Going Digital First while Safeguarding the Physical Core: How an Automotive Incumbent Searches for Relevance in Disruptive Times

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Abstract

Incumbent firms typically face significant risk of losing the relevance of their physical core when facing industry disruption driven by digital technologies. Existing literature emphasizes a digital first approach, whereby firm offerings are fundamentally redeveloped from a digital point of view, from the point of conception. While this prescription can help accelerate innovation, it does not tell us how incumbents might safeguard the relevance of their traditional physical core resources when going digital first. This is important, since major discontinuities in strategic repositioning, while often celebrated in digital innovation and transformation literature, create significant risks to firm survival. To this end, we conduct a grounded analysis of a European automotive firm's innovation journey over an eight-year period. We contribute to the digital innovation and transformation literature by developing a process model explaining how a digital first approach can be employed in a way that also safeguards the physical core.

Keywords: Digital first, digital innovation, digital transformation, incumbent firms, phygital

Introduction

"We used to have an invincible competitive advantage in our drivetrain for decades—our drivetrain is the best one in the industry. But due to electrification and autonomy, that whole differentiation advantage will completely fall away in [a few] years. Anyone can build an electric engine, and no one cares about your drivetrain anymore. We need to find other things that keep us relevant even though the competition is increasing so fast."

----Director of the Innovation Office at Alpha

The digital innovation literature identifies unique properties that distinguish digital products from traditional nondigital market offerings, such as reprogrammability, malleability, generativity, and a zero marginal cost of reproduction (Yoo et al., 2010; Yoo et al., 2012; Henfridsson et al., 2018). These attributes imbue digital born/only companies (e.g., Facebook, Google, Alibaba, Airbnb, Uber), with particular innovation dynamics that build on the flexibility and scalability of their digital core (Huang et al., 2022).

However, as digital technologies are becoming increasingly pervasive beyond the digital space, fusing with and fundamentally reshaping the "real" physical world (Nambisan et al., 2017; Baskerville et al., 2020), and impacting many organizations in society, our understanding of digital innovation needs to evolve and expand, particularly in relation to the physical world, which is typically backgrounded in the digital innovation literature (Baiyere et al., 2023; Cennamo et al., 2022; Yoo et al., 2012).

This is particularly noteworthy given the extensive digital innovation occurring in incumbent firm settings, such as manufacturing, where firms are increasingly exploring digital opportunities while also responding to new competitive threats stemming from digital technologies (Svahn et al., 2017; Oberländer et al., 2021; Sandberg et al., 2020). A key challenge for these firms is how to extend competitive advantages tied to their legacy *physical core*—a set of technologies and related resources that are often closely tied to the production of physical products (Drechsler et al., 2020)—to the digital space. Indeed, incumbents failing to combine digital and physical in a synergistic way run a risk of facing a situation where they lose position in both existing and emerging markets when embracing digital technologies (Svahn et al., 2017; Sebastian et al., 2017; Warner and Wäger 2019).

To cope with this risk of losing relevance, recent literature has emphasized a 'digital first' perspective to navigate the innovation process of incumbents (Baskerville et al., 2020; Yoo and Euchner 2020). Digital first refers to the fundamental redevelopment of market offerings from a digital point of view, from the point of conception (Yoo and Euchner 2020). In theory, this does not mean that there are no 'physical' dimensions of digital innovation; instead, digital innovation creates value only if it is contextualized in specific time, place, artifacts and actors in the physical world (Yoo et al., 2012). At the junction of this line of research, digital transformation literature further notes a significant organizational shift from a product-oriented to ecosystem-centered value creation logic over such digital first transition (Sandberg et al., 2020; Parker et al., 2016; Gawer 2014), which triggers inescapable tensions requiring ambidextrous management (Svahn et al., 2017; Gregory et al., 2015; Drechsler et al., 2020).

Yet, we know little about how incumbent firms might safeguard the relevance of their physical core when going digital first. This is important, since major discontinuity created in such strategic repositioning, while often celebrated in digital innovation and transformation literature, create significant risks to firm survival (Oberländer et al., 2021; Drechsler et al., 2020; Warner and Wäger 2019). Hence, we focus on the following research question:

How can incumbents embrace a digital first innovation approach while at the same time safeguarding the relevance of their physical core technologies?

We draw on an in-depth case study of Alpha, an incumbent automotive OEM, and its on-going journey to search for relevance in relation to the digital disruption characterizing the transportation industry setting, most notably shaped by autonomy, connectivity and electrification (ACE) technologies that provide new competitive dynamics as well as opportunities. Taking ambidextrous management as an analytical lens (O'Reilly and Tushman 2008; Gregory et al., 2015), we zoom in on the efforts made by key units and their most salient innovation projects at Alpha between 2015 and 2023, to examine the ways in which the firm continuously strives to reinvigorate the established resources for motor vehicles while embracing ACE technologies.

Our findings offer several valuable insights that speak to the literature on digital innovation and transformation. In particular, we propose a process model that explains how an incumbent can develop a digital first capability that helps it embrace disruptive digital innovation with strategic continuity.

Conceptual Background

Incumbent Challenges in Digital Innovation

Digital innovation refers to the use of digital technology to create novel products (Yoo et al., 2012). Because these market offerings build on digital technology, they have properties that distinguish them from nondigital products (Lehmann et al., 2022; Nambisan et al., 2017; von Briel et al., 2018). In particular, while incumbents in industrial settings earned their competitive positions on the basis of a 'physical core' that consists of rare, inimitable, and non-substitutable resources (Barney 1991) with a fixed product boundary, companies competing on the basis of a "digital core" in their market offerings (Huang et al., 2022) use a set of digital resources (i.e., digital technology components) that exhibit a 'difference-in-kind' versatility (Yoo et al., 2010) that can be repurposed into new business areas with low adjustment costs (Henfridsson et al., 2014; Nambisan et al., 2017). Consequently, digital technology creates disruptions that force incumbent firms to alter the value creation paths they have previously relied upon to remain competitive (Vial 2019).

Specifically, digital innovation often builds on value created through the decoupling of product functions from their related physical form or device (Yoo et al., 2010). This breaks with the traditional wisdom that value is embedded in products; instead, value creation occurs when a digital or physical resource is recombined, extended, and re-invented, often in an *ad hoc* network with other digital and physical resources in a particular context (Lusch and Nambisan 2015; Yoo 2010). Hence, architectural innovation is often required as not only the individual digital/physical offering is developed, but the relationship/interfaces between a set of digital/physical resources (Lyytinen et al., 2016; Henfridsson et al., 2014). For example, the combination of location-based mapping systems, mobile clients and sensor networks makes a physical vehicle an integrated part of an intelligent city transportation solution that responds to different travel demands in a specific time and place.

We know from previous research that the innovation processes required for such architectural innovations to materialize are characterized by horizontal relationships/ anarchic digital innovation networks (Lyytinen et al., 2016), or innovation ecosystsems (Adner, 2017; Jacobides, 2018), where a myriad of previously unconnected actors (e.g., hardware device manufacturers, software companies, content providers, etc.) weave together their individual offerings, business models, and technological architectures to develop a coherent, customer-facing solution (Jacobides et al., 2018). These new collaboration forms disrupt the actors' assumptions of a taken-for-granted product and its ecology (Boland et al., 2007). Here, the anchoring point is the system of innovations that materialize a focal value proposition, rather than what a firm is to deliver (Adner 2017). Accordingly, an incumbent firm' physical core has to be fundamentally revisited and rooted in broader innovation ecosystems in order to extend its relevance to value creation in digital innovation. Failure to do so might place a physical core at the risk of becoming obsolete and even a burden for incumbent survival in their transformation journey (Drechsler et al., 2020; Oberländer et al., 2021; Svahn et al., 2017). The challenging question is then how incumbents can strategically reposition their core and themselves in a competitive landscape of digital innovation.

Digital First to Maintain Relevance

To cope with the risk of 'losing relevance' in the digital age, emerging literature highlights the digital first perspective (Yoo and Euchner 2020) as a means to navigate the innovation process of incumbents. Focal to this perspective is a rethinking of the physicality of digital innovation and the importance of physical core in the process. As Yoo and Euchner (2020) notes, 'at the end of day, it is not a pure digital experience that really matters because most companies cannot create and capture value unless their offering is consumed by users, and that consumption requires some conversion of digital information into a physical manifestation' (p.12). This echoes to the recent viewpoint on digitization that digitized objects (e.g., app, music) always build on specific material bearers (e.g., cell phone, audio equipment) in real word, which embody or enable the storage, manipulation, transmissions, and presentation of digital information (Baiyere et al., 2023; Piccoli et al., 2022). In this regard, incumbents' physical core has a potential to maintain usefulness and serve as a strategic leverage point in digital innovation. The question then is how to renew the physical core in a way that can be leveraged to create new value when exploring new digital opportunities.

To this end, the physical core should be redeveloped from a digital point of view from the point of conception (Yoo and Euchner 2020). Such digital first repositioning holds a potential to generate value through 'hybrid' offerings that are distinct from purely physical- or digital-underpinned offerings. As an example, Oberländer et al. (2021) note the possibility to draw upon connectivity, data collection and insight generation technologies to exploit physical products for new connection value, including remote monitoring and proactive services building on new combinations of physical and digital technology. In a similar vein, Svahn et al. (2017) explain that Volvo vehicles can be repositioned as a digital platform in multisided markets by tapping into other business transactions (e.g., good delivery service) and existing innovation ecosystems (e.g., consumer electronics) to fulfil modern car owners' desire to remain constantly connected while driving. In both cases, the product meaning is fundamentally reshaped to an ecosystem keystone that fulfil a package of disparate, evolving and integrated services for a focal business setting (Wang et al., 2022).

In this regard, while digital first brings a physical dimension back to digital innovation, it implies a major strategic discontinuity in incumbent firms through introducing qualitatively different market offerings. However, we still have a significant gap in our understanding of how this digital first approach could be enacted in a way that safeguards incumbents' physical core at the same time. Addressing this gap in the literature is important because it facilitates to avoid a narrow view of digital innovation as an activity that predominately takes place in digital-born firms. Unpacking this process can enrich our understanding of the diversity of mechanisms at play in digital innovation setting beyond the tech giants (e.g., Facebook, Alibaba, Google) of today.

An Ambidextrous Approach to Digital First

While the ambidexterity literature has been largely disconnected from 'digital first' and digital innovation studies, it suggests a possible path to pursue a digital first approach. In particular, the extant digital transformation literature (Gregory et al., 2015; Svahn et al., 2017; Warner and Wäger 2019) emphasizes ambidexterity as a necessary capability for incumbent firms to navigate this repositioning process and extend their competitive advantage tied to the physical core in a digital world. At the heart of this capability, incumbents must simultaneously exploit existing resources and explore new opportunities (O'Reilly and Tushman 2008).

Prior research describes two different logics to achieve an ambidextrous management. In one long-established stream of studies, exploitation and exploration are devoted to two conflicting yet interrelated business goals, treating the exploitation occurring upon existing resources as separate from the exploration of new values based on novel resources (Tushman and O'Reilly 1997; Smith and Lewis 2011). Another emerging stream of studies instead regard exploitation and exploration as only seemingly contradictory and as being harmoniously combinable (Gregory et al., 2015; Oberländer et al., 2021). Under this blending perspective, incumbents can shape a sophisticated fused solution to achieve ambidexterity, which echoes to the underlying logic of digital first perspective. Hence, in this study, we draw upon this blended ambidexterity as an analytical lens to trace and understand how an incumbent firm goes digital first with strategic continuity.

Method

Given our aim to develop theory about what a digital first approach involves in the incumbent setting and what incumbent firms do to maintain the relevance of their physical core in the face of digital disruption, we draw on an revelatory case that can provide rich information about the variables of interest in both real-time and post-hoc (Gerring 2007).

Field Setting and Background

The advent of new sources of competition from 'tech-startups' and 'born electric and digital' firms in the late 2010s in the transport industry was not the first disruptive shift experienced by Alpha, a firm having gone several technological transitions. Starting with bicycle manufacturing a century ago, Alpha had developed extensive and world-known expertise in modularized production of engines and vehicles (i.e., the physical core) as an OEM product platform provider. In the 2010s, external pressures to make offerings more environmentally sustainable, and new technological opportunities (electrification and digitalization) contributed to new competitive conditions. Settled in its role as a world-leader in bringing new versions of combustion engine-driven trucks and busses to the market, Alpha faced an identity crisis as they realized they could not rely on their previous competitive advantage in making engine-driven trucks and busses. Indeed, moving towards electrification would not be enough, as virtually every firm would make electrified vehicles. Instead, the 'core' needed to be something else, the question being: what? We got access to key Alpha units/departments and initiatives where employees were trying to take steps towards answering this question and engaging in a series of innovation experiment projects launched since 2015. The process through which Alpha made efforts to maintain the relevance of its physical core in the face of the new technological opportunities constitutes the case on which we focused.

Data Collection

We employed a combination of interviews and field observations (in Sweden and Singapore), and document studies. All authors engaged in data collection, although the first and second author performed the most interviews and field observations (in total 65 interviews with 58 individuals) primarily between October 2021 and April 2023 (see Table 1). Key individuals were interviewed several times. All interviews were recorded and transcribed except for a few external partners and governmental actors where we took extensive notes during and after the interviews. We used a semi-structured interview guide including questions about why and how Alpha managed the challenge to ensure existing revenue streams by exploiting their existing assets, while also exploring new sources of revenue by engaging in more radical innovation activities (exploitation/exploration dilemma), and, in interviews with external partners, how the organization in question was collaborating with Alpha, and what activities were key in moving the innovation and collaborative process forward. After every interview and observation, we wrote field notes on interesting emerging themes.

We also observed a range of work settings and activities, including smaller group workshops involving Alpha and partners in Europe and Singapore, collaboration meetings and workshops with a broader set of collaborators, seminars on specific themes held by different partner organizations (the future of smart cities, the future of transport etc.), and roundtable discussions focusing on autonomous transport. Further, we attended conferences on Internet-of-Things (IoT) and the future of transport in Singapore and Europe. Notes were taken during and after the sessions.

Finally, we collected documents in the form of 1) follow-up emails with interviewees and workshop participants; 2) internal documents, newsletters, and website material from the involved organizations and the government, 3) industry reports about transport from consultancies, other governments, websites and trade press analyses. These enabled us to study the context in which the focal process was situated (Suddaby, 2006). Parts of the documentation were confidential.

Interviews
29 interviews with key individuals at the HQ/top management, working at different units (R&D, Sales & Marketing, Strategy, Autonomous solutions, Mobility solutions, eTruck solutions, Smart city solutions). Many of whom were coordinating/engaged in particular exploratory external partnering initiatives (e.g. SIUTS, LOTS, the Autonomous public transport initiative, Alpha Go, Data Mobility, Hub-to-Hub, Urban Bus Mobility). Staff engaged in different Innovation factories, Alpha cross-industry collaboration network, Former employees and Alpha's parent firm. 36 interviews with employees at partner firms and employees at government agencies related to key initiatives (e.g. network firms, start-ups in the ride-sharing/hailing space, telecom firms, governmental actors in transport/road/infrastructure domains) Interviews lasted 60-90 minutes, appr 80 hours in total.
Observations
11 internal meetings on innovation projects. 7 closed partner meetings between organizations (31 pages of field notes). 26 open webinars, talks and on-site seminars on Alpha's innovation experiments in Sweden and abroad.
Archival Material
Email conversations (follow-up discussions) with key individuals (approx. 26 pages). Project proposals, reports and PowerPoints (approx.180 pages). Local documents (protocols, presentations, strategy reports, solution blueprints) from Alpha and their partners, generated in innovation initiatives (approx.140 pages). Documents from governmental agencies, including smart mobility strategy documents, standards updates, reports descripting plans (approx. 700 pages).

Table 1. Summary of Data Collected

Data Analysis

Following a grounded approach (Gioia et al., 2012), we engaged in a multi-stage data analysis that involved several iterations between emerging concepts and consultations of the literature. In line with Gioia et al. (2012), we began with holistic reading and identifying first order codes that were close to our empirical transcripts, notes and archival data. One overall question guided this initial coding: What activities did Alpha perform to understand what role their core assets and capabilities tied to the "Truck" could play in relation to the new digital opportunities and threats?

Early on, we noted the absence of a well-defined, top-down, and organizational level strategy guiding Alpha's efforts to sustain the relevance of (by reframing and adjusting/renewing) their existing core resources. We rather found a set of parallel, local, often interacting activities performed by employees at a set of local functions, as they explored and tested possible development paths and roles for Alpha in the future. In a first coding round, we created lists of the activities that according to our data allowed Alpha to identify how they could explore new digital opportunities while also leveraging their existing core resources. Although performed by different employees at Alpha, this open coding revealed that some types of activities were repeated across units and teams. We clustered the 1st round open-ended descriptive codes (e.g., disconnecting from the firm's R&D perspective, identifying material bearers of an ecosystem solution, investing public and shared network resources that support data generation) into 2nd order themes (i.e., context probing, role probing, physical gripping, resource mapping, digital enabling, and physical embedding). We iterated this process of coding and relabeled the clustered codes (themes) based on consultations of the literature (Gioia et al., 2012).

We searched the literature for relevant ways of framing the process. Literature on digital innovation, transformation, and ambidexterity helped us forward but not entirely explain what we observed. Hence, we continued to engage in an inductive analysis of the data, going back to and writing memos of interesting themes tied to key interviews, and iterating with the literature.

At the end of this step, we arrived at a conceptualization including three aggregate dimensions (Gioia et al., 2012) representing three key processes: ecosystem probing, physical anchoring, and phygital infrastructuring. We performed additional interviews to gather more data about and refine the definitions of our tentative dimensions, and confirmed their presence over time and across units/cases.

In the final step of analysis, we specified and conceptualized the possible relationships between the three key processes; these relationships were indicated by the earlier substantive analysis and were, therefore, highly fitted to our data. We conceptualized the three processes as generative mechanisms (Henfridsson and Bygstad 2013) explaining how Alpha maintained the relevance of the existing resources tied to their physical offerings, while also pursuing new digital opportunities in the future landscape of digital transportation. We also identified the interplay among these mechanisms and the contextual forces at play, and traced the consequences in terms of new design patterns (Nambisan et al., 2017; Henfridsson et al., 2014) shared among products, services and capabilities that Alpha was developing and commercializing in different innovation initiatives. These design patterns serve as a generalized solution to a commonly occurring problem (e.g., how to safeguard the relevance of an OEM's physical core in future transportation settings in our case). The outcome of this stage helped us generate a conceptual model of digital first pursuit at incumbents in Figure 1.

Developing a Digital First Approach in the Incumbent Firm: The Case of Alpha

Alpha earned its position as a leading original equipment manufacturer (OEM) in Sweden after decades of development. However, the recent advance in digital technology underpinning autonomy, connectivity, and electrification (ACE) developments placed the company in a new position, wherein the preexisting assets and capabilities developed around truck production began losing their relevance in relation to the future expected competitive landscape. To rebuild the firm's relevance in this disruptive time, Alpha initiated a series of innovation experiments to redevelop their market offerings from a digital point of view. Below, we present the three practices that together composed the mechanisms driving this digital first process in Alpha between 2015-2023. We illustrate the practices with examples from two key innovation initiatives, although the practices were present across all innovation initiatives studied. (More data available upon request).

Ecosystem Probing

The first practice that had a salient role in Alpha's digital first pursuit was what we refer to as *ecosystem probing*. In this practice, Alpha disconnected from its internal R&D perspective when making sense of new technological opportunities (i.e., digitally-enabled solution spanning disparate products and firms), and took a systematic point of view to probe various demands in the wider innovation ecosystem in transportation. Approaching the 'system' rather than departing from internal pipelines was however not what Alpha was used to doing; "we need to learn this so that we can find out what needs we should try to care about", as a partnership manager said. To this end, Alpha engaged tentatively in a large set of external collaboration initiatives, often driven locally by different internal departments, thereby gradually learning what a "system" or "ecosystem" approach meant and what it could look like. Examples include the LOTS initiative in (2015) and Alpha Go (2017), where Alpha engaged in novel kinds of partnerships, including new partners and a new kind of openness to their own contribution (data available on request). A particularly illustrative example occurred in 2021, when the innovation office at Alpha initiated the SIUTS (Sustainable & Integrated Urban Transport System) project aiming to "develop a sustainable and efficient way for urban freight transport" (SIUTS project plan). The SIUTS project was located in the R&D center of Alpha, which by tradition explored new possibilities from a technology-centric perspective, departing from the in-house capabilities and next possible version of existing product lines. In contrast, the SIUTS project took another approach: reorienting the exploration away from an existing, internal and product-centric roadmap to an experimental, external, and solution-centric path. However, taking this new path was challenging because there were no available guidelines regarding how to depart from a 'system' view, or how to 'explore and understand the ecosystem'. Hence, the SIUTS members experimented with a set of activities aiming at understanding the stakeholder needs and positions. "Empathizing workshops" represented one such activity, where the SIUTS project engaged more than 30 practitioners i.e., from OEMs, transport companies, food suppliers, municipalities, digital service providers, technology companies to understand their everyday working lives, needs and expectations. By doing so, the SIUTS project took an outside-in perspective to explore opportunities afforded by new digital technologies. As described by the project director:

> *We want to understand the transport system. If you want to look into the change in that area of space, then you cannot be tech-focused. And Alpha is always oriented around the technology, at least in R&D. So then we need to push our limits and see our opportunities beyond the knowledge space we have today…We need to be creative and add on good ideas and build great ideas together with external partners that share the same vision and see the same future. Otherwise, we just build another nice truck again which we are quite good at before.*

Although the outwards focused activities were unusual and somewhat uncomfortable and awkward for the participants, they generated significant insights. For instance, in one of the 'switch hat' exercises run by the SIUTS project in October 2022, 14 ecosystem actors were asked to list the needs and benefits of another actor in relation to the vision of running urban transport in a radically new way. The meeting ended with the participants understanding what the new solution could actually mean and look like, and what could be the potential role of digital technologies in these solutions. Other activities iterated in other initiatives (e.g., urban passenger transport vehicle in the future launched in 2016; Urban bus mobility solution launched in 2018) similarly taught Alpha about the opportunities afforded by new digital technologies in relation to the highly varied needs among the multiple ecosystem participants involved in a focal business scenario.

The multiple ecosystem initiatives also provided Alpha the possibility to experiment with different roles in relation to those ecosystems and solutions. Despite its leading position in truck manufacturing, Alpha made great efforts to be flexible and humble when approaching the new value proposition tentatively discussed among diverse stakeholders in a focal business scenario. Specifically, while Alpha has strong barging power in the traditional supply chain of vehicle production, it is no longer the case when developing radically new solutions with vast scope and scale, such as "a sustainable and efficient urban transport system". This is because lots of new requisite resources and capabilities are controlled by the outside world. As such, the interaction mode with external partners changed from hierarchical, one-to-many relationship to many-to-many relationships including mutual dependencies that recast the historical roles and supply chain deliverables of the stakeholders involved, and required new and more coordination efforts from different stakeholders. For example, in on-road charging service for autonomous truck transport, "Alpha is no longer the important one; It is the energy suppliers who set the rules and tell us what we need to in order to be able to integrate with their charging station", as a product manager explained. In this process, Alpha experimented with multiple commitment modes in the different projects it engaged in. For instance, when the customers already developed some knowledge on autonomous haulage transport in mining industry with a third-party supplier of transport management system, Alpha decided to integrate with their existing system as a partner for the final solution development. In another innovation initiative aiming for a quite radical solution: “a fully autonomous public transport solution” for the city-state of Singapore, Alpha shared the orchestration role with other partners in a dynamic fashion for leveraging their expertise in developing vehicles with in-built intelligence and self-driving functionality. The manager in autonomous solution department explained,

> *I don’t think we will be able to rule the world and deliver all the transport solutions to everyone everywhere. At times, we will need to be as we are today, supplier of vehicles and somebody else will deliver the driver. But sometimes we will need to integrate into the whole system. And I think we need to be open to different ways of innovation as a partner or leader in new ecosystems, depending on the region, the situation in that area, and how different partners act.*

Physical Anchoring

An increasing understanding of stakeholder demands in the wider transportation system opened up a broad solution landscape for Alpha to dig into, including digital trucks, fleet management, on-road service, digital road freight management, transport management systems, and digital supply chains. It was therefore important for Alpha to choose which racing tracks to contribute to. In this process, one key criterion that different initiatives used was the possibility to locate the physical foothold of the digital-enabled solution, wherein Alpha’s preexisting resource base could be leveraged. We refer to this kind of practice pattern as *physical anchoring*. In the example of SIUTS project, this manifested in a specific physical design package focused on purpose-built vehicles, dynamic storage points, modularized load carriers, and their necessary connectivity and automation capabilities that enabled the consolidation of fragmented fright flows over time and space. As explained in the SIUTS project executive summary:

> *With digitalization in the transportation industry, goods must still be moved physically by vehicles in the future, which in many ways will differ from today’s solution. For example, autonomous multipurpose vehicles that can be modularized into different shapes and sizes are required for 24/7 delivery services in cities. As the vehicles go through this transportation process from shippers to receivers, it potentially becomes the data platform to enable and integrate diverse in-vehicle (e.g., connected goods, box solution for refrigerated goods) and out-vehicle (e.g., last-mile off-peak delivery, joint loading) services.*

Many members in Alpha’s innovation initiatives underlined that identification of material bearers was an important means to create linkage between emerging ecosystem solutions and the resources underpinning Alpha’s existing physical offerings. This insight emerged in early initiatives such as LOTS (2015) only to become reinforced over time. For instance, instead of reinventing a multi-purpose autonomous vehicle inspired by ecosystem probing from scratch, Alpha could largely draw upon its existing modular system to adapt the truck loading components for different pickup and delivery solutions, upon which requisite autonomy-specific components such as cameras, lighters and raiders were integrated by Alpha or partners to provide self-driving capability. Similarly, Alpha's expertise in modularization (e.g., partitioning complex systems, hiding internal components and focusing on interfaces) was also useful in the generation of ideas about how new kind of seats, self-cleaning components, or in-vehicle cameras (produced by Alpha or external partners) could be added or removed to public transport buses, and how interfaces could be developed to those new components.

Meanwhile, the new digital capabilities specified for the functioning of material bearers drove Alpha’s attention to the need to also renew existing IT resources locked in existing physical offerings. A salient example is the reassessment of the role of truck data for Alpha’s value creation. Previously, the abundant data from truck fleets (e.g., about driving behaviors, transport patterns, fuel consumption) were only created and used by the R&D department to improve the product design internally. However, with the new demand for connectivity emerging across innovation initiatives, there was a growing consensus in Alpha that truck data was a prerequisite for new kinds of externally provided services, requiring extensive access by and interoperability with partners and clients in any transport solution. A similar renewal demand was evident in the Singapore transport initiative, wherein Alpha and external partners invested heavily in discussing how existing data ownership architectures and existing data generation hardware (sensors, cameras) tied to specific vendors and product lines needed to change, to allow the data to be partly and safely shared in order for transport to be optimized in cities. In doing so, Alpha took the first step to link new digital opportunities back to its established core business. As emphasized by a senior manager:

> *The mission of these innovation initiatives is not just about 'exports', saying that we give away our hours and resources free and build new competence in others' businesses. More importantly, we also need to take back value to Alpha and leverage our resources to see how we can use them to speed up the transformation towards new technologies, so we can invest in them by ourselves.*

Phygital Infrastructuring

To make existing resources relevant to the future digital world, Alpha reconfigured and connected its resources to wider infrastructures including both physical and digital layers, which were intended to serve as the foundation of the aimed digital solution demanded by the wider transportation ecosystem. We refer to this third practice as *phygital infrastructuring*. In each innovation imitative we traced at Alpha from 2015-2022, this practice proceeded through two parallel activities over time. In the first activity, Alpha redeveloped its trucks into more open data sources able to generate data insights to multiple diverse stakeholders in the transportation ecosystem. For example, in the SIUTS project, Alpha worked with logistics analytics companies to test different sensor technologies for creating entirely new data that did not exist in the current transport system. Alpha actively developed open APIs and communication standards to make the new data connect seamlessly with other stakeholders' offerings. Both endeavors were supported by large investments in the wider infrastructure required in areas of expected implementation of the aimed for sustainable urban freight transport, such as control towers (operation centers for remote monitoring), location-aware devices for truck tracing on roads, and city transfer hubs with smart blocking systems. Together with its external partners, Alpha thus moved towards building a public, shared digital layer upon and interacting with the physical layer, which supported collective data creation and collection for the functioning of future transport solution (see Appendix A). As explained by the SIUTS project manager:

> *Obviously, our customers always have different brands of trucks and use different partners' services. So, if we try to sell this as an Alpha solution only, nobody is going to buy it. Hence, it is necessary to make our truck interoperable with different types of services that you can get. To this end, we need to open, standardize and industrialize the digital infrastructure [referring to the wider digital infrastructure beyond Alpha's internal digital infrastructure] as much as we can in the back end so that we have the flexibility to serve different needs and adapt to specific frontend data-driven solution for almost every customer.*

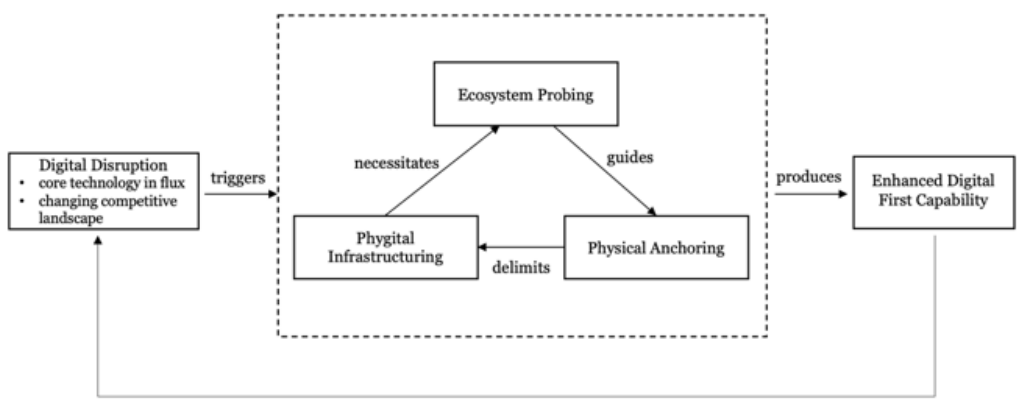
In the second activity, Alpha actively tapped its 'digital truck' into the key stakeholders' individual transport systems. For instance, the SIUTS project developed and tested an unmanned delivery solution in a city by building upon the existing delivery systems of multiple digital logistics partners. Here, Alpha integrated its truck management system into the major end-receivers' good management system and store terminal system to further provide an unmanned reception solution for customers. In addition, Alpha made agreements with the main energy suppliers in Stockholm city to integrate with their battery charging stations so that the Alpha trucks were supported by a reliable and attractive on-road service during freight transport. As such, Alpha embedded its digital truck into the whole loop of an urban transport solution, a firm step to transform Alpha's existing offering as a key building-block of future digital transportation ecosystem.

In the initiative for autonomous public transport for Singapore, efforts were further made to specify how Alpha's self-driving vehicles would plug into the Singapore government's (Land and Transport Agency) existing intelligent transport system (ITS) system. The ITS system included cameras on roads and a remote monitoring center where operators were notified of divergences/accidents on roads. Further, expanding its in-vehicle communication, Alpha and partners made efforts to ensure vehicle-to-vehicle and vehicle-x communication fitting with and extending Singapore's existing physical and digital infrastructure. This required Alpha to adjust to emerging standards and other partners' preferences since there were no agreed standards for communication between vehicles produced by different vendors at the time. As a manager in data & mobility services noted:

> *We have a particular emphasis on partner-driven services. Instead of using in-house development for customers, they are more about how we can make our technology work with other market stakeholders' technologies, and what solutions we need to coordinate together to make a complement system. By doing so, we will make sure that there is infrastructure ready for you to start operating, and we are the people who know how to service autonomous vehicles. So, we kind of become the core platform that provides everything to support your functioning and it is through us that you will make money.*

A Process Model of Going Digital First with Strategic Continuity

Our inductively derived model shows how three recursive mechanisms—*ecosystem probing*, *physical anchoring*, and *phygital infrastructuring*—together produced digital first product through which Alpha strives to stay relevant in the digitally driven industry transformation. Figure 1 provides an abstracted visual illustration of the model. We define and discuss the general operation of the three mechanisms below.



Concept	Definition
Ecosystem Probing	The process by which an incumbent senses new technological opportunities in wider innovation ecosystems.
Physical Anchoring	The process by which an incumbent creates bridges between emerging ecosystem solutions and its core resources tied to physical offerings.
Phygital Infrastructuring	The process by which an incumbent makes the physical footholds it developed a part of the phygital infrastructure underpinning emerging ecosystem solutions.

Figure 1. A Process Model of Going Digital First with Strategic Continuity

Defining the Three Mechanisms

At a general level, the mechanism of *ecosystem probing* refers to the process by which an incumbent senses new technological opportunities in wider innovation ecosystems through *context probing* and *role probing*. First, *context probing* involves activities through which the incumbent understands and defines future demands in multiple but specific innovation ecosystems. Second, *role probing* involves activities through which the incumbent experiments with multiple, parallel participation roles in different innovation ecosystems.

Alpha's ecosystem probing echoes past studies suggesting that digitalization spurs change in an incumbent's organizing logic (i.e., the rationales that product organization offers product functions or services) from an internal production-oriented logic to an external ecosystem-centered logic (Gawer 2014; Sandberg et al. 2020; Svahn et al. 2017). Dominating as an OEM product platform for decades, Alpha was used to working with a set of stable, shared internal resources to create derivative products characterized by a fixed feature scope and market boundary (Nambisan et al., 2017). However, digital technologies open new options for solutions design at ecosystem level (Adner, 20 Jacobides et al., 2018), where both the scale and scope of the innovation are extended beyond single product architecture to loosely coupled product systems spanning traditional industrial boundaries (Lyytinen et al. 2016; Nambisan et al. 2017). In this regard, a digitally-enabled ecosystem solution requires new collaborative arrangements around a layered modular product architecture (Yoo et al., 2010), wherein an array of individual offerings (i.e., digitized products and services) are developed and integrated into a joint, focal, customer-facing value proposition in a real-world context, a contextual embedding process highlighted by Lyytinen (2022).

As Alpha probed the wider demand landscape in transportation industry, it actively engaged in both orchestrator and follower roles in different innovation ecosystems, which is rarely noted in innovation ecosystem literature. While emphasizing the relevance for firms to participate in digital ecosystems, the literature implicitly assumes that firms pursue one rather than multiple different roles when building or approaching ecosystems (cf. Foss and Schmidt, 2022; Lingens et al., 2020) In particular, prior studies implicitly point at the orchestrator role, encouraging firms to strive for network effects and winner-take-all outcomes in digital markets (Parker et al., 2016; Henfridsson, 2020). Given its governance role in an ecosystem, the orchestrator therefore enjoys significant advantage in value capture by reaping the lion's share of gains in an ecosystem. However, the orchestrator also incurs the difficult task of attracting and incentivizing autonomous participants to act in ways that align with the focal value proposition (Gawer 2014). In the case of Alpha, however, the incumbent probed innovation ecosystems mainly from a value creation perspective, that is, a strong aspiration to be part of a coherent, digitally-enabled solution supported by various complementary offerings together. To this end, being open to the role it may take enables the incumbent to explore multiple ecosystems, through which the incumbent can potentially learn how to redefine and refresh its offerings in a new relationship to other participants' offerings. In other words, ecosystem probing serves as a means to explore the versatility (Huang et al., 2022) of existing resources in the future demand landscape to the maximum.

Physical anchoring refers to the process by which an incumbent creates bridges between emerging ecosystem solutions and its core resources tied to physical offerings through *physical gripping* and *resource mapping*. First, *physical gripping* involves activities through which the incumbent locates the physical footholds of emerging ecosystem solutions. Second, *resource mapping* involves activities through which the incumbent maps existing resource base (e.g., technologies, hardware, software, data, partner relationship) to potential physical footholds it is able to develop. Together, these activities let the ecosystem solutions inform the redesign of physical artefacts in a way that makes the incumbent's offerings of the key physical foothold in innovation ecosystems.

Alpha's physical anchoring was based on the fact that every digital innovation has one or more material bearers (Baiyere et al., 2023) that form the backbone of value creation and capture. Material bearers include IT assets[1] in terms of physical computing systems that enable the storage, manipulation, and transmission of bitstrings in terms of cost, speed reliability and so on (Baiyere et al., 2023), and more generally, the physical footholds that enable a conversion of digital information into a physical manifestation which can be consumed by users in the real world (Yoo and Euchner 2020). For instance, digital insights about the consumer demands are converted into design and become a physical product which is of value to users. Anchoring to the physical footholds commonly shared among different innovation ecosystems is vital to rebuild the relevance of incumbents in two aspects. First, apart from thinking of it as a concrete materialization as in prior studies, a physical foothold can also serve as a design pattern that is part of a generic solution to a recurring demand (Henfridsson et al., 2014). In the case of Alpha, multiple requisite physical footholds (e.g., rebuildable truck, smart loading machines, city hub ideas) are identified to provide a high-level, generic description of how to move goods or people from place A to B. These physical footholds have an abstract function, suggesting a cluster of patterned operations, purposes, services or components

[1] We define IT as the tangible resources including data, software and programs that are locked into the firm's physical systems, while digital is informational entities, modularized and exposed through a programmatic, non-material interface (Piccoli et al., 2022).

to respond to a commonly occurring demand across ecosystems (e.g., urban delivery, highway transport, unmanned transport, urban mobility). Firms, therefore, can materialize and specialize a generic design pattern in different settings by recombining it with other design patterns in a contingent fashion (Henfridsson et al., 2014). As such, physical footholds are the building block of value creation in broader innovation ecosystems, no matter what focal value proposition in question.

Second, when instantiating these abstract patterns or concepts into specific settings with actual products, the incumbent can get clear clues to link the new artifact design back to its wider set of resources (e.g., organizational, physical, IT) tied to its physical offerings. This occurs as the incumbent finds ways to reuse existing resource base in the further development of its products as part of identified physical footholds, which in turn often requires the renewal of those resources. For instance, in the setting of unmanned city deliveries, Alpha could rapidly adapt existing trucks running in the city to multi-purpose vehicles by reusing expertise embedded in their modular development system. At the same time, the unmanned requirement helped Alpha figure out the new digital capabilities (e.g., connectivity, autonomy) to develop, which required to lift its emerging expertise in robotics and adjust its data resources to be more open and interoperable. Together, this helped Alpha to rebuild the relevance of its physical offering to support future transportation landscape. In this regard, physical anchoring enables an incumbent to not only leverage its legacy production resources that have economics of scale advantage, but also develop specific digital resources that can maximize value creation when combined with the leverageable legacy resources. Accordingly, physical anchoring helps an incumbent to seek out a most relevant development path that continually exploits existing resources in an open-ended landscape of digital innovation.

Finally, *phygital infrastructuring* refers to the process by which an incumbent makes the physical footholds it developed a part of the physical and digital infrastructure that contributes to the functioning of emerging coherent, customer-facing ecosystem solutions. This occurs through *digital enabling* and *physical embedding*. First, *digital enabling* involves activities through which the incumbent reconfigures existing resources to make the physical footholds it developed as the open data source for generating digital insights shareable among diverse ecosystem actors. Second, *physical embedding* involves activities where the incumbent reconfigures resources to tap the physical foothold it developed into broader ecosystem actors' individual offerings. Together, these acts of inviting/ 'letting in' (pull) and plugging into (push) broader external actors' resources respectively facilitate the renewal of the incumbent's offerings by serving as the junction wherein physical use experience is converted into digital insights and vice versa (Cennamo et al., 2022). As such, the incumbent's product changes to be the foundation to create computed use experience (Baskerville et al. 2020) in an industry transformed by digital technologies.

Digital enabling is not a simple digitizing process through which a physical information-carrying object is converted into bitstrings. In such situations, digitizing is primarily an internal process following an engineering paradigm where a digital object is created to represent physical activities and objects in the real world. In the automotive industry, for instance, OEMs created anti-lock braking systems that use sensors to trace the brake pressure to prevent the wheel from locking up, infotainment systems for navigating and voice commands, and telematics systems for monitoring vehicle performance and driver behavior (Henfridsson et al. 2014). In these cases, digitizing generates a 'box' of hardware and software—a tight coupling between bitstrings, their operations and material bearers—which captures specific flows of data and its processing tied to specific physical products (Baiyere et al., 2023). As noted by Ross (2017), such digitization of 'everything' will not, by itself, make a company a digital business. In the case of Alpha, however, the digital enabling process goes beyond the box in the sense that the digital object (e.g., digital truck with open API interfaces) is accessible to diverse ecosystem actors across contexts whereby the tight connection between digital trace data and its material bearer (e.g., truck) could be broken. In doing so, an incumbent's offerings become the enabler to trigger waves of successive innovation in broader ecosystem contexts, making the incumbent a digital business (Baiyere et al., 2023). In other words, digital enabling goes beyond the creation of digital representation of existing, known products, actors and operations (i.e., digitization) by enabling digitalization (Lyytinen 2022) and generativity (Yoo et al., 2010) wherein a firm's digital resources can be continually used by future, partly unknown users.

To become a fundamental part of the infrastructure of broader innovation ecosystems, an incumbent's offerings not only need to be shareable among and enable users, but also must be physically embodied, scalable and economically sustainable (Piccoli et al., 2022). By engaging in physical embedding, i.e., actively connecting the digitally enabled physical footholds it developed to different actors who occupy the key positions in the flow of activities across an innovation ecosystem, the incumbent leverages its scaled physical resources to tap its offerings into various ecosystem actors' individual products and services. In this regard, physical embedding serves as an interconnecting activity that taps into the value path of other actors. While prior literature in digital innovation conceptualizes such activity as a competitive strategy (e.g., envelopment, piggybacking, path channeling) to capture value from others (Eisenmann et al., 2011; Henfridsson et al., 2018; Parker et al., 2016), we show that an incumbent firm conducts it from a value co-creation perspective whereby diverse actors can draw upon the physical foothold it developed to gain digital insight into users' physical consumption precisely and in a timely way. This, in turn, facilitates to develop a systematic, digital-enabled solution that shapes and creates new user experience in the physical setting.

In summary, we conceptualize the three mechanisms as ongoing and mutually shaping. In combination, they represent a digital first approach involving a continuous oscillation between "reaching outwards" (through ecosystem probing), anchoring inwards (through physical anchoring), and securing and reinforcing one's role in the infrastructural base of emerging innovations (phygital infrastructuring). Specifically, ecosystem probing *guides* physical anchoring by identifying the mismatch between existing physical resources and blanks in identified ecosystem solutions. Physical anchoring further *delimits* the way to execute physical infrastructuring by specifying the physical footholds that the incumbent is able to develop and digitally enable, and delineating the scope of external actors who build upon the developed physical footholds. Over time, the necessity to adapt phygital infrastructuring for the evolving, open-ended landscape of digital innovation (Henfridsson et al., 2018; Nambisan et al., 2017) propels the incumbent to re-probe the broader ecosystems again. In other words, phygital infrastructuring *necessitates* ecosystem probing.

Outcomes of the Mechanisms

The three mechanisms drive an incumbent's digital first transformation. Specifically, the existing physical core technology and related resources are renewed and reconfigured with digital technology and resources to function seamlessly as part of an ecosystem solution (e.g., off-peak delivery, autonomous transport in city), rather than a single, stand-alone product (e.g., a truck). Such hybrid offerings shift from a goods-dominant logic to delivering functions-as-a-service (Lusch and Nambisan 2015) by building upon a repeatable pattern of actions that are shared among different projects—that is, repositioning the physical core to be the foundation of the functioning of broader innovation ecosystems. This *enhanced digital first capability* therefore serves as a generalized principle (Nambisan et al., 2017) to solve an incumbent's 'losing relevance' risk while extending its strategic continuity at the same time by safeguarding the relevance of physical core in multiple future-oriented business scenarios. At overall level, this implies that our work adds to previous work conceptualizing firms' repurposing of resources to new contexts in radical ways that threatens rather than safeguard strategic continuity (e.g. Garud et al., 2016).

Contextual Triggers

How does the process of developing digital first offerings start? Our research at Alpha shows that developing digital first offerings is triggered by a sense of urgency of the incumbent to rethink its role and the relevance of its 'core' in relation to disruptive times wherein the dominant technologies in its industry are threatened by emerging digital technologies and the competitive landscape is changing with the entry of digital native companies (Sebastian et al., 2017; Drechsler et al., 2020). For example, the technological advance towards electric, autonomous vehicles overturns the existing combustion drivetrain technology that Alpha dominated for decades. Because the shift from combustion-engine to electric drivetrains significantly decreases the technical barrier and differentiation potential, the focal competitive arena is drifting to other areas such as battery and even from battery to innovative system-level solutions Both are outside the existing knowledge domain of Alpha as an OEM and lead to the risk of obsoleting its existing resource base during this technological transition.

At the same time, more digital native companies are participating in the same industry by moving from the digital to the physical space. In our case, Alpha identified Amazon and multiple digital start-ups who create their logistic systems and acquire/build their own truck fleet in the transportation industry. As these digital native companies increasingly erode the market share of incumbents in the physical space, incumbents experience the challenge to find different paths to combine physical core with digital capabilities so that they remain competitive in the digital age. Together, these contextual conditions triggering the actualization of the mechanisms (Henfridsson and Bygstad 2013)—that is, a set of interacting processes that imply a new way to search for relevance in disruptive times through developing digital first offerings.

Implications

Our process model contributes to the digital innovation and transformation literature (see, e.g., Yoo et al. (2012), Henfridsson et al. (2018), Drechsler et al. (2020), Gregory et al., (2015), Warner and Wäger (2019). First, we develop a process model explaining how an incumbent develops a digital first product in relation to digitally driven industry transformation. Responding to Yoo and Euchner's (2020) call for more research on how industrial companies can create new digital value for their physical products, the process model unpacks three mechanisms underpinning digital first offering development: ecosystem probing, physical anchoring, and phygital infrastructuring. Each mechanism adds to the understanding of how the physical core, as the assets and capabilities tied to the physical offerings, can be renewed to be relevant in emerging digital futures. Prior work notes the role of physical artifacts as the material bearers that form a bedrock for digitalization (Yoo et al., 2012; Baiyere et al., 2023; Piccoli et al., 2022), as well as how digital technologies may fundamentally shape and reconceptualize physical artifacts in a digital first world (Baskerville et al., 2020). Although this research speaks to the importance of physicality of digital innovation, it does not specifically examine the underlying process by which the physical artifacts are leveraged and maintain their strategic continuity when going digital first.

Second, our research suggests that ambidexterity management during digital transformation can involve a blending logic, which differs from the ambidextrous management logics previously illustrated in the digital transformation literature (Gregory et al., 2015; Oberländer et al., 2021; Sebastian et al., 2017). In the process model, the three mechanisms provide a vivid and deep elaboration of how exploration and exploitation are harmoniously combined into one process, as incumbents search for relevance in the disruptive times shaped by digital technologies. Specifically, when an incumbent explores new opportunities afforded by digital technologies through ecosystem probing, the preexisting physical core can serve as a strategic leverage in a way that helps to sense viable opportunities through physical anchoring and seize them through phygital infrastructuring. Hence, we show how incumbents enact a cognitively sophisticated 'single solution' (Gregory et al., 2015) to achieve ambidexterity, which differs from the traditional "balancing" logic, which assumes that exploitation and exploration are separate processes, tied to separate solutions, that somehow, sometime, need to be reconciled (Drechsler et al., 2020; Gregory et al., 2015; Taylor and Helfat 2009).

Finally, our findings also speak to recent conceptualizations of digital transformation as an ongoing process of strategic renewal wherein incumbents embrace new digital technologies (Warner and Wäger 2019). Echoing to the emphasis of resource renewal in supporting this transformation journey at incumbents in prior studies (Drechsler et al., 2020; Oberländer et al., 2021; Gregory et al., 2015), we provide early insights into how the renewed resources can be further reconfigured in an orchestrated way, which facilitates incumbents to resolve the potential competing concerns (Svahn et al., 2017) emerging from resource renewal. Alongside the isolated examination on the strategic renewal of different types of isolated resources in extant digital transformation literature (Oberländer et al., 2021; Sebastian et al., 2017), future research should focus on how new dependencies are created in such processes of renewal, wherein multiple resources need to be adjusted and reconfigured simultaneously and harmoniously in order to safeguard the sustainable transformation and maintained relevance of incumbent firms.

In addition to the theoretical implications outlined above, managers in incumbent firms can learn from our findings as they practically struggle in reenergizing their physical core beyond the relevance to existing revenue stream and preventing it from becoming a burden in digital transformation. To this end, the three mechanisms provide practical guidance to maintain the strategic continuity of a physical core as a leveraging point for digital first move. Despite valuable contributions, our study is located in an ongoing digital transformation journey without clearcut 'final' outcomes at this stage. However, the enhanced digital first capability developed in this process has resulted in a general innovation pattern that brings forth a plethora of novel initiatives to move forward. In this regard, the three mechanisms are likely to play out in other incumbent settings established with a physical core.

Concluding Remarks

Since Yoo et al.'s (2010) seminal work on 'the new organizing logic of digital innovation' 10 years ago, digital born companies have been in the spotlight on the stage of scholarly and popular debate, leaving industrial giants in the dark corners, and implicitly making them seem as being at an extreme disadvantage, partly due to their legacy physical core technologies and related resources. However, as digital technology becomes increasingly pervasive and ubiquitous in the real physical world, it becomes important to bring industrial companies back to center stage by rethinking the role of physicality in digital innovation. Our process model of developing digital first offerings represents an attempt in this direction by showing how an incumbent can change how it leverages its physical core as an advantage in the new competitive landscape of digital innovation.

Although there is no clearcut answer to the question of whether our case is a 'success story', we demonstrate digital first moves that have been successful in terms of the interim outcomes achieved. For instance, Alpha has developed a capability to both incrementally improve their R&D while also engaging in explorative innovation, resulting in a set of new commercialized solutions. Similarly, this digital first move has resulted in a plethora of ideas inside Alpha about potential evolution trajectories forward. In this process, the three mechanisms were key for these outcomes to materialize, and we expect it to be difficult for any industrial firm to neglect them in the journey to embrace digital first.

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Appendix A. The Phygital Infrastructure of SIUTS Project

Expected building block of phygital infrastructure in SIUTS project	Description of building block
Governance layer	
Ecosystem-level data handling	Structures for managing borders concerning ownership, monetization & cross-firm sharing of existing and new sources of individual and smart city data.
Partner governance	Ecosystem boundary principles. Criteria for vetting new partners/third party developers.
Digital layer (data and services)	
Connectivity services	Packaged connectivity subscription services tied to physical layer (for diverse ecosystem actors).
Data integration	Consultancy and technology services for the data storage, access, processing (AI, cloud services, etc) and consolidation from ecosystem actors.
Function integration	Ecosystem platform services providing access to shared functionality and standardized interfaces allowing inter-application interaction.
Ecosystem fleet management	Software for e.g. monitoring, driving patterns analysis, route planning and continuous traffic optimization of multipurpose vehicles in future smart cities.
Smart & sustainable delivery	End customer services for ordering and booking one-stop off-peak unmanned logistics service.
Physical layer (device and network transmission foundation)	
Multipurpose vehicle	Multipurpose electric vans, cargo bikes and drones that can be modularized into different shapes and sizes for supporting 24/7 delivery services in cities with reduced congestion, vehicle kilometres and energy use.
Integrated city hub	Fixed and mobile open urban consolidation physical centres that serve ecosystem actors with a variety of functions including storage and reloading for transshipment, last-mile delivery, unmanned pick-up of deliveries, handling of return flows and recycling.
Smart lock	Gate lock and alarm at receiver-ends (e.g., restaurant, apartment) that can automatically trace and identify transport vehicles throughout the shipment journey all day.
Smart box	Reusable, cooled, and traceable boxes for sustainable deliveries of chilled food in a verified unbroken cold chain.
In-vehicle intelligence	Sensors, gateways on vehicles with GPS, lidar, radar, radio enabled tags (RFID) on goods making the vehicle capable of interpreting and acting on its internal and external environment.
On-road foundation	Smart roads, including electricity chargers and sensors. Adjustments to temporary establishment of integrated city hubs (e.g. in terms of devotion of space, signage, etc).
Connectivity foundation	Technological gear & systems for flexible bandwidth & low latency data-transfer (e.g. 5G) (for vehicle-vehicle and vehicle-tower communication).