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POLICY REPORT

Innovation and Vulnerability at the Italian–Swiss Border: the Cervinia–Zermatt Cable Car

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*This policy report examines the Matterhorn Alpine Crossing (MAC), an innovative cable car system that connects Italy and Switzerland through the Alps. Launched in 2023, this project showcases the potential for modern engineering to enhance regional connectivity and economic growth, while also posing significant challenges in terms of environmental conservation and operational efficiency. The report draws on a range of interdisciplinary literature, focusing on environmental management and sustainable infrastructure development. This analysis reveals that the infrastructure encountered critical challenges stemming from its environmental impact and the need for improved management practices. The findings advocate for a comprehensive approach that prioritizes environmental sustainability and robust stakeholder engagement to ensure the project's long-term viability. Proposed recommendations emphasize the importance of adaptive management strategies that respond to ongoing environmental and operational challenges. The report suggests that with thoughtful planning and committed execution, MAC could become a benchmark for integrating technological innovation with environmental stewardship in sensitive regions.**

Executive Summary

The Matterhorn Alpine Crossing (MAC), inaugurated on July 2, 2023, stands as an important achievement in Alpine transport and tourism, bridging the Italian municipality of Cervinia and the Swiss resort of Zermatt. This high-altitude cable car not only connects two nations but also represents a leap towards integrating technology with environmental conservation. Conceptualized in the 1930s and realized decades later, this project was envisioned to boost tourism and facilitate easier cross-border movement. However, the journey from conception to operation has been fraught with challenges. Early stages of the cable car's operation revealed significant issues: unexpected maintenance closures and utilization rates that fell short of projections, underscoring deeper problems in infrastructure resilience and market acceptance. These operational challenges are mirrored by concerns over environmental impact. The delicate Alpine ecosystem

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possesses unique vulnerabilities that demand careful management. The literature reviewed emphasizes the precarious balance required to implement such ambitious projects without compromising environmental integrity. It highlights the need for sustainable practices that align closely with the goals of preserving natural landscapes while fostering economic development.

The report identifies a crucial gap in the existing management approaches, particularly in stakeholder engagement and environmental monitoring. To address these issues, some recommendations are suggested:

- Develop a dynamic governance model that includes continuous stakeholder dialogue to ensure that the project adapts to both environmental and community needs.
- Enhance operational protocols to prevent disruptions and maintain high service standards.
- Strengthen environmental oversight and integrate sustainability at every phase of operation to safeguard the Alpine habitat.

By implementing these strategies, MAC can serve as a starting point for future projects, demonstrating if and how innovative infrastructure can coexist with critical conservation efforts.

1. Introduction

On July 2, 2023, the inauguration of the Cervinia–Zermatt cable car took place, marking a significant milestone in Alpine transport and tourism. This new cable car connects the Italian resort of Cervinia with the Swiss resort of Zermatt; ascending to 4,000 meters with a border crossing point at 3,480 meters, it is the highest current continuous cable car crossing in the Alps and the highest border crossing in Europe, connecting Switzerland and Italy in around ninety minutes (Matterhorn Alpine Crossing 2024). The cable car system features state-of-the-art technology and is designed to offer panoramic views of the Matterhorn and surrounding peaks (see Figures 1 and 2). It was originally supposed to operate year-round, providing a crucial link between the two countries and boosting the region's tourism, particularly in the summer and shoulder seasons when skiing is less prevalent.

The project was envisioned by the two countries as early as the 1930s, with the first section being constructed starting in 2018 between Trockner Steg and the Klein Matterhorn. The work was then completed five years later by the Swiss company Zermatt Bergbahnen with the creation of a three-cord cable car featuring 10 cabins, capable of transporting up to 1,300 passengers per hour across the Theodul Glacier, with a route of 1.6 kilometers covering an elevation difference of 363 meters. During the inauguration, officials from both Italy and Switzerland emphasized the project's importance for cross-border cooperation, tourism, and regional development. However, the project already raised concerns in its early stages about environmental impacts and several local associations reported some difficulty on the part of Zermatt Bergbahnen in sharing data, information, and sustainability reports for the project before it became operational (Famurewa 2019).

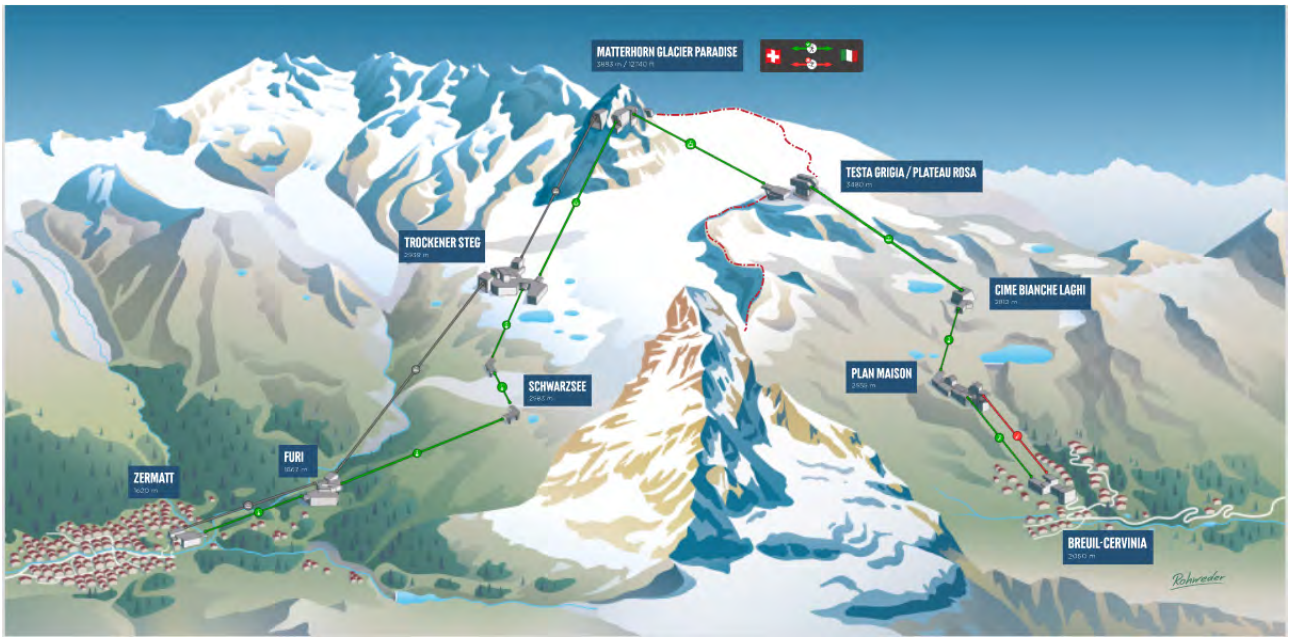

Figure 1. Matterhorn Alpine Crossing and the Stations of its Journey. Source: https://matterhornalpinecrossing.com/en#anchor-panoramicmap

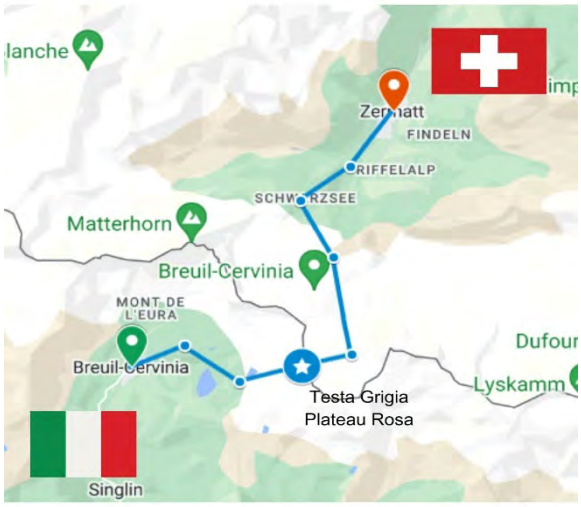

Figure 2. The Cross-border Journey of Matterhorn Cable Car. Three stations are in Italian territory (Cervinia, Pian Maison, Cime Bianche), five are in Swiss territory (Zermatt, Furi, Schwarsee, Trockner Steg, Matterhorn Glacier Paradise), and one (Testa Grigia, Plateau Rosa) is just at the border crossing. Source: author's elaboration on Google Maps.

The vulnerabilities of the Alpine transport system are well known, both in freight and passenger transport (see Figure 3). For several years, the Alpine Conference has been a body that brings together various institutions from the countries along the Alpine chain, aiming to monitor the state of the art and propose effective solutions. In particular, the Innsbruck Declaration issued during the fifteenth Alpine Conference (Alpine Convention 2019) set the goal of achieving "climate-neutral" and "climate-resilient" Alps by 2050, to be pursued through a series of monitoring actions and intermediate targets.

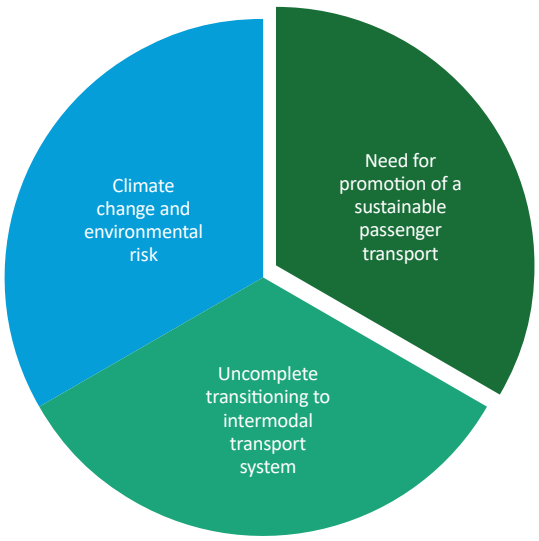

Figure 3. Fragilities of the Alpine System of Transportation. Source: author's elaboration on Alpine Convention (2019; 2023; Transport Working Group of the Alpine Convention 2022).

In this context, the role of the cable car as a symbol of modernity and connectivity is even clearer, but it is also as a reminder of the vulnerabilities faced by mountain environments due to climate change and increased human activity. It is worth noting that as a consequence of global warming, the State border, defined via the watershed, has shifted right near the Plateau Rosa station by approximately by 100 to 150 meters southward due to the retreat of the Theodul Glacier, from 1940 to today (Swisstopo 2024).

On the other hand, several innovative technologies are integrated into the project: notably, a baggage handling system that transports travelers' luggage and, similarly—though on a smaller scale compared to the most modern airport systems—allows for risk-based screening and efficient sorting at the border and during customs checks. This is a "sensitive" issue for modern customs administration strategies, especially in airports but not limited to them (Wong and Brooks 2015; Bigo 2022), particularly in Europe, on the eve of the new Customs Code reform (Arendsen 2024). Within a few months of the cable car's opening, however, several issues emerged (SonntagsZeitung 2024): the baggage handling system did not function as expected due to a lack of effective coordination between Italian and Swiss authorities, and significant sporting events that the cable car was supposed to support did not come to fruition. The Matterhorn Cervino Speed Opening ski race, heavily criticized by environmentalists (Franciolli 2023) and scheduled for November, was canceled due to weather conditions. Moreover, bids for the 2030 and 2034 Winter Olympics were both rejected, likely due to a lack of public support and the inefficient and dispersed logistical setup (Wong Sak Hoi 2023).

In December 2023, Zermatt Bergbahnen announced an unexpected three-month closure for maintenance (Keystone-ATS 2023), later reduced to two. After the first winter season, there was already talk of a "flop" (SonntagsZeitung 2024; Rota 2024), as the numbers were not encouraging. During the winter season, around 8,000 skiers per day reached the Klein Matterhorn from Zermatt on the Swiss side, but only 800 of them crossed into Italy using MAC (SonntagsZeitung 2024). What exactly is not working for what was supposed to be the flagship of the new generation of Alpine crossings? Some have pointed to the cost of the ticket: approximately 360 Swiss francs per person for a round-trip day excursion. This is a high price, but likely in line with other Alpine attractions, such as the Jungfraujoch in Switzerland (on the border between the cantons of Bern and Valais), and the affluent clientele, primarily from Asia and the United States, that the project has targeted from the outset. There are likely social and environmental issues that have impacted the project's success and deserve to be investigated in detail. This policy report aims to address these, presenting possible options and recommendations for managing this infrastructure.

Section 2 introduces some theoretical approaches deemed useful for defining the issues at hand (borders as complex and multidimensional objects of study, territorial singularities, digitalization of customs control, and redefinition of risk analysis). **Section 3** describes contexts where these approaches have been applied, evaluating their applicability to the case in question. **Section 4** presents some conclusions, and **Section 5** suggests recommendations based on three areas of analysis:

1. Improving the performance of the infrastructure.
2. Achieving effective and seamless border controls.
3. Ensuring environmental sustainability.

2. A Different Approach Regarding Borders

An innovative approach to the study of border areas can be traced back to the 1920s, to scholar Paul de La Pradelle, who identifies the "*frontière*" not merely as a line but as a genuine zone where collaborative dynamics of interaction take place between states. However, this concept should be seen more as a starting point than a conclusion in subsequent literature (Perrier 2020b), given the many and varied issues related to the topic of borders. Borders, due to their mobility, complexity, and variability over time and space, require a multidisciplinary approach that can encompass various perspectives (Brunet-Jailly 2005; Rumford 2012). They also necessitate approaches tailored to the specific territorial realities they encompass. A unique case can be found in the Alpine region.

2.1 Management of border areas in the Alps

An organic approach to this new perspective to border management has already been extensively studied in the Alpine framework (Amilhat Szary 2013; Fourny 2013) noting the fluid and evolving nature of border regions in the Alps and the need for a dynamic equilibrium, where a range of nuanced governance options is implied. Among the themes addressed by this line of study, two seem to have played an important role in the MAC case: the lack of feedback and consensus on the project, and the apparent absence of sustainability in long-term infrastructure planning. Regarding the first point, it is worth noting that concerns, particularly from the Swiss population, were not limited to environmentalist groups skeptical of this specific project. There was significant opposition to the Winter Olympics bid (Hess 2017), and, in more recent times, to the ski championship scheduled on the glacier in November 2023 (Franciolli 2023). On the Italian side, a well-known writer, Paolo Cognetti, an expert on and passionate advocate of the Alps, publicly opposed the event in several interviews, emphasizing the need to protect glaciers as public goods (Gritti 2023). As for the double rejection of the Olympic bids, it does not appear that the construction of new infrastructures was a positive factor. On the contrary, in a recent assessment model for the Winter Olympic Games (Müller et al. 2021), which assigns scores to host cities from the past 16 editions, the construction of new infrastructure is to blame: this may have negatively influenced the Olympic Committee's decision.

The long closure period during the peak winter season raises questions about the full sustainability of the Matterhorn project on the already fragile Alpine environment. Alps are heavily impacted by global warming and deprived of their original ecosystem. Many monitoring authorities provide valuable data and strategic plans, but, as highlighted in the literature, cooperation has obstacles and limitations (Wassenberg 2020), being characterized by a formal overlap of institutional presences rather than a substantial consolidation of competencies (Botteghi 2020). This often reduces the effectiveness of interventions, particularly in areas that require timely and sometimes extra-institutional action plans and capabilities.

2.2 A special case: logistic border singularities

The construction of a cross-border cable car, which spans the territories of two countries and features an interchange station for border crossing, brings to mind another important area of study: border singularities (Perrier 2020a). Originating from something rare at the location of borders, singularities can be the solution to diverse issues. We can observe interesting specificities in transportation infrastructure such as airports, tunnels, and bridges. Despite the physical location of the infrastructure, the border singularity typically requires multilateral and custom-made arrangements, where strategies and controls are shared among all relevant stakeholders. This is a fundamental prerequisite, though not the only one, and it is not sufficient to eliminate all the ambiguities associated with the status of singularity. A significant example is the Euro Airport Basel–Mulhouse–Freiburg (Reitel 2020), located on French territory less than four kilometers from the French–Swiss border. It is one of the few airports in the world operated jointly by two countries, France and Switzerland, based on a 1949 convention. On the airport premises, there are two separate sections and two Customs areas, Swiss and French, but all the decisional models and strategies are based on a joint governance. The airport features a last-generation baggage handling system with high performance cross-belt sorters (Alstef 2016; International Airport Review 2023), embodying a new process for additional oversight of hold baggage. This ensures smooth controls and an extremely low percentage of mishandled baggage, making the Euro Airport a front-runner within the latest European standards for baggage handling and safety checks (see Figure 4).

Figure 4. Automatic Cross-belt Sorter (Baggage Handling System) for Basel–Mulhouse Airport. Sources: Alstef Group (2016); EuroAirport (2024).

How baggage handling and checks affected the Matterhorn cable car will be discussed in the following section, as well as whether and to what extent an airport model, with successes and challenges, can be applied to a cross-border cable car.

2.3 Border management and Customs controls

Another relevant topic addressed by the cross-border cable car case is the passenger and baggage check system at the moment of border crossing. The literature has sparked an interesting debate, far from having exhausted the issue: how can an effective and modern control authority ensure uninterrupted flows of goods and people, where the traditional trade-off between efficiency and security in a globalized world is overcome? Arendsen (2024) aims to highlight how, considering the upcoming Union Customs Code reform, the Customs Authorities of the member states must continue the work, partially included in the previous reform, of adapting risk analysis systems. This adaptation contributes to the ongoing development and management of a centralized and shared data hub, moving towards the much-anticipated goal of a truly unified European customs system. Bigo's (2022) perspective focuses on the digitalization of controls and the shift in perspective required from the involved stakeholders. A few years earlier, Wong and Brooks (2015) had described this trend toward the dematerialization of security controls in the aviation sector. A useful parallel can be drawn with another contribution (Dijstelbloem 2021) that outlines the characteristics of new digitized border infrastructures, identifying disruptive elements of innovation in the technology they incorporate. Their impact on the control of flows of people and goods therefore requires a renewed study of the relationship between technology and political choices.

3. Border Singularities Approach Applied to the Alpine Framework

3.1 Not only the Matterhorn: The case of the Aiguille du Midi

Another important cross-border cable car in the Alpine framework is the Aiguille du Midi, a prominent peak in the Mont Blanc massif, at an altitude of 3,842 meters, built in 1955 and still active as an important cross-border infrastructure (Mont Blanc Natural Resort 2023). The Aiguille du Midi is connected to Chamonix, France, via a two-stage cable car system; in addition, the Panoramic Mont-Blanc gondola links the Aiguille du Midi to Pointe Helbronner on the Italian side of the border, enabling visitors to traverse between France and Italy over the Mont Blanc massif (see Figure 5).

The Aiguille, with the transnational management of its tourist site, represents a case of successful infrastructure in an area, Mont Blanc, where cross-border cooperation proceeds with both achievements and contradictions (Botteghi 2020). It is interesting to note that Pointe Helbronner is one of the three areas at the root of the unsolved border dispute between France and Italy over the two slopes of the Mont Blanc (Gautheret 2020). Nevertheless, this did not prevent a sort of effective management of this cross-border infrastructure, whose value is shared by local stakeholders as a common resource. The Aiguille du Midi, however, also faces significant challenges, particularly in terms of environmental impact and sustainability. The increasing

Figure 5. Route of the Aiguille du Midi Cable Car. Source: Mont Blanc Natural Resort (2023).

number of visitors, driven by the site's popularity, places a strain on the delicate alpine environment. Managing the balance between promoting tourism and preserving the natural landscape is a constant challenge for the authorities involved. Additionally, the cross-border nature of the site complicates governance, as the coordination between different national regulations and environmental policies is not always optimal. The need to protect the Mont Blanc massif's unique ecosystem while continuing to attract tourists presents a complex dilemma, highlighting the extent to which cross-border infrastructure requires coordinated efforts from the relevant authorities to navigate these challenges effectively. The presence, amidst significant divergences, of established ecological sensitivity and the proactive involvement of the Mont Blanc Observatory in disseminating climate change data may have positively influenced this scenario so far.

3.2 The Matterhorn cable car and the Basel–Mulhouse Airport

As mentioned in sub-section 2.1, a parallel can be drawn between MAC and the shared governance model of the Basel–Mulhouse Airport. However, to what extent is the reality of an international airport applicable to an alpine cable car? There are naturally significant differences due to the specificities of the two modes of transport, but there are also interesting analogies:

1. The border singularity status: both structures face successes and tensions due to this condition within local communities. For example, the Basel–Mulhouse Airport has faced issues related to noise pollution in the past (Reitel 2020), just as the Alpine Crossing now must manage its own challenges with local stakeholders and environmental fragility.
2. The matter of controls: the airport sector certainly has a unique nature and organization that evolves over time. However, as highlighted long ago (Salter 2008), airports are contemporary spaces that simultaneously exhibit the opportunities and vulnerabilities of globalization. In this sense, the Alpine Crossing is quite similar, as it is an innovative yet fragile engineering project, exposed to climate change and hindered by limited user feedback and engagement.

What seems truly different between the two realities is that the Basel–Mulhouse Airport has built a credible governance model over time through a genuinely multilateral and shared approach, where both French and Swiss authorities are always involved in all relevant strategic decisions. This aspect is not evident in the alpine cable car. The project was conceived and implemented almost entirely through Swiss initiative, with the operator Zermatt Bergbahnen focusing more on informational activities rather than true engagement with the local community. It does not appear that Italy and Switzerland have ever worked together on governance or monitoring tables regarding this new infrastructure, nor has the monitoring body specific to the transport sector, the Alpine Convention, adapted its multi-year intervention programs to account for the existence of this new infrastructure. Similarly, the interaction between Customs authorities for the design of new passenger and baggage control methods occurred through conventional institutional channels that did not include the redesigning of risk analysis strategies or the adoption of new security control technologies, likely to result in a loss of efficiency from not leveraging technological innovations from the airport sector in this new context.

4. Conclusions

Is it fair to label MAC a failure just a few months after its reopening? Probably not, and it may be too early to draw conclusions from the current user statistics. This new infrastructure needs time to settle into its role within the region and establish its market position within the tourism sector. What stands out in this situation, aside from the public dissent, is the lack of active dialogue between the project's promoters and other institutional stakeholders in the region. This dialogue should go beyond press releases to include genuine, ongoing engagement and monitoring of a dynamic and evolving situation—much like the territory itself, which requires flexible and inclusive governance models at every level.

As for redesigning customs control processes, it is understandable that establishing a dialogue between institutions on process innovations might not happen overnight, especially in a time of significant change for Customs administrations across Europe. However, this example illustrates an expansion, not necessarily of physical borders, but of border thinking (Meena 2014). New borders are emerging everywhere, even in remote and hard-to-reach places, such as a frontier at 3,500 meters above sea level, managed by a high-altitude cable car system. Sometimes these efforts succeed; other times, they falter. This partial setback should not be seen as a reason to close the discussion, but rather as an opportunity to open it up critically and constructively. We should aim to identify actions that can improve the management of these complex border spaces, with a particular focus on benefiting the local populations.

5. Implications and Recommendations

Despite its challenges, MAC represents a significant engineering achievement, but its future success depends on addressing critical issues in infrastructure performance, border controls, and environmental sustainability, according to the model in Figure 6.

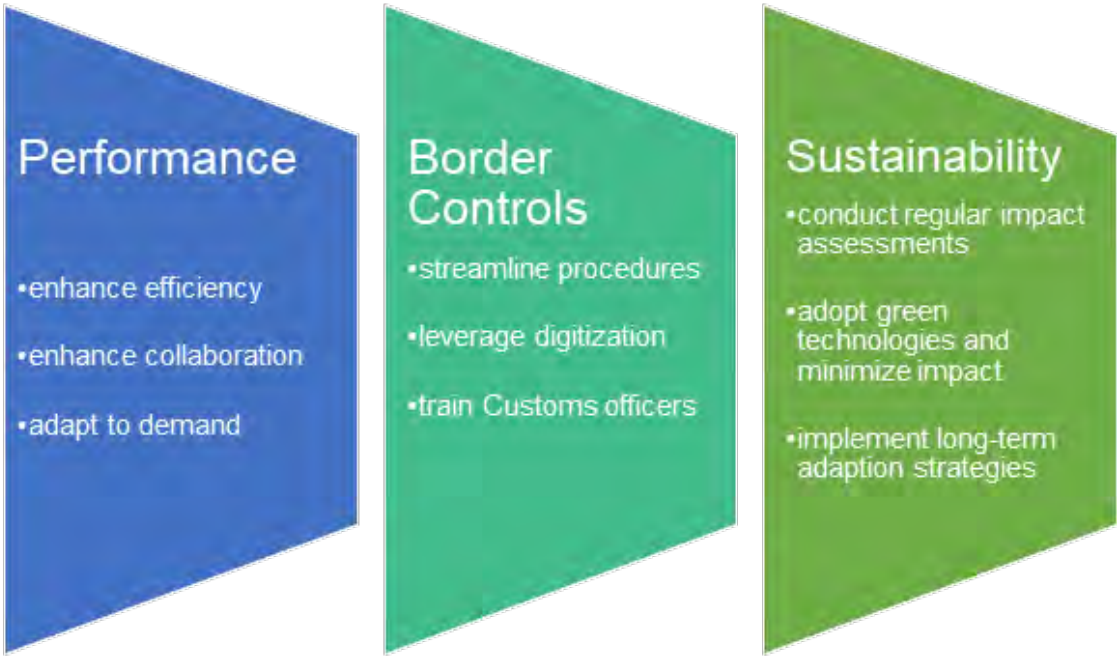

Figure 6. Policy Recommendations for Implementing Better Strategy in MAC. Source: the author.

To ensure the longevity and effectiveness of this cross-border cable car system, the following recommendations are proposed.

5.1 Improving overall performance

The initial performance of MAC has not met expectations, largely due to a lack of clear communication, coordination, and alignment with stakeholder interests. For this reason, it could be useful to implement the following initiatives:

Enhancing operational efficiency. MAC must address the operational inefficiencies that have emerged since its launch. The extended closure for maintenance just months after opening has raised concerns about the robustness of the infrastructure. To improve performance, it is crucial to implement a rigorous, ongoing maintenance schedule that minimizes downtime during peak tourist seasons. Additionally, investing in advanced monitoring systems can help predict and prevent mechanical failures before they result in costly shutdowns. By adopting a proactive maintenance strategy, Zermatt Bergbahnen can improve reliability, reduce operational costs, and enhance the overall visitor experience.

Enhancing collaboration. A joint Swiss–Italian working group to oversee the operation and promotion of the Alpine Crossing should include representatives from both countries' tourism boards, local governments, and the operator, Zermatt Bergbahnen, to ensure that the infrastructure meets the needs of all parties.

Adapting to market demand and pricing strategy. The underwhelming initial usage rates suggest that MAC has not yet found its niche in the tourism market. To improve its performance, a targeted marketing strategy should be developed to attract diverse visitor segments, particularly those who may be interested in cross-border experiences. This could include tailored packages that integrate the cable car journey with other local attractions, such as ski resorts or cultural sites. Additionally, the pricing strategy should be re-evaluated to ensure it is competitive with other high-altitude attractions, while still providing value to a broader demographic.

5.2 Achieving effective and seamless border controls

One of the critical challenges facing MAC is the implementation of efficient and seamless border controls. The dual nature of the crossing, connecting two countries with different customs and border policies, presents unique challenges.

Streamlining Customs procedures. Current procedures may need to be re-evaluated to ensure they do not disrupt the flow of passengers. One recommendation is to implement a pre-clearance system for customs and immigration checks, allowing passengers to complete these processes before arriving at the border station. This approach could significantly reduce wait times and enhance the overall user experience.

Leveraging digitalization. In line with broader trends in border management, MAC should explore opportunities for digitalization to enhance control measures.

For example, the integration of real-time data sharing between Swiss and Italian border authorities could enable more responsive and flexible border controls. Additionally, the adoption of a centralized data hub, as suggested in recent Customs reforms, could facilitate more efficient risk analysis and decision-making. These digital tools can help maintain the balance between security and efficiency, ensuring that MAC remains a safe and attractive option for travelers. The two Customs Authorities should assess the opportunities to adjust their existing Customs agreements to this new framework, needing effective and minimally intrusive controls.

Training staff. Border officers should receive specialized training to handle the unique challenges posed by this cross-border infrastructure, focusing on quick processing of passengers, fraudulent documents, and ensuring the safety and security of the crossing.

5.3 Ensuring environmental sustainability

MAC operates in a fragile alpine environment, where the impact of infrastructure on the local ecosystem is a significant concern. The sustainability of this project is critical not only for the environment but also for maintaining the area's attractiveness to tourists. It could be useful to envisage the following actions:

Conducting regular environmental impact assessments. The Swiss and Italian governments, in collaboration with environmental NGOs, should conduct regular assessments of the crossing's impact on the local environment. These assessments should focus on factors such as wildlife disturbance, pollution, and the impact on glaciers.

Adopting green technologies. The infrastructure should incorporate the latest green technologies to minimize its environmental footprint. This includes using renewable energy sources for the operation of cable cars, implementing waste management systems, and reducing carbon emissions through efficient transportation practices.

Implementing long-term climate adaptation strategies. The alpine region is particularly vulnerable to the effects of climate change, including glacial retreat, permafrost thaw, and increased risk of natural hazards such as avalanches. To ensure the sustainability of MAC, it is essential to develop long-term climate adaptation strategies. This could involve reinforcing infrastructure to withstand extreme weather events, as well as investing in research to better understand the impacts of climate change on the local environment. Additionally, collaboration with international climate organizations can help ensure that MAC is at the forefront of best practices in climate resilience, an initiative not only useful in itself but also valuable for understanding the complex movements of people at borders, as well as the medium- to long-term prospects of an economic initiative that can represent a significant opportunity for value creation worldwide, attracting clientele from all over the globe.

Sustainability is perhaps the most significant challenge among the recommendations presented here. The critical question is whether it can be realistically achieved within the context of MAC and the current framework of the Alpine Convention. The future of the cross-border cable car depends on this—its long-term viability hinges on our ability to implement sustainable practices. Beyond that, MAC has the potential to set a precedent as a model of sustainable governance for innovative infrastructure. This project could serve not only as a case study but as a foundation for future environmental strategies in border regions, guiding other projects toward success in a rapidly changing world.

Acknowledgement

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