a transition from selling vehicles to providing comprehensive mobility services, marking a significant departure from conventional business models.

Connected and automated vehicles could also change the delivery of mobility itself. Mobility as a service (MaaS) is a model for supplying a wide range of passenger transport services through a single digital customer interface[48]. Connected and automated vehicles could fit into this vision through the widespread deployment of automated taxi fleets. This would enable more seamless delivery of transport services,

*48. https://doi.org/10.1787/94052f32-en.

potentially reducing the need for personal vehicle ownership and parking spaces near homes and workplaces. Some deployments of automated vehicles take the form of taxi fleets. Other forms of vehicular automation, like fully automated train systems and autonomous tractors are evolving in other contexts.

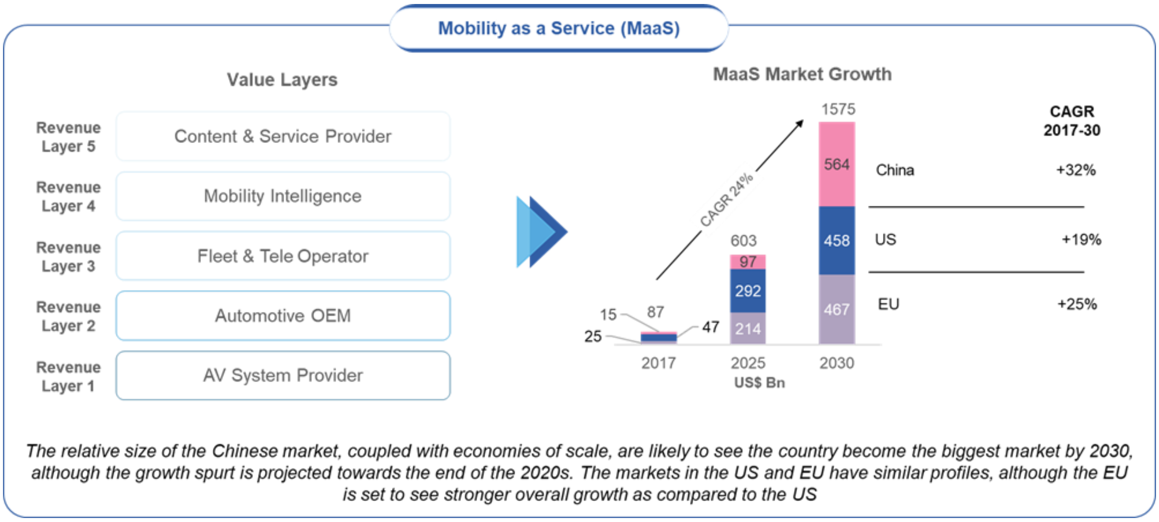


Figure 58: MaaS forecasts and Revenue Layers

Over the medium term, Mobility as a Service (MaaS) is a growing industry that intends to provide individuals and businesses with integrated, on-demand transportation solutions. It represents a paradigm shift from traditional modes of transportation, in which consumers can access a variety of mobility alternatives through a single platform, frequently via a subscription-based approach. The market is predicted to expand rapidly in the next years, owing to rising urbanization, increased traffic congestion, and a need for more sustainable transportation alternatives.

Passengers' preferences for utilizing taxi services and ride-sharing services across the country are expected to increase. Hence, this is likely to lead the companies to enhance the options and expand their operations to be provided in mobile applications, to retain their respective market shares in a highly competitive market.

Companies are positioning within the value stack in above diagram. Key player in this MaaS ecosystem today are Uber Technologies, Didi Chuxing Hertz, Avis budget Group, Moovit.

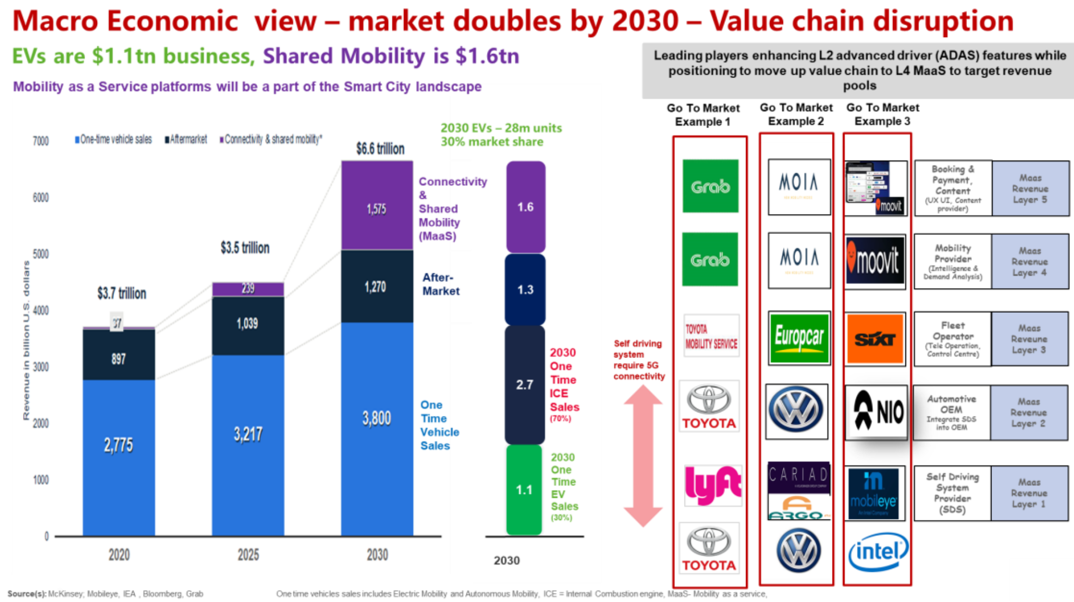


Figure 59: MaaS Macro Economic view

Some example of wider Maas use cases:

- In January 2023, The Mobility Department of the City of Tampa launched a Mobility as a Service (MaaS) trial project with the City's new mobility partner, Moovit. Moovit debuted in Tampa as an urban mobility software that assists users in planning multimodal trips, whether they want to walk, bike, scoot, drive, ride the streetcar, or take the bus. In addition to delivering precise and reliable urban mobility information, Moovit offers mobile ticketing for public transportation, real-time arrival information, and displays parking lots and park-and-ride locations, unlike Google Maps or Waze.
- In October 2022, Shanghai inaugurated an all-in-one mobile platform for green commuting, marking an important step forward in the development of the city's Mobility as a Service (MaaS) system. The Suishenxing app, the world's first metropolitan MaaS platform established by a government, has completed its fundamental features, which include public transportation, taxi hailing, and smart parking. Users can get a swipe-for-all pass that contains all public transportation codes through its public transportation service. After registering and activating the payment feature on MaaS, it can now be used on Shanghai's 1,560 bus routes, 17 ferry lines, and 11 Metro lines.

8.3.5 Electric Vehicles and Sustainability

The push towards electric vehicles (EVs) is a central component of the digital transformation in the automotive industry. With a focus on sustainability, automakers are investing heavily in EV technology and charging infrastructure. Industry research from BloombergNEF[49] emphasizes the strategic importance of navigating this shift to remain competitive in a market increasingly shaped by environmental considerations and regulatory pressures.

The automotive industry is undergoing a period of profound change. As outlined discussed in previous chapters there are many vectors of change including Vehicle connectivity, shared mobility, ADAS and AD. However, it is electric vehicles and battery technology have taken centre stage both with consumer sentiment and both industrial and regulatory policy at present. The international Energy Agency (IEA)[50] reports that sales of EV are seeing exponential growth and have exceed 10 million in 2022 or 14% of sales.

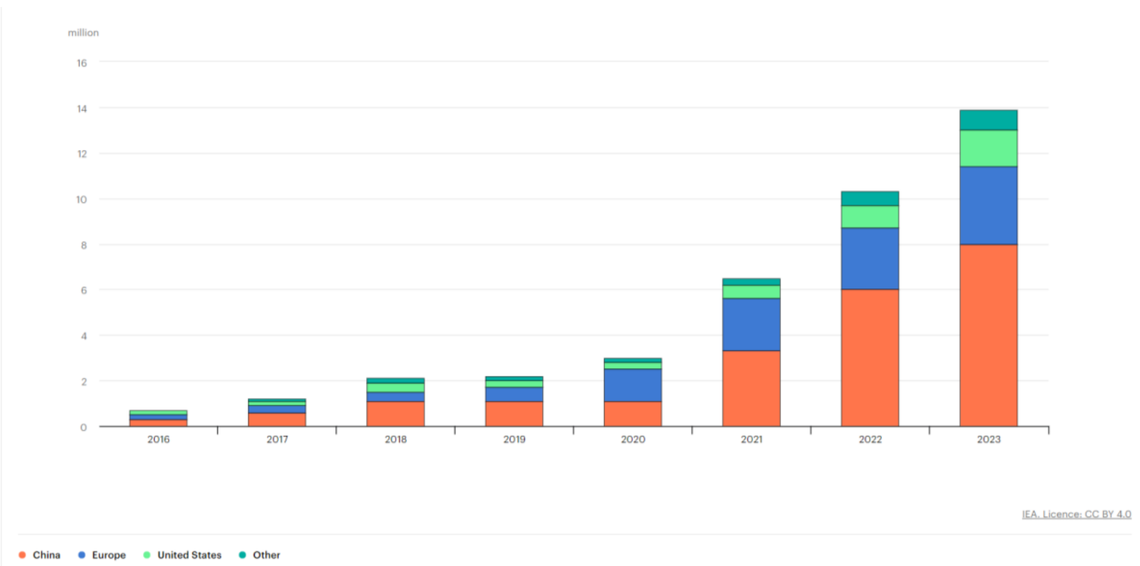


Figure 60: Electric car sales 2016-2023 (IEA)

EV sales have continued to grow strongly in 2023 and national policies and incentives will help bolster sales while a return to very high oil prices can further motivate prospective buyers.

*49. https://assets.bbhub.io/professional/sites/24/2431510_BNEFElectricVehicleOutlook2023_ExecSummary.pdf

*50. IEA, Electric car sales, 2016-2023, IEA, Paris https://www.iea.org/data-and-statistics/charts/electric-car-sales-2016-2023, IEA. Licence: CC BY 4.0

Research and Markets[51] report that the global electric global electric vehicle market demand is expected to reach $1.7 trillion by 2030, expanding at a CAGR of 14.5% over the forecast period. Total global EV vehicle sales are forecast to hit 51.6 million in 2035, according to data and analytics company GlobalData. The long-term picture is getting brighter, but challenges remain. EVs reach 44% of global passenger vehicle sales by 2030 and 75% by 2040. Despite rapid EV adoption, less than 50% of the global passenger vehicle fleet is electric by 2040.

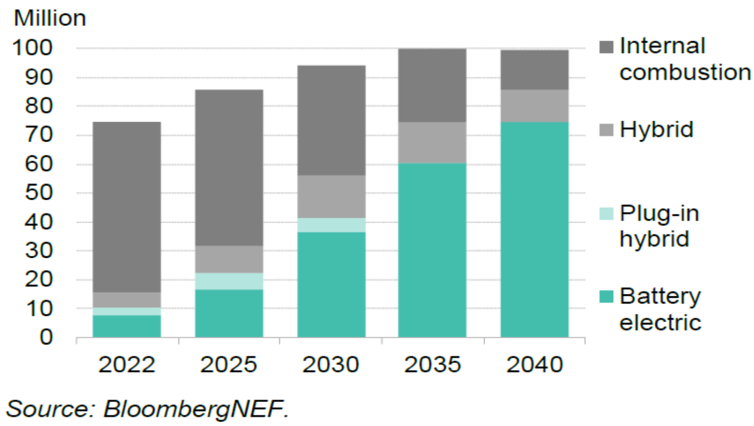


Figure 61: Global passenger vehicle sales by drivetrain

The EV market is getting more competitive as new companies, including smartphone ecosystem players, are entering the field. Companies such as Huawei and Xiaomi have already announced their entry into the smart electric car field to diversify business opportunities. Sony has partnered with Honda to produce affordable EVs. New start-ups like Nio, Li Auto, Xpeng, Lucid Motor, Fisker and Rivian are also trying to follow Tesla's wheel tracks and disrupt traditional auto OEMs, many of which hesitated to invest in EV development in the initial phase. As next-gen cars will be much more software-driven, we will likely see more new players entering the market. However, the traditional players will still have an advantage thanks to their scale of manufacturing and well-established supply chains. Nevertheless, we expect a fierce battle between traditional and newer players in the coming years as EVs become increasingly mainstream.

The progress of sustainability and EV production are tightly coupled. Counterpoint[52] report that increased EV adoption will not, by itself, contribute to the goal of reducing overall vehicular pollution. While increased EV sales are positive, we also need to focus on setting up smart production ramps, more efficient battery manufacturing processes, battery recycling plants and charging infrastructure powered by renewable energy sources like solar, wind, hydro and nuclear. Unless we also adopt clean energy sources, the vision of attaining net-zero carbon emission will remain out of reach.

*51. https://www.researchandmarkets.com/reports/5023846/global-electric-vehicle-market-size-share-and#src-pos-1
*52. https://www.counterpointresearch.com/insights/electric-vehicles-forecast-2030/

CO2 requirements are driving the Electrification sustainability agenda[53]. Electric vehicles are the key technology to decarbonise road transport, a sector that accounts for around one-sixth of global emissions. Ambitious policies continue to be critical to growth in electric vehicle markets worldwide. Following the 2015 United Nations Climate Change Conference (COP21) agreement in Paris, many countries and cities have announced goals to eventually ban internal combustion engines. The European Commission also released the Clean Mobility Package in November 2017 to set new CO2 emission standards and guidance for cleaner mobility. Cities including Athens, Madrid, Mexico City, Paris and Stuttgart have announced plans to ban diesel cars by 2030 or earlier. Car manufacturers followed these regulatory commitments with their own pledges to move away from the production of ICEs. **BMW** plans to mass-produce EVs, **offering 12 models by 2025**. Renault plans to produce 25 electrified models by 2024, including 10 pure EVs. Volkswagen will invest up to **$84 billion in battery and EV technology to electrify all 300 of its models by 2030**. China set a timeline of peaking its CO2 emissions around 2030, And reach net-zero greenhouse gas (GHG) emissions by 2060. and has indicated it plans to ban the production and sale of fossil fuel cars in the near future.

Many current regulations encourage the proliferation of privately owned EVs by offering financial and/or or non-financial incentives, including tax rebates, access to priority lanes, free parking or free electricity, and penalizing vehicles with emissions as shown in Figure below. This figure outlines how the European emission regulations are set to become stricter through 2025 - increasing penalties to auto makers for excess emission per vehicle.

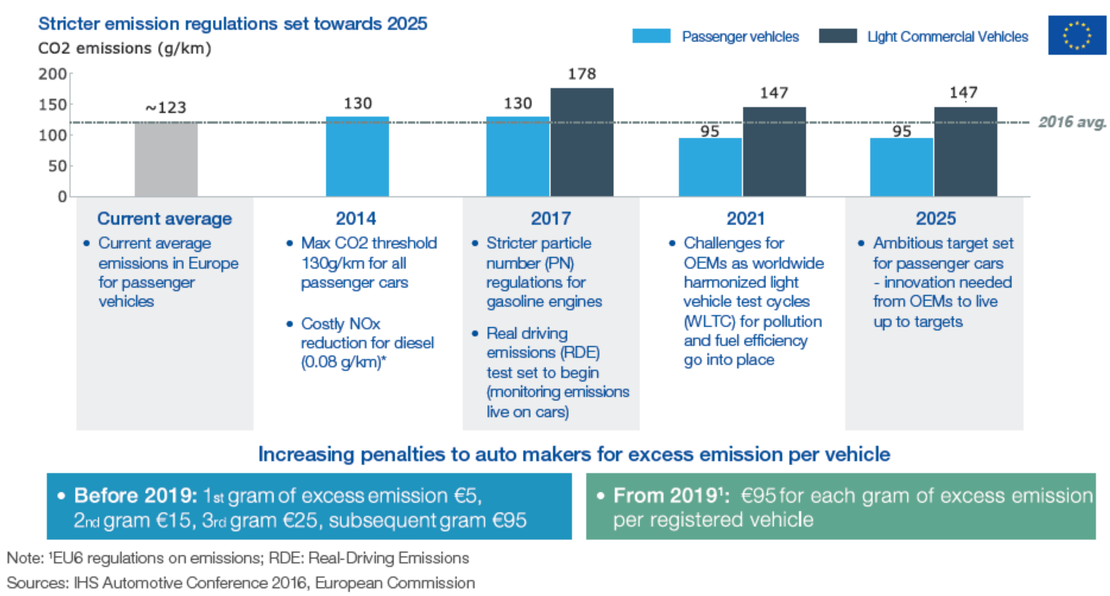


Figure 62: EU regulations on emission to 2025

*53. http://www3.weforum.org/docs/WEF_2018_%20Electric_For_Smarter_Cities.pdf

8.3.6 Software Defined Vehicles (SDV) and compute requirements

To meet rising customer demand for more digital automotive experiences, the automotive value chain must embrace vital enablers of the digital transition namely software and compute power.

McKinsey report that the by 2030, the global automotive software and electronics market is expected to reach $460 billion, representing 6 percent growth (CAGR) from 2019 to 2030. The development of SDV is transforming the automobile industry by incorporating advanced software systems that can control and coordinate various functions of the vehicle, such as infotainment, driver assistance, and connectivity, among others. This has led to the creation of sophisticated electric/ electronic (E/E) architectures that can adapt to changing requirements and enable new capabilities in modern vehicles. The E/E architecture is evolving from independent, function-specific ECUs towards a centralized architecture.

Most existing cars have a distributed E/E architecture and there are up to 100 ECUs in the vehicle, one for every function, such as braking, steering, windows, seats, door locks etc. and it is characterized by significant wiring harnesses as outlined in the figure below from Renesas[54] .

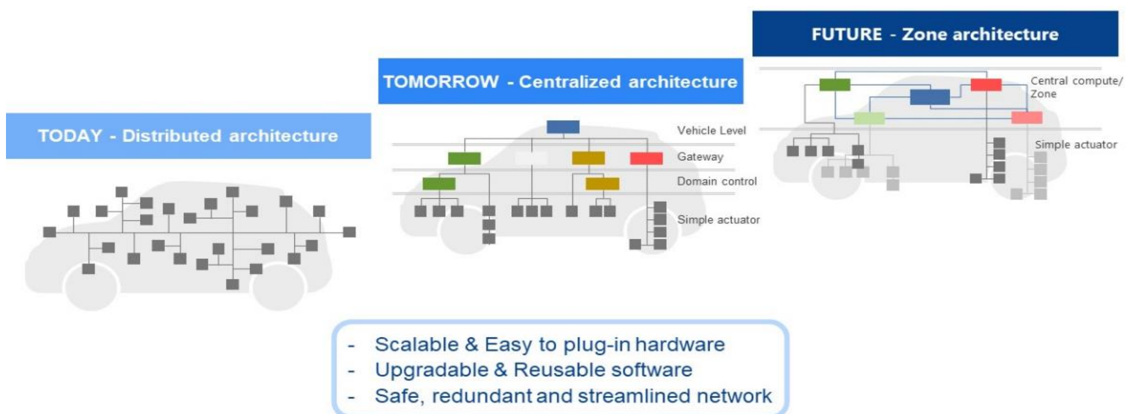


Figure 63: E/E Architecture Transformation

With the advent of Tesla, the E/E architecture of vehicles has started to change from **a distributed architecture** to **a domain /centralised architecture** with ECUs grouped by function (e.g., functional domains for ADAS, chassis, brakes, HMI). Ultimately this will transition to a **zonal architecture** where ECUs are grouped by their location in zones inside the vehicle.

*54. https://www.renesas.com/us/en/blogs/evolution-ee-architecture-and-software-platform-r-carrh850

McKinsey[55] in their report on next-generation E/E architecture outlines that the value of automotive compute units will grow from $91bn in 2023 to $139bn in 2030. The stakes are high for both auto and chip makers as each automotive domain has distinct requirements. For example, the ADAS/AD and infotainment domains require high compute power with the compute units in the $1,000 to $4,000 range depending on the SAE ADAS/AD level being supported. Zonal compute units by contrast for the Body/Powertrain/ Chassis will have average selling prices of $50-$70 each.

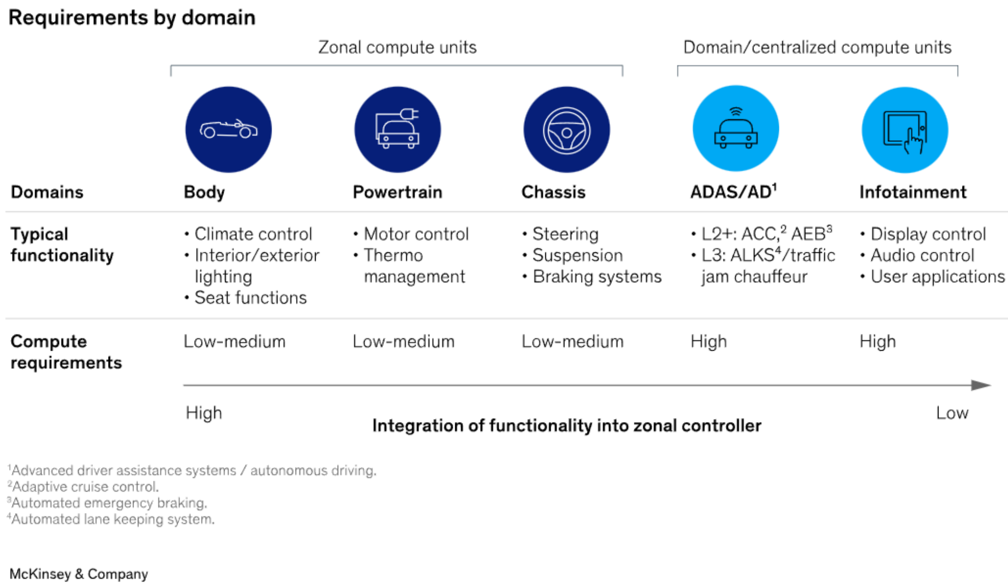


Figure 64: Compute requirements of each car domain

Zonal and centralized E/E architectures will play a key role in the digital transformation to software defined cars. They will allow for the simplification of control units, continuous software updates, and through-the-car lifecycle monetization. As part of this process, OEMs in particular need to balance business benefits against potential costs. For example, they must decide how much compute power is required now and in future and strike a balance on trade-offs. The most successful will prioritize a strategic approach, creating an optimal model for transition over time.

*55. https://www.mckinsey.com/industries/semiconductors/our-insights/getting-ready-for-next-generation-ee-architecture-with-zonal-compute

8.4 Automotive Case Studies

8.4.1 Case Study: Battery Passport (BP)

Battery Passport (BP) – Regulation and work in progress of BP solutions as first instance of digital product passports (DPP4.0) impacting the automotive value chain.

The digital battery passport initiative in the automotive industry follows EU regulation requirements addressing the urgent need for sustainable, efficient, and transparent battery management. It presents a comprehensive solution to an industry-wide challenge, balancing environmental responsibility, regulatory compliance, customer satisfaction, and operational efficiency. A digital product passport for batteries is a dynamic Digital Identity for battery status and service tracing during its entire lifecycle: status, health management, energy trading and recycling. This will aggregate the battery stack information across the entire value chain, including data on raw material extraction, production, usage and all the way up to recycling.

8.4.1.1 Submitted by

Thorsten Dikmann, BASF / Dr. Jürgen Grotepass, Huawei

8.4.1.2 Context

The automotive sector is confronted by critical challenges with regards to the resilience of the supply chain and the environmental impact of the production and utilization of vehicles. Considering the last 20 years, statistically more than one event occurred every second year that had major impact on the availability of needed goods produced “just in time”. With a growing demand especially within the rapidly expanding electric vehicle domain, the traditional linear supply chains reveal fracture points risking the business model of a whole industry, leading to a need to re-think existing models towards a circular approach. Furthermore, customers demand more sustainable products which goes along with additional requirements from regulatory authorities. A whole industry is affected – and it is obvious not one player can solve these radical challenges alone. Catena-X, started as a publicly funded project by the German Federal Ministry for Economic Affairs and Climate Action and based on the Gaia-X European cloud, addresses this call for a change by providing a digital ecosystem a grown in a sphere of radical collaboration.

Rooted in the Catena-X use case “Circular Economy”, the Battery Passport is the multi-faceted solution tailored to the challenges of the rapidly growing electric vehicle sector. In general, the focus on Digital Product Passports and the Battery Passport as first concrete implementation is a transformative approach enhancing business processes in the automotive sector, focusing on three key aspects: maximizing product transparency, fulfilling regulatory compliance, and improving circularity potential of the used materials.

The Battery Passport aims to streamline the data exchange in the supply chain, fostering transparency and accountability from the extraction of raw materials to end-of-life battery recycling. This oversight is not merely about enhancing efficiency; it marks a significant step towards a sustainable and circular economy, reducing waste and promoting material reuse.

Figure 65: Why Digital Product Passports like the Battery Passport are relevant: The information in a digital passport maximizes the product transparency and at the same time fulfills regulatory requirements. The data lays the foundation for a circular economy of the used materials

Beyond operational benefits, the Battery Passport contributes directly to customer service improvements. By providing detailed insights into a battery's lifecycle and environmental footprint, the Battery Passport empowers consumers to make informed choices, thereby boosting consumer trust and satisfaction. This aligns with the increasing demand for sustainable and ethically sourced products.

Regulatory landscapes are becoming increasingly stringent. The Battery Passport addresses this by offering a clear pathway for compliance, particularly considering the European Commission's publication of the proposal for an Ecodesign for Sustainable Product Regulation (ESPR) on March 30th, 2022. The ESPR aims to set ecodesign requirements for sustainable products, amending Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC. This proposal regulation introduces the concept of a Digital Product Passport (DPP) with five key principles to ensure technology neutrality, interoperability, and alignment with EU harmonization legislation. The Battery Passports alignment with these regulations ensures that automotive manufacturers adhere to environmental standards, avoiding penalties and contributing to broader climate goals.

Moreover, the new Batteries Regulation (Regulation (EU) 2023/1542), published on July 28th, 2023, sets rules on sustainability, performance, safety, and information requirements about batteries, emphasizing the need for a digital battery passport. This passport is vital for enhancing transparency along supply and value chains, enabling the tracking and tracing of batteries and providing information on their cell chemistry, electrochemical properties, manufacturing processes, state of battery and other attributes such as physical dimensions or CO2 footprint.

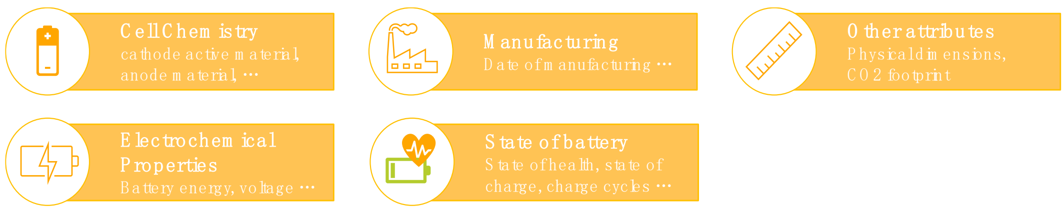


Figure 66: The Battery Passport is a digitial twin of one battery. It contains a variety of data including electrochemical properties, information about the cell chemistry and manufacturing information or sustainability indicators like the product carbon footprint. Additionally, dynamic parameters like the state of health are included which will be updated over the lifetime of a battery.

In summary, the BP initiative in the automotive industry addresses the urgent need for sustainable, efficient, and transparent battery management. It presents a comprehensive solution to an industry-wide challenge, balancing environmental responsibility, regulatory compliance, customer satisfaction, and operational efficiency.

8.4.1.3 Business Benefits

The Battery Passport initiative offers significant business advantages to the automotive industry, primarily through the trusted Catena-X data space. This facilitates first-time value derivation by ensuring a reliable data exchange network.

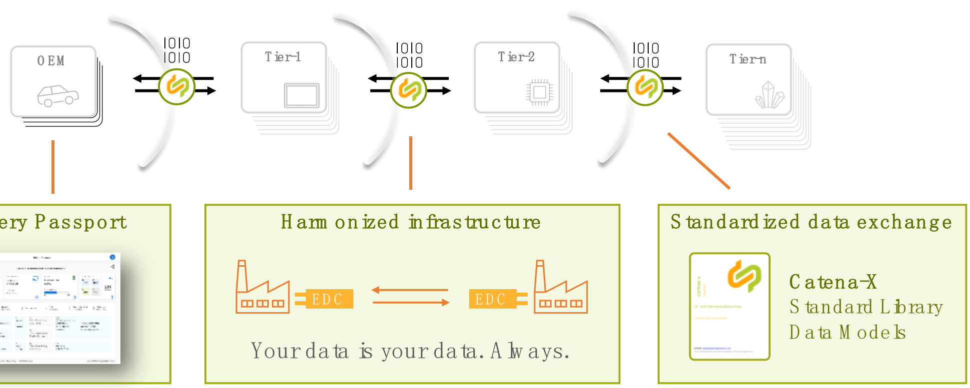


Figure 67: To issue a Battery Passport as vehicle manufacturer (OEM) and economic operator of a battery, a sophisticated digital interaction needs to be established in the value chain. All supplier on every tier layer benefit from a harmonized infrastructure guaranteeing data sovereignty with key components like the Eclipse Dataspace Connector (“EDC”). Data exchange itself is based on agreed and aligned standards. Beyond illustrated tiers, additional business opportunities are given for dismantlers and recyclers.

For Supplier Tiers and Manufacturers:

The initiative ensures efficient data exchange improving supply chain transparency and efficiency, thanks to the harmonized infrastructure of Catena-X data space. This data exchange leads to more effective resource utilization by avoiding complex individual connections. An integral part of the Catena-X environment, the Standard Library publishes aligned standards of all members of the Catena-X association, to ensure interoperability, the “common ground” for data exchange in the network.

For Customers/consumers:

End-consumers benefit from access to more sustainable products. The Battery Passport accompanied by parallel Catena-X use cases like “Traceability” improve liability for claims for environmentally friendly and ethically sourced materials, increasing consumer trust and loyalty. Through the standardized data exchange, having detailed product information with status information of the battery enhances the purchasing experience and satisfaction.

For Dismantler and Recycler:

The End-of-life (EOL) and recycling rules cover the collection and EOL treatment of post-consumer waste batteries and pre-consumer battery manufacturing waste. The Battery Passport initiative integrates digital tracking and reporting systems within recycling during the process of dismantling and recycled material. It opens new market opportunities, encouraging innovation in sustainable practices and technology.

8.4.1.4 Solution or Innovation Detail

A Digital Product Passport (DPP) in the automotive industry, particularly for the Battery Passport initiative, encompasses several key requirements and innovations:

DPP Requirements:

- Issuance by a recognized authority.
- Standardized referencing of product characteristics.
- Validation of source information while safeguarding internal product details.
- Support for the composition of products in supply chains, creating a “product passport supply chain.”
- Minimal manual interactions in generation, management and exchange of information.

The fulfillment of these requirements is crucial for efficient and sustainable product passports in the ecosystem, enabling real supply chain sustainability and monitoring.

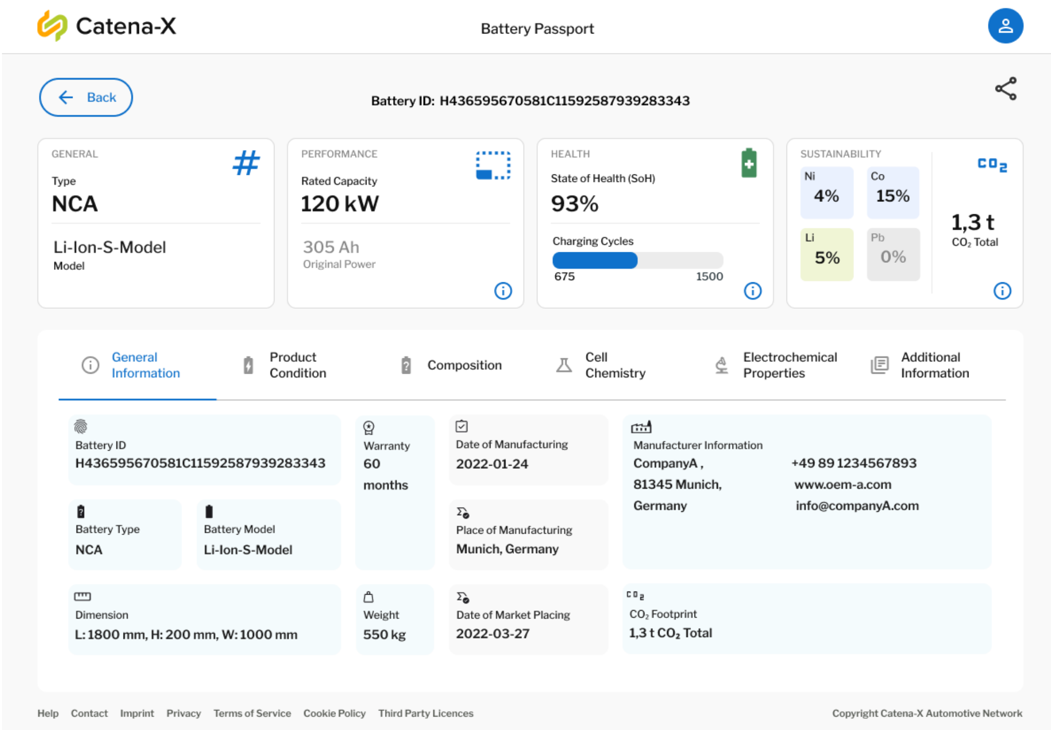


Figure 68: Tangible visualization of a Battery Passport in the Catena-X Battery Passport viewer application

Implementation:

- The BP initiative integrates digital tracking and reporting systems into the battery supply chain.
- Digital tagging and monitoring of batteries from production to end-of-life recycling.
- Catena-X network support, offering data sovereign exchange in a decentralized network with role-based access through usage policies.

Technical Innovations:

- Advanced digital technologies for secure data management and IoT for real-time tracking.
- Significant research and academic contributions to ensure efficiency, security, and scalability.

Stages and Results:

- Varying stages from conceptual development to technology trials and commercial pilots.
- Anticipated improvements in supply chain efficiency, regulatory compliance, consumer trust, and environmental sustainability.

Special Features:

- Innovative digital technologies addressing environmental and operational challenges.
- Harmonized infrastructure and standardized data exchange within Catena-X service.

By focusing on these enhanced aspects, the BP initiative stands out as a pioneering solution in the automotive industry, bridging technological innovation with environmental responsibility and supply chain efficiency.

8.4.1.5 Ecosystem

Catena-X establishes a digital ecosystem for the global automotive industry, focusing on secure data exchange between participating entities. Catena-X is growing internationally, rooted within Germany now first European hubs have been established - more are to come e.g. in Japan, USA, and China in 2024.

By 2023 ten use cases have been established for value creation in the Catena-X data space with the Digital Product Passport being one of the building blocks. In the context of Digital Product Passport, Catena-X is of relevance as it seeks to create a standardized framework for the exchange and management of product-related information throughout the automotive value chain based on Open-Source components. "Radical Collaboration" is the approach for manufacturers, suppliers, and other stakeholders – it's a solution for the whole industry and the whole industry is invited to participate in the development.

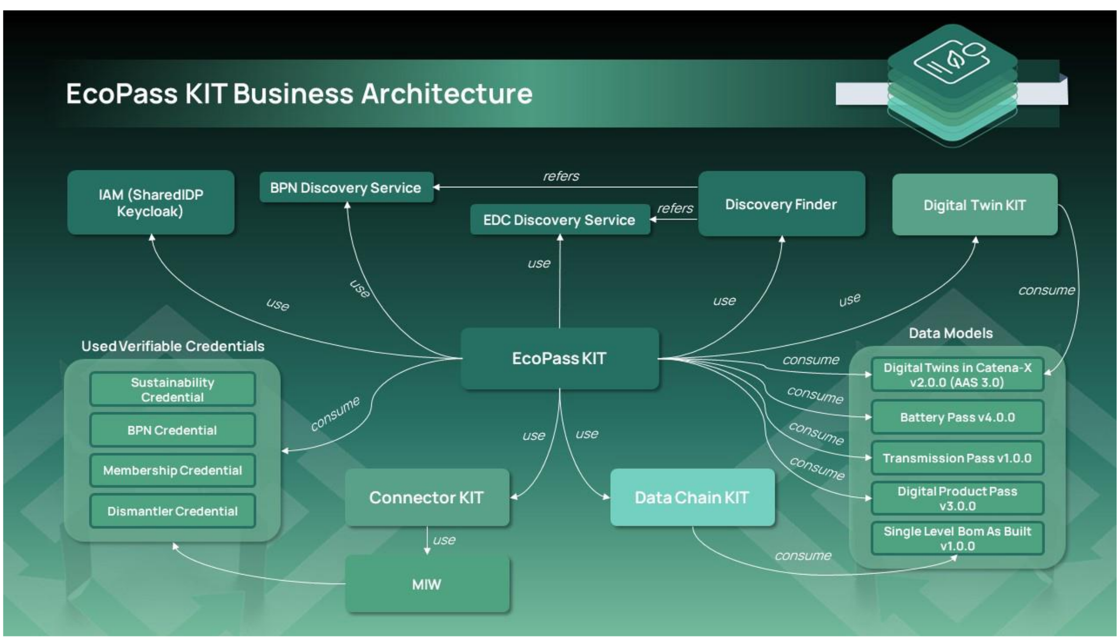


Figure 69: The Catena-X EcoPass KIT gives a comprehensive overview on the dataspace and components. Stakeholders find information needed to exchange Battery Passport information

By implementing Catena-X, data integrity and enhanced traceability of products can be ensured. Catena-X works on various standards addressing different tiers of the Catena-X Operating Environment. These include 1) data discovery services, 2) semantics to model data relations, digital twins, and governance processes, 3) APIs for data chains, registries and data pooling, 4) identity and access management features, 5) services for product lifecycle and quality management, and 6) automotive-related sustainability documentation methods and metrics (including data models for product passports).

For the Battery Passport – among other Digital Product Passports – Catena-X provides the EcoPass KIT ("Keep it together"). The EcoPass KIT is the key enabler for various stakeholders to use Digital Product Passports. It provides a comprehensive overview of the business context and benefits of product passports in general, offers guidelines for industry stakeholders and gives a detailed description and helping information how to implement digital product passports.

8.4.1.6 Business Model

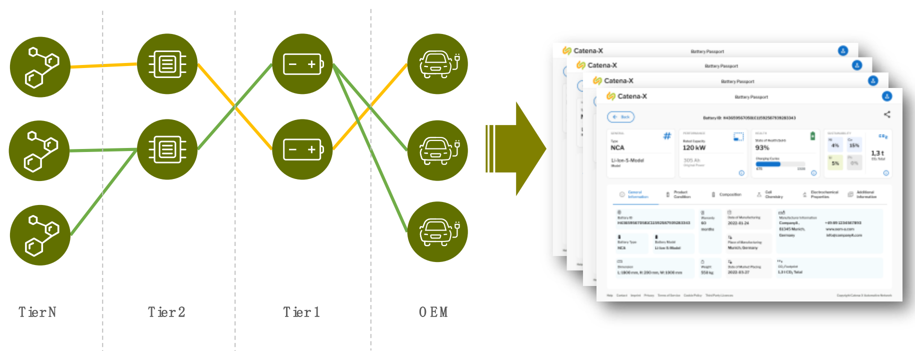


Figure 70: The data exchange between partners in the automotive supply chain is exponentially complex. Traditional point-to-point connections do not fit this complexity. Catena-X provides a decentral approach based on a harmonized infrastructure. The Battery Passport is based on this infrastructure

The Business Model for the Battery Passport (BP) initiative incorporates several innovative strategies:

<u>Integration of different stages of supply chain</u>

- Participants in the automotive supply chain negotiate product specifications and terms with suppliers and customers, adhering to legal regulations and company policies.
- The Battery Passport, akin to a passport for a product, serves as a trustworthy certificate of a product's identity and key characteristics, crucial for the product's acceptance and handling in the manufacturing process.

- The Battery Passport allows for efficient data gathering and reuse, aiding economic operators in making informed choices. Responsibility for compliance with battery passport provisions lies with the operator placing the battery on the market, with provisions for delegation of updating information to other operators.

These enhancements provide a comprehensive view of the BP's business model, its impact across different stakeholders, and its potential to transform the automotive industry.

Customer Strategies:

- Product Sales and Subscriptions: Revenue generation through product sales, and subscriptions for data services related to battery health monitoring and energy management systems.
- Customer Satisfaction and Loyalty: Focusing on enhanced customer satisfaction to foster brand loyalty and long-term customer relationships.
- Operational Cost Reductions: Streamlining existing processes, leading to cost savings.
- Transaction Fees: Implementing fees for “addon-services”, e.g. for certification or transaction services within the ecosystem.

Ecosystem Integration:

- Wider Platform Business Model Potential: The Battery Passport initiative can be integral to a broader ecosystem encompassing energy management, smart homes, automotive services, and renewable energy solutions.
- Roles Within the Platform: Entities may assume roles as platform operators, data providers, service integrators, and third-party service providers.

Relation to GIO Industry-specific Ecosystem Concepts:

- Ecosystem Approach Benefits: Enhanced collaboration and data sharing among diverse industry players.
- Platform Business Model Potential: Integration of various services and products centered around battery lifecycle management.
- Trusted Data Sharing Necessity: Essential for maintaining transparency, compliance, and consumer trust.

Business Case Components:

- Energy Management Systems: For battery health monitoring and connectivity to green energy supplies.
- Energy Storage and Provision: Catering to diverse sectors like data centers, smart homes, and car charging stations.
- Recycling and Re-Use Services: For batteries, linking with applications like car charging stations.
- This business model leverages the ecosystem approach, offering diverse revenue streams and strengthening the value proposition for all stakeholders involved.

8.4.1.7 Further information and references

www.catena-x.net - the first open and interoperable data ecosystem giving transparency and provide an environment for the creation, operation, and collaborative use of data chains along the automotive value chain.

European Commission (March, 2022). Proposal for a new Ecodesign for Sustainable Products Regulation (ESPR).

https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products-regulation_en

European Union (July, 2023). Regulation of the European Parliament and of the Council concerning batteries and waste batteries, repealing Directive 2006/66/EC and amending Regulation (EU) No 2019/1020.

https://eur-lex.europa.eu/eli/reg/2023/1542/oj

https://thebatterypass.eu/resources/ - Battery Passport Content Guidance – separate publicly funded project by the German Federal Ministry for Economic Affairs and Climate Action with excellent resources on the EU battery regulation and the battery passport.

9 Conclusion

This paper has explored various aspects of ecosystems as they relate to digital transformation in vertical industries in general, with a specific focus on the manufacturing, healthcare and automotive industries.

Abstract models such as those produced by the London Business School and TM Forum can help provide an understanding of how ecosystems are constructed and operate in different industries. The efficacy of ecosystems in creating value within a vertical depends on how that vertical is typically organized, and how organizations within the vertical interact with each other. These models also provide a decision-making framework which players can use to decide how they should participate within the ecosystem, and interact with other players.

New opportunities within a vertical industry can be modelled and analyzed using the Digital Services Innovation Framework, which helps to prioritize new technology-driven use cases and design appropriate business models to bring these to market – often involving multiple ecosystem players.

A key enabling element of any ecosystem is the free-flow of knowledge and data between ecosystem players. This area has attracted the interest of regulators, for example within the EU and China, with a view to creating an environment where trust can be created to facilitate the free flow of data with appropriate controls. Initiatives such as IDS, Catena-X and Gaia-X aim to create practical systems for the safe and controlled sharing of data within an ecosystem.

Within some ecosystems, platforms have a significant role to play in enabling and encouraging the growth of the ecosystem. Platforms can facilitate smaller, innovative players to bring their solutions to market, by lowering barriers to entry. Marketplaces and shared platform services make it faster and easier to launch solutions, whilst strong governance ensures equity and positive behavior on the part of participants.

In this white paper, the manufacturing, healthcare and automotive industries were used as exemplar verticals, exploring the unique needs of their customers/users with regard to digital transformation and ICT products and services. A number of real-world case studies were explored in some detail, kindly contributed by GIO participant companies.

This paper has illustrated the importance of ecosystems for encouraging innovation and promoting growth within a vertical industry. It has provided tools which can be used to analyze the maturity and needs of ecosystems, thus helping organizations to plot a path towards success within their respective industries.