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Abstract. This article investigates the relationship between technologies and organizational culture by focusing on the deployment of two technologies—the Geographic Information System (GIS) and the Tunnel Boring Machine (TBM)—within a binational organization engaged in constructing a tunnel for a high-speed railway. It challenges the traditional view of technology as an independent variable affecting organizational structures and processes, advocating instead for a relational and non-deterministic perspective that recognizes the mutual influences of humans and technologies in developing new work practices and organizational processes. Employing a theoretical framework drawing on Media, Technology, and Organization Studies (MTOS) and Science and Technology Studies (STS), the article underscores the mediating role of technological artifacts in the shaping of organizational culture. It emphasizes the importance of technologies in organizing both material and non-material aspects of organizational life while highlighting the co-constitutive relationship between technical objects, work practices, and organizational processes. Empirically it demonstrates how GIS and TBM contribute to actualizing a binational culture within the studied organization. In doing so, it illustrates how technologies can influence organizational culture and promotes a deeper understanding of the agential power of objects, while remaining stripped of deterministic interpretations. This approach not only enriches our comprehension of organizational culture, but also bridges theoretical gaps between MTOS and STS.

Keywords: Organizational Culture, STS, MTOS, Cross-Border Organizations.

1 Introduction

Technology has often been considered an independent variable, i.e. an element external to the organization, which follows its own development dynamics and then impacts the organizational structure and work processes ([1], [2]). However, when a relational and non-deterministic perspective towards technology is adopted, one can look at the organization in a different way, namely as a context of use for various technologies whose outcome remains open and uncertain. This means looking not at the *impact* of technology, but at the *mutual role* of humans and technology in the development of new work practices and organizational processes (see e.g., [3]).

These are the premises upon which the article builds its contribution regarding the relationship between technologies and organizational culture. While much research

concentrates on how to build a culture that embraces technology (see e.g. [4]), this article approaches the topic the other way around. It focuses in fact on the mediating role of technological artifacts in the construction of organizational culture and on the co-constitutive relationship that arises between technical objects, work practices, and organizational processes, in the context of a cross-border binational enterprise. The research question (RQ) is therefore: *How can technologies contribute to shaping the binational culture of a cross-border enterprise?*

In theoretical terms, the article employs a perspective informed by Media, Technology, and Organization Studies (MTOS, see e.g., [5]) and Science and Technology Studies (STS, see e.g., [6]; [7]) to highlight the significance of technologies in organizing both material and non-material aspects of organizational life. It focuses on the relationship between technology and organizational culture by empirically exploring how two technologies—the Geographic Information System (GIS) and the Tunnel Boring Machine (TBM)—contribute to defining the binational culture of a cross-border company responsible for the megaproject of constructing a tunnel connecting two European countries that will host a high-speed railway line.

The contribution of the article is twofold. Empirically, it demonstrates how a unique case of binational culture is implemented and actualized through the use of two technologies. In line with a theory elaboration [8] approach, the article attempts to build a bridge between MTOS and STS to showcase the agential power of objects, stripped of deterministic aspects. The value added by employing this theoretical lens lies in restoring a space for human choice, as well as the human responsibility for the technologies that are created and used, without, however, disregarding the role that technologies play in organizational life. This, in turn, allows for further awareness of the potential symbolic use of technologies by management to change, maintain, or strengthen (at least in part, see [9]) the organizational culture. STS are well-known for their ability to offer nuanced understandings of social phenomena (see, e.g., [10]); however, they have also been criticized for their power-political biases (particularly ANT, see [11]) and for being merely descriptive. This represents a limitation of approaches informed by STS. Combining STS with MTOS is therefore an attempt, albeit partial, to overcome this limitation.

The article is organized as follows: first, the theoretical background is presented, beginning with an exploration of how organizational culture remains an ambiguous, and continuously interpretable concept, and then zooming in on the role of technologies for organizational culture. The third section presents the methodology employed, followed by results. A final section discusses results and concludes the article.

2 Theoretical background

2.1 Organizational Culture: a Pervasive, Plastic Concept

About the relevance of examining organizational culture, scholars broadly concur; nevertheless, what precisely constitutes ‘organizational culture’ remains a subject of ongoing debate. This debate is animated by a range of disciplines (sociology, psychology, management, anthropology) and diverse epistemological traditions (positivist, interpretivist, reflexive epistemology) which have led to quite a few

definitions. Although today the term ‘organizational culture’ is essentially viewed as an organizational construct, it is deeply rooted in the studies of cultural anthropology and folklore. The use of contrasting and sometimes incompatible conceptions of organizational culture has engendered a certain ambiguity, intensified by two typical traits of culture: its simultaneously pervasive and inevitable presence in the organizational action (i.e., pervasiveness) and its being static and dynamic at the same time (i.e. plasticity). However, to provide a definition, we can say that organizational culture identifies a particular lifestyle of an organization, and cultures can be understood as collective phenomena capable of incorporating people's responses to the uncertainty of existence [12]. Because of such an understanding, organizational culture is often defined as a ‘soft’ dimension of the organization, an element that, on one hand, concerns everyone but, on the other, is difficult to relate directly to objectives and performance and which can therefore be relegated to a secondary priority.

Regarding the pervasiveness of organizational culture, it can be observed that, although managers may avoid dealing with culture directly, they are in fact part of it and thus contribute, along with all the other organizational actors, to continuously defining and redefining it through interpretations. As Silvia Gherardi notes, even researchers are, in their own way, part of the organizational culture they examine, since this culture is ultimately the finished product of a process involving producers, consumers, and researchers [13]. In this regard, one of the most central authors in the analysis of culture, Mats Alvesson, has repeatedly discussed the role of symbolic management of culture that managers can have (see e.g.,[9], [14], [15]). For example, they can help define an organizational culture through formal and informal practices: by sanctioning certain behaviors over others, thereby signaling what is relevant and what is not, or by displaying an informal or highly formal attitude. These behaviors, in turn, can be interpreted differently by the people experiencing them, making such behaviors susceptible to diverse, and often vastly different, interpretations. Consider, for instance, the decision to create an open space office: it can convey the idea of collaboration, but at the same time, it may carry the notion of control and visibility.

Concerning the second key element of ambiguity associated with organizational culture – what we have called here ‘plasticity’ - this is represented by its capacity to both generate stability and coherence and evolve over time (e.g., [16]): where the first aspect recalls a static and objective conception of culture, the second prompts a more holistic view of culture as a constantly changing, dynamic, and circular process [17]. In line with this understanding, the underlying assumptions of organizational culture are continually validated or refuted depending on the interpretations that organizational actors give to the symbols presented to them [17]. Returning to the example of the open space office, this might symbolize a less hierarchical and more collaborative organizational culture, hence based on trust, but also a culture oriented towards opportunism, thereby necessitating constant mutual monitoring. From this perspective, organizational culture is in constant evolution; it is created and recreated through collective negotiation (see e.g., [18]), which highlights its ambiguities and inconsistencies arising from discordant interpretations of reality.

From this brief overview, it should be clear that organizational culture remains an ambiguous concept, for which there is no single interpretation that can be empirically demonstrated, but rather many interpretations are possible. Mats Alvesson further suggests that there are however several common assumptions among the different

approaches to organizational culture, whereby cultural phenomena are tied to history and tradition; must be sought in depth, are difficult to grasp and represent, and must be interpreted; are of a collective nature and are shared by the members of a group; are primarily conceptual in nature, being linked to meanings, interpretations, beliefs, knowledge, and other intangible elements; are holistic, intersubjective, and emotional, rather than strictly rational and analytical [14]. According to this view, culture is a world of experiences, meanings, values, and interpretations that are shared and learned, and which are partly expressed, reproduced, and communicated in symbolic form.

However, the ways this world of experiences manifests can be more or less explicit. Manifestations include, for example, formal practices (such as formal hierarchy, job descriptions, remuneration systems, formalized organizational policies); informal ones (such as behavioral norms); organizational narratives (such as anecdotes); organizational rituals (such as company parties and events) and myths (for instance, how the company was born); the jargon used (ways of speaking and interacting, typical expressions, specialized languages, etc.); various artifacts and aspects of the physical structure of organizations (technologies, architecture, furnishings, physical spaces, modes of dress, etc.); declared values (present in formal documents) and those actually in use (that is, concretely acted upon by participants). All these cultural manifestations are interpreted, evaluated, and activated in various ways within the organization, as members have differing interests, experiences, responsibilities, and values. In this frame, stories and storytelling have been considered particularly useful for building and understanding culture [19]. While recognizing the incompleteness of artifacts in exhaustively explaining organizational culture, this contribution focuses on two specific (technological) artifacts and on how these contribute to defining the binational culture of the enterprise under study.

2.2 Technologies and Organizational Culture

Studies examining the relationship between organizational culture and technologies predominantly focus on how culture influences the adoption and use of a given technology: for example, scholars investigate why some managers and employees in public organizations are more willing to adopt new technologies than others, emphasizing the role of organizational culture in shaping this willingness, thus highlighting the importance of culture in influencing technology adoption behaviors [20]. Others have approached the phenomenon differently: for instance, scholars observed that in the construction sector organizational culture and IT together can influence knowledge sharing [21]. However, following the work of Margrethe Olson, it also seems relevant to question how technologies influence organizational culture [22], especially given the increasingly equivocal [23] nature of IT technologies and the fact that organizational culture and technology adoption are two of the most critical issues organizations face in today's global society [20]. In this direction, other scholars recently studied how AI systems are integrated into and shape workplace dynamics, thus highlighting the cultural embeddedness of AI [24]. These authors emphasize that AI systems are not neutral tools but are shaped by and shape the organizational cultures in which they are embedded. This mutual shaping would therefore influence how AI systems are perceived and utilized in different organizational contexts.

Although with a different approach, in this article, I move in the same direction to answer the RQ and adopt a conceptual framework informed by STS and MTOS to shed light on the role of technologies in shaping both the material and immaterial aspects of organizational life.

Technologies as Driving Forces. As previously observed, technologies can be viewed as artifacts that are integral to an organizational culture. Depending on the perspective adopted toward culture, these artifacts can be symbolically manipulated to achieve objectives and are interpreted differently by various individuals (see e.g., [14]; [15]). Notwithstanding this, technologies have often been regarded in organizations in a deterministic manner, as "autonomous factors impacting on society from outside" [25, p. 31], as external elements impacting the organization by following their own development dynamics, which subsequently affect the organizational structure and work processes ([1]; [2]). This technological determinism, however, implies that "technologies drive the development of social structure and cultural values according to its own logic, […] It is the belief that characteristics inherent in technology manage the direction of its development and set conditions for social change" [25, p. 31].

In this vein, while the idea that technical inventions shape organizations still permeates business manifestos [26], softer versions of technological determinism are nevertheless detectable in academic writing too [2]. In that regard it is of interest the posture assumed by Timon Beyes, Robin Holt, and Claus Pias who examine the mediating role of objects in organizational life, urging a recognition of objects as true 'agential forces' in that these afford a certain process of organizing [5]. Responding to this call, Maria Laura Toraldo and Jeanne Mengis, for instance, explore how a traditional object - the chair - as a significant cultural artifact impacts and shapes organizational life and social dynamics [27]. These authors emphasize that chairs, beyond their primary function of seating, serve as powerful symbols and tools that mediate human interactions, represent social hierarchies, and influence organizational and social cultures. Similarly, other scholars explore the evolution of the clock as a central figure in organizing modern work and personal life: the clock was once a means to synchronize and manage labor, promoting a structured workday that separated personal time from professional obligations, but now, with advancements in digital technology, the role of the clock is transforming [28]. These authors discuss how modern technologies redefine our interaction with time, moving away from collective synchronization towards personalized time management. They argue that the clock, once a symbol of industrial efficiency and control, is now part of a complex system of devices that influence our daily routines and personal goals, marking a significant transformation in how time mediates life and labor in contemporary society. More in general, objects can "be configured as a technological medium that enables and shapes, perhaps even in some ways conditions or determines, organization" [2, p. 2]. With this declaration of intents, the authors distance themselves from contemporary STS approaches, particularly the sociomaterial tradition that views organizational and work practices as "always, by definition, the result not just of a sum of material and social elements, but of processes that are simultaneously social and material" [29, p. 5], instead proposing a conception of technologies as "organizing objects" that somehow *determine* organizations.

Starting from these premises, this article adopts a distinct stance. While acknowledging, on the one hand, the value of symmetrical and relational approaches to technology typically advanced by STS studies (see, e.g., Actor-Network Theory [30] or The Mangle of Practice [31]), and, on the other hand, the theoretical contributions of MTOS studies [2]—notably their ability to closely examine objects and reveal their agential capacities as media—I propose a more nuanced perspective: technologies are understood here not as objects that *determine* and organize (culture), but as objects that *contribute to organizing* (culture).

The Mutual Role of Humans and Technologies. As already noted by Sally Wyatt, one problem with technological determinism is, in fact, that "it leaves no space for human choice or intervention and, moreover, absolves us from responsibility for technologies we make and use" [32, p. 169]. To fill this gap, here I borrow from STS, and particularly from the work done by Nelly Oudshoorn and Trevor Pinch, the idea that users of a technology—employees of a particular company, in this instance—possess more options of use than those prescribed by the technology itself and its designers [33]. Indeed, the importance of studying technologies 'in practice', evaluating them not in terms of their technical characteristics and the changes they are supposed to bring to the workplace, but in relation to their situated use and the support they provide to ongoing work and organizational practices has been given prominence (see e.g. [34], [35]). Accordingly, I argue that managers and workers do not simply use technologies in the manner determined by their designers; rather, they employ them in alternative ways, for instance, as technical tools but also as symbolic resources. In turn, these technologies in use transform work practices and help *sensemaking* [36] organizational culture.

This more nuanced and relational approach will shed some light on the mutual role that emerges between humans and technologies in the shaping of organizational culture. When a relational and non-deterministic perspective towards technology is adopted, one can look in fact at the organization in a different way, namely as a context of use for various technologies whose outcome remains open and uncertain. Therefore, while much research concentrates on how to build a culture that embraces technology (see e.g. [4]), this article approaches the topic the other way around. It focuses indeed on the mediating role of technological artifacts in shaping organizational culture and on the co-constitutive relationship that generates between technical objects, work practices, and organizational processes. The following section describes the methodology employed to address the previously presented research question.

3 Methodology

Data were collected within a binational cross-border organization, hereafter referred to as T. This organization was established in 2015 as a binational company, legally established under French law, owned by the French State and the Italian State Railways. T oversees the construction of the 57.5 km mega tunnel connecting France and Italy, which will accommodate a high-speed railway line.

Data collection is ongoing and forms part of a longitudinal study started in 2020 and spanning approximately five years that explores the relationship between binational

culture and organizational change. Data were collected through various qualitative research techniques: in-depth interviews with top and middle managers as well as employees at different hierarchical levels (N=75 of which 20 were to females, and the rest were to males), participant observation during formal and informal meetings and events (N=18), and analysis of internal and external documents. Concerning the interviews, 27 were conducted in French with native French-speaking personnel, and the remaining were conducted in Italian. Most of the respondents were middle or top managers aged 40 or older, while 4 people were ordinary employees aged over 30. Although a common interview protocol was adhered to, an open-ended format was also employed to elicit as rich a description as possible of the events and processes related to the study topic. Interviews lasted between 60 and 120 minutes and were recorded and transcribed verbatim.

The research adopted an interpretive approach to data collection and analysis [37]. More precisely, interviews and other documents were subjected to iterative deductive and inductive Template Analysis [38]. Generally, this involved gaining as close a familiarity with the data as possible, followed by preliminary coding, relying also on *a priori* themes based on theoretical ideas that have informed research on the link between organizational culture and technologies. More specifically, the deductive analysis started from the literature and the researcher's expectations, where *a priori* themes expected to be relevant to the analysis were defined. As the data were read, fragments of text related to these themes were coded, and at the same time, new themes (inductive analysis) were defined according to recurrent items in the transcripts. After coding several interviews and data pieces, an initial template of themes was defined and then applied through an iterative process of coding, noting where difficulties arose, and modifying the template accordingly based on insights from the transcripts. This cycle was repeated until a final template was established. The following subsection presents a brief description of the company under study.

3.1 Case Description

T was established in 2015 as a French simplified joint-stock company, jointly controlled by the French Government—holding a 50% stake through the Ministry of Economy—and the Italian Government—holding a 50% stake through the Italian State Railways. The French and Italian States nominate members of the company's board of directors, which includes a non-voting representative from the EU. This arrangement signifies that T embodies the collective will of both France and Italy, as well as the European Union, and operates under a binational mandate (i.e., by statute). Among the directors, the French State appoints the President, while the Italian State appoints the General Director, who is supported by an Administrative and Financial Director appointed by Italy and a Legal Director appointed by France, along with two Adjunct Executive Directors—one for France and one for Italy, both appointed directly by the General Director. The company's registered office is located in France, where at least half of its staff must be based, although its operational headquarters are in Italy. T directly employs around 200 people but indirectly manages more than 2,500 through the companies that are contracted for the construction sites (data updated to November 2023). T operates uniformly across both France and Italy, employing a mix of Italian and French personnel in both countries.

The company mission is to oversee and coordinate the megaproject of constructing the tunnel connecting France and Italy, which will accommodate a high-speed railway line between the two countries. This mission must be executed in a mandatorily binational manner, making this organization distinct from companies that undertake similar projects (such as the Brenner), which however operate differently in the two countries involved in the megaproject (Italy and Austria in the case of the Brenner).

Challenges arising from this mandatory binationalism include, for instance, the requirement to draft all documents in both French and Italian, apply French law to all the contracts and comply at the same time with anti-mafia laws in both Italy and France. Moreover, all meetings are conducted in both languages, with English not permitted. However, the balance of French and Italian elements that characterizes this mandatory binationalism does not only concern language or the application of the law, but also other aspects of organizational life, such as structure and projects. For example, most of the Directions are binational, namely, they operate on both sides of the border employing nationally mixed teams in different proportions. To give another example, on the French side, T has financed a project to protect the natural habitat of the so-called natterjack toad. To counterbalance this initiative, on the Italian side of the border, a parallel project has been developed to save a protected species of butterfly. While the European Union, through the involvement of the two member states, imposes this peculiar binational status on T and regards this organization as a true laboratory (referred to as 'atelier' in the company's internal documents) of cultural integration, it is largely up to T to operationalize this binationalism 'by design' on a daily base.

Just as with other aspects of T's organizational life, technologies are part of the cultural artifacts that the company can use to shape its being binational daily. In this regard, Geographic Information Systems (GIS) and Tunnel Boring Machine (TBM), which are instrumental in the coordination and realization of the tunnel (the mission of T), represent two particularly distinctive technologies for this organization.

According to a general system of intelligent construction technology [39], T employs GIS to organize work inside and outside the construction sites and often does so in combination with a 3D Building Information Modeling (BIM) system, namely a digital container of three-dimensional information related to a building or infrastructure. Different TBMs are instead employed to excavate the different parts of the tunnel, in Italy as well as in France. In other words, while GIS serves to design the tunnel – or to 'virtually' build it – TBMs serve to excavate the tunnel – or to 'physically' build it. Both tools can be considered cutting-edge technologies, in that they are the most advanced and innovative technologies currently available in their respective fields. Both the TBM and GIS therefore mediate the organizational life of T: they function as artifacts that act, on one hand, as technical tools for accomplishing certain tasks - organizing work at construction sites in the case of GIS and excavating the tunnel in the case of TBMs – and, on the other, as symbolic resources that encapsulate the very idea of a binational culture.

4 Findings

This section presents the study findings focusing on GIS and TBM. It shows how they contribute to mediating and constructing the unique binational culture of T.

4.1 The Geographic Information System as a Technical Tool and a Symbolic Resource

GIS is a fast-emerging green area of the digital revolution with various applications in the construction industry: research has shown that the adoption of GIS technology is rapidly expanding and being utilized more in building projects to visually track construction activities [40]. As a framework for the collection, management, and analysis of data rooted in geographic location, GIS integrates many types of data, analyzes spatial location, and organizes layers of information into visualizations using maps and 3D images (see, for instance, [41]). With this capability, GIS reveals deeper insights into data, such as patterns, relationships, and situations, helping users make more informed decisions. Key components of GIS include data input, management, analysis and visualization, and data output and sharing. Data input is the process of collecting or providing data to the GIS from various sources, such as satellite imagery, aerial photography, and field observations. This data can relate to geographic features (rivers, roads, etc.) or other spatially related data. The feature called data management involves storing, retrieving, and managing data in databases. GIS uses spatial databases which integrate spatial data (location) with other types of data. Data analysis is the core functionality of GIS which includes spatial analysis (examining the spatial relationships between features), temporal analysis (observing changes over time), and predictive modeling. Also, GIS can analyze patterns, trends, and spatial relationships within the data. Through visualization, spatial data can be presented in a visual format such as maps and 3D models and this makes it easier to understand and communicate complex spatial relationships. Finally, through the output and sharing function, reports, maps, and other outputs that can be shared with others or integrated into other applications are generated. In T, GIS is utilized in a multifaceted manner. For instance, it is instrumental in guiding Tunnel Boring Machines (TBMs) underground, through GPS, to ensure accurate excavation of tunnels. As highlighted by a company manager in fact:

The tunneling machines, guided by GPS, must precisely reach designated locations. However, this is complicated by the fact that the fixed points within the tunnel, located in hydrologically sensitive compartments, are continuously subject to movement and variation over time (manager #5)

Additionally, GIS is integrated with Building Information Modeling (BIM) to facilitate the technical creation of three-dimensional models of construction sites and the overarching mega-project. However, the use of GIS extends well beyond its practical application as a technical tool within the company; it also serves as a symbolic resource. This dual functionality is exemplified by the company's unconventional approach to GIS, which involves a distinctive method that merges French and Italian geographical coordinates. This innovative approach is designed to mediate and balance the interests of the two distinct countries involved in the mega-project, according to the mandatory binationalism. As a manager explains, the integration of geospatial data of the two countries reflects a deliberate effort to bridge cultural divides and enhance collaboration between the French and Italian teams:

During the drafting of the project, T evidently confronted this issue [the misalignment in the georeferencing systems of the two countries]*, as the project was intended to be cohesive. Consequently, from the outset, the enterprise began to reflect on these aspects and thus established its own parameters, referred to as the 'T coordinates'* (manager #1)

In this case, the perfect balance between the two States involved in the mega-project that GIS seeks to engender is employed as a symbol of cultural integration, as further explained by another manager:

Our GIS is based on the T coordinates. Everyone involved in the project is aware of this because if you try to integrate your 'piece' of the design into the system, you'll see that it takes off and ends up, like, let's say, on another continent! This happens because you didn't use the 'correct' coordinates, which are instead the 'T coordinates'. It is in the context of binationalism that we undertook all this [...] thus, this situation is also to some extent a result of this binational complexity. The T coordinates were developed because the Italian IGM and its French counterpart have two different reference systems, meaning their points cannot automatically align. However, our GIS was designed to interface with both, to create a unified project. Now that we have it, we need to ensure that our project is stable and firmly positioned in that area, at those points, because otherwise, we risk causing the tunnel to descend or rise or distort. Exaggerating a bit, we run the risk of not meeting or not emerging at the intended exit point... because, after all, you are 2000 meters underground and all you can do is triangulate and attach yourself to fixed points in the high mountains (manager #5)

The idea of creating a new, unique georeferencing system specifically for T aims, on one hand, to emphasize the unique binational nature of this organization, and on the other hand, to bypass the issue of one country's superiority over the other. At the same time, however, GIS is integrated into BIM, which acts as a common environment and conveys the idea of disintegrating binationalism. In other words, through the BIM, the GIS generates a new common working area, thus dissolving the very idea of two separate countries, implying instead that is possible to have a common ground where they are totally indistinguishable and something new emerges. Indeed, as two IT technicians observed, "the system allows everyone to see what we are doing together*"* (IT technician #1) and "is a common language, a common ground" (IT technician #2). In this sense, as emphasized by Mr. BIM (as nicknamed by the company), the manager who oversees the entire BIM project, BIM almost represents a form of standardization, and it is effectively a "shared data container, a collector of various information that works in harmony with GIS" (manager #2). Whereas the technical characteristics of the peculiar georeferencing system created by the company lead back to the idea of disintegrating the two cultures with the aim of generating a new common one, the same idea is further reinforced by the discourse carried out by the management.

4.2 The Tunnel Boring Machine as a Technical Tool and a Symbolic Resource

As with GIS, TBMs are used in various domains, including the mining industry [42] and for building tunnels, such as in the case of the Quiling tunnel [43]. This involves

design considerations, opportunities for innovation, but also technical challenges (see [42],[43]). While GIS is a predominantly digital and virtual technology, TBM is a predominantly physical technology that integrates digital elements. For example, it interacts with GIS to navigate underground. In fact, tunneling in hard rock with tunnel boring machines is one of the most mechanized construction processes [44]; here, mechanization also applies to the installation of the temporary excavation support and the final lining. Computer-aided process systems have been developed, including sensor-supported gathering and computer-aided storage of all relevant tunnel operational and survey data; computer-aided visualization and control of the most important boring machine systems; and computer-aided, process-oriented control of all operational processes. TBM is thus a specialized tool used for boring tunnels with a circular cross-section through a variety of soil and rock strata. It can bore through anything from hard rock to sand. TBMs are used in the construction of tunnels for roadways, railways, and pipelines. They are particularly useful for projects that require tunnels of significant length, deep underground, or beneath urban areas where the disruption caused by traditional excavation methods would be unacceptable. In this vein TBM is "in essence, a 'traveling' industry", as argued in a company document (press folder, external document #2). Typically, the main components of a TBM include a cutter head, a shield, a conveyor system, an installation system and control cabin (see, for instance, [45]). The cutter head is the front part of the machine that breaks the rock or soil. It is equipped with various cutting tools designed for specific geological conditions. The shield is a large metal cylinder that follows the cutter head and temporarily supports the tunnel walls until a permanent lining can be installed. The conveyor system is used to remove the excavated material from the front of the machine to the back, where it can be transported away from the tunnel face. Installation equipment is used to place the tunnel lining. As the machine advances, precast concrete segments are installed to line the tunnel walls, ensuring stability and preventing collapse. Finally, each TBM has a control cabin, which is where the operators manage the TBM's operations, monitoring its progress and adjusting its direction as needed. TBMs can be categorized based on the type of ground they are designed to bore through, and the choice between these types depends on the geological conditions of the tunnel route. Using a TBM can significantly reduce the amount of surface disruption, making it an ideal choice for urban areas or sensitive landscapes. The use of TBMs also tends to result in smoother tunnel walls and a more uniform tunnel diameter, which can simplify the installation of systems within the tunnel and improve its overall quality.

In T, different TBMs are employed for excavating various parts of the tunnel at different times, and Italian and French employees share a common understanding of this technology. For example, in September 2019, the TBM named 'F.':

Completed the excavation, which began in 2016, of the first 9 km of the tunnel where the trains will pass. The TBM, weighing 2,400 tons and with power equivalent to eight Formula 1 engines, advanced an average of 15-20 meters per day (press folder, external document, #2).

From a technical standpoint, these tools serve to mechanize excavation, making the digging operations safer. In fact, they constitute:

Impressive machinery custom-built to dig quickly and safely underground and are used in the longer sections where the mountain allows it. TBM […] enables the mechanization and automation of all excavation, clearing, and material transportation operations, thereby minimizing both the duration of the work and the number of operators that need to be present. The cutters on the head of the boring machine break the rock without wearing it down, thus limiting the formation of dust and, therefore, its dispersal into the environment (press folder, external document #1)

However, as in the case of GIS, the role of TBM extends well beyond its practical application as a tool to accomplish technical tasks; it also serves as a symbolic resource**:** a symbol at the same time of integration and of disintegration. It represents a symbol of integration between the two countries as it physically embodies both the company mission and its (binational) culture. As an interviewee puts it:

For the first 9 kilometers of the base tunnel last year, we essentially celebrated the arrival of the tunnel boring machine [...] And that moment, when there is this boring machine, which is really an important symbol, because in the end you realize the magnitude of what we must manage when you see the machine digging into the mountain… We saw it live, and it practically reached this milestone with representatives from the Italian government, representatives from the French government, employees, mayors, and European Union politicians (manager #1)

The completion of the first 9 km excavation by the TBM is celebrated as a significant milestone and it symbolizes the profound connection between two countries that, until now, remained 'distant'. The TBM not only represents this newly forged union but also the physical point where these two countries converge. This pivotal moment is commemorated through tailored events and fondly recalled by various employees, a sentiment that this manager well conveys:

Well, the end of the excavation ... in my opinion it was really crazy, that is, when the tunnel TBM knocked down the last diaphragm, and in fact we realized that we had dug the first nine kilometers of the base tunnel, in my opinion, it was a huge satisfaction, for everyone, because then the company decided to do [an event]*…practically we all went, from the technician to the secretary, we were all there, also those who hadn't been able to go down to the tunnel…luckily I was able to go down, it was also, I mean, I was able to enjoy everything, even the environment, the noise, the dust, and at that moment, it was really nice, let's say, it wasn't annoying, but the others were also able to watch it live, in my opinion it was a moment of unity and of, there's finally a result (laughs) no?* (manager #5)

Moreover, the TBM serves as a powerful symbol of both the dissolution of borders and the absence thereof. As the construction manager pointed out, "underground, I can assure you, there are no borders; there is neither France nor Italy" (manager #6). Thus, the TBM and its excavation efforts help to foster and manifest the absence of national boundaries, promoting a kind of disintegrated binationalism that transcends conventional nation-states, where identities such as French or Italian persist merely as

ideas. This message is echoed by other interviewees who describe the TBM as the quintessential emblem of T's binational culture:

The TBM [is a binational symbol] *'cause it passes through, goes beyond, punctures and emerges elsewhere. It departs from one territory and arrives in another, it knows that there is always the diaphragm, the strong emotional moment of this hole where the workers meet [...] it is underground, therefore, in a place where it is visually difficult for those who are not geologists to identify the frontier, because obviously we find it difficult to visualize the frontiers, except those we are used to crossing* (manager 4#)

As a corollary to this, it is also significant that a miniature version of the TBM has been symbolically placed at the entrance of the company headquarter in Italy, preceded by three flags - French, Italian, and that of the EU - and followed by a giant photograph of the mega tunnel under construction. Again, in this case as well, as with GIS, the idea of a unique binationalism, which combines, integrates, and even disintegrates French and Italian cultural elements, is reinforced through symbolic elements such as discourse and managerial practices, i.e. the celebration event for the excavation by the TBM.

5 Discussion and Conclusions

The article shown how GIS and TBM act and are configured both as technical tools as well as symbolic resources of the (dis)integrated binational French Italian culture of T. The table below summarizes the main results.

Table 1. Summary of findings. GIS and TBM as technical tools and symbolic resources

Technology	As Technical Tool	As Symbolic Resource
GIS	- Coordinating and structuring the binational project; - Guiding TBMs in the excavation of the tunnel; - Helping structuring data into BIM	- Interfacing with the Italian and French georeferencing system to create a unified vision (*integration*); - Supporting the creation of a new language, neither Italian, nor French (*disintegration*)
TBM	- Excavating different parts of the tunnel at different times; - Ensuring better safety within the tunnel	- Deep connection between the two countries through the underground encountering (*integration*); - Breaking down binational boarders and transcending conventional nation-states to create something new, neither Italian, nor French (*disintegration*)

As shown, both technologies contribute to shape the organizational culture of T; in this vein they are foundational and infrastructural tools [5] influencing how T's binational culture is articulated in practice. These technologies are not merely functional objects for completing technical tasks, such as coordinating construction work or digging a tunnel; they are also employed as symbolic resources that embody and convey the complexities and ambiguities (pervasiveness and plasticity) of a binational organizational culture which is nevertheless subject to different interpretations. Indeed,

in an organization without a common language, continually negotiating which language to use and when—French, Italian, or both—GIS, through BIM, establishes a common framework for using and creating a unified language, essential for all. Thus, while T's GIS on one hand integrates the French and Italian components by merging them, on the other hand, it promotes the dissolution of these distinct components to construct a new, common language. Similarly, the TBM not only creates a physical meeting point between the two countries but also transcends their borders to promote a higher idea of binationalism. The result is a kind of (dis)integrated binational culture, one that complies with the binationalism imposed by the States and the EU, but in doing so, somewhat paradoxically, disintegrates it daily, thus generating something new.

However, the issue here is that these technologies mediate the binational culture and define it only to the extent that they are integrated into practices and symbolically reinforced by discourses: the technology contributes to organizing binationalism in T, while T itself organizes around this technology through practices that are as much social as they are material. Indeed, what would the TBM represent without the event celebrating its first excavation? What would GIS signify without Mr. BIM and his team's promotion of a new common language?

Although technologies mediate, they do not determine the organizational culture; rather, there emerges a process of mutual articulation between humans and nonhumans that produces what might be defined, with Law, as "heterogeneous engineering" —a function of the interaction among diverse elements as they are integrated into a network [46, p. 113]. This process fosters an organizational culture that presents a (dis)integrated view of binationalism, emphasizing its ambiguous nature and susceptibility to various interpretations. In this dynamic, technologies play a role and necessitate closer observation over time and in their interactions with other practices.

To conclude, this paper employed a theoretical-analytical lens combining different STS and MTOS informed approaches to highlight not the impact of new technologies on organizational culture, but rather their role in mediating and constructing it through a process of mutual human-nonhuman articulation. The article contributes to stress the idea that technologies are not merely tools or conduits; they are foundational and infrastructural, significantly influencing the possibilities of organizational actions, yet they do not operate in isolation. While it empirically demonstrates how a unique case of binational culture is implemented and actualized through the use of two technologies, it theoretically restores a proper space for human choice and responsibility in the creation and use of technologies, without disregarding the role these technologies play in organizational life. This perspective also allows for a greater awareness of the potential use of technologies, both technical and symbolic, in terms of maintaining, strengthening, or changing organizational culture. As we have seen, T in fact symbolically manipulates these technologies to reinforce a certain cultural message, but other modes of symbolic management could be considered: just as an open space can symbolize openness but also control, TBMs could represent something different from what has been conveyed as a message by the organization thus far. This, in turn, has implications for organizational objectives and practices.

As shown, in T, the top-down imposition of binationalism by the States and the European Union provide constraints but also a framework within which both humans and nonhumans are summoned to enact the binational culture. This scenario certainly presents a unique case; therefore, future research should explore similar dynamics in

less constraint-bound organizations and with other methodologies and research techniques too. Furthermore, T represents a very particular kind of merger, being a single organization resulting from the collaboration of two States and the EU, operating uniformly across both Italy and France, and employing a mix of Italian and French personnel in both countries according to an imposed binational framework. This characteristic makes this case rather unique. In this vein, a comparison with other organizational mergers could be beneficial for further development in this line of research.

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