CERN IdeaSquare Journal of Experimental Innovation, 2023; 7(3): 20-31
DOI: https://doi.org/10.23726/cij.2023.1478

ORIGINAL ARTICLE

Tech to Organization. Assessing and designing technology adoption with design thinking

Nicolò Cocchi,[1*] Clio Dosi[1], Matteo Vignoli[1]

[1]University of Bologna, Bologna, Italy
*Corresponding author: nicolo.cocchi2@unibo.it

ABSTRACT

This article explores the adaptation of design thinking for technology adoption projects, focusing on its role in assessing technology value within organizations and designing fitting applications (i.e., products, services, processes, or systems that use the technology). Through a case study conducted at a European Design Factory, we investigated seven technology adoption projects managed with design thinking processes. Our results validate an exploratory framework called "*Tech to Organization*", an adapted design thinking process tailored to technology adoption projects, along with five purpose-built tools to tackle such projects. This research provides managers and designers with a structured approach to managing the complexities of technology adoption.

Keywords: Innovation management; Technology management; Design thinking.

Received: September 2023. Accepted: November 2023.

INTRODUCTION

In today's rapidly evolving business environment, organizations are increasingly driven to adopt new technologies to remain competitive and adapt to changing market dynamics. Adopting new technologies holds significant potential for improving productivity, streamlining operations, and achieving sustainable growth (Iansiti 1995). However, adopting a new technology within an organization is not without its challenges (Parente and Prescott 1994; Magistretti, Dell'Era, and Verganti 2020). Organizations often face numerous hurdles and complexities, ranging from technical and logistical issues to cultural and organizational barriers (Karlsson, Taylor, and Taylor 2010; Coco, Colapinto, and Finotto 2023). Despite these challenges, however, many companies launch projects to adopt specific technologies, such as – to name a few – blockchain, Internet of Things, customer relationship management, or business intelligence. These projects often start with a constraint on the technology to be adopted, leaving the design team with the task of assessing the technology to identify its value for the organization and designing a specific application that uses it (Cocchi, Dosi, and Vignoli 2023a).

The successful adoption of a new technology into an organization requires a structured process that enables a comprehensive understanding of its potential, its implications, and the steps needed to implement it effectively into the organization (Karlsson, Taylor, and Taylor 2010). In this paper, the design process that defines whether and how a technology selected for use by an organization can be embedded into the organization's existing products, services, processes, or systems (Dell'Era et al. 2017; Apostolov and Coco 2021). According to this perspective, technology adoption is a process involving the assessment, design, and implementation of the selected technology (Figure 1). Assessing entails the identification of the value that the selected technology can bring to the organization, designing involves the definition of specific solution concepts that use the selected technology, and implementing encompasses the definition of specific actions and obstacles that come with the implementation of these concepts in the organization. To illustrate, consider a scenario where a company is contemplating the adoption of drone technology into its facility management services. Our research delves into how the design thinking process can be tailored to assess the value of drones with the company's operations, design suitable applications for the drones, and establish a roadmap for the implementation of drone technology.

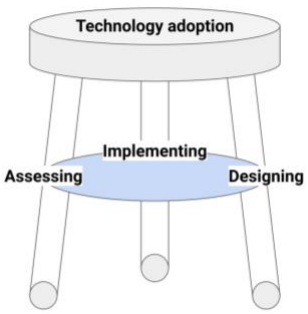


Fig. 1. Design thinking for technology adoption projects

Many organizations have found that anchoring technology choices in a deeper understanding of the value sought by users enables them to strike a better balance between the feasibility, viability, and desirability of potential solutions (Kim et al. 2020). Thus, design thinking (Brown 2008), one of the most widely used approaches to problem-solving and innovation (Liedtka 2015), emerges as a promising process that can enable an organization to identify the value of a given technology, design what to do with the technology, and define a roadmap for implementing the technology in its systems, products, services, or processes. Indeed, although design thinking has traditionally been seen as a human-centered approach (Martin 2010; Micheli et al. 2019; Mincolelli et al. 2020) driven by user needs and wants in the development of products and services (Cocchi, Dosi, and Vignoli 2021; 2023b), recent research has demonstrated the effectiveness of design thinking in traditionally less human-centered contexts, such as technology-driven organizations and projects (Mahmoud-Jouini, Fixson, and Boulet 2019).

In such projects, organizations need to adapt design thinking methods by considering the technological constraints that affect the project since the very beginning of the design process (Cocchi, Dosi, and Vignoli 2023a). Mahmoud-Jouini, Fixson, and Boulet (2019) showed the necessity for organizations intending to implement design thinking to differentiate between projects that start from "*pure*" users' needs without any technological constraints in the solution, and those that start from technological constraints and seek to assess the value of the technology. Adapting design thinking to projects that do not start from users' needs but already entail a technological constraint in the solution is not an obvious task. While the traditional process follows a "*Need to Tech*" approach, the process constrained by technology requires a "*Tech to Need*" approach (Balboni et al. 2021). Although the literature recognizes that the two processes are different, there is a complete lack of analysis of *how* design thinking should be adapted when faced with technology adoption projects. To address this gap, this study aims to answer the following research question: *how design thinking can be adapted to support technology adoption projects?*

To answer this question, we conducted single case study with embedded units (Yin 2009), where the case study is Oper.Space and the embedded units are selected projects. Oper.Space is a European Design Factory that uses design thinking as its primary methodology for conducting innovation projects and delivering solution concepts to industry partners. Oper.Space represents an ideal setting for our research as it also undertakes technology adoption projects for partner firms, with the aim of assessing the value of technologies that the partners want to adopt, designing fitting applications for these technologies within the partners' products, services, processes, or systems, and providing the partners with well-defined roadmaps for implementing the technologies. By analyzing seven technology adoption projects carried out by Oper.Space over the years 2017-2022, we identified five purpose-built tools (i.e., technologies abilities, contexts/fields of application, technology-driven problem reframing, technology-driven research questions, proof of value prototype) to tackle such projects and conceptualized an adapted design thinking process tailored to technology adoption projects, which we called "*Tech to Organization*". This paper contributes to the existing literature by providing a scaffolding process structure for managers and designers dealing with technology adoption projects, enabling them to rely on the Tech to Organization process and adopt a specialized approach.

The rest of the paper is structured as follows. In the next section, we present the theoretical background of design thinking. We then illustrate the methodology we employed to address the research question. Next, we present the results of our study. Finally, we discuss our findings and outline our conclusions.

THEORETICAL BACKGROUND

Design thinking refers to "*a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity*" (Brown 2008, p.2). This definition, one of the most cited in the design thinking literature (Micheli et al. 2019), highlights the three lenses through which design thinking approaches innovation: desirability, feasibility, and viability (Brown 2009; Menold, Simpson, and Jablokow 2016). Desirability concerns whether users will find the product or service compelling and how they will interact with it, feasibility refers to the possibility of adapting the technology for the solution in the organization, and viability addresses the financial and economic sustainability of the solution for the firm (Carlgren, Rauth, and Elmquist 2016). These lenses serve as guiding principles throughout an innovation process, ensuring that the end product or service meets user needs, is technically achievable, and is economically sustainable for the business. To design at the intersection of desirability, feasibility and viability, design thinkers activate a very specific mindset (Vignoli, Dosi, and Balboni 2023), that spans across empathy, to being experimentation driven. Such a mindset is not obvious, and often requires significant struggles to be learned (Coco, Calcagno, and Lusiani 2020). Indeed, Brown's (2008) definition also qualifies design thinking as both an individual-level characteristic (i.e., "*sensibility*") and a process (i.e., "*methods*").

In this research, we look at design thinking as a methodology, namely a systematic method, that includes step-by-step processes and related tools (Auernhammer and Roth 2021; Auernhammer and Roth 2023). In this perspective, design thinking can be conceptualized as a

process comprising three main stages (Liedtka 2015). The first stage involves gathering data about user needs. It entails empathizing with the people who will use the product or service to gain a deep understanding of their needs and wants (Dell'Era et al. 2020), thus defining the problem to be solved from their perspective (Beckman and Barry 2007). The second stage revolves around generating the widest range of ideas to solve the identified problem (Micheli et al. 2019). Finally, the third stage entails prototyping the ideas by transforming them into tangible representations (McCullagh 2013) and testing the ideas with potential users to assess their effectiveness (Beverland, Wilner, and Micheli 2015). Although leading design consultancies (e.g., IDEO) and schools (e.g., Stanford Design School) employ different terminologies (e.g., Discovery and Interpretation vs. Empathize and Define) and process visualizations (e.g., Diamond-based graphs vs. Process diagrams with hexagon) to describe design thinking, these consultancies and schools adhere to a shared process scaffolding, which consists of collecting data on user needs, generating ideas, and testing them with users (Liedtka 2015).

A wide variety of tools are used to support the design thinking process. In a recent systematic literature review, Micheli et al. (2019) identified the eight main tools used in the design thinking process: ethnographic methods, personas, journey maps, brainstorming, mind maps, visualization, prototyping, and experiments. Ethnographic methods include observations (Seidel and Fixson 2013), contextual interviews (Stickdorn and Schneider 2010), and the use of informant diaries (Beckman and Barry 2007) to collect data about users. Personas and journey maps are useful tools for synthesizing the findings of user research. Personas are fictional profiles, often developed to represent a particular group based on their shared interests, representing a character with which the design team can engage (Stickdorn and Schneider 2010), while journey maps describe the experiences a customer has as well as their emotional responses to the experience (Dalton and Kahute 2016). Personas and journey maps are often used in the process to spark off ideation sessions. Among the tools used to generate ideas, brainstorming and mind maps stand out. Brainstorming is a collaborative process that encourages the search for solutions that might not be possible in individual sessions (Seidel and Fixson 2013), while mind maps are diagrams for representing items linked to and arranged around a central theme that can be used to stimulate new ideas (Kumar 2012). Visualization techniques such as drawings, sketches, and pictures (Dalsgaard 2014), field experiments (Micheli et al. 2019), and rapid prototypes (Dosi, Mattarelli, and Vignoli 2020) are used in the process to make the ideas tangible, learn from making, and test the ideas with users (Dosi, Cocchi, and Vignoli 2021).

However, as the existing literature tends to consider design thinking as a fixed set of steps and tools, only scant research has analyzed how the standard design thinking process varies according to the objectives that characterize different innovation projects (Magistretti et al. 2022; Cocchi, Dosi, and Vignoli 2023a). Dell'Era et al. (2020) have recently outlined four distinct interpretations of the design thinking process, each marked by different operational approaches: creative problem-solving, sprint execution, creative confidence, and innovation of meaning. Creative problem-solving seeks to inspire insightful perspectives to guide the development of creative and original solutions that meet user needs. Sprint execution aims to accelerate the development process and reduce market uncertainty to bring new solutions to market quickly. Creative confidence aims to foster a new innovation mindset among employees, encouraging the adoption of novel approaches, practices, and methodologies that catalyze innovation and change. Finally, innovation of meaning aims to generate novel strategic visions that fundamentally redefine the trajectory of organizational development. As a result, the overall design thinking process can vary, for example, depending on whether the goal of the underlying innovation project is to generate creative and original product or service solutions (i.e., using design thinking as creative problem solving) or to create a new strategic vision (i.e., using design thinking as innovation of meaning) (Magistretti et al. 2022). Such variations in the structure of a design thinking process may be further exacerbated in cases where design thinking deals with technology-driven projects, as the technology constrains the development of the process and the nature of a technology-driven project is different from that of a human-centered project (Mahmoud-Jouini, Fixson, and Boulet 2019; Cocchi, Dosi, and Vignoli 2023a). This lack of research on how design thinking varies based on the objectives that characterize different innovation projects limits our understanding of the relationship between design thinking and innovation outcomes (Seidel and Fixson 2013; Carlgren, Rauth, and Elmquist 2016; Magistretti et al. 2022). Indeed, recent explanatory views of design thinking recognize that variation in performance outcomes arises from how design thinking methods and tools are combined and adapted to address specific innovation challenges (Mahmoud-Jouini, Fixson, and Boulet 2019; Liedtka 2020; Cocchi, Dosi, and Vignoli 2023a). Given our specific focus on technology adoption, this paper investigates whether and how design thinking should be tailored to projects focused on technology adoption.

METHODOLOGY

Research setting

We conducted the research at Oper.Space, the Design Factory for Open Innovation at the University of Bologna. Oper.Space is an interdisciplinary innovation

hub that brings together students, teachers, researchers, and industry partners. Annually, Oper.Space conducts approximately 200 innovation projects, employing design thinking methodologies to generate innovative solution concepts. Moreover, over the past six years, Oper.Space has actively engaged in technology-driven projects, exploring opportunities, and developing solution concepts for industry partners based on emerging technologies. Accordingly, Oper.Space represents an ideal research setting for our study, given its emphasis on design thinking as the main methodology for conducting innovation projects, its active participation in technology-driven projects, and the fact that design thinking mindset, processes, and tools are deeply rooted in the organization's culture (Siggelkow 2007).

Oper.Space follows a structured organizational scheme for its innovation projects, wherein different roles and responsibilities are allocated to ensure effective project management. Initially, a senior manager from Oper.Space discusses with a project champion from a partner firm an innovation challenge that the partner wishes to address. If these discussions are fruitful for both parties, a project brief is defined. Oper.Space then assembles a design team - typically composed of four professionals with an interdisciplinary background and familiarity with design thinking methodologies - responsible for carrying out all design-related activities associated with the project. To ensure the smooth running of the project, an Oper.Space design thinking coach assumes the role of a project supervisor. This role includes supervising the design team's activities, ensuring the coherence of the project, and managing the collaborative relationship with the partner firm. To fulfill their role, design thinking coaches have the autonomy to adapt the methods and tools employed during the process in a flexible way, according to the specific needs of the project and drawing upon their sensibility and expertise. These design thinking coaches are professionals who have undergone a rigorous two-year training program focused on design thinking projects.

In this context, we conducted a single case study with embedded units (Yin 2009), where the case study is Oper.Space and the embedded units are selected projects.

Cases selection

To initiate our research, we held a one-hour meeting with nine design thinking coaches from Oper.Space, during which we asked them to list, and briefly describe, in a shared Excel spreadsheet, the technology-driven projects carried out by Oper.Space in which they were actively involved. As a result, we constructed an initial database of eighteen technology-driven projects carried out by Oper.Space over the years 2017-2022. Each project entry included the following details: Design thinking coach(es) – Year of project implementation – Partner company in which the project was conducted – Partner universities (if any) – Number of professionals involved in the design team – Project brief – Short description of the project.

Table 1. Selected technology adoption projects

#	Brief project description	Industry (company)
1	Using drones for facility management services	Facility management (Company A)
2	Using cosmic ray neutron sensing (CRNS) for smart farming services	Tobacco manufacturing (Company B)
3	Using biomass fractionation for smart farming services	Tobacco manufacturing (Company B)
4	Using artificial intelligence for data processing	Bank (Company C)
5	Using blockchain for banking services	Bank (Company D)
6	Using visual intelligence for banking services	Bank (Company D)
7	Using vertical farming for food services	Education (Company E)

Then, in order to deepen the project briefs of the eighteen technology-driven projects, we conducted nine semi-structured interviews with the nine design thinking coaches. We selected the coaches who were responsible for supervising and coordinating the design activities for the selected projects. As a result, we identified seven projects that focused on technology adoption in the brief, while the remaining eleven projects had a different focus (for example, finding a new market for a technology that the partner company already had in-house). We therefore restricted our database to these seven projects, which were carried out for five firms operating in four different industries (Table 1).

Data collection

For each of these seven technology adoption projects, we gathered data by conducting interviews with the four design thinking coaches who coordinated these projects and accessing the archival data related to these seven technology adoption projects.

Interviews—We conducted four semi-structured interviews with the design thinking coaches responsible for supervising and coordinating the design activities of the seven technology adoption projects. These interviews aimed to understand what worked and what did not work during the process, determine whether the design thinking coaches made any adaptations to the conventional design thinking process when handling technology adoption projects, and, if so, to ascertain the reasons and methods behind such adaptations.

Archival data—Additionally, we collected Oper.Space's official documentation related to the seven technology adoption projects. Specifically, for each project, we collected the document detailing the project brief jointly established by Oper.Space and the partner firm, as well as the slides presented by the design teams (and supervised by the design thinking coach) to the partner firms during the mid-term and final presentations. Mid-term presentations are milestones where the design teams present the preliminary findings

of their project. Final presentations are milestones where the design teams present and hand over the final solution concept to the partner firm. In total, we collected seven project briefs, seven mid-term presentations, and seven final presentations.

Data analysis

As a first step, we went through the transcription of the four semi-structured interviews conducted with the design thinking coaches and analyzed the passages in which the interviewees mentioned why and how they made adaptations to the conventional design thinking process. For instance, while discussing project 1, design thinking coach 1 stated: "*In this project, I believe it would have been misleading to start with user research. Since the technology had to be embedded in the final solution, we needed to understand where it could have brought value within the organization and how it could have helped solve user needs. So, before delving into user research, I urged the design team to conduct an extensive exploration of the technology*". She also added: "*I employed a tool that, in my opinion, could have helped the [design] team in finding where the technology might have been useful. Let me check…this tool! Here, I encouraged the [design] team to think about the abilities of the technology [...]. The tool [...] motivated the [design] team to gain a better understanding of the technology while also prompting them to diverge and hypothesize about the contexts in which the technology could have added value*". This passage shows the description of a specific new tool introduced by the design thinking coach in the process and a reflection related to the difficulty of starting with users' research since the very beginning.

Then, we triangulated the answers provided by the design thinking coaches with the project documentation related to the selected projects, including the project briefs, mid-term presentations, and final presentations (Jick 1979).

Based on these analyses, we identified five new tools introduced across the seven technology adoption projects, distinguishing them from classical design thinking tools (Liedtka 2015). Additionally, with an abductive process and going back and forth from literature and data (Ahrens and Chapman 2006), we abstracted three processual phases: "*Technology-Organization fit*", "*Context research*", and "*Solution concept design*" and defined an adapted design thinking process, called "*Tech to Organization*", tailored to the objectives of technology adoption projects.

Once we conceptualized the model, as asked by qualitative studies, we came back to the field and to our interviewees to validate the proposed model. To validate the Tech to Organization process, we conducted a three-hour workshop with the design thinking coaches that supervised the seven technology adoption projects. In this workshop, we first presented the adapted tools introduced by them during the process. Then, we outlined the Tech to Organization process, highlighting the process phases and goals. Finally, we sought feedback from the design thinking coaches regarding the Tech to Organization process, including their perspectives on what aspects could have been effective, what might have been ineffective, and what modifications they would have suggested for the process. This workshop facilitated a comprehensive discussion and refinement of the process based on the collective expertise of the participants.

RESULTS

Tools for technology adoption projects

The analysis of the project documentation revealed five tools employed by the design thinking coaches across the seven technology adoption projects. These tools differ from those used in classical design thinking processes. Table 2 provides a definition of each tool and an example from project 1 (i.e., using drones for facility management services).

"*Technology abilities*" and "*Contexts/fields of application*" are tools that design thinking coaches have used in the early exploratory stages of the process to facilitate a comprehensive exploration of the technology within the organizational boundaries. On the one hand, *technology abilities* aims to unpack the technology (e.g., drones) into the actions it can perform, fostering a shift in perspective that encourages viewing the technology as a set of functions (e.g., access to hard-to-reach areas, non-contact temperature sensing, sensing of wavelengths invisible to the human eye) rather than an isolated entity. On the other hand, the *contexts/fields of application* tool involves exploring the various potential fields of application within the organization (i.e., products, services, processes, systems) where the technology could be feasibly implemented (e.g., roof maintenance services). Design thinking coaches found that abstracting and describing the functions of the technology and subsequently linking these individual functions with potential fields of application for the technology facilitated the design teams to move beyond functional fixedness (Duncker 1945) and brainstorm more areas where the technology could have been applied within the organization. As the design thinking coach who supervised project 1 stated: "*Constrained by both the technology and the organizational context, the design team struggled to explore contexts beyond the mainstream applications of the technology. I felt that the classical tools we use at this stage, such as desk research, mind maps, and benchmarking, fell short*". She further explained: "*As the team began to consider the technology in terms of its functions rather than the technology per se, they were able to complement fairly intuitive fields of applications with some truly unexpected ones. Linking the technology abilities to*

Table 2. New tools identified

New tool developed	Definition and related example
Technology abilities	Actions that the technology can do. Typically, technology abilities are listed deductively, after a study of the technology itself
	e.g., In the drone project, the technological abilities of drones are abilities such as *'access to hard-to-reach areas'*, *'non-contact temperature sensing'*
Contexts/ Fields of application	List of contextual applications where the organization has a role with its business. They might represent internal processes or specific business activities
	e.g., In the drone project, the contexts were related to facility management services and ranged from *'bridge maintenance'*, *'civil building facilities management'*, *'roof maintenance'*, *'green space maintenance'*
Technology-driven problem reframing	Process of reframing the initial problem by selecting a subset of abilities, application contexts and benefits for detailed investigation. It expresses the challenge by listing the selected ability, context, and potential benefits of technology adoption
	e.g., In the drone project, visual inspection of roofs was selected as the most promising opportunity to save time and money and improve workers' safety
Technology-driven research questions	Technology-driven research questions play the same role as the assumption that designers abstract and then test. Indeed, they are questions that the design team needs to answer through different learning channels such as interviews, observations, generative sessions, and experiments. However, these questions are specifically related to the technology
	e.g., In the drone project, technology-driven research questions were divided into feasibility (e.g., '*Can a worker accurately assess roof conditions remotely through video or images without being physically present?*'), viability (e.g., '*Can the organization sustain the new process with its current resources and capabilities?*'), and desirability (e.g., '*Do workers express concern about the introduction of the new process?*') questions
Proof of Value prototype	Traditionally, Proof of Value seeks to determine what benefits could be derived for customers or the organization if an idea or product were built, and what measurable value would be gained if the idea were pursued. In Tech to Organization, Proof of Value is a prototype that aims to define what value the technology can bring to users. Proof of Value is defined abductively by linking user needs and technology abilities in a specific application context. Proof of Value defines **how** the technology can bring value to those users in that context
	e.g., In the drone project, the Proof of Value was the result of the field experiment in which the drone collected video images of the condition of a school roof. This content was delivered to an evaluator, who normally assesses roof conditions in person, to understand whether the roof could be assessed

different fields of application has been extremely useful in complementing the exploration phase of the technology".

"*Technology-driven problem reframing*" is a tool that adapts the conventional problem reframing process, shifting the focus from users' needs and problems to the technology itself. This tool has been developed to prevent the issue of problem framing leading to a reframed challenge centered solely on users' needs, potentially neglecting the role of technology. This, in turn, ensures that the subsequent ideation and testing stages incorporate the technology, thus avoiding the potential creation of a mismatch between the project brief and the final solution concept. The tool involves reframing the project brief - which typically includes the technology, a broad context for the use of the technology within the organization, and the overall value that the technology can bring - to include a focus on the function of the technology, a narrow application for the technology within the organization, and a clearly outlined value proposition. For instance, the use of technology-driven problem reframing in the case of project 1 lead to reframe the project brief as follows: from "*we assume there's some potential* [general value] *in the application of drones* [technology] *into urban infrastructures* [broad field of application]" to "*we assume drones equipped with high-resolution cameras can enhance the visual inspection* [technology function] *of unsafe roofs for working at heights (for example, those not equipped with safety cables for workers)* [narrow field of application] *would help reduce costs and time, while simultaneously enhancing safety for workers and improving service quality for the customer* [value proposition]".

"*Technology-driven research questions*" is a tool developed to facilitate the testing phases by considering the technology aspect. Indeed, after the selection of a technology application, design teams have to address questions concerning its feasibility, viability, and desirability. For example, design teams might be left wondering "*Can a worker accurately assess roof conditions remotely through video or images without being physically present?*", or "*Can the organization sustain the new process with its current resources and capabilities?*", or "*Do workers express concern about the introduction of the new process?*". By defining and framing these questions considering the technology, design teams can spark off testing sessions to get answers from the stakeholders they are designing for. Although these questions serve a similar purpose as the assumptions that designers test (Liedtka 2015), they differ in that they consistently incorporate the technology aspect. This integration of technology-related inquiries ensures that the design goals remain attuned to the capabilities and limitations of the technology, fostering a more narrow approach to problem-solving.

"*Proof of Value prototype*" is a tool that has been introduced in the process to test the value that the

technology brings to the users. As a technology adoption project needs to provide an assessment of whether or not the technology should be adopted in a proposed field of application, it becomes crucial to ascertain whether the technology can perform as expected and to define the benefits it can offer. To achieve this, the design thinking coaches introduced the Proof of Value prototype into the process as a means of conducting real-world testing. For example, in the case of project 1, the Proof of Value prototype involved a field experiment in which a real drone equipped with high-resolution cameras captured video footage of the condition of a school roof, which was then made available to the maintenance team.

Tech to Organization process

By analyzing the project documentation and the interviews with the design thinking coaches, we abstracted and defined an adapted design thinking process tailored to technology adoption projects, which we called Tech to Organization. Tech to Organization aims to assess the value of bringing a given technology within an organization and to design an appropriate application for that technology. The process consists of three main stages: technology-organization fit, context research, and solution concept design. In line with traditional design thinking processes, each of these stages includes both divergent and convergent phases. However, contrary to a conventional design thinking process, it starts with a strong focus on the technology to be adopted. Table 3 presents the Tech to Organization toolkit. Figure 2 shows the structure of the Tech to Organization process. In the appendix, as a reference for readers, we have reported a summary of the application of the Tech to Organization process in the context of drones for facility management services (i.e., project 1).

Stage 1. Technology-Organization fit

The Tech to Organization process begins with a challenge (i.e., project brief) based on a technology that an organization wants to adopt into its products, services, processes, or systems (e.g., using drones for facility management services). The first stage of the process involves an exploratory phase in which the selected technology is thoroughly investigated to understand its most promising applications within the organization's existing activities (e.g., using drones to maintain green spaces, assess bridges, and inspect roofs). This exploratory dive into the technology and the organization's activities provides a wide range of potential alternatives, increasing the likelihood of finding a suitable technology-organization fit. To facilitate the search for a good technology-organization fit, Tech to Organization relies on conventional research methods such as desk research, mind mapping, benchmarking, and interviews with technology experts. Additionally, the process employs functional analysis techniques (i.e., technology abilities) to abstract the functions of the technology and generate many potential applications (i.e., contexts/fields of application) based on the identified functions.

Table 3. Tech to Organization toolkit

Stage	Divergence / Convergence	Examples of activities (Examples of tools)
Technology – Organization fit	Diverge	**Identification of technology abilities** (Abilities list generated from a deep study of the technology)
		Identification of potential applications for the technology (Brainstorming, desk research, mind map, workshop to list potential applications)
		Identification of opportunities (Pairs of technology abilities and contexts. See figure in the appendix)
	Converge	**Selection of the most interesting pairs of technology abilities and contexts of applications** (Expert interviews, field observations, focus groups)
		Technology-driven problem reframing (Ability + Context + Benefits template)
Context research	Diverge	**Identification of the AS-IS system** (Stakeholder map, ethnographic interviews, contextual observations)
		Definition of potential TO-BE systems (User journey, what if scenario)
	Converge	**Definition of research questions**
		Ranking of research questions (2x2 matrix with importance and organizational knowledge as axes)
		Define and test the Proof of Value prototype(s) (Execution of the Proof of Value prototype)
Solution concept design	Diverge	**Idea generation** (How might we questions, brainstorming)
		Test of ideas (Rapid prototyping)
		Assess (Iterate on idea generation and test)
	Converge	**Solution concept envisioning**
		Feasibility assessment (Proof of Concept)
		Business design

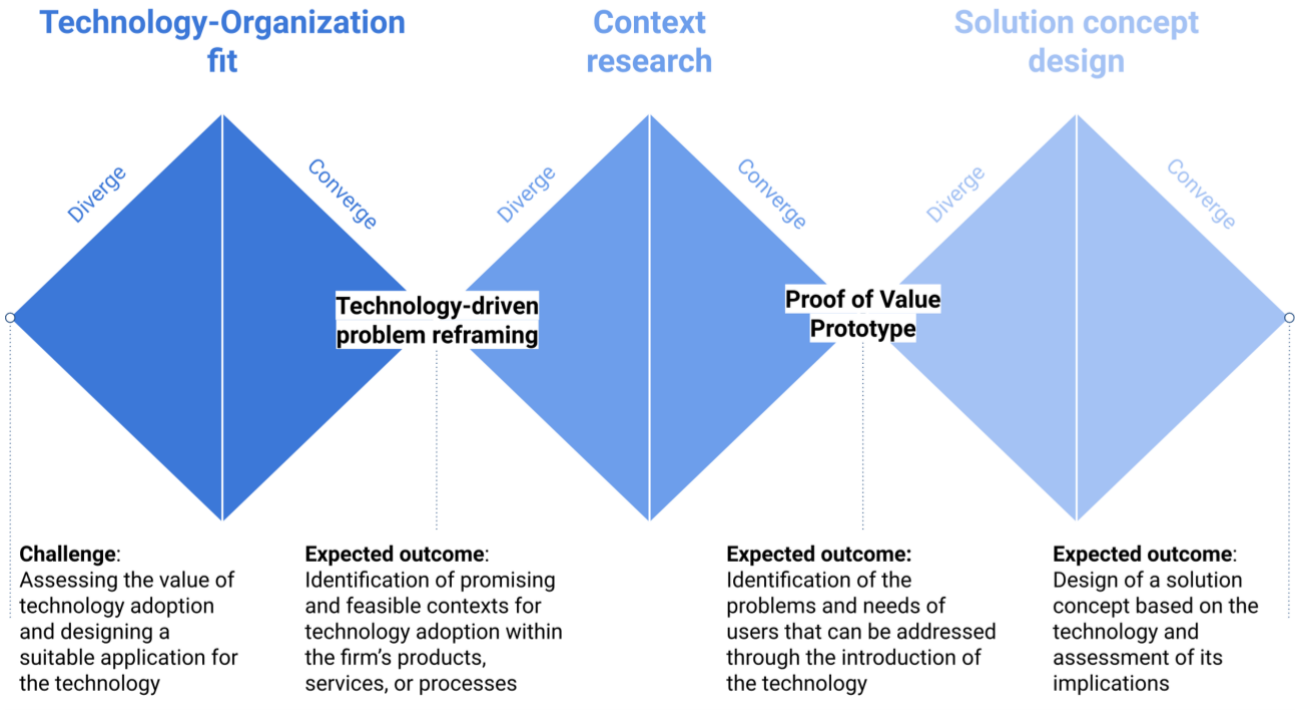


Fig. 2. Tech to Organization process

After identifying potential uses of the technology within the organization, the process converges on the selection of the most promising field in which to apply the technology. This selection is achieved by providing evidence as to why the deployment of the technology is more relevant in a particular application than in others (e.g., demonstrating why drones for roof inspection is a more promising application than drones for green areas). Such evidence may include quotes from expert interviews, trends and facts from desk research and benchmarking, and fit with relevant organization's key performance indicators (KPIs). The outcome of this phase of the process is the technology-driven problem reframing, namely the reframing of the initial challenge that includes a focus on the function of the technology, a narrow application for the technology within the organization, and a clearly outlined value proposition (e.g., from "*we assume there's some potential in the application of drones into urban infrastructures*" to "*we assume drones equipped with high-resolution cameras can enhance the visual inspection of unsafe roofs for working at heights would help reduce costs and time, while simultaneously enhancing safety for workers and improving service quality for the customer*").

Stage 2. Context research

After selecting a technology application, the process explores the application context (e.g., roof inspection process). This exploration involves mapping the application context to understand its current state, namely identifying all the stakeholders involved (e.g., who are the actors involved in the roof inspection process?), understanding the problems and needs of each actor (e.g., what are the needs of the maintenance team? what are the needs of the client organization?), and delineating the blueprints and touchpoints of the application context (e.g., how does the roof inspection process unfold?). This exploratory phase, which gathers data mainly through ethnographic methods such as contextual interviews and observations, aims to identify the pain points of the actors involved in the current application context and to ideate a desired TO-BE context based on the application of the technology. The Tech to Organization process then moves into a convergence phase, during which the design team tests the TO-BE context. To achieve this, the process pushes design teams to unpack the TO-BE context and plan its testing by formulating technology-driven research questions for the various actors involved. These questions encompass uncertainties associated with the application of the technology, including dimensions of feasibility (e.g., "*Can a worker accurately assess roof conditions remotely through video or images without being physically present?*"), viability (e.g., "*Can the organization sustain the new process with its current resources and capabilities?*"), and desirability (e.g., "Do workers express concern about the introduction of the new process?"). A 2x2 matrix is used to organize these research questions. This matrix categorizes the questions according to their importance (critical vs. supplementary) and the existing organizational

knowledge (well-established vs. limited). The selection of research questions allows design teams to design the testing in collaboration with the stakeholders for whom the solution is being designed. The execution of the test allows the team to assess the previously hypothesized problems and needs (e.g., before testing, the common belief was that using drones for surveillance would simply involve sending a pilot into the field. However, during testing, the team recognized the crucial need for a pilot with specific knowledge of the specific observations to be made) and the TO-BE scenario. Three outcomes can accompany the evaluation of the TO-BE scenario. The first outcome is "*no way*", meaning that the technology cannot perform as expected and does not add value to the selected context. In this instance, the process can conclude. Alternatively, the design team can pick up another promising application of the technology and repeat this second stage of context research. The second outcome is "*not yet*", indicating that the technology is not yet sufficiently mature, although its potential value is substantial. In such cases, the primary task for the company is to develop an implementation strategy, involving new knowledge, processes, and/or resources. The third outcome is "*yes*", meaning that the technology is promising and has delivered significant value to the domain, and that the company has a clear implementation plan, even considering the potential need for new knowledge, processes, and resources.

Stage 3. Solution concept design

The final stage of the Tech to Organization process involves the development of a solution concept and its business model. This stage uses ideation techniques to explore the implementation possibilities of a positively evaluated TO-BE scenario. These techniques mainly include brainstorming and rapid prototyping of ideas to make concepts tangible. Again, experimentation is used to validate or reject hypotheses related to both the solution concept and its business model. Using the insights gained from testing prototypes, the design team progressively refines the articulation of the final solution concept and its associated business model, along with a roadmap with all the steps required to implement the technology.

DISCUSSIONS AND CONCLUSIONS

This research addressed a critical gap in the existing literature by exploring how design thinking, traditionally centered around human needs and desires, can be adapted and leveraged to support technology adoption projects. Through an examination of seven technology adoption projects carried out using design thinking methodologies by Oper.Space, the Design Factory for Open Innovation at the University of Bologna, this research contributes to the existing literature by illustrating five specifically designed tools tailored for these projects and by delineating an adapted design thinking process tailored to technology adoption projects, which we called "*Tech to Organization*". Empirically, this research is among the first to investigate such adaptation in design thinking processes.

On a theoretical level, Tech to Organization reveals how the design thinking process can be adapted and employed to tackle technology adoption projects, thereby contributing to the ongoing conversation about the implementation of design thinking in technology-driven projects (Mahmoud-Jouini, Fixson, and Boulet 2019) and the variability of standard design thinking processes based on the objectives inherent in diverse innovation projects (Magistretti et al. 2022). While the stages of technology-organization fit, context research, and solution concept design, along with the divergence and convergence phases fostering a balanced exploration and selection of viable paths, embody an adaptation of design thinking principles to the specific challenges of technology-driven projects (Cocchi, Dosi, and Vignoli 2021), the pronounced initial emphasis on technology and the organizational context distinguishes the Tech to Organization process from conventional design thinking processes. Consequently, this study suggests that in projects constrained by technological considerations (e.g., the inclusion of the initial technology into the final solution concept), thorough investigation of the technology before embarking on the user research stage is imperative.

A significant managerial contribution of this research centers on the provision of a toolkit tailored to each phase of the Tech to Organization process. The toolkit offers a practical guide for practitioners involved in technology adoption projects. By outlining tools and techniques for both the divergent and convergent phases, the study offers design teams with a specialized approach to address technology adoption projects using design thinking.

However, it is important to recognize the limitations of this study. First, the empirical investigation focused on a specific organization that addresses technology adoption in a unique way, potentially limiting the generalizability of Tech to Organization. Future research could complement our findings by implementing, testing, and potentially refining the Tech to Organization process. Second, despite Oper.Space's experience in design thinking processes, it must be acknowledged with due caution that we did not test for the presence of all design thinking attributes within the Tech to Organization process. As such, future research could explore the extent to which Tech to Organization is comparable to a '*vanilla*' design thinking process.

In conclusion, this study contributes to the body of experimental studies within this journal (e.g., Balboni et al. 2021; Cocchi 2023) by advancing our understanding of the adaptability of design thinking processes to different goals of innovation projects.

REFERENCES

Ahrens, T. and Chapman, C.S., 2006, Doing qualitative field research in management accounting: Positioning data to contribute to theory, Accounting, organizations and society, 31(8): 819–841. https://doi.org/10.1016/j.aos.2006.03.007

Apostolov, M. and Coco, N., 2021, Digitalization-based innovation—A case study framework, International Journal of Innovation and Technology Management, 18(05). https://doi.org/10.1142/S021987702050025X

Auernhammer, J. and Roth, B., 2021, The origin and evolution of Stanford University's design thinking: From product design to design thinking in innovation management, Journal of Product Innovation Management, 38(6): 623–644. https://doi.org/10.1111/jpim.12594

Auernhammer, J. and Roth, B., 2023, *What Is Design Thinking?* In: Design Thinking Research: Innovation–Insight–Then and Now (pp. 169-–196), Cham: Springer Nature Switzerland.

Balboni, B., Dosi, C., Marchini, S., Mincolelli, G. and Vignoli, M., 2021, N2T 'Need to Tech discovery' tool: enabling interaction with scientists in CBI students' projects, CERN IdeaSquare Journal of Experimental Innovation, 5(1): 22–31. https://doi.org/10.23726/cij.2021.1289

Beckman, S.L. and Barry, M., 2007, Innovation as a Learning Process: Embedding Design Thinking, California Management Review, 50(1): 25–56. https://doi.org/10.2307/41166415

Beverland, M.B., Wilner, S.J. and Micheli, P., 2015, Reconciling the tension between consistency and relevance: Design thinking as a mechanism for brand ambidexterity, Journal of the Academy of Marketing Science, 43(5): 589–609. https://doi.org/10.1007/s11747-015-0443-8

Brown, T., 2008, Design thinking, Harvard Business Review, 86(6): 84–92. https://hbr.org/2008/06/design-thinking

Brown, T., 2009, Change by design: How design thinking transforms organizations and inspires innovation, New York: Harper-Collins

Carlgren, L., Rauth, I. and Elmquist, M., 2016, Framing design thinking: The concept in idea and enactment, Creativity and Innovation Management, 25(1): 38–57. https://doi.org/10.1111/caim.12153

Cocchi, N., 2023, Motivating students to attend open innovation initiatives. A motivational structure perspective, CERN IdeaSquare Journal of Experimental Innovation, 7(2): 33–50. https://doi.org/10.23726/cij.2023.1451

Cocchi, N., Dosi, C. and Vignoli, M., 2021, The Hybrid Model Matrix. Enhancing Stage-Gate with Design Thinking, Lean Startup, and Agile, Research-Technology Management, 64(5): 18–30. https://doi.org/10.1080/08956308.2021.1942645

Cocchi, N., Dosi, C. and Vignoli, M., 2023a, Tech to Market. Finding and designing suitable technology applications with design thinking, Proceedings of the International Conference on Engineering Design (ICED23), Bordeaux, France, 24–28 July 2023. https://doi.org/10.1017/pds.2023.332

Cocchi, N., Dosi, C. and Vignoli, M., 2023b, Stage-Gate hybridization beyond Agile. Conceptual review, synthesis, and research agenda, IEEE Transactions on Engineering Management, https://doi.org/10.1109/TEM.2023.3282269

Coco, N., Calcagno, M. and Lusiani, M., 2020, Struggles as triggers in a design-thinking journey, Creativity and Innovation Management, 29: 103–115. https://doi.org/10.1111/caim.12384

Coco, N., Colapinto, C. and Finotto, V., 2023, Fostering digital literacy among small and micro-enterprises: digital transformation as an open and guided innovation process. R&D Management, https://doi.org/10.1111/radm.12645

Dalsgaard, P., 2014, Pragmatism and Design Thinking, International Journal of Design, 8(1): 143–155. Available at:https://www.ijdesign.org/index.php/IJDesign/article/view/1087

Dalton, J. and Kahute, T., 2016, Why empathy and customer closeness is crucial for design thinking, Design Management Review, 27(2): 20–27. https://doi.org/10.1111/drev.12004

Dell'Era, C., Altuna, N., Magistretti, S. and Verganti, R., 2017, Discovering quiescent meanings in technologies: exploring the design management practices that support the development of Technology Epiphanies, Technology Analysis & Strategic Management, 29(2): 149–166. https://doi.org/10.1080/09537325.2016.1210785

Dell'Era, C., Magistretti, S., Cautela, C., Verganti, R. and Zurlo, F., 2020, Four kinds of design thinking: From ideating to making, engaging, and criticizing, Creativity and Innovation Management, 29(2): 324–344. https://doi.org/10.1111/caim.12353

Dosi, C., Cocchi, N. and Vignoli, M., 2021, TEN Transform Emergency Now! - Facing COVID 19 with Open and Frugal Innovation, Proceedings of the International Conference on Engineering Design (ICED21), Gothenburg, Sweden, 16–20 August 2021, Vol. 1, pp. 2971–2980. https://doi.org/10.1017/pds.2021.558

Dosi, C., Mattarelli, E. and Vignoli, M., 2020, Prototypes as identity markers: The double-edged role of prototypes in multidisciplinary innovation teams, Creativity and Innovation Management, 29(4): 648–666. https://doi.org/10.1111/caim.12410

Duncker, K., 1945, On problem-solving, Psychological Monographs, 58(5). https://doi.org/10.1037/h0093599

Iansiti, M., 1995, Technology integration: Managing technological evolution in a complex environment, Research policy, 24(4): 521–542. https://doi.org/10.1016/S0048-7333(94)00781-0

Jick, T.D., 1979, Mixing qualitative and quantitative methods: Triangulation in action, Administrative Science Quarterly, 24(4): pp. 602–611. https://doi.org/10.2307/2392366

Karlsson, C., Taylor, M. and Taylor, A., 2010, Integrating new technology in established organizations: A mapping of integration mechanisms, International Journal of Operations & Production Management, 30(7): 672–699. https://doi.org/10.1108/01443571011057290

Kim, E., et al., 2020, User-centered design roadmapping: anchoring roadmapping in customer value before technology selection, IEEE Transactions on Engineering Management, 69(1): 109–126. https://doi.org/10.1109/TEM.2020.3030172

Kumar, V., 2012, 101 Design Methods: A Structured Approach for Driving Innovation in Your Organization, Wiley, New Jersey, United States.

Liedtka, J., 2015, Perspective: Linking design thinking with innovation outcomes through cognitive bias reduction,

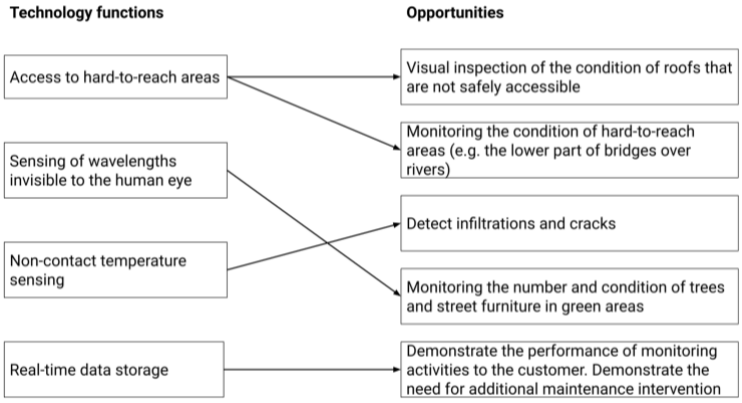
Journal of Product Innovation Management, 32(6): 925–938. https://doi.org/10.1111/jpim.12163
Liedtka, J., 2020, Putting technology in its place: Design thinking's social technology at work, California Management Review, 62(2): 53–83. https://doi.org/10.1177/0008125619897391
Magistretti, S., Bianchi, M., Calabretta, G., Candi, M., Dell'Era, C., Stigliani, I. and Verganti, R., 2022, Framing the multifaceted nature of design thinking in addressing different innovation purposes, Long Range Planning, 55(5): 102163. https://doi.org/10.1016/j.lrp.2021.102163
Magistretti, S., Dell'Era, C. and Verganti, R., 2020, Searching for the right application: A technology development review and research agenda, Technological Forecasting and Social Change, 151, 119879: 1–18. https://doi.org/10.1016/j.techfore.2019.119879
Mahmoud-Jouini, S.B., Fixson, S.K. and Boulet, D., 2019, Making design thinking work: Adapting an innovation approach to fit a large technology-driven firm, Research-Technology Management, 62(5): 50–58. https://doi.org/10.1080/08956308.2019.1638485
Martin, R.L., 2010, Design thinking: achieving insights via the "knowledge funnel", Strategy & Leadership, 38(2): 37–41. https://doi.org/10.1108/10878571011029046
McCullagh, K., 2013, Stepping up: Beyond design thinking, Design Management Review, 24(2): 32–34. https://doi.org/10.1111/drev.10238
Menold, J., Simpson, T.W. and Jablokow, K.W., 2016, The Prototype for X (PFX) framework: assessing the impact of PFX on desirability, feasibility, and viability of end Designs. In: International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, Vol. 50190, p. V007T06A040. https://doi.org/10.1115/DETC2016-60225
Micheli, P., Wilner, S.J., Bhatti, S.H., Mura, M. and Beverland, M.B., 2019, Doing design thinking: Conceptual review, synthesis, and research agenda, Journal of Product Innovation Management, 36(2): 124–148. https://doi.org/10.1111/jpim.12466
Mincolelli, G., Cocchi, N., Dosi, C. and Vignoli, M., 2020, "OPER.TEN" Transform Emergency Now! - facing Covid-19 with Open Innovation and Human Centered Design, Strategic Design Research Journal, 13(3): 658–668. https://doi.org/10.4013/sdrj.2020.133.28
Parente, S.L. and Prescott, E.C., 1994, Barriers to technology adoption and development, Journal of political Economy, 102(2): 298–321. https://doi.org/10.1086/261933
Seidel, V.P. and Fixson, S.K., 2013, Adopting design thinking in novice multidisciplinary teams: The application and limits of design methods and reflexive practices, Journal of Product Innovation Management, 30: 19–33. https://doi.org/10.1111/jpim.12061
Siggelkow, N., 2007, Persuasion with case studies, Academy of Management Journal, 50(1): 20–24. https://doi.org/10.5465/amj.2007.24160882
Stickdorn, M. and Schneider, J., 2010, This Is Service Design Thinking, Amsterdam: BIS Publishers.
Vignoli, M., Dosi, C. and Balboni, B., 2023, Design thinking mindset: scale development and validation, Studies in Higher Education, 48(6): 926–940. https://doi.org/10.1080/03075079.2023.2172566
Yin, R.K., 2009, Case study research: Design and methods, Vol. 5, Sage.

APPENDIX

The case of drones for facility management services

Rekeep S.p.A., a leading Italian company that provides services for buildings, people, and cities, embarked on a strategic initiative to evaluate whether and how to adopt drones into its facility management services.

Stage 1. Technology-Organization Fit



In this stage, the design team abstracted the functions of drones (e.g., access to hard-to-reach areas, non-contact temperature sensing, sensing of wavelengths invisible to the human eye, real-time data storage). From these functions, the design team identified three facilities management processes where the organization operated with a potential good fit for the technology: green areas, roof inspection and bridge monitoring. For example, drones equipped with high-resolution cameras could have improved the visual inspection of roofs. The integration of drones with thermographic cameras could have detected water leaks that can penetrate walls. In the end, the team identified roof inspection as the most valuable opportunity. Accordingly, they reframed the initial challenge from "*we assume there's some potential in the application of drones into urban infrastructures*" to "*we assume drones equipped with high-resolution cameras can enhance the visual inspection of unsafe roofs for working at heights would help reduce costs and time, while simultaneously enhancing safety for workers and improving service quality for the customer*"

Stage 2. Context Research

The team conducted in-depth research into roof inspection processes, including contextual interviews and observations. They mapped stakeholders, needs and touch points to create a TO-BE context. The team then formulated research questions which guided the testing process and addressed uncertainties about adopting drones into roof inspections. The team selected the most important questions and ran a short prototype/experience for each to get answers. They ran tests that revealed unexpected needs, such as specific pilot awareness (i.e., before testing, the common belief was that the use of drones would simply involve sending a pilot into the field. However, during testing, the team recognized the crucial need for a pilot with specific knowledge of the specific observations to be made). Additionally, in terms of desirability, the team tested whether workers felt intimidated by the introduction of the new process. For feasibility, the team tested whether a worker could understand the conditions on the roof without being there, just by watching a video or pictures. For viability issues, the team tested whether the organization could support the new process with its current resources and capabilities. The company successfully evaluated a proposed TO-BE scenario of drones for roof inspections.

Stage 3. Solution Concept Design

Once the key questions were answered, the team created a service with specific roles, competencies, tasks, and calculated costs/revenues. The result was the "*Drones and Roofs*" service, which improves safety, efficiency, and service quality in facilities management. The team also provided the organization with an implementation roadmap.