EUSALP EU STRATEGY FOR THE ALPINE REGION

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ACTION GROUP 5

To connect people electronically and promote accessibility to public services

CROSS BORDER CONNECTIVITY IN THE ALPINE REGION:
ANALYSIS AND DEVELOPMENT ACCORDING TO NETWORK EVOLUTION

AG5 lead team

Région Autonome Vallée d'Aoste Regione Autonoma Valle d'Aosta

80 million people, 7 countries, 48 regions, mountains and plains addressing together common challenges and opportunities

European Commission

Interreg Alpine Space AlpGov

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Executive Summary

The study covers the economic and technical feasibility for cross-border backbones of connectivity across the Alps. By complementing the targeted network infrastructure with distributed computing power, digital ecosystems and possible strategic applications, the analysis aims at supporting the Alpine region in facing **major challenges**, such as:

- leveraging on its specific geographical position in Europe, as an area of connection and exchange among communities and economic areas, as well as a natural laboratory for cross-country collaboration, institutional development and environmental sustainability;
- fostering the knowledge and information society to face global changes and reinforce its competitive and innovative position, for both export development and tourism attractivity;
- rebalancing negative demographic trends of mountain areas, attracting new residents and contrasting the combined effects of ageing and new migration models, by striking a new, positive equilibrium between rural and urban models of citizenship, with a specific focus on harmonic balance between human presence and natural environment.

The analysis has mapped a sample of the existing cross-border connectivity infrastructures across the entire Alpine Region. The purpose of this sample-based mapping is not to cover all the existing or potential cross-border links, but rather to provide a **possible blueprint for intervention and technical replicability**. The analysis has classified the connectivity gaps according to four main criteria: Maturity, Access, Ownership, and Governance. The feasibility of recommended intervention has been classified with a score for each of the 19 cross-border routes selected as a sample for the analysis, providing possible guidelines for interventions, while targeting the provision of neutral facilities and local shared infrastructures.

The **guidelines for possible investments** discussed in the study include the following steps:

- **Close cross-border backbone rings**
  Fiber-optics backbone connection for critical cross-border areas shall be completed across the entire Alpine Region, starting with the segments with higher priority and lower level of current infrastructural resources.
- **Improve backhauling coverage and redundancy**
  Replace/integrate radio bridges and wireless links, where present and available, with shared fiber optics connections, providing FO backhauling to 4G and 5G base transmission stations (BTS) and/or antennas for fully redundant, high-speed and low-latency territorial coverage.
- **Provide distributed resources for sensorization and near-real-time computing**
  Identify, design and implement modular solution of edge computing, fog computing and appropriate sensor devices for monitoring areas/roads/routes and tracking access, presence and transit of vehicles, people and wildlife.
- **Develop and adopt the software architecture for interoperability and open innovation**
  Define the set of rules for API-based interoperability of public and private data sources, processes and algorithms, terms of use, rights and limitations for access and licensing.
- **Define and monitor the adoption of governance rules for digital ecosystems**

Establish a EUSALP-based governance table, on a voluntary base, to define rules for the implementation of digital ecosystem involving both public and private organization, incorporating suggested requirements for open data/open algorithms, data portability, privacy protection, free flow of non-personal data.

- **Implement "minimum viable solutions" for suggested applications and planning for modular replication and scalability**
  The four possible strategic application identified are: Smart & Sustainable Outdoor Sport Areas, Smart Nature Park, Smart Village: Digital Tourism and Smart Agriculture, Smart Mobility & Logistics

Finally, the **main recommendations** of the study are the following:

- It is of upmost importance for sustainable development and competitiveness of the Alpine area to invest in cross-border infrastructure and full coverage of the territory with ultra-broadband and low-latency connectivity networks, integrated with digital ecosystems made of distributed computing resources, architectural platforms, interoperable applications and open data.
- While several cross-border connectivity «gaps» must still be filled, the required investments may not be difficult to implement but they require to tackle both the «fragmentation problem» in marginal areas and the relevant governance issues, providing neutral facilities and local shared infrastructures.
- To unleash the economic potential of cross-borders areas, and in general of the Alpine Region, the recommended starting point is acting both on enabling infrastructures factors («connectivity/IoT/distributed computing resources» and «digital ecosystems») and innovative strategic applications.

The four **cross-sectoral strategic applications** suggested in the study, Smart Mobility & Logistics, Smart Nature Parks, Smart Outdoor Sport Areas, Smart Villages for digital tourism and advanced agriculture, range from advanced mobility and logistic solutions, based on availability of digital infrastructures of high-speed, low-latency connectivity and sensorization of roads, passes and railways, to the transformation of the existing residential and touristic assets of the Region in "*smart & sustainable digital zones*": from outdoor sport areas, to nature parks, to logistic infrastructures, to smart villages and sustainable, digital tourism and agriculture. The recommendation, hence, is to define a so-called "*minimum viable solution*" for each one of the listed projects, to be implemented in areas with the highest level of feasibility and growth potential, targeting a subsequent replicability and scalability in order to reach a critical mass across the entire Alpine Region, while granting consistency of institutional and technological governance, as well as the desired level of openness and interoperability in the resulting digital ecosystem. These recommendations are therefore addressed not only to authorities at the EU level, but also to regional/local institutions and private organizations that share the same objectives and that can benefit for the standardization and the scalability of the suggested investments in terms of cost saving, increased efficiency and effectiveness.

Thanks to the technological evolutions, the Alps shall become again, as they have been representing for centuries, a living laboratory of innovation and intercultural exchange, leveraging – with the help of **connectivity infrastructures and digital ecosystems as development drivers** – on the many distinctive competitive advantages of their unique territory, with the ambition of representing the most effective experiment of development

towards the future of a stronger union among European people, as an example of institutional and economic success of international collaboration among different territories.

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1. Introduction

EUSALP is a 'Macroregional strategy' integrated framework endorsed by the European Council, which may be supported by the European Structural and Investment Funds among others, to address common challenges faced by a defined geographical area relating to Member States and third countries located in the same geographical area which thereby benefit from strengthened cooperation contributing to achievement of economic, social and territorial cohesion.

In the aim of EUSALP, the activities are carried out by 9 Action Groups dealing with different topics. The present study was carried out by Action Group 5 of EUSALP.

AG5 is structured into two subgroups. Subgroup 1 is dealing with connectivity and digitalisation, Subgroup 2 with integrated approaches to the provision of services of general interest (SGI).

The Autonomous Region of Valle d’Aosta is responsible for Subgroup 1, the Swiss Center for mountain regions SAB is responsible for Subgroup 2.

The EUSALP AG5 Subgroup 1 deals with all aspects concerning strategies about technological infrastructures (i.e. public ultra-broadband initiatives in market failure context) and general opportunities/issues of digitalization (i.e. e-government). Aim of the subgroup is to focus on technical elements that can support subgroup 2, that is focused with integrated strategies for services of general interest.

The overall goal of AG5 Subgroup 1 is to propose a strategic approach to promote ultra-broadband connectivity among Alpine regions and to foster digitalization of Services of General Interest and public administration (i.e. open data, e-government, etc.).

This study, worked out under the activities of the Subgroup 1, focuses, therefore, on the analysis of cross-border connectivity in the Alpine Region and find proper development according to network evolution and economic trends.

It aims to identify infrastructural needs in order to build a common vision on how to invest in connectivity within EUSALP and identify technical and economic priorities to enable future developments, also in the next European Program Period 2021-2027.

Starting from an overview in marginal areas, the study has developed some economic models, enabling infrastructures and practical applications to boost sustainable growth of territories enabled by connectivity and digital ecosystems.

The document is structured in different chapters: beginning from a description of economic models and related socio-economic processes, it describes emerging digital ecosystems and their governance.

Then it shows the emerging communication technologies and highlights the EU approach with 5G architecture in order to better contextualize the actions that will be proposed. In accordance with them, the document emphasizes the fact that not only optical fibers but also neutral locations for PoPs and towers are required.

Within this framework, the study analyses the connectivity in most important cross-border paths in the Alps that can boost the digital ecosystems previously described.

Finally, practical applications are presented and an approach on how to capitalize the results is proposed.

Why improve Alpine cross-border connections?

High-speed, reliable and secure cross-border connectivity is a key driver of economic growth and the competitiveness of Europe. Digital connectivity is a General Purpose Technology (GPT) which is having a major impact on the way in which we live and work: in areas such as the Alpine Region, subject to a high level of fragmentation of networks because of geographical constraints, making it available at optimal levels across borders, and not only within national context, is an essential challenge for both private companies and public institutions, which are using digital networks to provide essential services and to improve productivity and social inclusion.

Despite the development in EU national digital networks that is already taking place, cross-border connections – especially with coverage of rural and mountain area such as in the Alpine Region - have not been so far considered an essential priority for many reasons. On one hand, most of the public incentives and the related investment programs have been developed at the national or sub-national level. On the other hand, private investment on cross-border digital connections have been prone to a classic case of market failure, as in many other markets for the provision of public infrastructure with lack of private interest in specific capital expenditures. The most common form of market failure is the persistence of monopoly-type structures - or closed oligopoly - in the provision of ultra-broadband infrastructure, even when officially no legal monopoly exists any more. In many cases, the dominance of incumbent telecommunications operators arising from their historical monopoly position has been one of the key obstacles to investments and development of effective competition in providing cross-border connections. But other market failures may be associated with lack of economies of scale and scope. Difficulties in obtaining legal permission to operate and/or to use existing logistic infrastructures, inefficient allocation of radio-spectrum, poor information and limited capital markets are all further examples of market failures affecting cross-border connections. They have been typically addressed through regulatory policy: liberalizing licensing regimes, facilitating efficient access to radio-spectrum and regulating access to dominant operators' networks have all been cornerstones of the policies that have provided the foundation for the rapid expansion of broadband services, yet, in most cases, only within national borders, with little effect on incentives to reduce the fragmentation of networks among bordering nations. Fragmentation of networks, according to several economic and technical studies, represents a major obstacle to provisioning the necessary level of performance, reliability and security required by modern digital services.

Why Alpine cross-border connectivity is an "ecosystem" and not just an infrastructure?

While connectivity is the critical element of this analysis, cross-border digital networks should be considered more than just segments of traditional infrastructures. Rather, they can be considered as an "ecosystem" that comprises different elements that use connectivity to

interact in different ways, enabling public institutions and private companies to collaborate and to share synergies and economies of scale, as well as developing specific competitive advantages which are peculiar to the Alpine Region. A digital ecosystem can be defined as a multi- layered system of well interconnected high-capacity communications networks both at the international and local level, with bandwidth-intensive, high-performance and secure services and applications, enabling the interaction and collaboration among all relevant stakeholders of a territory.

Why cross-border connectivity as a goal of EUSALP strategy?

Defining the improvement of cross-border connections as the development of a “digital ecosystem” rather than simply as an effort to close the network gaps in a mountain and rural area such as the Alpine Region, helps in confirming the role that the EUSALP strategy can play in using digital connections and coverage as a tool for social and economic development. EU initiatives have often played a “push” role in ensuring the right environment for the provision of digital infrastructures and the development of networks at the domestic level. We need to add also “pull” strategies aimed at promoting favorable conditions for both private and public investments in digital applications across a wide set of innovative services, establishing an enabling environment, including an appropriate legal framework, and fostering the development of applications.

What should be the role of EUSALP in the provision of cross-border connections?

There are essentially two different roles: making markets at national and European level work more efficiently and ensuring equitable access for all, favouring synergies among the different chapter of intervention, insofar as digital networks represent a case of General Purpose Technologies that can support several areas of development.

Providing digital networks in marginal areas – and the Alpine Region has all the possible limitations in that sense, being at the same time rural, mountain and border zone - poses significant economic and technical challenges. Costs in areas of low population density are higher and, unlike other ICTs, the provision of ultra-broadband has technical constraints of speed, coverage, security and reliability.

Why not only closing gaps but also fostering competitiveness?

The technical and economic analysis to the negative effects – rooted within technical literature - of “network fragmentation”, where the lack of robust and redundant cross-border connections may be considered as a case of market failure, when limited or insufficient incentives to investment for both public and private operators exists.

The lack of sufficiently interconnected national/regional infrastructures must also be seen in the light of cybersecurity and data protection/aggregation, issues that are already at the center of the EU public agenda on ICT policies, where the urgency of creating a single, integrated digital market is essential to compete globally, not only for the players in Alpine area, but for the whole European economy.

The issues related to cross border connectivity, though, are not only related to cross-border fiber optics “back-bones”, but also to “back-hauling” infrastructures for improving the high speed/low latency coverage of connectivity in the Alpine Region. It is the integration of backbone and backhauling infrastructures, together with the evolution towards edge/fog computing and 5G infrastructures, that represents, as explained in the report, the real opportunity for developing innovative applications that can improve the benefit for the alpine population and economy, in coordination with the other EU initiative targeted at the development of the digital economy. Some of these applications, related to many different chapters of the EUSALP strategy (such as: smart mobility & logistics, support to tourism & agriculture, public services, environmental protection, etc.) have been addressed in the report, providing a blueprint for possible implementation of minimum viable solutions that can be replicated across the Alpine region.

The challenges set forth by this report are to address and influence the political commitment by local, regional, national and European institutions towards considering the investment in cross-border digital infrastructures as a priority for the Alpine region, in particular in mountainous and marginal areas.

2 Economic model

The analysis of the economic model and the underlying economic processes is aimed at framing the context of the feasibility study. In order to define what impacts and repercussions the creation of an Alpine fiber optic backbone could have on the territory, a synthetic economic model is needed to identify strengths and weaknesses, opportunities and risks that could arise and the types of enabled networks of strategic importance (networks between Public Administrations, networks between Data Centers, networks between Companies, etc.).

Due to the complexity of coordinating the international efforts required to set up a cross-border infrastructure, the analysis covers the strategic challenges for the governance and management of a possible digital infrastructure located across the border areas, as well as the digital ecosystem and value-added cross-border services that could be created following the development of a transnational fiber-optic network, identifying the most appropriate models.

The study, starting from the draft document on the "Financial dialogue" produced by the AG5, targets most effective best European, national and regional economic instruments to finance the initiative. A first economic estimate of the necessary interventions is also addressed, in order to identify which financing methods could be adopted.

As a background, one shall remind that the EUSALP program involves 7 different countries, 5 EU Member States (Austria, France, Germany, Italy and Slovenia) and 2 non-EU Member States (Liechtenstein and Switzerland) - with 48 regions and more than 80 million residents. The project aims at helping the Alpine region in facing major challenges, such as:

- leveraging on its specific geographical position in Europe, as an area of connection and exchange among communities and economic areas, as well as a natural laboratory for cross-country collaboration and institutional development;
- fostering the knowledge and information society to face global changes and reinforce its competitive and innovative position, for both export development and tourism attractivity;
- rebalancing negative demographic trends of mountain areas, attracting new residents and contrasting the combined effects of ageing and new migration models, by striking a new, positive equilibrium between rural and urban models of citizenship, especially under the "Smart Village" approach.

One must acknowledge that, due to the complexity of investment activities and subsequent operations, the Alpine cross-border backbone requires a very high degree of cooperation and transdisciplinary work in order to succeed. Therefore, its financing options may target integrated programs, such as Interreg, as opposed to more focused financing programs.

2.1 Goals and economic context

The Alpine Region has the historic opportunity, thanks to the technological evolutions, to regain its role as a "hinge" of Europe, instead of representing a physical barrier, by interconnecting areas with a unique set of natural, cultural and socio-economic characteristics. The ultimate purpose of this analysis is therefore not only the technical feasibility of a cross-border backbone of digital connectivity, but rather, and more ambitiously, to evaluate the roadmap towards the innovative reconstruction of the peculiar network of interconnections that for centuries has represented the crossroad of exchanges among European people. The goal is therefore ensuring that an appropriate level of technological infrastructures and governance solutions is in place across the Region, to play the role of enabling platform of innovative solutions for many social, cultural and economic developments: far from following any paternalistic approach with respect to perceived backwardness and underdevelopment, the Alps shall become again, as they have been representing for centuries, a living laboratory of innovation and intercultural exchange, leveraging – with the help of new technologies – on the many distinctive competitive advantages of their unique territory, with the ambition of representing the most effective experiment of development towards the future of a stronger union among European people, as an example of institutional and economic success of international collaboration for the entire world.

2.2 Economic importance of backbone for broadband connection

A vast stream of economic research shows how capillary broadband infrastructures and digital data via the internet are playing an increasingly large role in the lives of citizens, government and business. For the Alpine Region to remain attractive and competitive, adequate levels of coverage for internet speed and access, that can be provided by ultra-broadband, are essential.

For example:

- an increase of 10 % in broadband connections in a country could result in 1 % increase in GDP per capita per year (see: L. Holt, M. Jamison, "Broadband and contributions to economic growth: lessons from the US experience", Telecommunications Policy v. 33 p. 575-581; Global Industry Leaders' Forum, Broadband enabled innovation, ITU, 2011.)
- a 10 % increase in broadband connections could raise labour productivity by 1.5 % over five years;
- investments in broadband could also help deliver quality education, promote social inclusion and benefit rural and remote regions.

Some stakeholders consider that broadband is so important that it should be seen as an essential utility, alongside other utilities such as road, water, electricity and gas. Similarly to other types of infrastructure (like roads, power lines, water distribution pipes, etc.) broadband passive infrastructure is typically characterized by high capital expenditure, low operational expenditure, low economies of scale, stable returns from low rates over a long period and is highly local, hard to duplicate because often it constitutes a natural monopoly. On the other hand, technology (active equipment) is characterized by high operational expenditure, economies of scale and is subject to limited regulation. Passive infrastructure represents today the most critical bottleneck in the process of upgrading and deploying a next generation network.

In 2010, the European Commission also set out a common framework for action at EU and Member State levels to meet these targets. Requirements for Member States included the need to: (i) develop and make operational national broadband plans by 2012; (ii) take measures, including legal provisions, to facilitate broadband investment; and (iii) use fully the Structural and Rural Development Funds.

In September 2016, the Commission identified in a Communication commonly known as the 'Gigabit Society for 2025' three strategic objectives for 2025 that complement those set out in the Digital Agenda for 2020:

- Connectivity of at least 1 gigabit for all main socio-economic drivers (such as schools, transport hubs and the main providers of public services);
- all urban areas and all major terrestrial transport paths to have uninterrupted 5G coverage; and
- all European households, rural or urban, to have access to internet connectivity offering a download speed of at least 100 Mbps, upgradable to Gigabit speed.

2.3 The coverage of rural areas remains insufficient, especially in the Alpine Region

The general increase in fast broadband coverage hides a significant discrepancy between coverage in urban and rural areas. Across the EU, coverage in rural areas was 47 % of the households in 2016, against the overall average of 80%. Only three, relatively small or urbanized Member States, Malta, Luxembourg and the Netherlands had coverage in their

rural areas equivalent to the urban areas (see *Figure 12*). In many Member States, rural coverage is far below the total coverage and for 14 Member States the high speed.

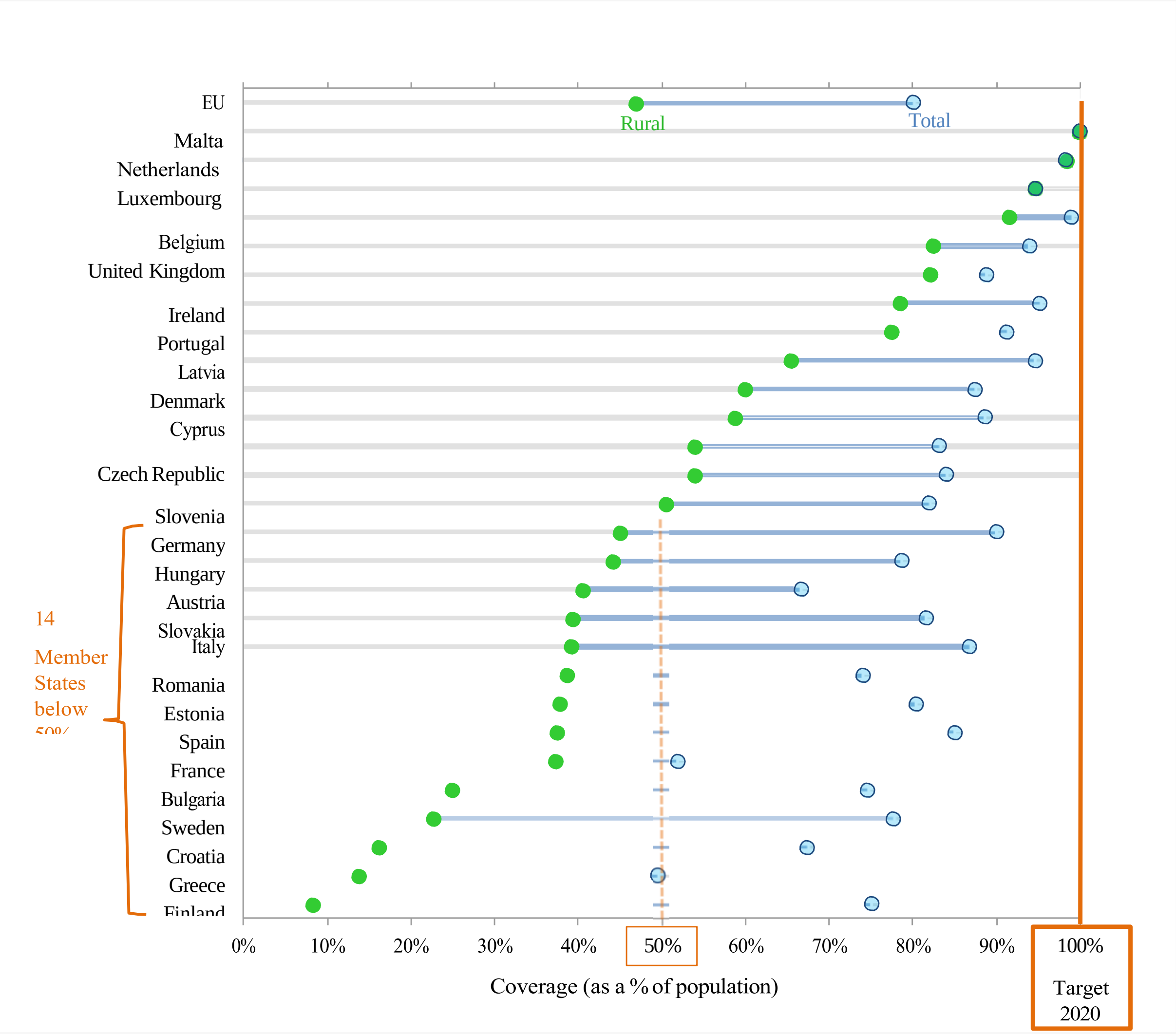


Figure 1: 30 Mbps coverage in rural areas compared to total coverage in 2017

Source: ECA analysis based on Commission data.

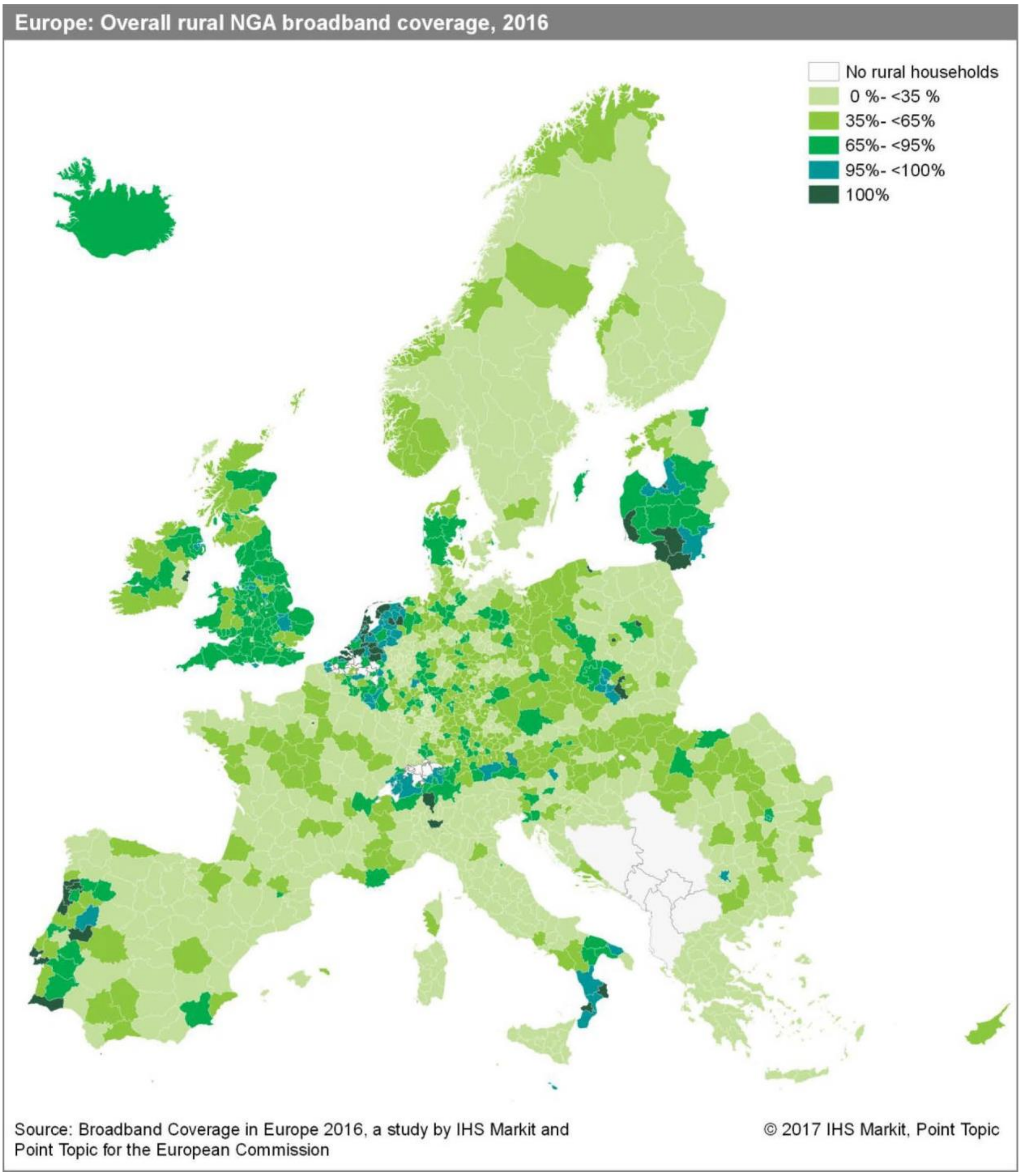


Figure 2: Overall rural NGA broadband coverage, 2016

According to the overall assessment of infrastructure for connectivity and digitalization indexes, over a third of the Alpine Region's countries exhibit comparatively low levels of digitization – including connectivity and digital public services – which signals a need for intervention in this area.

Indeed, the Alpine Region's aggregate as well as several of the concerned countries' individual performance on the EU Digitization Index reveals a challenge in this area, which substantiates the aims of AG5 of the Region's strategy to enhance the level of access to fast broadband network as well as to other important digital solutions and services. A need for intervention working towards increased levels of digitization is thus clearly present.

2.4 Economic implications of networks' topology

Connectivity networks across the Alpine region, and indeed all-around European countries, have been designed, built and operated by telco operators and/or by local Governments according to a rather narrow-minded national perspective. Their characteristics – such as lack of cross-border fiber-optics ring for redundancy and lower density of coverage near the borders – have been resulting in a set of separate and fragmented "islands", where communication networks are tangent to one each other but not integrated for the support of seamless and advanced digital services and not appropriately interconnected for service continuity and disaster recovery.

Fragmentation of networks

A growing number of researchers have expressed concerns over the past years against the dangers of splintering or breaking up the Internet into loosely coupled islands of connectivity. A number of potentially troubling trends driven by technological developments, government policies and commercial practices have been rippling across the Internet's layers, from the underlying infrastructures up to the applications, content and transactions it conveys.

Fragmentation tampers the effectiveness of networks not only for lack of integration of physical infrastructures but also in terms of layers of services that require comprehensive interoperability to release their full potential: from mobility to logistics, from protection of territory to emergency interventions, from services of general interest to tourism.

The current technical conditions can be said to involve fragmentation "*of*" the Internet, or its underlying physical and logical infrastructures. The governmental and commercial cases often more directly involve fragmentation "*on*" the Internet, or the transactions it conveys, although they also can involve the infrastructure as well. It is therefore opportune to take a holistic overview of the nature and scope and engage in the dialogue and cooperation that is needed to avoid the pitfalls of fragmentation.

The "open Internet" approach provides a baseline logic from which fragmentation departs and against which it can be assessed. Particularly important are the notions of unconstrained reach with integrity; a unified, global and properly governed root and naming/numbering system; interoperability; universal accessibility; the reusability of capabilities; and permissionless innovation.

On top of the traditional 4-layer structure of Communications architecture, in this study we shall refer to a fifth "content and transactions" layer on the top of the basic four layers; the resulting scheme is therefore the following.

Communication Layers

5. Content and Transactions Layer
4. Application Layer
3. Transport Layer
2. Network/IP Layer
1. Physical/Link Layer

This distinction between the underlying physical and software-enabled logical infrastructure and its utilization is useful for the purpose of this study and was central to the working definition of Internet governance that was agreed to by the United Nations Working Group on Internet Governance in 2005.

Three forms of fragmentation can be defined as relevant to the purpose of this study:

- **Technical Fragmentation**: conditions in the underlying infrastructure that limit, diminish or impede the ability of systems to fully interoperate and exchange data packets and of the Internet to function consistently at all end points, with a reliable and robust interconnection of backbones among national clusters of nodes.
- **Governmental Fragmentation**: Government policies and actions that limit, constrain or prevent certain uses of the Internet to create, distribute, or access information resources.
- **Commercial Fragmentation**: Business practices that limit, constrain or prevent certain uses of the Internet to create, distribute, or access information resources.

The Technical fragmentation, which is the main focus of this study, pertains essentially to layers 1-4 of the model above, with a specific purpose on Layer 1 about Physical/Link connections. Fragmentation may vary greatly according to a number of dimensions or attributes, such as:

- **Occurrence**: whether a type of fragmentation exists or is a potential
- **Intentionality**: whether fragmentation is the result of deliberate action or an unintended consequence
- **Impact**: whether fragmentation is deep, structural and configurative of large swaths of activity or rather applicable to a narrowly bounded set of processes, transactions and actors
- **Character**: whether fragmentation is generally positive, negative, or neutral

Technical Fragmentation

When the Internet concept was first articulated, a guiding vision was that every device on the Internet should be able to exchange packets with any other device, regardless of national and/or political borders. Universal connectivity was assumed to be a primary benefit. But there are a variety of ways in which the original concept has been poorly implemented in

national physical infrastructures, if not eroded through complex processes. Four issue-areas can be identified in technical fragmentation:

- Internet addressing
- Interconnection
- Naming
- Security

Within these categories, several kinds of fragmentation of varying degrees of significance can be identified:

1. Network Address Translation
2. IPv4 and IPv6 incompatibility and the dual-stack requirement
3. Routing corruption
4. Firewall protections
5. Virtual private network isolation and blocking
6. TOR "onion space" and the "dark web"
7. Internationalized Domain Name technical errors
8. Blocking of new gTLDs
9. Private name servers and the split-horizon DNS
10. Segmented Wi-Fi services in hotels, restaurants, etc.
11. Possibility of significant alternate DNS roots
12. Certificate authorities producing false certificates

Governmental Fragmentation

The most common imagery of "governmental fragmentation" is of the public Internet being divided into digitally bordered "national Internets". Movement in the direction of national segmentation could entail, inter alia, establishing barriers that impede Internet technical functions, or block the flow of information and e-commerce over the infrastructure, or imposing tariffs and asymmetric taxation on transactions.

The main issues in Governmental fragmentation are:

- content and censorship;
- e-commerce and trade;
- national security;
- privacy and data protection;
- data localization;
- fragmentation as a national strategy

Within these categories, 10 kinds of fragmentation of varying degrees of significance can be identified:

1. Filtering and blocking websites, social networks or other resources offering
2. undesired contents
3. Attacks on information resources offering undesired contents
4. Digital protectionism blocking users' access to and use of key platforms

5. and tools for electronic commerce
6. Centralizing and terminating international interconnection
7. Attacks on national networks and key assets
8. Local data processing and/or retention requirements
9. Architectural or routing changes to keep data flows within a territory
10. Prohibitions on the transborder movement of certain categories of data
11. Strategies to construct “national Internet segments” or “cybersovereignty”
12. International frameworks intended to legitimize restrictive practices

Commercial Fragmentation

The nature of Commercial fragmentation often pertains to the organization of specific markets and digital spaces and the experiences of users that choose to participate in them, but sometimes it can impact the technical infrastructure and operational environments.

Five issue-areas are identified:

- peering and standardization;
- network neutrality;
- walled gardens;
- geo-localization and geo-blocking;
- infrastructure-related intellectual property protection.

Within these categories, 10 kinds of fragmentation of varying degrees of significance can be distinguished:

1. Potential changes in interconnection agreements
2. Potential proprietary technical standards impeding interoperability in the IoT
3. Blocking, throttling, or other discriminatory departures from network neutrality
4. Walled gardens
5. Geo-blocking of content
6. Potential use of naming and numbering to block content for the purpose of intellectual property protection

Drawing on the survey of fragmentation examples, a “top 10” set of cases is suggested that are a) fairly pressing or at least worth keeping a close watch of; b) worth examining in greater detail than was possible in this paper; and/or c) potentially amenable to progress through multi-stakeholder dialogue and collaboration. These are:

- Sustained delays or failure to move from IPv4 to IPv6
- Widespread blocking of new gTLDs
- Significant alternate root systems
- Filtering and blocking due to content
- Digital protectionism
- Local data processing and/or retention requirements
- Prohibitions on the transborder movement of certain categories of data

- Strategies for “national Internet segments” or “cybersovereignty”
- Walled gardens
- Geo-blocking

Taking into account these 10 cases and the preceding discussion, six sets of challenges stand out as being both pressing and particularly amenable to productive analysis and multi-stakeholder dialogue and cooperation:

- Fragmentation as Strategy
- Data Localization
- Digital Protectionism
- Access via Mutual Legal Assistance Treaties (MLATs)
- Walled Gardens
- Information Sharing

2.5 Economic and Social Costs of network fragmentation

The lack of integration among national/local sub-networks has several economic and social costs.

Inefficient or redundant costs for providing business continuity and disaster recovery

According to several researches, the majority of companies and local institutions are not prepared for a business-affecting emergency involving the loss of access to communication networks. The Disaster Recovery Preparedness Council found that nearly three quarters of organizations worldwide aren’t properly protecting their data and systems. This phenomenon is especially endemic in economically marginal zones, such as the mountain areas of the Alpine region. The potential consequences of not having an appropriate business continuity program are extremely grave. Consider the many risks that an organization may face: network outages, natural disasters, active shooter events, data breaches and more.

Operational failure

Many companies that aren’t effectively prepared for disaster situations simply cannot bounce back from a significant crisis. In fact, up to 75 percent of businesses fail within three years after a major disaster. The good news is that research shows companies with business continuity planning recover faster and more effectively following an emergency.

Injuries and deaths

In natural disasters, violent incidents and other dangerous emergencies, the safety of citizens, employees, visitors, customers and other individuals becomes a very real concern.

This is particularly true in organizations without an effective business continuity plan. Companies that use traditional, hard-copy planning methods often fail to effectively communicate with stakeholders during an emergency, which leaves them ill equipped to respond to the situation at hand.

Financial losses

Data breaches, server downtime, weather emergencies and other crises can be extremely costly, especially when you haven't made a plan to mitigate unnecessary financial damage. As several cases have shown, organizations and businesses may incur into significant financial losses due to downtime alone, not taking into account the other causes of financial loss, such as insurance claims, lost product and public relations efforts.

Damages to reputation

An organization's response to a crisis can have a huge impact on the way their stakeholders, their customers and the general public view it. Following a data breach, people may perceive it as unsecure. In the wake of a social gaffe, they might feel that the institution/company is untrustworthy.

Lost productivity

In a 2014 study, 78 percent of companies reported losing one or more mission-critical applications at some point—and 28 percent lost the use of a data center for more than a week. This kind of significant disruption has a trickle-down effect throughout an organization, slowing down productivity and damaging various aspects of the business.

According to a recent Gartner's study on "Business Continuity Management (BCM) Program Maturity":

- 39 percent of organizations that developed their own comprehensive BCM framework (Level 5) recovered all mission-critical business processes according to predefined RTOs and RPOs, or while only experiencing minor problems.
- 12 percent of Level 5 organizations experienced significant problems in recovering one or more mission-critical business applications.
- In contrast, only 13 percent of organizations with no BCM framework in place (Level 1) were able to recover all mission-critical processes according to predefined recovery objectives.
- 15 percent of Level 1 organizations experienced significant problems in recovering one or more mission-critical business applications.
- Overall, business continuity management programs improve disaster recovery rates by as much as 17 percent.
- By 2019, Gartner predicts that 35 percent of organizations with BCM programs that lack maturity will endure major problems recovering one or more mission critical business processes. This is a 17 percent increase compared to 2015.

Despite greater awareness on the business continuity front, research suggests that the cost of data center downtime has increased significantly. Mean (average) costs increased by 36.6 percent between 2010 and 2013, then jumped up another 7.2 percent in 2016. Cybercrime is the fastest growing cause of data center outages. Cybercrime rose from 2 percent of outages in 2010 to 18 percent in 2013 to 22 percent in the latest study.

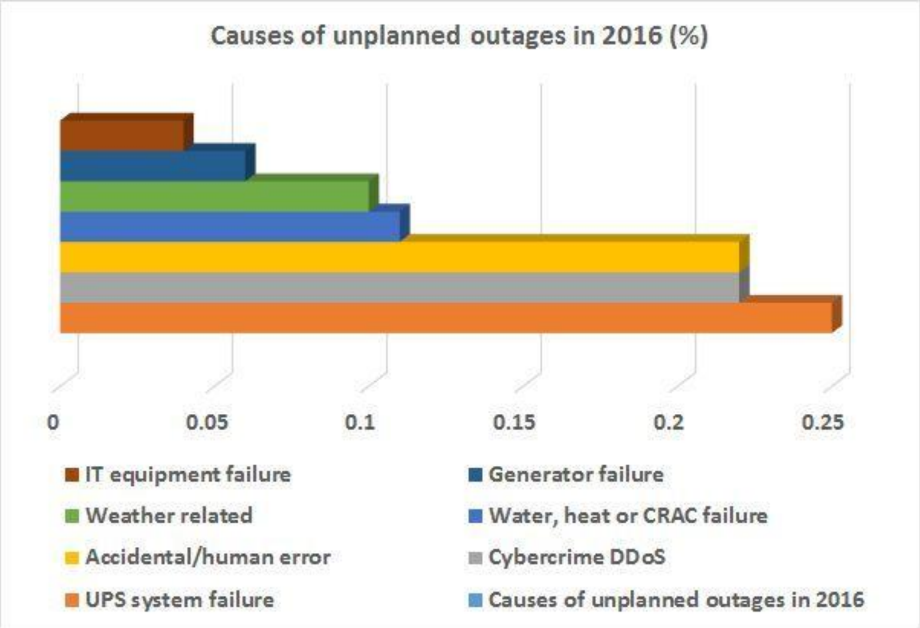


Figure 3: Causes of unplanned outages in 2016

Statistics show that inadequate planning is a widely known vulnerability that plagues recovery initiatives for numerous organizations.

- Only 30 percent reported to having a fully documented disaster recovery strategy in place.
- 32.1 percent reported to having a plan that outlines the specific business critical applications and components that need to be recovered.
- 33 percent revealed that their disaster recovery plan proved inadequate when deployed in response to an outage.
- 15.4 percent didn't even consider a fully documented plan applicable to their situation.

Businesses Losses Explored

Whether it's damage to brand reputation or a direct hit to corporate finances, poor business continuity management can result in a catastrophic loss of data and productivity. Following an outage:

- 35 percent of organizations lost at least one mission-critical application
- 11.7 percent for hours at a time.
- 24.3 percent lost multiple mission-critical applications.

- 18.8 percent lost most or all of their data center functions.
- 12.1 percent loss data that could not be recovered.

Reported losses by organizations amid unplanned outages range from zero to millions.

- 36.7 percent suffered no financial loss
- 18.3 percent lost $1000 to $6000
- 10 percent loss $50,001 to $100,000
- 3.3 percent loss 100,001 to 500,000
- 2.1 percent loss more than $5 million

In some cases, the reported repercussions threatened hinder core operations and put business continuity in serious jeopardy:

- 25.9 percent of recovery efforts consumed staff time that impacted the business.
- 13.8 percent of recovery costs the company money that wasn't included in the budget.
- 9.6 of organizations suffered damage to their brand reputation.
- 9.2 of recovery efforts resulted in disruptions that had a major impact on revenue potential.
- 7.1 of organizations suffered permanent losses.

According to a "Disaster Recovery Benchmark Preparedness Survey" held in 2014, organizations use different approaches companies to business continuity management:

- 42.9 percent of organizations report to use a remote disaster recovery site that mirrors most of their primary site
- 20.4 percent of organizations use a secondary site that is not similar to their primary disaster recovery site
- 29.2 percent of organizations rely on a software-based disaster recovery solution
- 26.3 percent of organizations rely on a hardware-based solution for disaster recovery (replication)
- 15 percent use the cloud for some or all of their disaster recovery environment
- 10.8 percent trust an MSP or hosted solution to support their disaster recovery needs

When communication networks are fragmented and/or poorly connected through unreliable links, the costs of providing an effective program for business continuity and disaster recovery are much higher, due to lack of scale and inefficient location of the nearest point of backup, when considered only within the respective national border.

2.6 Limits of existing infrastructures

Inefficient, expensive and/or unreliable local loops for backup and continuity of connection, often based on radio bridges though microwave links.

A microwave link is a communications system that uses a beam of radio waves in the microwave frequency range to transmit data between separate locations, which are typically used in mountain regions for covering remote areas with cellular services, where copper/optical fiber lines are not available. The costs of maintenance and hw/sw updates for microwave links can be very high due to remote locations and unavailability of supporting utilities, such as energy provisioning and road access. Moreover, microwave links show severe technical limits for the purpose of providing a secure infrastructure for SGI, such as:

- Involve line of sight (LOS) communication technology
- Affected greatly by environmental constraints, including rain fade
- Have very limited penetration capabilities through obstacles such as hills, buildings and trees
- Sensitive to high pollen count
- Signals can be degraded during solar events

Lack of scale for appropriate cybersecurity protection and higher risks of exposure to cyberattacks

Cybersecurity is also a limit on existing infrastructures and is increasing importance day by day. The Alpine Region, with its critical role of cross-road of digital exchanges among European nations, shall not underestimate the need to target an adequate level of technological protection and governance process against a growing level of cyber risks, both at the local and at the global level.

Cybersecurity Facts and Figures are reported in Annex.

This study sets forth the necessity to include cybersecurity issues as a technological and governance layer in any relevant project involving technological infrastructures and digital initiatives across the Alpine Region. An appropriate coverage of cybersecurity tools and processes shall therefore be considered for any future program of public intervention in the area.

2.7 Other limits related to computing resources

The Alpine Regions suffers not only from a lower level of coverage and reliability of territorial connectivity due to network fragmentation, but also from a lower density of computing resources and a higher average distance from large-scale data centers, infrastructures that provide the largest share of digital services for public and private usage.

Furthermore, the digital transformation of economic and social processes, the evolution towards IoT (Internet of Things) and Industry 4.0 will only become a reality through the convergence of Operational Technologies and Information Technologies (OT & IT). According to the policies set forth by the European Union within “Horizon 2020”, both Cloud

Computing and Edge Computing will be required to cross the IT-OT gap, and to support the diffusion of disruptive technologies such as cyber-physical systems, machine-to-machine communication, Big Data and machine learning, and human-robot collaboration will transform public services, logistics and mobility, as well as manufacturing and automation sectors.

The market of Cloud computing is developing fast. Estimates by the EC (*EU Digital Single Market, Report of "Uptake of Cloud in Europe", 10 June 2015*) indicate that these developments could lead to the growth of the European cloud market from €9.5bn in 2013 to €44.8bn by 2020, i.e. almost five times the market size in 2013.

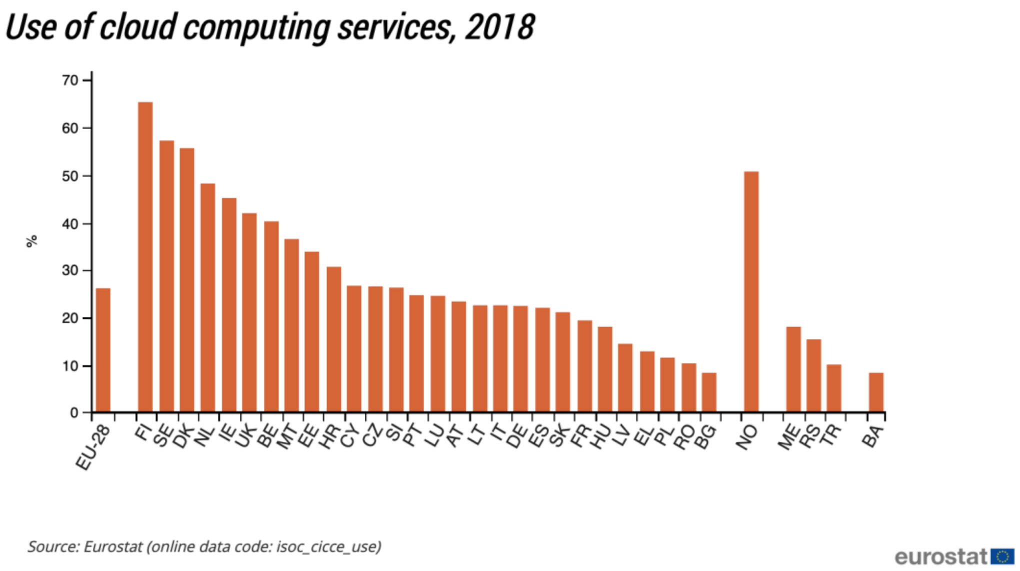


Figure 4: Usage of Cloud Computing Services in EU, 2018

Eurostat shows the current state of play in the European Union regarding the use of cloud computing by enterprises:

- 26 % of EU enterprises used cloud computing in 2018, mostly for hosting their e-mail systems and storing files in electronic form.
- 55 % of those firms used advanced cloud services relating to financial and accounting software applications, customer relationship management or to the use of computing power to run business applications.
- In 2018, many more firms used public cloud servers (18 %) than private cloud servers (11 %), i.e. infrastructure for their exclusive use.
- Compared with 2014, the use of cloud computing increased particularly in large enterprises (+21 percentage points).

Essentially, instead of building or expanding their own IT infrastructure (which would include hardware and involve developing and maintaining software applications and databases), public institutions and private enterprises can access computing resources hosted by third parties on the internet (the 'cloud'). In technological terms, cloud computing is a model for providing enterprises with ubiquitous, flexible, on demand access over the internet to a

shared pool of configurable computing resources, including servers, databases, software applications, storage capacity and computing power.

Indeed, running an application primarily in a public cloud – particularly a big data application – implies that the data to be processed needs to be transferred within the cloud boundaries. These data transfers may result in increasing service latency, which results in an ineffective solution for near-real-time applications such as logistics, safety or health care, as well as a low perceived quality of experience by end-users, on top of being expensive both in time and money for the application manager.

Moreover, privacy constraints may prevent some business areas to rely on third-party platforms. Following the success of public clouds, integrated software platforms are being made available so that private data centers could rely on the same technologies as public cloud. These data centers are owned by local organizations – e.g. by public institutions, corporations, universities, etc. – and are used on a regional basis. Because the size of the physical infrastructure is limited, these private clouds do not offer as much scaling ability as public clouds, but the latency of services is orders of magnitude lower as data locality is exploited. While initially research focused on the operation of applications within a single cloud, i.e. confined to the physical boundaries of one data center, recent trends focus on optimal distribution of computational tasks between multiple clouds, leading to so-called multi-cloud applications. A popular example of multi-cloud deployments is the hybrid cloud, where a public cloud is used to supplement the computing power available within a private cloud when in need, e.g. during a burst peak demand.

From public clouds, the virtualization technology has gradually spread to private clouds. Private clouds rely on the same virtualization principles as public clouds, but are mono-tenant. Usually, the physical infrastructure is hosted locally, e.g. by a corporation, a university, etc., and used for their own needs. The advantage for private clouds to rely on virtualization technology in this situation is to enable a better overall use for the infrastructure, as the physical hardware can be shared better among competing processes, and also have better isolation, which leads to better resilience. Unlike public clouds, private clouds do not appear to scale infinitely, and are usually sized to withstand a specific workload, estimated high-enough to meet most of the demand. More recently, the trend has been to consider the cloud as a generic entity, regardless of the physical location of the infrastructure. The application is then run over multiple clouds. This situation is called multi-cloud. This category may be divided into four further subcategories:

- community clouds, which mutually share the infrastructure;
- hybrid clouds which rely on the use of at least one public cloud and at least one private cloud;
- federated clouds, which, like the community clouds mutualize infrastructure costs, but, in addition, provide a unique interface as entry point.

At the same time, the recent proliferation of Internet of Things (IoT) devices results in a constant steam of data being transmitted from the edge of the network – where these IoT devices are connected – to a consumer application.

While these IoT devices may be streaming data back to the consumer application directly, most deployments rely on a data broker that sits between the IoT devices and the

application, to serve as a central relay point between all IoT devices and all (sub) components of the application. This deployment is known as a publisher/subscriber model, or pub/sub for short. All of these elements (the broker, the applications components) are commonly deployed in (private or public) clouds.

This approach is sub-optimal in the sense that data always needs to be transferred back from the edge of the network to a more central cloud before it can be processed. Consequently, the architecture completely disregards the ability of IoT devices to (pre)process data on their own. In one of following chapters we will go deeper in new Information and Communication Technologies that can face these challenges, including 5G networks and Edge Computing.

3. Digital Ecosystem

After having analyzed economic models that are behind ICT processes we see here which Digital Ecosystem is possible with its governance.

Data at the heart of the challenges of cross-border integration and institutional governance

For public institutions in the Alpine Region as well as across Europe, the question of protecting sensitive public and private information is related to that of data management, confidentiality and security. In theory, 5G networks provide an opportunity for operators to enter the cloud computing market they failed to enter throughout the 2000s.

However, whilst they can offer control over the network, it is not sufficient to convince companies and digital actors to hire operators to manage and process their data. Thus, the value created by 5G networks could be transferred to the current dominant players outside of Europe.

The involvement of technologies using the cloud raises the question of the governance and security of data passing through, stored in or processed by the cloud. On top of measures taken in Europe notably concerning the processing of private data via the General Data Protection Regulation (GDPR) and the Regulation about Free Flow of Non-Personal Data, there is the need for a systematic regulatory framework governing these activities and the uses made of the data collected. There is also no clear regulatory framework concerning the way technological implementations (API, containers, etc.) should be undertaken to allow interoperability between equipment and services on the market. On a market dominated by non-European players, and with the implementation of legal measures, such as the Cloud Act, not only the Alpine Region but also European institution at large, in theory, soon find themselves in a position of dependency and vulnerability.

These stakes are also relevant to 5G, which will enable the development of cloud services by further improving network performance.

The sovereignty and security of institutional members, companies and civil societies in the context of 5G network deployment will necessarily involve a regulatory, economic and political response.

The first step is to encourage the harmonization of European regulations. To be able to face up to the players supported by huge domestic markets, minimize costs and thus avoid delays, a coordinated European response must be found, ensuring a high level of exigence in all Member States. European players cannot be the most efficient and responsive if they are required to comply with different regulations in each of the areas in which they operate. This response must include the definition of authorities charged with issuing 5G deployment authorizations for the European territory, defining device selection criteria and conducting the tests required for the entire Single Market.

Another step, put forward in this study, is to develop the sharing of passive infrastructures. In an environment in which operators' investment efforts will be significant, solutions must be

found to reduce these expenses. The savings generated would help to ensure network security and develop infrastructures rapidly, thereby achieving the connectivity objectives. In this situation, the attribution of frequency use authorizations is one key element, but the sharing of passive infrastructures is another possibility that should be given serious consideration.

Implementing a 5G network requires densifying existing radio sites, which requires massive investments estimated at Euro 56 Bl by 2020 for the 28 member States of the European Union. The emergence of passive infrastructure managers able to make this investment and provide the sites to operators could help to accelerate deployment, while preserving the competitive balance necessary to innovation.

Finally, encourage the development of a European ecosystem based on 5G usages

The development of a dynamic and innovative ecosystem based on 5G usages shall be encouraged. The usage battle is of the utmost importance. 5G will cause some players to disappear and new champions, proposing disruptive models, to emerge. Indeed, if Europe is lagging behind in some of the technologies essential to 5G (cloud solution for example), this technological revolution also creates an opportunity to reshuffle the cards. Actors within a specific industry who understand and develop new uses specific to 5G may introduce disruptive models that may upset established positions. Thus, in this battle over 5G uses, the first players to benefit from an environment and use cases to develop their services will take a decisive lead in imposing their solution at the global level. The race to develop an ecosystem concerns the fundamental economic players and must enable European operators to capture some of the value created. Today, they are trapped between non-European device manufacturers (notably Chinese), which have colossal R&D resources thanks to captive domestic markets, and cloud infrastructure operators, mostly American, which are already several steps ahead.

On top of infrastructural investment, a critical challenge is define a set of rules for cross-border data exchange, in order to establish an appropriate digital ecosystem for the Alpine Region. According to the policies set forth by the European Commission, the free flow of non-personal data generated by IoT applications as well as by the dissemination of sensors on the territory will be a pre-requisite for a competitive data economy within the Digital Single Market. To fully unleash the data economy benefits a free flow of data is needed, allowing companies and public administrations to store and process non-personal data wherever they choose, within the EU.

The Free Flow of Non Personal Data Regulation (Reg. 2018/1807 of the European Parliament and of the Council of 14 November 2018 on a framework for the free flow of non-personal data in the European Union), applicable as of 28 May 2019, aims at removing obstacles to the free movement of non-personal data across Member States and IT systems in Europe.

The Regulation ensures:

- Free movement of non-personal data across borders: every organisation should be able to store and process data anywhere in the European Union,

- The availability of data for regulatory control: public authorities will retain access to data, also when it is located in another Member State or when it is stored or processed in the cloud,
- Easier switching of cloud service providers for professional users, encouraging providers to develop codes of conduct regarding the conditions under which users can port data between cloud service providers and back into their own IT environments,
- Full consistency and synergies with cybersecurity provisions: any security requirements that already apply to businesses storing and processing data will continue to do so when they store or process data across borders in the EU or in the cloud.

An early example of success in the definition and in the applications of rules for constituting a digital ecosystem as enabling platform for smart services in the Alpine Region is the “E015” Digital Ecosystem applied by Lombardy, in Italy E015 digital ecosystem is an open, competitive, non-discriminatory digital environment for the development of integrated software applications. The initiative was born from the collaboration to support the EXPO 2015 exhibition in Milan, for the benefit of all the companies and businesses of territory. Through the E015 environment, each "adherent subject" (company, body, association) can join the ecosystem: membership is free and can be activated online through the E015 Website. E015 provides members with guidelines for participating in the ecosystem –i.e., the E015 “common language” – for interoperating with other members. Members can contribute to the ecosystem in different ways. They can:

- publish E015 APIs, i.e., expose part of their own information assets in the ecosystem through Web services, so that other members can ask for them in order to build integrated applications for the end-user.
- Build E015 end-user applications, i.e., develop Web sites, mobile apps, information kiosks etc. providing end-users with value added contents and functionalities by asking for the data provided in real-time by the E015 APIs.

E015 was initially promoted to foster the development of innovative services for tourists and visitors during the Universal Exposition of Milan 2015. In particular, it aimed to help matching the offer of digital contents, provided by various owners of information, with the needs of business players interested in creating value-added services for end-users. From the beginning, E015 adopted an overarching model addressing not only technological standards but also processes, roles and governance aspects in an integrated way. Today E015 is still a reference relationship environment engaging a growing number of participants in the development of innovative APIs and applications which cover various domains, ranging from mobility to logistics to tourism, from healthcare to cultural heritage, etc.: As of 2019, there are more than 400 types of different “digital connections” among public and private organizations, enabling a long list of applications for public use.

The interconnection of targeted Alpine areas shall create a critical mass of networks with positive externalities that will encourage all stakeholders, public and private, to develop their

services and join the network. The creation of such a critical mass will, in itself, trigger the development of a pool of technical competences and resources that can help to enhance other emerging networks in the region. The ease of exchange of skilled manpower between areas will assist in this capacity building carried out through the training and technical support activities. By concentrating on specific innovative projects, it should be possible to encourage other stakeholders to join in a controlled and phased manner over the mid-term. The visibility of initial implementations will encourage the developments of scalable initiatives in other areas.

A list of possible applications addressing the opportunities and managing the threats set forth in this feasibility study is discussed in the following sections.

The Alpine Region, a natural laboratory for combining advanced connectivity and a «Green New Deal»

As this study has tried to discuss, the infrastructures of connectivity in the Alpine Region can be considered a case study of the socio-economic effects of:

- Negative Externalities of Fragmentation
- Positive Externalities of Network Interoperability
- Economies of Density for specific social, economic and environmental factors

The attempt of the feasibility study has been to reverse the traditional approach, oriented to identify and cover the «gaps» of peripheral regions, vice versa seeking the specificities of the territory in terms of higher growth potential and new factors of competitiveness at the global level.

With a «Green New Deal» being targeted by political institutions at all levels, the Alpine Region provides a natural laboratory for experimenting a new concept of sustainable growth, reversing the traditional logic of programs targeted to peripheral areas, which are inspired by the need to cover the (assumed) permanent gap of attractiveness and productivity with respect to more developed regions.

The Alps are «*green by natural design and by historical practices*», therefore environmental sustainability in the Region becomes a competitive advantage with respect to larger urban areas, and must be transformed in a driver of attractivity for both financial investments by public and private players as well as a magnet for talents and human capital seeking a better combination of professional opportunities in the «green economy» combined with a superior quality of life.

The many different socio-economic processes to be enabled by EUSALP activity are being classified according to 3 technological factors (redundancy, coverage and latency) related to the development and governance of connectivity infrastructure.

Factors *Processes*	**Redundancy**	**Coverage**	**Latency**
Mobility	High	High	High
Health Care	High	Medium	High
Territory supervision	High	High	Medium/High
Fire Supervision	High	High	High
PA SGI	High	Medium	Low
Tourism	Medium	High	Medium/High
Education	Low	Medium	Medium
Research	High	Low	Medium

Table 1: Factors and processes

A new paradigm: identifying "Minimum Viable Solutions" for the Alpine Region.

When lack of legacy infrastructures is a competitive advantage for innovation, periphery becomes a new center. The development of a cross border, Region-wide technological infrastructure and the establishment of a digital ecosystem for governance of socio-economic processes, shall be enabling a new cycle of financial and social investment will pursue many of the institutional objectives of the EUSALP strategy (competitiveness, attractiveness, contrast to demographic decadence, environmental protection, sustainable mobility and higher level of social services).

A tentative sizing of the financial needs related to each initiative shall be anticipated with 3 stages of investments, measured across both social and economic impact to be achieved:

1. Minimum Viable Solution
2. Critical Mass/Tipping Point
3. Endgame

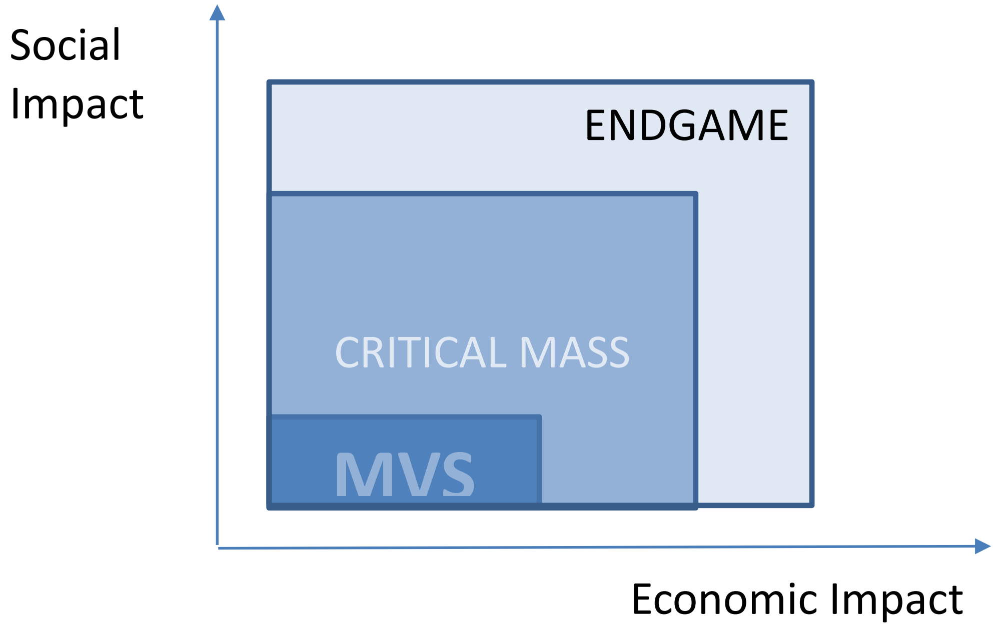


Table 2: The scheme of Minimum Viable Solution

As an example of the approach, one can consider the following illustrative steps:

1. **MVS**: FO ring VDA/FR/CH through main Alpine passes/tunnels
2. **Critical Mass**: All Cross-border FO rings within existing road/railway infrastructures
3. **Endgame**: all relevant segments of secondary Alpine valleys

The practical application being described below have been selected with the logic of addressing all the most relevant factors discussed in this study, and namely:

- Exploitation of specific factors of competitive advantage of the Alpine Region
- Development of cross-border connections and interoperability among communication networks, computing resources and digital ecosystems
- Sustainability from both environmental and socio-economic perspective
- Scalability via replication at relatively low marginal costs
- Eligibility for public financing as well as attractivity for private investments

4. Communication services, evolution and approach for Alpine Area

We introduce communication services that are involved in the services that have been described in previous chapters and are the building blocks of the examples of practical applications that are shown in following part of the document. We start with an overview of the communication trends highlighting the fact that not only the last mile is important in the user experience that is also depending on the application and service. Then we focus on the EU approach on future communications that is strictly related to evolving 5G architecture.

4.1 Communication trends

To introduce the following discussions, we can briefly depict a general model where telecommunication services are organized with a tidy structure based on following levels:

Backbone

It's the highest level of the network hierarchy and refers to the core of communication services based on long distance systems of a communication operator. It's widely deployed on optical fibers and, at this level, interconnection with other players occurs. There are different examples of commercial backbones nowadays, as that from CenturyLink in Figure 5 (see https://www.centurylink.com/asset/business/enterprise/network-map/centurylink-network-maps.pdf).

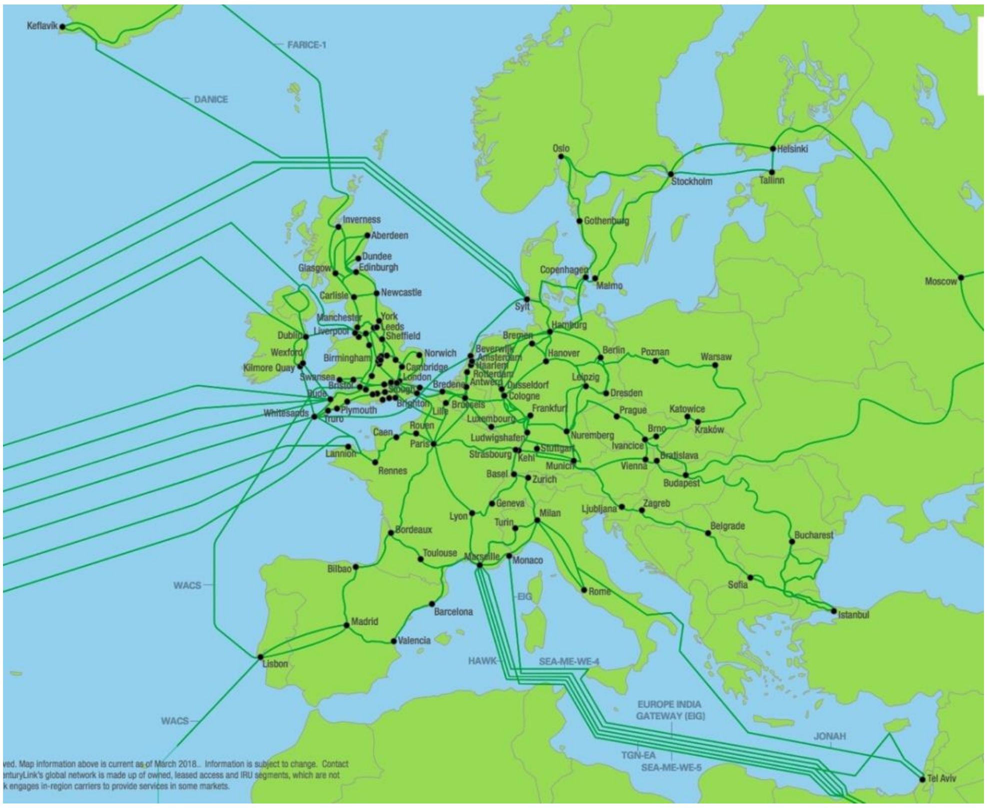


Figure 5: example of carrier backbone

Backbones are relevant also for allowing for interconnection between the research community and the high capacity data processing facilities they require for their research purposes. In EU, on the national level, the National Research and Educational Networks (NRENs) provide end-to-end connections of researchers and HPC centres as well as for HPCs with one-another, On a European level (and beyond) GÉANT provides cross border links between the NRENs and thereby generates a backbone network for the research surrounding for its 42 members: it provides nodes for the interconnection with the NRENs at 31 sites across Europe (see https://www.geant.org/Resources/#maps).

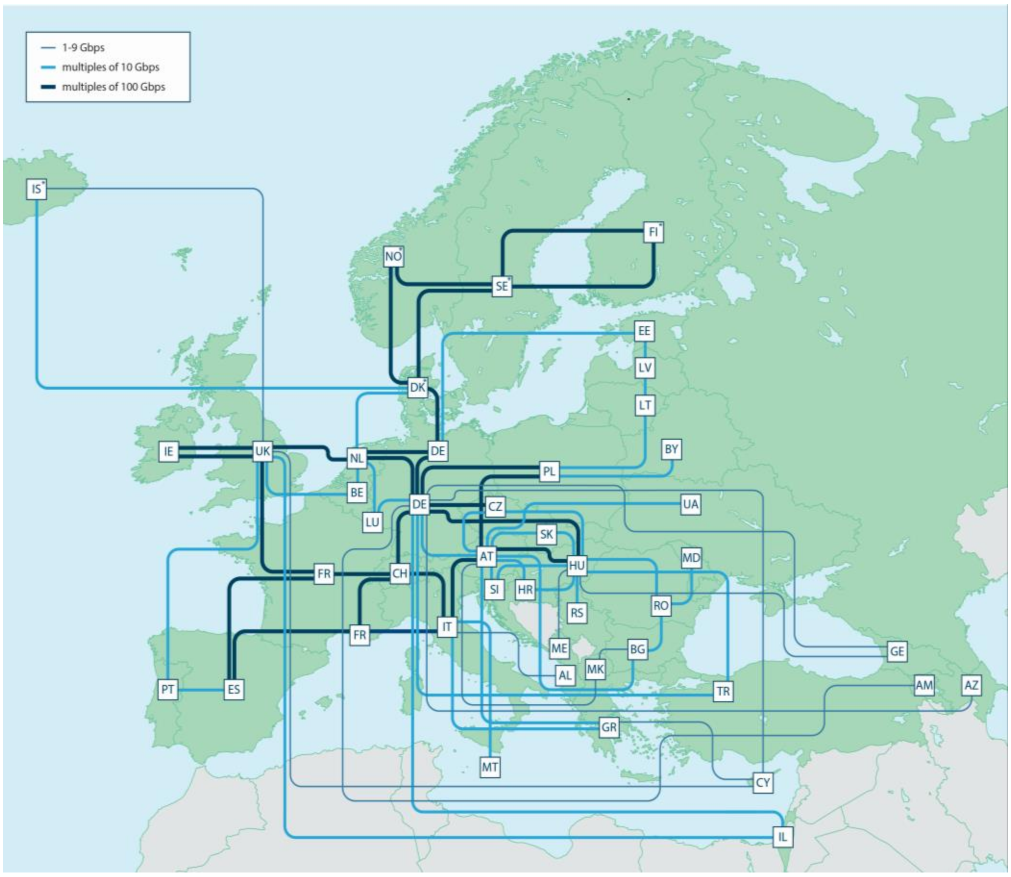


Figure 6: GEANT and NRENs

It's important to underline that such resources (dark fibers or DWDM channels) can also be used for unconventional uses. An emerging case is Time and Frequency distribution over fiber that meets increasing requirements from financial industry in trading online services, energy trading and 5G synchronization requirements.

Backhaul

It is the medium range systems that connects the core of the network to local Points of Presence (PoPs). They're generally deployed on optical fibers but also wireless technologies can be used especially in rural and mountain areas. Wired is usually a very expensive solution and often impossible to deploy in remote areas, hence making wireless a more suitable and/or a viable option. Multi-hop wireless architecture can overcome the hurdles of wired solutions to create efficient large coverage areas and with growing demand in

emerging markets where often cost is a major factor in deciding technologies, a wireless backhaul solution is able to offer 'carrier-grade' services, whereas this is not easily feasible with wired backhaul connectivity. Below an overview of current ecosystem (see https://www.edgemicro.com/our-solution/Edge-Colocation-data-centers/).

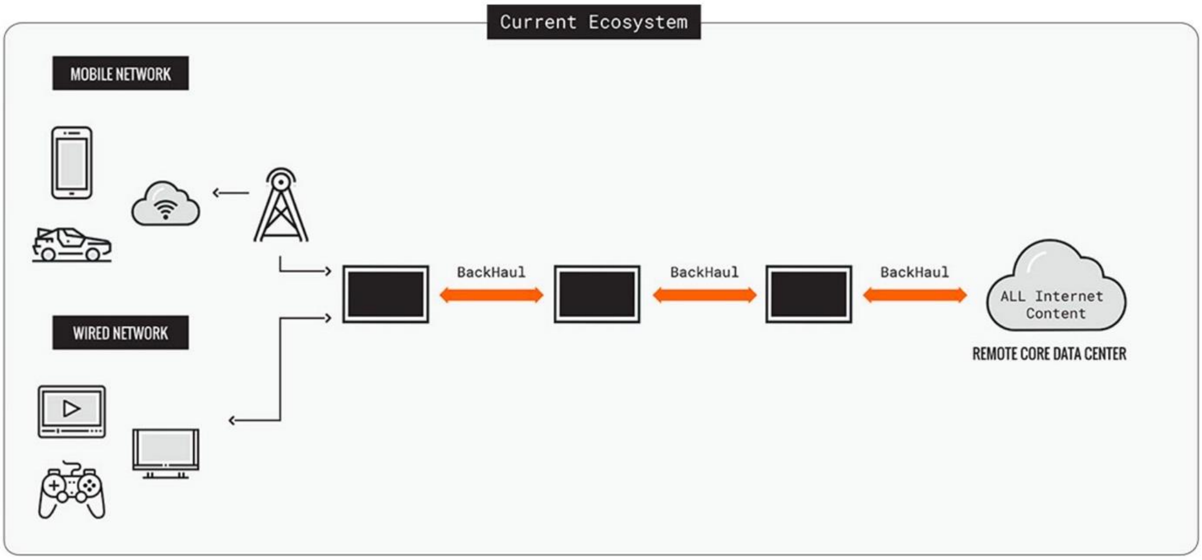


Figure 7: backhauling

Access

it refers to the connection of customers to local PoPs. Different technologies can be used (fiber, copper and wireless). While mobile customers are necessarily connected with wireless technologies, fixed customers are connected with both wired technologies (FTTx, XDSL, coax cables, etc) and wireless technologies (Wi-Fi, 4G, WiMax, etc.) In last group we normally talk now about Fixed Wireless Access (FWA). Sensors or other IoT devices that can use some wireless technologies due to low capacity requested.

A generic graphical description of three levels is shown in following picture.

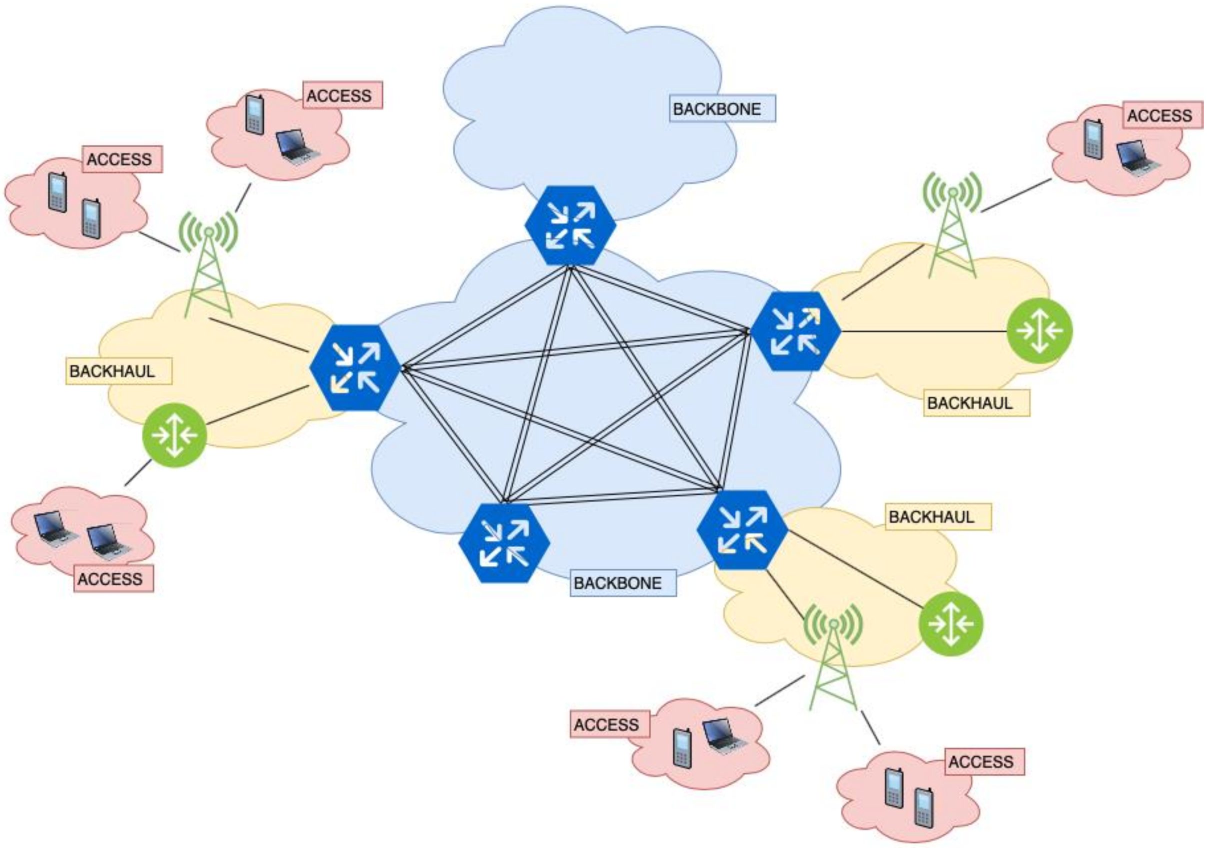


Figure 8: Backbone, backhaul and access

It's worth to notice that in practical deployments this structure is not always fixed with an overlapping of tiers depending on scale, environment and other internal or external factors.

Moreover, within the operator's category we don't consider only players as traditional Carriers or Internet Service Providers (ISPs) but also other companies that, although their main business isn't to sell connectivity, own and manage a backbone network. Big Internet giants (Google, Facebook, etc.) are part of this category as they have a global network and they are interconnected at the edge of their Autonomous Systems (AS) with other operators that provide connectivity to final users. This general scheme provides a warning on the importance of having the better interconnection, to provide a better user experience for actual and future services where ensuring low latency is a key factor. In fact, a common misunderstanding is related to bandwidth vs throughput:

- *bandwidth* is related to the maximum amount of data that can travel through a channel in a unit of time;
- *throughput* is related to the real amount of data that is travelling through a connection within two points in a specific time period.

So, while bandwidth is an important element of telecommunication services, related to a specific link in the overall environment on the other hand throughput, as an end-to-end

parameter, provides a measurement to the efficiency of the connection to the service and is strictly related to the availability of good interconnections. This difference is always misunderstood in many discussions when bandwidth of last mile connection is considered the only quality parameter but it's not a guarantee of the quality of an end to end service.

For this reason, players as CDNs (Content Delivery Networks) are playing a key role in modern Internet architecture and other players (in addition to some strategic factors) are developing their own networks, in order to keep their services as close as possible to the end users. In all emerging applications, having services closer to end user also implies having reduced latency as having short paths within the source and user of an application or a service. This is very important in some sectors like IoT or connected cars, where low latency is necessary to deliver a certain decision following the received inputs.

The concept of low latency is widely discussed and it's mainly related to the application or the service that must be carried on communication networks. In typical Over The Top Television (e.g. Netflix or Amazon Prime) latency is not a critical issue as they are On-Demand services. Also considering emerging applications, requested latency is below 100 ms for gaming, if we consider typical user experience when a gamer acts on his console and expect an action on the screen of a remote user in multirole games. Same requirements are requested for IoT applications. Only connected vehicles require latencies of an order of magnitude lower. This concept is well explained in the following picture included in a communication from the EU Commission to EU parliament, reporting different expected latency and speed for different applications or services for single user.

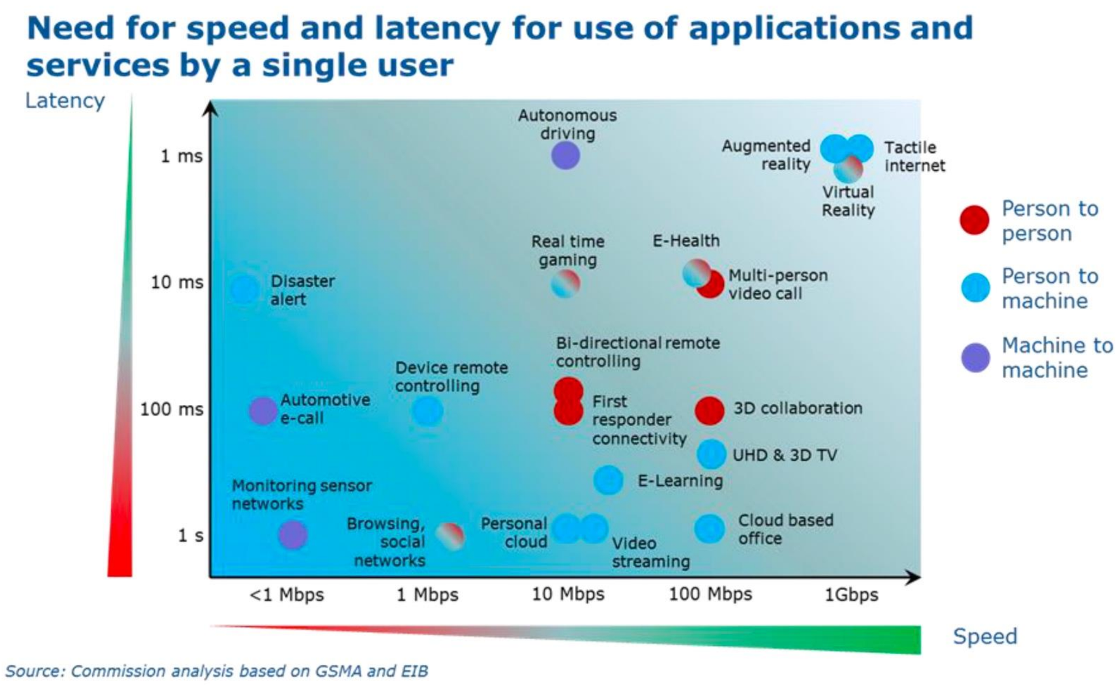


Figure 9: Speed and latency

Last note on communication evolution is related to the interconnection within different operators where two entities are key players:

- *Colocation facilities*: these are data centers generally owned and operated by companies that provide open access to every kind of customers, even carriers and Internet Providers. This allows different operators to host their communication devices in a place where other network subjects are largely present, being able to exchange data without the need of expensive point-to-point long distance connections.
- *IXPs (Internet Exchange Points)*: network facilities that enable the interconnection of more than two independent Autonomous Networks, primarily for the purpose of facilitating the exchange of Internet traffic.

Often Colocation facilities and IXPs are partners in different metro areas, especially in European Market where IXPs are widely developed. The following map from IX-F (http://www.ix-f.net/) highlights that different IXPs already exist in Alpine Area with a greater density than other European areas.

Figure 10: Euro-IX IXP map

4.2 Network evolution and European Union Approach

As already introduced, new services based on ultra-high bandwidth and low latency are made possible only through the advent of the 5G revolution. The matter is closely followed by the European Commission through a series of programs aimed at leading global developments towards this strategic technology.

Having identified the 5G opportunities early, the European Commission established a public/private partnership on 5G in 2013. This is the EU flagship initiative to accelerate research and innovation in 5G technology, publicly funded through the Horizon 2020 program. EU investment in 5G research and standards is necessary to support the traffic

volume expected by 2020 but also to boost networks and internet architectures in emerging areas such as machine-to-machine communication and the IoT.

To ensure early deployment of 5G infrastructure in Europe, the Commission adopted in 2016 an action plan with the objective to start launching 5G services in all EU member states by end 2020 at the latest, followed by a rapid build-up to ensure uninterrupted 5G coverage in urban areas and along main transport paths by 2025. To monitor the progress of this action, plan the Commission launched the European 5G Observatory in 2018, a monitoring tool concerning major market developments in Europe in a global context. It also reports on preparatory actions taken by member states such as spectrum auctions and national 5G strategies. The third report on the main elements for consideration in such national strategies from a European perspective was published in March 2019 (A study prepared for the European Commission DG Communications Networks, Content & Technology by IDATE Digiworld).

The following picture from a study of 5G PPP, supported by EU (5G Empowering Vertical Industries) depicts the general structure of 5G future networks.

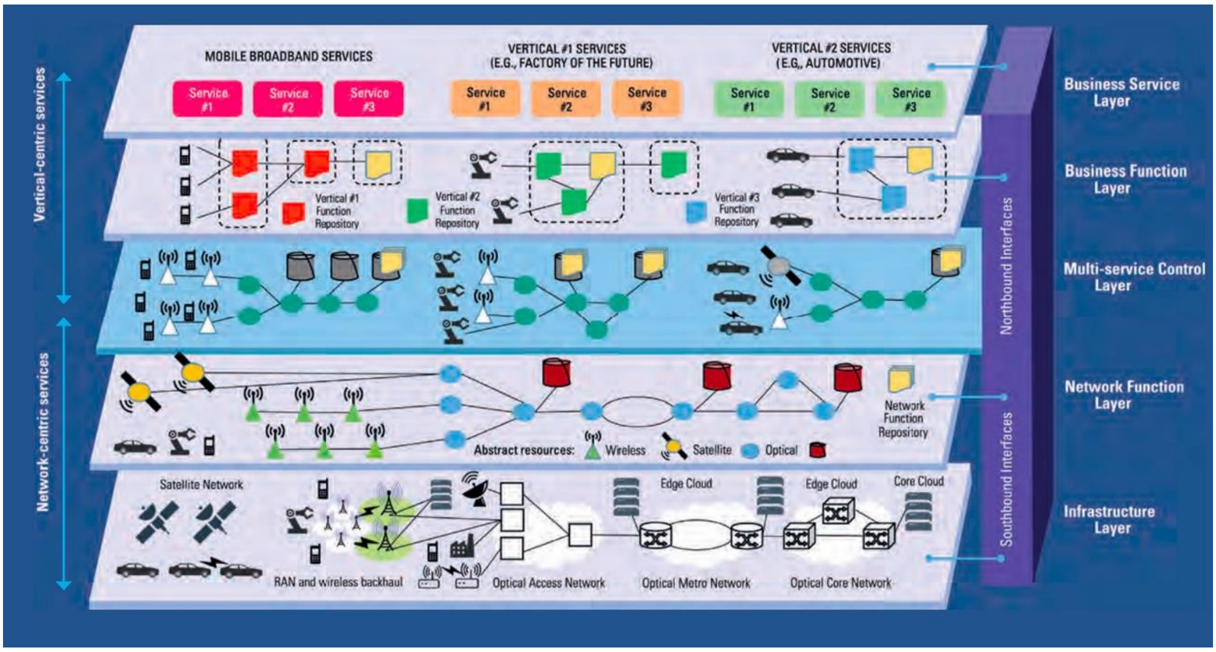


Figure 11: 5G future networks

As we can see, there are different layers in the model grouped in Network-Centric Services and Vertical-Centric Layers. Infrastructure and Network Function belong to Network Services while Business Function and Business Service to Vertical Services: Multi-Service Control Layer is the point of contact of two groups.

Regarding this layered approach one key aspect is the presence, next to classical broadband services, of vertical services related to different vertical markets: picture shows 2 very interesting examples as automotive and factory of the future but others can be mentioned or will be available in the future. This will be possible with a massive usage of software with APIs exposed to Business Service Layer to implement required service in lower layers:

necessarily this "softwarization" will involve all layers, including infrastructure and network. New emerging and disrupting technologies as SDN and NFV are core in this process. The following picture depicts this new paradigm where:

- *Software Defined Networking (SDN)* is used at network level to increase a dynamic resource of available resources accordingly to Cloud paradigm with a separation of forwarding level from control level;
- *Network Function Virtualization (NFV)* is introduced to demand classical network operations with servers that can be virtualized (different virtual servers on one or more physical servers).

Practically, a network architecture that enables the multiplexing of virtualized and independent logical networks on the same physical network infrastructure is expected and is normally called 5G network slicing. Each network slice is an isolated end-to-end network tailored to fulfil diverse requirements requested by a particular application.

For this reason, this technology assumes a central role to support 5G mobile networks that are designed to efficiently embrace a plethora of services with very different service level requirements (SLA). The realization of this service-oriented view of the network leverages on the concepts of SDN and NFV that allow the implementation of flexible and scalable network slices on top of a common network infrastructure.

From a business model perspective, each network slice is administrated by a mobile virtual network operator (MVNO). The infrastructure provider (the owner of the telecommunication infrastructure) leases its physical resources to the MVNOs that share the underlying physical network. According to the availability of the assigned resources, a MVNO can autonomously deploy multiple network slices that are customized to the various applications provided to its own users.

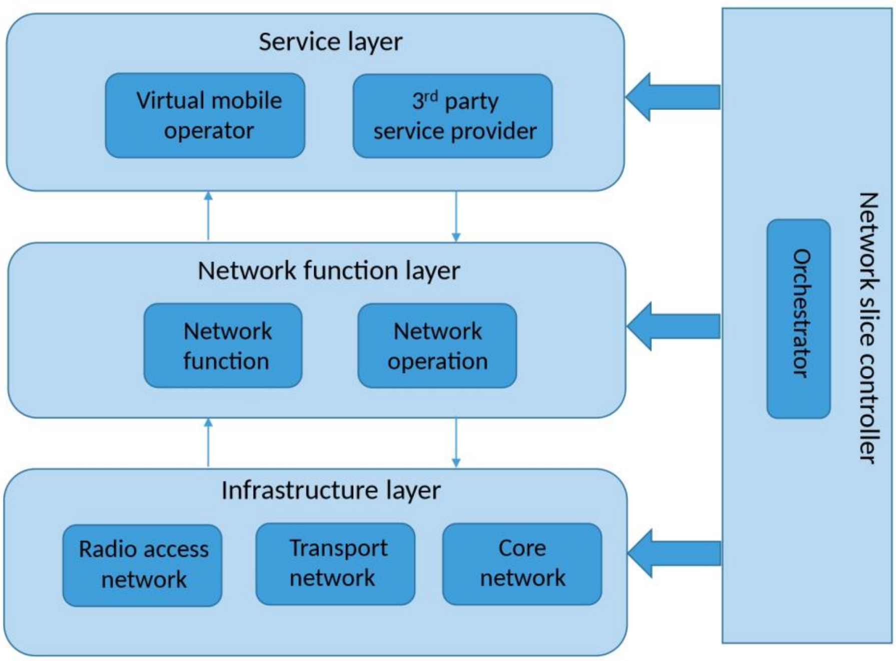


Figure 12: SDN/NFV general schema (source Wiipedia)

As mentioned before, an essential point is about physical infrastructures ownership. Although some players in telecommunication industry still have the idea of vertical integration (from infrastructure to services) some signal from the market in nascent 5G era are showing that, to face huge investments requested with these technologies, infrastructure sharing will be a must while competition will be on services (quality, price, etc.). So shared fiber cables, data centers and towers will be the building block of future communication systems.

Some very important questions that are still open regards how these building blocks will be dependent on each other and how widespread they will be. For example there are some players that are fostering the idea of having small data centers in each tower location in order to ensure the latest possible latency from edge computing systems to end users while others are still firmly believe that Data Centers in big metro areas are enough to satisfy the surge of low latency requests.

In other words, we can talk about Cloud Computing where shared computational resources are hosted in few Data Centers mainly located in metropolitan areas. Otherwise, when computational resources are hosted in many data centers scattered in different areas, we can talk of Edge Computing.

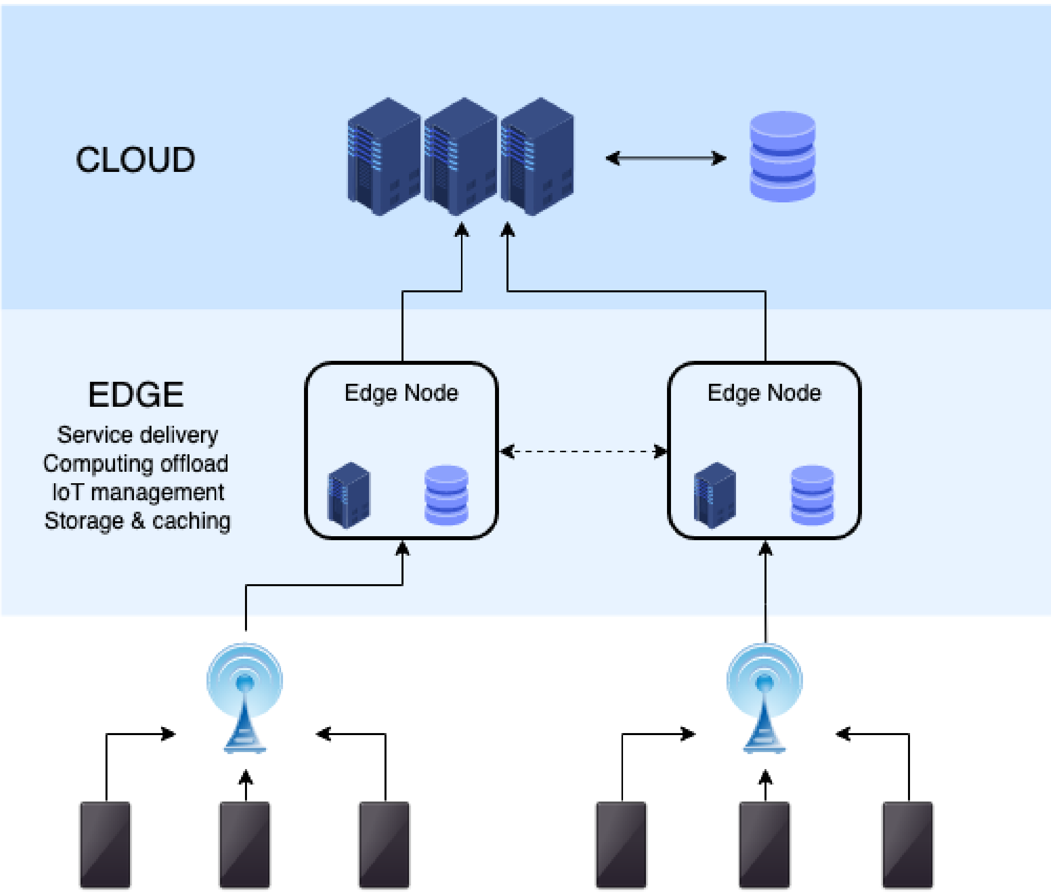


Figure 13: Edge computing general schema (source Wikipedia)

We should note that sometimes we also hear about Fog Computing that is a standard defining how edge computing should work, and it facilitates the operation of compute, storage and networking services between end devices and cloud computing data centers.

4.3 Network implementation in Alpine Area

The gaps evidenced in previous chapter can and must be covered through an innovative approach that design the infrastructural architecture of cross-border regions with an appropriate combination of centralized and decentralized technological resources, including the interconnection of proximity data centers and the implementation of Fog Computing resources. The recent concept of Fog Computing is a logical extension from Cloud Computing towards the edge of the network (where machines and sensors are located), enabling applications that demand guarantees in safety, security, and real-time behavior, in a low-latency environment. Following the European Union approach and communication trends already described, it's easy to think the implementation of same concepts in Alpine Region: this would also help in enabling Smart Villages, that are two strategy points in discussion within the EUSALP governance.

The Edge Computing paradigm was introduced to overcome these limitations. It aims to extend cloud services up to the edge of the network, i.e. include all devices, in particular those that produce the data, in the processing chain. Empirical studies (see *F. Bonomi, R. Milito, J. Zhu, and S. Addepalli, "Fog computing and its role in the internet of things", in Proceedings of the First Edition of the MCC Workshop on Mobile Cloud Computing, ser. MCC '12, ACM, 2012, 13–16*) identify latency and jitter as a dominant concern in systems that require rapid response. Therefore, several research projects consider placement of applications on geographically distributed clouds. Nearby clouds generally perform better in terms of latency; this consideration eventually leads to the conception of fog computing. Fog computing is a sub-paradigm included within edge computing, whose aim is to extend cloud computing and services to the edge of the network. The distinguishing characteristics of edge computing are its proximity to end-users, its dense geographical distribution, and its support for mobility. Services are hosted where they are used: at the network edge, and even on end-devices such as IoT devices, or access points. By hosting services locally, service latency is reduced and the quality of service (QoS) is improved, resulting in superior user-experience. This paradigm is ideally suited for many public service and industrial applications, since in-network processing can improve energy efficiency, and data delivery reliability, due to the reduced communication and congestion.

Given the ad-hoc (and often chaotic) nature of wireless IoT environments, fault-tolerant cloud management becomes critically important for IoT-based Fog Computing systems. This is especially true for critical public and private applications, which require high degrees of reliability. According to technical literature, proactive fault tolerance can be achieved through two complementary mechanisms. First, multi-path networking can mask network failures: multiple parallel network paths are active simultaneously for the communication between two network nodes. Second, node replication can mitigate node failures: a virtualized node is replicated onto multiple physical nodes.

Therefore, cross-border infrastructure for both integrated connectivity and distributed computing power will be essential for competitiveness of Alpine Region and as enablers for the goals set forth in the Digital Single Market policies. Next generation infrastructures enabling 5G connectivity and services will be critical resources, vital for the good functioning of a multiplicity of key economic and societal processes (mobility, health, environmental protection, tourism, education, manufacturing, etc.). A strategic approach is needed to ensure synergies among Member States initiatives in particular for large-scale experimentation and deployment.

The development of appropriate coordination mechanisms in order to reinforce the Alpine Region social and economic potential and capabilities in the area of smart networks and services requires coordination among several stakeholders. This is especially important when transferring knowledge to new application areas such as mobility, energy, and health. The scope of the challenge to be addressed requires the creation of innovative value chains across different sectors such as network equipment and service providers, big data, cloud, software-defined infrastructures and Internet of things technologies and services.

The current levels of investment towards 5G experimentation and deployment actions are not focused on the specific needs of the Alpine Region and are however not sufficient to reach the critical mass required for cross-border dissemination, let alone at European scale. Currently, various public and private stakeholders are investing in 5G testing capabilities, but often in an uncoordinated manner, resulting in duplication of efforts and lack of strategic planning at European level. A closer coordination of investments would foster integration of resources. Coordination with national programs and initiatives as well as other financial instruments at EU level ("blending") is needed to ensure the coordination for supporting large-scale experimentation and deployment programs of public interest. Whereas CEF Digital projects will focus on cross-border corridors, complementary public investment in areas beyond cross-border sections will be necessary to achieve pan-EU corridors for connected and automated mobility.

The expected evolution of 5G infrastructure, in theory, will offer Terabit capacities and perceived zero-latency and will be based on near-real-time capable service provisioning infrastructures leveraging opportunities of next-generation cloud and next-generation Internet of Things (IoT) technologies. Key technologies will include for example Visible Light Communication, software defined radio and network technologies enabling spectrum reform, cloud native network and service architectures designed for Artificial Intelligence and Big Data, green cloud and edge/fog computing. Security and trust and energy efficiency are also key requirements to support a human centric Internet.

The social and economic objective is to consolidate European strongholds in connectivity whilst seizing current emerging technological opportunities in future generations of connected devices, and in future service platforms. Such platforms are expected to contribute to the SDG's (sustainable development goals) with a sustainable platform infrastructure underpinning energy and resource optimized digital processes across a myriad of applicative segments.

Under the main strategic objectives of the European Commission "Connected Europe: 2025 objective", the main socio-economic drivers, schools, universities, research centers, transport platforms, public service providers - such as hospitals and public administrations -, as well as

the companies that depend upon digital technologies, will all require very high-speed gigabit connections. All residential areas, main roads and rail routes must have uninterrupted 5G coverage.

5G is a breakthrough technology, bringing transformation possibilities in multiple sectors. This is due mainly to three reasons:

1. High speed and very low latency. This enables applications that are more demanding in terms of responsiveness (autonomous cars, remote-surgery, etc.);
2. Decentralization. A local network core is placed on each antenna. This notably enables the development of edge/fog computing (i.e. data processing without involving a data center distant from the actual site on which the data are processed);
3. Slicing capacity. 5G enables network use to be separated according to the demands of a user - such as a company that processes a lot of data - according to usage.

This means that cloud computing applications can be deployed (functions ensure via the cloud and therefore independently of the performance of the terminal - telephone, computer, etc.), while maintaining regular use of the network for basic functions. Its strong growth will therefore enable the massive development of the internet of things (IoT), which will play a fundamental role in the fields of mobility, augmented reality, industrial product and energy networks. Edge computing and artificial intelligence (machine learning and deep learning) will enable operators to propose new services to the general public and industrial customers (maintenance assistance via augmented reality, real-time modification of production tools - development of farms of robots -, autonomous vehicle services, virtualization of the gaming offer, etc.).

In critical functions such as mobility, logistics, health care, industrial processes, the 5G network architecture offers the possibility for a “client” (application, company, etc.) to ask directly for virtual network resources to meet its specific requirements (data speed, latency, etc.). For example, a mobility service provider could obtain specific network resources to guarantee the stability of its connection and very low latency to enable the deployment of a fleet of autonomous vehicles.

At the same time, certain business models will evolve, turning towards high added value services. In civil society, 5G will enable the development of solutions to ensure territorial connectivity and access to public services. With a sufficient level of penetration and adoption, the new telecommunications networks will overcome the constraints of physical and geographic installation, providing higher added value services to the whole territory in fields such as healthcare and education, for example. Using augmented reality tools, whose efficiency is improved by 5G, healthcare professionals located throughout the territory could perform complex interventions requiring specific expertise, under remote supervision by experts in regional centers.

The Alpine Region, within the European framework of transition to 5G technologies, must make sure that the conditions of developing a usage ecosystem are fulfilled. This initially implies a capacity for experimentation, bringing together private and public organizations, users and solution developers to foster and refine both functions and usages. Investments and coordination at the European scale are fundamental. It is important to remember that the

Chinese and American economies have sizeable domestic markets to enable their national champions to develop these activities and to make considerable headway immediately.

Any delays in deploying territorial connectivity will have a knock-on effect, delaying the development of the 5G ecosystem by European players. Such a delay may prove impossible to catch up, in view of the resources implemented by our competitors. The rapid deployment of 5G networks represents a major competitivity challenge for our industries, infrastructures and territories.

As discussed, low latency is a key element of 5G that will foster the development of new usages. However, most of the value generated by low latency could be captured by global players, affording them a dominant position thanks to their widespread computation capacity and the absence of specific regulations. In other words, increasing network rapidity increases the value of the services proposed on these networks. Today, these services are dominated by non-European players. This raises the question of sovereignty with respect to control over the data generated in each country's territory, as well as the capacity of operators to guarantee the security of their networks.

A 5G network is a combination of a physical infrastructure and a software infrastructure, whose function is to adapt the network's response to customer usages. For example, this adaptation will enable the large computation capacities required for video games to be used on the same network as the massive connectivity required for the industrial IoT. The difference between the architecture of a 5G network and the conventional telecommunication network as we know it, is this separation between the different systems making up the physical network infrastructure (relays, antennas, etc.) and the software architecture. "Superior" level functions (data processing, computation capacity, artificial intelligence, etc.) are performed separately from the physical infrastructure transporting the data. This is known as network slicing.

The 5G network service will therefore be supplied via two technologies: NFV (Network Function Virtualization) and SDN (Software Defined Network). The virtual network layer - composed of VFN (Virtual Network Functions) developed within the framework of NFV - translates user requirements into instructions that can be used by operators to exploit, if necessary, sections of the physical infrastructure.

The physical layer of the infrastructure is managed by the SDN. This enables network control, which previously relied on fixed hardware components, to be centralized in the form of software on more powerful servers, free of the constraints related to the physical infrastructure (control plan, network configuration, etc.). Therefore, the virtual infrastructure adapts to usages, and even several different usages, with their different characteristics and requirements at the same time, by segmenting the network.

In this study we focus only on infrastructure layer that can enable future networks as the deployment of upper layers are the responsibility of the various service providers that will be involved. The basic idea is to enable networks with same tiered structure (backbone, backhaul, access) with high penetration also in mountains following the request of having reduced latency to ensure future services with the highest possible availability. The latest target needs, as primary requirement, diversified paths to ensure service continuity also in

case of fiber cable cut that is the major blocking issue in today communication networks. This concept is depicted in the following picture.

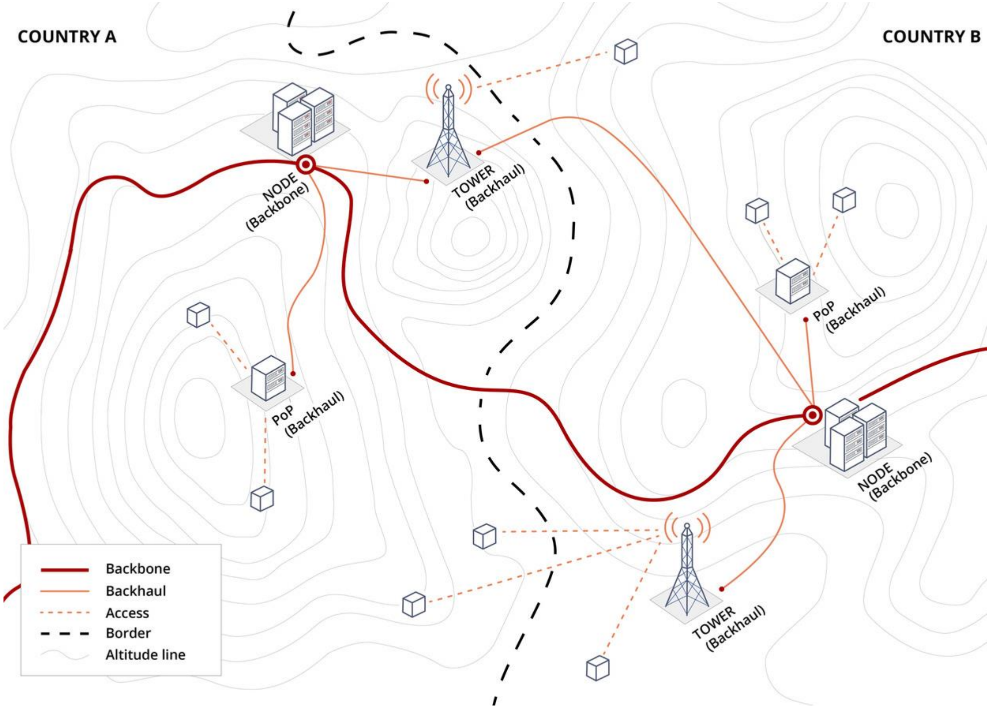


Figure 14: Network implementation concept

Of course, while backbones are sometimes in place (see next chapter) what is often missing is a reliable backhaul to deliver the increased amount on traffic expected with future networks where different services can be delivered and some of them need the highest availability. As already mentioned, one of major problems in communication services is fiber cut that need long recovery times due to civil works requested (on average 6 to 8 hours). Having diverse paths to connect local PoPs is a theoretically simple solution to fix this issue.

Moreover, the deployment of future networks will require (also in mountain areas) neutral locations to host servers (for services close to end users but also for increased use of software in network operations) and towers to hosts antennas and other radio devices to provide connectivity in mobile services but also for fixed lines with FWA technology.

Regarding co-location spaces, they don't refer to large spaces but small data centers (around 100 m^2) to meet expected requirements for servers and communication equipment: such capillarity can't be followed by actual datacenter players so new actors can be expected in the future for this trend.

Some ISPs are already providing connectivity with wireless technology instead of using wired connection in remote areas: while transmission on copper lines doesn't guarantee high speed unless being close to the local node, optical fibers in access networks are not deployed in low population areas where there is no return on investments. Wireless requires lower investments and with current technologies can provide single home connections at 100

Mbps with next step to 1Gbps. FWA at high capacity requires licensed frequencies to ensure expected quality of service.

A final remark is on the implementation of common infrastructures as forecasted by many studies on networks that will carry current and future services. Among these, in addition to communication services we can mention also Time and Frequency Services that can also be provided on optical fibers.

To summarize, the proposed approach for the Alpine Region is based on:

- Overcoming the fragmentation of connectivity networks, by completing cross-border and cross-valley links, with appropriate technological solutions, ranging from fiber optics to wireless technologies.
- Providing proximity data center to foster the convergence between cloud and fog computing for the backend
- Adopting the architecture of 5G technologies to allow low-latency applications for the front end
- Developing a common set of rules for data exchange, to constitute an Alpine Region digital ecosystem, based on the successful example of E015 in Lombardy.

5 Existing infrastructures and gaps

In this chapter we focus on the existing infrastructures highlighting the gaps to build backbone/backhaul rings that are necessary to provide reliable and more pervasive services in Alpine Area. We start describing the methodology, then showing the scouted infrastructures and closing with some action proposed.

5.1 Methodology of the Study

Having a feasibility study approach, the analysis has mapped a sample of the existing cross-border connectivity infrastructures across the entire Alpine Region. The purpose of this sample-based mapping is not to cover all the existing or potential cross-border links, but rather to provide a possible blueprint for intervention and technical replicability.

The different steps adopted are mentioned in any of following paragraphs but it's important to summarize them here in order to have a clear overview of the process.

First criterion adopted is **dividing the Alps on geographical basis**, so we present the study in:

- Wester Alps
- Central Alps
- Eastern Alps

For their definition please refer to following chapter.

Within this classification potential cross-border routes have been indicated with the **support of AG5 Group members**, giving the priority in more challenging marginal areas of the Alps which is often coincident with the mountainous zone of the Alpine arc.

The scouting of existing fibers in cross-border areas has been conducted with **AG5 members** interviews or national contact and with information gathered from **Internet Service Providers**, **Telecom Operators** and other **infrastructural operators** (railways, motorways, etc.) that have been indicated in each interested area. This process has had different iterations in order to verify information already obtained and to have more details.

In evaluating the potential links **other additional criteria** have been used in addition to the maturity (so the availability of fibers) of scouted path:

- how such infrastructures are accessible, so how they're close to other building blocks of future network architecture;
- how much the ownership is fragmented;
- the complexity of the governance in each connection.

Three different levels are possible in each criterion:

- Positive (blue bullet)
- Average (yellow bullet)
- Negative (red bullet)

Combining the level of each criterion, we ranked the potential feasibility of cross-border connections as follows:

- **Full**: when NO red bullet is present and MAXIMUM 2 yellow bullets are scored
- **Partial**: when MAXIMUM 1 red bullet and 1 yellow bullet is present
- **Low**: in other worst cases

With adopted approach, while we evaluated some interesting routes where potential business models can be developed, we also elaborated a **common vision of intervention that can be used by EUSALP stakeholders** and policy makers in different areas of the Alps, also in those not directly involved in this study.

5.2 Infrastructure analysis overview

Analysis of existing infrastructures started from West area of the Alpine Region as knowledge is based on experience of the authors. Then research continued in other Alpine areas but at this stage it’s not complete as some parts are still missing. Actually, accuracy is high regarding West of the Alps, good related to the East while some information is still missing in Central Alps.

In Western side existing Cross Border infrastructures are mainly the following, listed within the main metropolitan areas they are connected and with cross border part underlined.

1. Milan - Lugano - Gotthard Tunnel - Zurich
2. Lyon - Frejus Tunnel - Turin
3. Marseille - Col de Larche - Turin
4. Marseille – Nice - Genoa - Milan

These are mainly optical fiber cables that are owned by different carriers that normally sell in a wholesale market to other carriers (or other operators) resources (e.g. optical fiber pairs at least) for long haul connections. As example an operator A that needs to have resources from Turin to Marseille can buy a pair of fibers directly from carrier B that owns resources between the two cities, but can also buy both from carrier C (in France), between Marseille and Col de Larche/Colle della Maddalena (border), and from carrier D (in Italy), between Turin to Col de Larche/Colle della Maddalena (border). Typically, contracts are on IRU (Indefeasible Right of Use) basis. is a permanent contractual agreement, that cannot be undone, between the owners of a communications system and a customer of that system. The word "indefeasible" means "not capable of being annulled, or voided, or undone." The customer purchases the right to use a certain amount of the capacity of the system, for a specified number of years. IRU contracts are almost always long term, commonly lasting 20 to 30 years.

It’s important to note that, for economic reasons, while these resources are crossing mountain areas, they’re not available for backhauling services but exclusively for backbones. A simple comparison is with routes. A backbone is like a motorway in transports: even if they cross mountain/rural areas they’re often inaccessible. This is particularly true when infrastructure ownership belongs to commercial carriers that do not appreciate give IRU of parts of their infrastructure but prefer giving all the way from one city to the other in order to raise the highest margins. For this reason, it’s key to evaluate and/or exploit potential infrastructures that are in same locations but more easily engageable.

Sometimes infrastructures are primarily owned by infrastructure owners (as motorways or railways) that do not have telecommunications as main business. If correctly involved they can provide fibers at reasonable conditions but most of all they can also provide facilities to set up local PoPs that match the general architecture described in previous chapter.

With our research it seems that another route is available within France and Italy through Tunnel du Mont Blanc but that resources are owned by incumbent operators on each side (Orange in France and TIM in Italy) with a physical connection in the middle of the tunnel and are not available on wholesale market. So, it’s not included in previous list and figure.

Another route that can be easily available is through Tunnel du Grand Saint Bernard especially now that Regione Valle d’Aosta has completed the deployment of cables with its project named VDA BroadBusiness.

We also discovered cables from Sion (CH) to Locarno (CH) through Domodossola (IT). Last one also cross Italian infrastructure that was developed some years ago by Regione Piemonte from Verbania to Domodossola and can be useful to create alternative paths within Switzerland and Italy.

5. Lausanne - Grand St. Bernard Tunnel - Aosta
6. Geneva - Mont Blanc Tunnel - Aosta
7. Geneva/Lausanne - Simplon Tunnel – Turin/Milan

Since the beginning of feasibility study, route (1) increased level of interest from at least one carrier, BICS, as reported on its website where network map shows a path within Geneva and Turin. Currently we don’t know if such path is operational or not but for sure it will be possible thanks to VDA BroadBusiness project that deployed new infrastructure in the Region: initially for backhauling purposes but available (in combination with other parts) to develop backbone links connecting different Metropolitan areas.

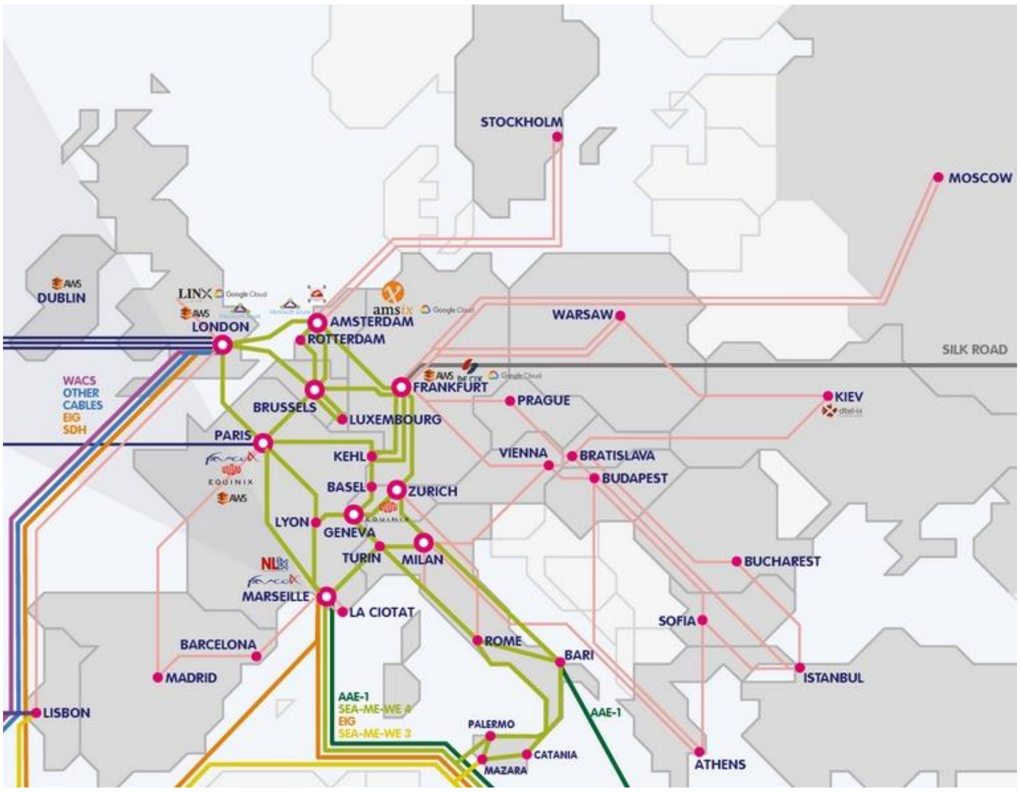


Figure 15: BICS connections map (source BICS website)

Regarding same area, there are other routes that will be available later because needing more investments to fill missing parts.

8. Lyon - Col Petit Saint Bernard – Aosta/Turin
9. Nice - Col de Tende - Turin

These are based on already existing infrastructures as railways or cross border ski resorts that can allow an easier deployment of optical fibers. All listed scouted infrastructures in the west-side region are depicted in the following picture:

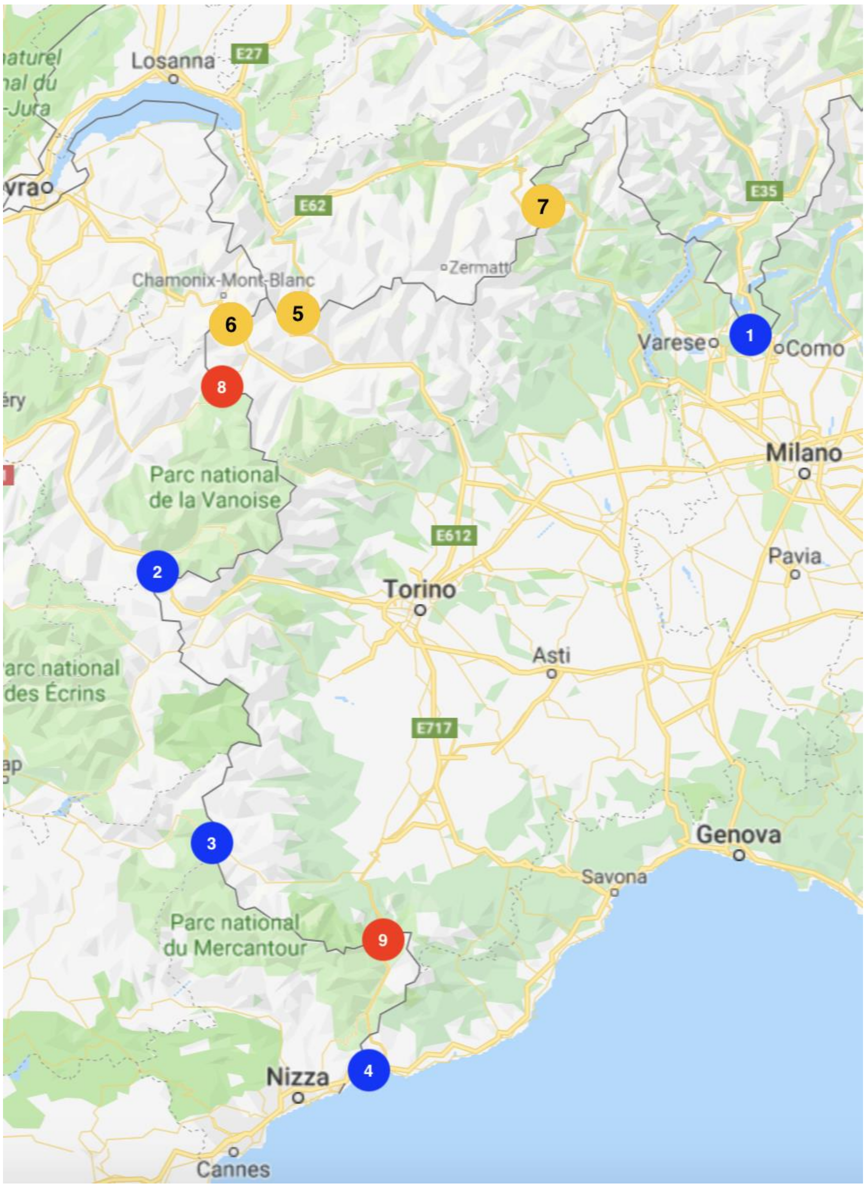


Figure 16: Western Alps cross-border infrastructures

In Central Alps we've seen the most important Internet route made by cross border cables in Como-Chiasso area. We've scouted another potential route along Bernina Pass railway from Italian town of Tirano and Sankt Moritz in Engadina Region of Switzerland while we have a lack of informations at Spluga Pass ans San Bernardino Pass.

We have also scouted several cross border optical fibers in the Sudtirol region: most part of the regional network is managed by Infranet Spa, a recently born company mostly controlled by the Autonomous Province of Bolzano. In particular we can highlight the following links:

1. Bressanone –Innichen - Lienz
3. Bozen - Brenner Pass - Innsbruck
5. Malles Venosta - Resia Pass - Tirol
6. Malles Venosta - Valico (Tubre) – Engadina

Due to the administrative and political composition of the area we also consider infrastructures that can be provided in the Autonomous Province of Trento by Trentino Digitale SpA, mainly owned by the same public body. Such infrastructures (fibers but also sites for PoPs and towers) are very important to complete expected reliable architectures to provide future proof services.

Among these, the first is the only active link, since on link (2) there isn't a clear situation on fiber ownership of fibers from Brenner pass to Innsbruck and there are no infrastructures on the Austrian or Swiss side in the other cases.

Finally, some cross-border infrastructures have been spotted between the Friuli Venezia Giulia Italian region and Slovenia. Fibers are available, although not connected, in Gorizia/Nova Gorica (4) both in Via San Gabriele/Erjavceva ulica and at Vrtojba along the highway, owned by T-2 on the Slovenian side and Regione FGV on the Italian side.

Figure 17: Gorizia/Nova Gorica infrastrucutes

Other publicly owned border fibers in the Friuli Venezia Giulia region are available at the Interporto di Trieste Fernetti (8), Rabuiese Pass (9) and Fusine in Valromana (7), a fractional parish of Tarvisio town. These resoures are available thanks to Friuli Venezia Giulia broadband plan that can provide also additional infrastructure in route. Also, from Friuli Venezia Giulia there are cable of Italian operator Retelit at Tarvisio (2) at Austrian border with fibers commonly used by international carriers.

Regarding Cross Border Connectivity within Slovenia and Italy, it's increasing importance with the growth and final exploitation of Rune Project (https://www.ruralnetwork.eu/) that has been supported by the Connecting Europe Broadband Fund (CEBF) with an Equity investment. In an interview the promoters of Rune underlined the importance of having cross

border connections with Italy to have more reliability while providing ultrabroadband FTTH connections to Slovenian facilities, especially in rural areas.

Most of the information we know about the Slovenian side come from the Surveying and Mapping Authority of the Republic of Slovenia, which has made available to the public the Slovenian Cadaster of Public Infrastructure through a Qgis project.

All listed scouted infrastructures in the east-side region are depicted in the following picture:

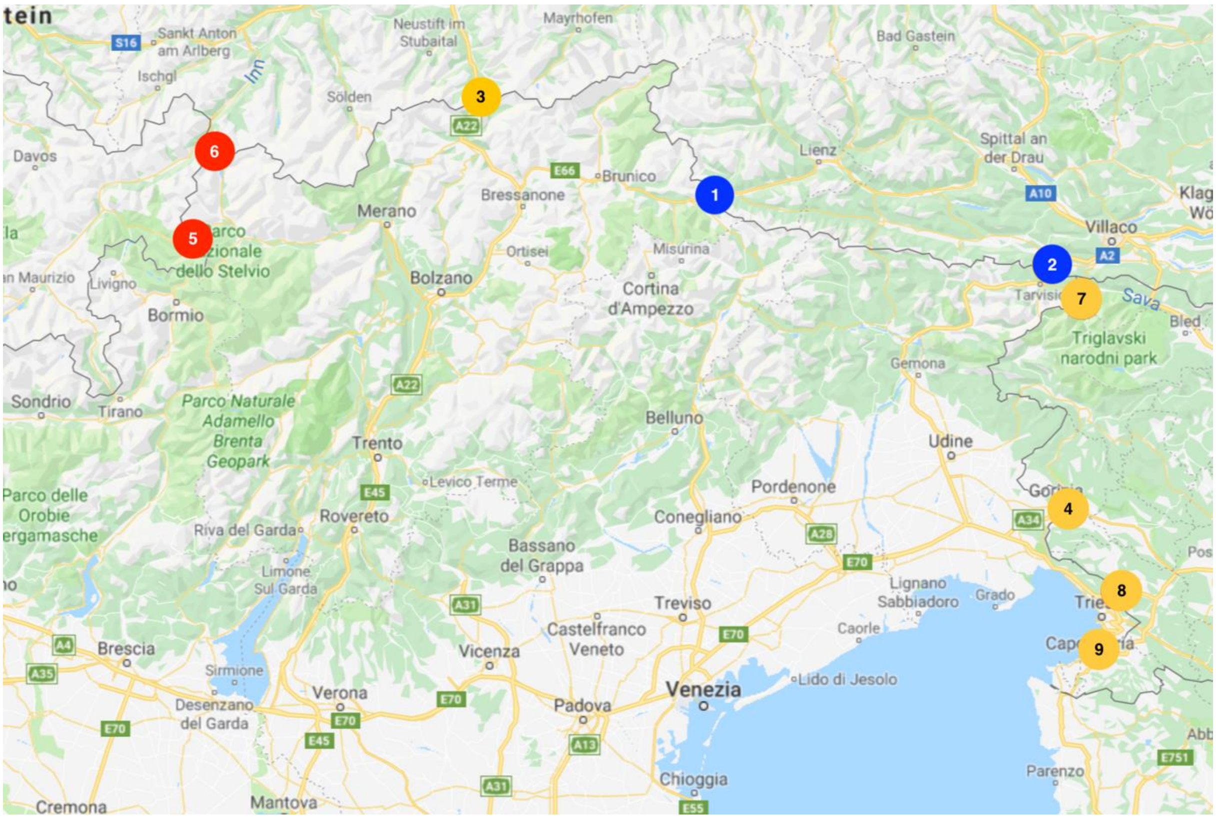


Figure 18: Eastern Alps cross-border infrastructures

The color code used in the previous maps matches the maturity level of the related infrastructures: we use blue where infrastructures are already available and exploitable, yellow where infrastructures can be deployed with little effort and eventually red where relatively high investments are required.

Ad additional remark is about the potential usage of optical fibers cables on long haul electric transmission lines with aerial fiber optic cables. This opportunity has been already exploited at least in Italy where Terna S.p.A. the national high voltage transmission grid is providing to communication operators. Aerial cables can be complementary to terrestrial cables:

- they are more secure in terms of availability as they are completely isolated to other infrastructures so they aren't below the risk of unexpected damage
- maintenance and new activations are more complex so require longer time

Final point is about Italy where a national broadband plan is ongoing managend by Infratel SpA that made public tenders to cover market failure areas. All these were awarded by Open Fiber SpA that has now in charge the deployment of new fiber infrastructures in such areas (in addition to be a market company in other non market failure areas). Plans are not respecting initial scheduling so, when the situations will be more clear, also these infrastructures should be added to the overall framework.

For these reasons they are preferred on backbones connections than in backhauling or access lines. Although this approach can be easily done by each national transmission grid company, it can be also done on transnational grids but needs to face the same governance issues on terrestrial cables.

5.3 Infrastructure evaluation

Maturity level cannot be the only criteria to evaluate cross border physical connections (eg fiber cables). To explain this concept, cables already existing with great availability couldn't be used because of different reasons as in following examples:

- they are owned by private companies that don't want to sell assets to competitors or not interested to sell at all;
- interested links are a combination of fibers with different owners and this increase the complexity in management while combining different players often both private and public;
- they don't match the overall model depicted in this study, that considers also PoPs and towers as enabling infrastructures for future proof networks. So existing cables that are far from the places that can host towers and PoP require huge investments to have requested connections

Following above mentioned criteria we checked every physical path scouted in order to make a first feasibility evaluation. Analysis is summarized in a table that reports all scouted infrastructures that can be involved to build new links or new services, also in existing paths: fibers are grouped into major routes for each of which a feasibility score is computed taking into account four criteria:

1. **maturity of the existing connections** is level of availability of infrastructures required; it can be Positive when infrastructure already exists within end point, Average when maximum 20 Km of fibers are missing and Negative when more kilometers are needed and/or informations are missing on one side of the path;
2. **ease to access to infrastructures** is about the access to the existing fiber optics and the closeness/availability to other neutral facilities; it can be Positive when existing fibers are close (max 1 Km) to locations where PoPs/Towers are already in place and managed by open and neutral owners or easily buildable by such entities, Average when fibers are farther (max 5 Km) to neutral and open PoPs/Towers locations, Negative when PoPs/Towers are even farther (more than 5 Km) or location are owned by entities that do no guarantee openness and neutrality (e.g. vertical integrated telecommunications operators);

3. **ownership fragmentation** is about number of owners on each physical route; it can be positive when there is maximum 1 owner on each side of border, Average when there are maximum 2 owners on each side and Negative with more owners;
4. **complexity of governance** is related on the ownership and governance of found fiber infrastructures; it can be Positive when they are owned by open and neutral players (they can be both public entities or private companies), Average when on one side there aren't no open and neutral players, Negative when it happens on both sides.

For a better graphical view we can show different scores with different colored bullets:

- Positive (**blue bullet**)
- Average (**yellow bullet**)
- Negative (**red bullet**)

Following subparagraphs show the detail of different subgroups (region to region) of cross border connections where, based on the combination of different criteria, feasibility score can be:

- **Full**: when NO red bullet is present and MAXIMUM 2 yellow bullets are scored
- **Partial**: when MAXIMUM 1 red bullet and 1 yellow bullet is present
- **Low**: in other worst cases

For our convenience we have divided the Alps in three different Areas: it's important to mention that this is only for our scope and do not reflect any geographical or political classification.

5.4 WEST Side of the Alps

It's the area from the Sea (area around Nice in France) to Simplon Pass (included). We found and analyzed 8 routes

Nice - Col de Tende - Turin

The infrastructure from Nice to Col de Tende in French is not yet available and in the Italian side till Cuneo but can be deployed along the railway that connect two cities or easier from the town on Ventimiglia in Italy (but early in France alog le Roya river). From Cuneo there are scouted infrastructures to Turin. Despite this lack of infrastructures we can state this potential connection as Average for Access, Ownership and Governance. So it can be classified at **Low** feasibility stage.

Marseille - Col de Larche - Turin

This is probably one of the best infrastructure route as there are different cables available from different carriers. It's Positive also in terms of Ownership while Access is Average and Governance is Negative as the ownership is of private companies that are focused on long distance services so not very open in selling parts of their assets. So it can be classified as **Partial** feasibility stage.

Lyon - Frejus Tunnel - Turin

Even if not widely used by carriers as previous route, this is already available from the two metropolitan cities. While Ownership and Access levels are equal to previous route, Governance is better because the ownership on Italian side (motorway company SITAF S.p.A.) in pretty open. So it can be classified as **Full** feasibility stage.

Lyon – Col du Petit St. Bernard – Aosta/Turin

Infrastructures from VDA Broadbusiness Project are already available just close to Col Petit Saint Bernard on Italian side while they're missing on French side. There are plans from French company Fibrea, now acquired by infrastructural operator Covage, to connect La Rosiere to its backbone in Savoie in a couple of years. Once available the overall path will have a good access to other potential interested sites bit without a complete rate on ownership and governance. So it can be classified at **Low** feasibility stage.

Geneva - Mont Blanc Tunnel - Aosta

There are fiber cables by STMB, owner of the motorway from Geneva to Mont Blanc Tunnel, and again in Vallée d'Aoste from VDA Broadbusiness. While on French side cables arrive at the entrance of the tunnel, fibers of VDA project aren't yet at italian entrance, they need some small civil works. In the tunnel ducts are available so fibers are easily deployable. Other criteria are all Positive, so this path can be classified at **Full** feasibility stage.

Lausanne - Grand St. Bernard - Aosta

Already mentioned VDA Broadbusiness fibers arrive also at the proximity of the entrance of the Tunnel on Italian side. Swiss telecom operator Swisscom has fibers also in the tunnel so with very small civil works the direct path can be easily defined. Access ans Ownership are both positive while governance is only Average since there is a vertical integrated carrier ownership on swiss side. So we have a **Full** feasibility stage.

Basel - Simplon Tunnel – Turin/Milan

Due to geographical reasons there is already a cable that is connecting Briga to Locarno (both in Switzerland) crossing the northest part of Piedmont (Italy). So it intersects infrastructure available there in the town of Domodossola. This system can be available to connect Geneve and Lausanne to Turin and Milan after some real interconnection of the two

separate infrastructures. Access to the infrastructure seems Positive while ownership and governance are on Average Level. So it can be classified as **Partial** feasibility stage.

5.5 CENTRAL side of the Alps

It's the area from the Simplon Pass (excluded) to the Drava River included. We found and analyzed 6 routes.

Milan - Lugano - Gotthard Tunnel - Zurich

This is for sure the most infrastructure path from Switzerland to Italy: the majority of carriers in Milan use this route as gateway to the rest of the world. Ownership of cables is well defined in both countries and the paths are on motorways so not easily accessible to and from local PoPs or towers. As cables are mainly owned by private companies Governance is not easy for backhauling purposes. So it can be classified as **Partial** feasibility stage.

Sondrio - Bernina Pass - Sankt Moritz

This is a potential new route from Switzerland to Italy that matches the scopes of present study. Maturity is still at Low level as there is no evidence of existing fiber infrastructures. On other hand other parameters are all at Average level so can be classified at **Low** feasibility stage.

Malles Venosta - Valico (Tubre) – Engadina

With all informations on italian side thanks to Infranet there are some missing points on Austrian side. For those reasons we have Negative maturity and Average level on Access, Ownership and Governance. . So it can be classified at **Low** feasibility stage.

Malles Venosta - Resia Pass - Tirol

This path is same conditions of above.

Bolzano - Brenner Pass - Innsbruck

We don't have the official certainty that existing availability of fibers on Austrian side but there is some evidence about fibers on motorway from Bolzano to Innsbruck ,so accessibility is only Average as Governance, while Ownership is well defined. So this path can be classified at **Full** feasibility stage.

Bressanone - Lienz

After some interviews we can classify this link with High maturity in terms of existing fibers. Fibers can be easily accessible (at least on Italian side) and ownership is well defined with some missing point on governance on Austrian side. So we have a **Full** feasibility stage.

5.6 EASTERN side of the Alps

It's the area from Drava River (excluded) and the Sea around the city of Trieste. In this area we have found and analyzed 5 routes.

Gorizia - Nova Gorica

These two municipalities are united despite they are in different countries. There are infrastructures both in Via San Gabriele/Erjavceva ulica (owned by T-2 on the Slovenian side and Regione FVG on the Italian side) and at Vrtojba along the highway (owned by Telekom Slovenije and DARS on the Slovenian side and Regione FVG on the Italian side). Moreover, the infrastructure foe coming Rune Project enforce the presence of infrastructures on both sides even not yet connected. So it can be classified Average in term of maturity. Regarding other criteria we can state this potential connection as Positive for Access and Ownership, while only Average in terms of Governance. So it can be classified at **Full** feasibility state.

Tarvisio – Kraninska Gora

We have a clear view on Friuli Venezia Giulia owned infrastructures till Fusine (in Tarvisio Municipality) and we know that on the Slovenian side there are infrastructures owned by Telekom Slovenije and Telemach arriving from Kranjska Gora, though we don't know neither the type nor the topology. With this partial lack of information, we classified it as Average in terms of maturity. Regarding other criteria we can state this potential connection as Positive for Access and Ownership, while only Average in terms of Governance. So it can be classified at **Partial** feasibility state.

Tarvisio - Villach

Since long rime the route is crossed by at least a cable owned by Italian infrastructural communication operator Retelit and A1 Austria. This is a typical backbone infrastructure to connect big cities in each country. It's widely used by large carriers as GTT and Cogent that declares PoPs in Udine and Wien. At least on Italian side there is also infrastructure owned by Friuli Venezia Giulia that is well deployed till the border. Regarding other criteria we can state this potential connection as Average for Access, Governance, and Governance (even on Austrian side it's owned by former incumbent, it's more open than in other countries) . So it can be classified at **Partial** feasibility state

Trieste - Fernetti - Sesana

It has same characteristics of route Tarvisio - Kraninska Gora.

Trieste - Rabuiese - Koper

It has same characteristics of previous route.

The following table reports all potential connection together.

	Maturity	Access	Ownership	Governance	**Feasibility**
Milan - Lugano - Gotthard Tunnel - Zurich	● (dark blue)	● (light orange)	● (dark blue)	● (brown)	**Partial**
Lyon - Frejus Tunnel - Turin	● (dark blue)	● (light orange)	● (dark blue)	● (light orange)	**Full**
Marseille - Col de Larche - Turin	● (dark blue)	● (light orange)	● (dark blue)	● (brown)	**Partial**
Marseille - Nice – Genoa/Milan	● (dark blue)	● (light orange)	● (dark blue)	● (brown)	**Partial**
Lausanne - Grand St. Bernard Tunnel - Aosta	● (light orange)	● (dark blue)	● (dark blue)	● (light orange)	**Full**
Geneva - Mont Blanc Tunnel - Aosta	● (light orange)	● (dark blue)	● (dark blue)	● (dark blue)	**Full**
Basel - Simplon Tunnel – Turin/Milan	● (light orange)	● (dark blue)	● (light orange)	● (light orange)	**Partial**
Lyon - Col du Petite St. Bernard - Aosta/Turin	● (brown)	● (dark blue)	● (light orange)	● (light orange)	**Low**
Nice - Col de Tende - Turin	● (brown)	● (light orange)	● (light orange)	● (light orange)	**Low**
Sondrio - Bernina Pass - Sankt Moritz	● (brown)	● (light orange)	● (light orange)	● (light orange)	**Low**
Bressanone – Lienz	● (dark blue)	● (light orange)	● (dark blue)	● (light orange)	**Full**
Bolzano - Brenner Pass - Innsbruck	● (light orange)	● (light orange)	● (dark blue)	● (dark blue)	**Full**
Malles Venosta - Resia Pass - Tirol	● (brown)	● (light orange)	● (light orange)	● (light orange)	**Low**

	Maturity	Access	Ownership	Governance	Feasibility
Malles Venosta - Valico (Tubre) - Engadina	● (brown)	● (light orange)	● (light orange)	● (light orange)	**Low**
Tarvisio - Kraninska Gora	● (light orange)	● (dark blue)	● (light orange)	● (light orange)	**Partial**
Tarvisio - Villach	● (dark blue)	● (light orange)	● (light orange)	● (light orange)	**Partial**
Gorizia - Nova Gorica	● (light orange)	● (dark blue)	● (dark blue)	● (light orange)	**Full**
Trieste - Fernetti - Sesana	● (light orange)	● (dark blue)	● (light orange)	● (light orange)	**Partial**
Trieste - Rabuiese - Koper	● (light orange)	● (dark blue)	● (light orange)	● (light orange)	**Partial**

Table 3: Feasibility matrix

5.7 Regulatory framework and governance

Telecommunication services in European Community are under Communication Framework that are received in every member State. A fundamental principle of the framework is mutuality within member States: an entity (whatever is its corporate form) that has the license as telecommunication operator in a country can have activities in other countries of EU community.

This general principle should be a great opportunity in theory but practically request additional investigations before generating asymmetries within countries. In Italy the tax pays to maintain the license, in case of operating a fiber network, mostly depend on potential final customers that can be served with the networks, so it depends on population in the coverage area. Last remark about regulatory is the presence of Switzerland and Liechtenstein in EUSALP Region but not as EU member states: this implies non-applicability of mutuality within Switzerland/Liechtenstein and every Region of EUSALP Area belonging to EU countries. All these concerns suggest further investigations to uniform the situation within different regions involved in EUSALP Area and find better conditions for new initiatives that can help mountain cross country areas.

With this regulatory framework the preferred governance model in operating new infrastructures is a partnership within two players (one in each cross-border region) with regular license in its country. Following the experience in some countries, it’s preferred not

involving retail telecommunications operators to this process, also in case of concession after a tender and under specific contract. To ensure the best neutrality and openness it's better involving infrastructural operators, public/private consortiums or, if necessary, wholesale only telecommunication operator.

About the scale, the analysis has highlighted a heterogeneous context on existing infrastructures and deployable so a unique entity to manage all cross-border communications infrastructures shouldn't be effective: this heterogeneity is strengthened also by the difference of the territories, people, history, etc. Therefore, a partition of the Alpine territory in different areas for the management of cross border links is preferable.

5.8 Actions proposed

Where collected informations are sufficient, a minimum set of actions are proposed in order to help local stakeholders: we concentrate our interest in a subset of analyzed routes, limiting the proposal on most feasible so on what declared with Full Feasability and Partial Feasablity in previous analysis. They are shown in following picture where:

- Blue lines show Full feasibility Links
- Orange lines show Partial Feasability Links
- Grey lines show national links in each country

We remark that lined does not represent the real physical path of infrastructures but only main point they cross as often owners do not disclose all data (eg KMG files) to be layered on a map. With the presence of national links (grey lines) we're able to show the proposed backbone or backhauling rings.

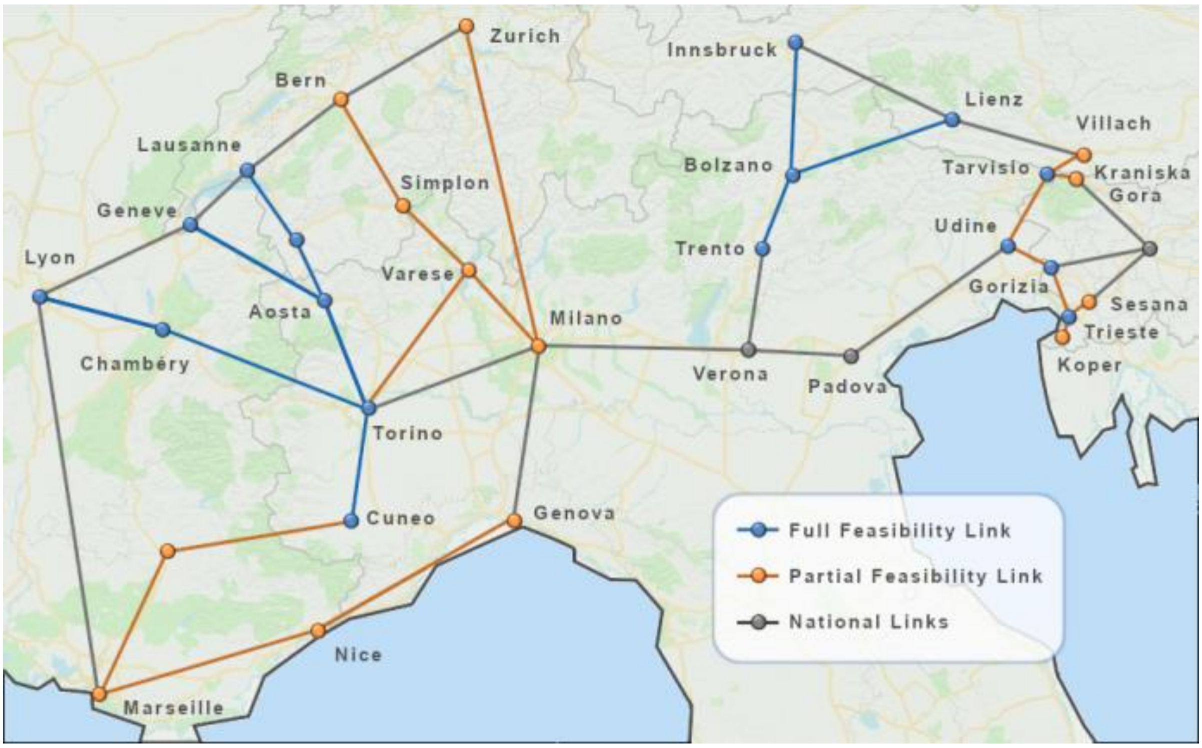


Figure 19 – Potential Alpine rings

We suggest a step-by-step approach that tests every criteria encountered before suggesting different actions depending on them.

- **Governance & Ownership** - It's the most important to be scouted and fixed: also with fibers already available, a not defined governance is a blocking point. We already underlined that the best approach is involving neutral players to have the greatest openness. Moreover, an ownership with different players is not helping with the governance itself
- **Maturity** – Once governance issues are solved, starting from Positive level of maturity routes helps in having almost ready rings to implement the strategies and the projects in this study. If maturity is only Average it means that some investments are needed; generally small investments are requested to complete the missing parts as stated before.
- **Access** – If Access is classified as Positive it means that some sites are already available and/or the connection is very easy to be deployed. On the other hand if it's only Average, more investments to create and/or connect new sites are requested.

Following geographical classification within western part of the Alps, Central Part of the Alps and Eastern part of the Alps, the following paragraphs provide an overview of the connection shown in previous picture.

5.7.1 WESTERN part of ALPS

Marseille - Col de Larche - Turin

With a Low governance level, this point is very crucial: this path is widely used by carriers so it an effective backbone route. On other hand infrastructure owners, which are themselves carriers, are not so open in selling portions of fibers for backhauling In such situations there's no a clear solution except working on case by case approach. Once hacked this point and found the best governance model, it's quite easy working to build and connect requested PoP to the main route.

Lyon - Frejus Tunnel - Turin

This route is easier than the previous one because of the governance and we have evidence that the owner of fibers (at least on the Italian side) already experimented the creation of local PoPs and backhauling giving the ownership of some fibers to TOP-IX that is a non profit consortium that has different ISPs within its membership, so ensuring the requested neutrality to as many market operators as possible. Cables are already available from two end point (Lyon and Turin) without any needed investment to complete the path.

Geneva - Mont Blanc Tunnel - Aosta

The situation is quite clear as there are two players on each side of Mont Blanc: Région Autonome Vallée d'Aoste (RAVDA) in Italy and Autoroutes et Tunnel du Mont Blanc (ATMB) in France owns fibers that can be used and, especially, they are no directly involved in telecommunications market. The only Average maturity can be overcome with laying new fiber cables in the ducts already present in the Tunnel du Mont Blanc. Also maturity is easily

Lausanne - Grand St. Bernard - Aosta

In this case governance hast to be fixed while owners of fibers Swiss side of Tunnel du Grand Saint Bernard are private operators (Swisscom and Netplus). Meanwhile on Italian side owner is still RAVDA so we think a working solution can be found. The Tunnel itself owns fivers for monitoring purposes but many are unused in layered cables so available. To fix infrastructure issues only work requested are the connection of different cables at two entrances of the tunnel.

Basel - Simplon Tunnel – Turin/Milan

The presence of a cable from Briga to Locarno crossing Italy in Domodossola helps a lot in this quite new route while in the Italian city other resources are available, included fibers owned by Regione Piemonte from there to Verbania. So in terms of Governance/Ownership this fragmentation has to be solved before making any kind of investments. These are related to the connection of different infrastructures in Domodossola.

5.7.2 CENTRAL part of ALPS

Milan - Lugano - Gotthard Tunnel - Zurich

This big route from Switzerland to Italy has same characteristics of route Marseille - Col de Larche - Turin

Bolzano - Brenner Pass - Innsbruck

There is the most important communication route within Austria and Italy with a new tunnel under construction that will also have fiber cables that will contribute to the goals of this study. Meanwhile, we have the certainty of the ownership of cables on the motorway on the Italian side we don’t on the other. But cables already exists and are connected so first point is to clarify and face governance questions. After that next point is building and connecting PoPs to deploy next generation services.

Bressanone - Lienz

There is still a lack of informations about the owner on Austrian side so that is the major point to be fixed before working concretely on this route. On the other hand, infrastructures are

already connected, based on the information gathered with interviews. This means that finding and connecting the right locations for local PoPs will be the action to follow after Governance.

5.7.3 EASTERN part of ALPS

Gorizia - Nova Gorica

It seems the most feasible actions regards the linking of the municipalities of Gorizia (Italy) and Nova Gorica (Slovenia), also for the specific interest or some Internet Providers. A possible technical solution is:

- finding open/neutral locations on each sites (better if public owned or controlled) that can work as cross border PoPs where telecommunications operators can be hosted with their network devices;
- digging and place fiber cables within two locations;
- managing new infrastructures with a partnership of two selected companies on each side (better if controlled by local governments) in order to have the best openness and neutrality

Tarvisio – Kraninska Gora

It has the same characteristics of previous with more uncertainty on Governance. While we had the map of all communication infrastructure in Slovenia, it's still to be known the effective ownership of them but it should be fixed with further support of the National Government. Also in this case the connection of national infrastructures on each side will require small investments due to the fact they are very close.

Trieste - Fernetti - Sesana

It has same characteristics of route Tarvisio - Kraninska Gora.

Trieste - Rabuiese - Koper

It has same characteristics of previous route

Tarvisio – Villach

The major issue here is about solving the involvement of national Austrian incumbent in an operation where sharing infrastructures is the key and starting point.

5.8. General guidelines for interventions

What is reported is the starting condition to boost potential interventions starting all new features and service included in 5G Framework with its basic architecture. This will enable all practical applications that are discussed and deepened in specific chapter that will follow.

So in addition to opening new backbone routes and/or closing some backhaul routes, to increase service availability, other building blocks are necessary to have service availability expected:

- Towers and their fiber connection: these are already included in previous analysis in rating existing and potential routes – we evidenced route feasibility also with the closeness to the sites that are ready for towers hosting radio devices;
- Edge/Fog Computing and new PoP facilities: as in previous point these facilities are small locations that are close to major fiber routes in order to have small civil works to connect them with optical fiber;
- IoT and other Edge devices for M2M M2U connections these devices /sensors and more) are key enablers to build the data that will be used in future applications;
- Software ecosystem: it's the final but probably most important block to create expected future applications.

The following table list all of them with a timeline priority where High means within 1 year from decision, Medium 1 year later and Low 2 additional years.

Guidelines for intervention	**Priority**
Closing backbone loops	High
Towers and Fiber connection	Medium
Fog computing and new PoP facilities	Medium
IoT and other Edge devices	Low
Software ecosystem	Low

6 Investment model

Assessment of required investments

One of the major problems of this project is that the construction of fiber-optic cable networks has traditionally been supported, if not just hosted, by. existing infrastructure networks: roads, railways, pipelines, or electricity transmission lines. The vast majority of industrial costs of construction of fiber-optic cable networks along these existing infrastructure networks is related to the required civil works. These costs represent a major fixed and sunk investment, increasing the risks faced by the network operators. By lowering the cost of access to these infrastructure networks and reducing the risk associated with it, governments and public authorities can significantly increase incentives for private investment into backbone networks

Involvement of public and private stakeholders

The development of cross-border broadband infrastructure involves many different stakeholders. Defining the appropriate conditions and incentives for all the relevant stakeholders to take part in the project will allow full leverage on the resources and assets available, as well as attract capital and competences from external contexts.

From the private sector, we can distinguish two types of stakeholders: industry-related and external partners. The first category encompasses:

- Local companies owning infrastructures and willing to share/grant access
- Telecom operators and service providers interested in selling services over the network,
- Network providers interested in placing active equipment in all the nodes and to deliver those services,
- Other telecom companies willing to lease the dark fiber
- Non-telecom companies wishing to lease dark fiber for their own needs.

There are then other relevant stakeholders that can benefit from the infrastructure to deliver social benefits through ICT services, such as hospitals, schools, elderly and social housing companies, research centers and public administration authorities and offices. The public sector should also be included in some cases and thus act as an “anchor tenant” and to reduce the demand risks in the short/medium term while waiting for demand to pick up over the medium/long term. Finally, institutional stakeholders at local, regional, national and European level might play an important role in terms of regulation and support.

Targeted level of cooperation among stakeholders

Given the very complex organizational nature of an Alpine cross-border backbone, the desired level of cooperation among stakeholders must include activities at all relevant levels: European, national, regional and local activities.

European-level cooperation is essential for the pursuing of institutional objectives of inclusion, development and competitiveness. A cross-border infrastructure can realign and harmonize the scattered levels of digital empowerment of citizens and businesses. Local support is indeed necessary to enable the actual utilization of services and to support economic sustainability in the long term. Funding programs with a focus on transboundary, transnational or trans regional cooperation should represent the priority, associated with local initiatives undertaken by local authorities.

6.1 EU financial support to broadband infrastructures

The European Commission estimated in 2013 that up to 250 billion euro will be required to achieve the 2020 broadband targets. However, the re-use of existing infrastructure and effective implementation of the Cost Reduction Directive could bring down these costs.

The telecommunication sector is the major private investor in broadband infrastructures. Some segments of the market, such as rural areas, are not attractive to private investors. Financing from the public sector, whether national, regional or municipal, is required to provide acceptable broadband connectivity in these areas. The EU is an additional source of financing complementing other sources of public funding (national regional or local) in areas subject to market failure. In some Member States it can constitute the main source of public funding.

For the 2014-2020 program period, almost 15 billion euro, including 5.6 billion in EIB loans, is available to Member States from the EU for supporting broadband, a significant increase over the 3 billion euro for the 2007-2013 period. This represents around 6 % of the total investment needed. There are five main sources of funding:

Source of funding	**Type of support**	**Amount in program period** *(million euro)*	
		2014-2020	**2007-2013**
European Structural and Investment Funds (ESIF): European Regional Development Fund (ERDF)	Grants	6 019	2 456
European Agricultural Fund for Rural Development (EAFRD)	Grants	921	282
European Fund for Strategic Investments (EFSI)1	Loans	2 032	-
Connecting Europe Facility (CEF)			
CEF Debt instrument	Loans	16	
WIFI4EU Initiative	Grants	120	

Connecting Europe Broadband Fund (CEBF), of which from the Commission from the EIB and EFSI	Equity	240 100 140	-
European Investment Bank (EIB)	Loans	5 600	
Total available		**14 948**	**2 738**

1 EFSI amounts are as of end of June 2017.

Table 4: Summary of funding sources for the program periods 2007-2013 and 2014- 2020

Source: ECA analysis based on Commission and EIB data.

The Commission, together with the Member States, manages the Structural Funds (ERDF, EAFRD). The Commission also provides a guarantee in support of projects financed by the EIB. The EIB is responsible for the management of its own loans and, the European Fund for Strategic Investments (EFSI). The Commission manages the Connecting Europe Facility (CEF) and part of the available funding for broadband under CEF is envisaged to be invested in the Connecting Europe Broadband Fund (CEBF). The CEBF will be managed by an independent Fund Manager and mandated to act according to the terms of reference agreed by the EIB, the Commission and the other funding partners.

6.2 Fragmented economic approach

Each of the Member States operates within its own technological, competitive and legal environment; this influences the way that each is seeking to meet the Europe 2020 targets. When the public authorities used the gap funding model for public tenders for broadband infrastructure, the result was usually the use of cable and fiber solutions.

According to the Commission (https://ec.europa.eu/digital-single-market/en/main-financing-tools) there are four models for public sector support for broadband:

- Direct investment (publicly run municipal investment model) – where the deployment and operation of the network is controlled by a public authority and the network is available to all operators (known as a wholesale open access network);
- Indirect investment (privately run municipal investment model) – where a publicly contracted private company builds an open network over which operators can provide its services to individual customers;
- Support to community-led initiatives (the community broadband model) – a bottom-up approach with broadband deployment done by private initiative involving local citizens;
- Operator subsidy (gap funding model) – a public authority provides the funding needed to bridge the gap in investment between what is commercially viable for the private sector and what is needed to provide adequate infrastructure.

6.3 State aid for broadband investments

Public investment in broadband by Member States, like other forms of investment, is subject to State aid rules, designed to limit any distortion of competition from public sector support. The broadband State aid guidelines were adopted in 2009 and revised in January 2013. They set out the scope of possible State intervention for broadband in relation to speeds of 30 Mbps, by defining different areas as black, grey or white, depending on the extent of competition to provide coverage. The white areas are in principle eligible for State aid. In grey areas the Commission must carry out a more detailed analysis in order to verify whether State intervention is needed. In black areas broadband services are provided under competitive conditions and State aid is permitted only under certain conditions, including whether or not a 'step change' in service provision is delivered. The Commission's position is that, while these guidelines refer to the Digital Agenda which mentions specifically to 30 Mbps, they are also relevant for the 100 Mbps and the Gigabit Society targets. However, some Member States interpret the State aid guidelines differently: they take the view that public funding is prohibited when the intervention increases the speed beyond 30 Mbps in black and grey areas. This difference of interpretation has led to Member States choosing not to use public investment to support operators in black and grey areas.

6.4 Crowding out of public investment

There is currently no legal obligation for the operators to implement their deployment plans made during the mapping process. An operator can decide not to deploy broadband in an area it had previously planned to invest in. Conversely, an operator can also decide to deploy broadband in an area where it previously planned not to invest, potentially crowding out public investments. Both cases lead to a delay in broadband coverage in market failure areas. Most of the investment in high-speed broadband is related to passive physical infrastructure. The task essentially involves civil engineering works such as digging trenches, holes, laying duct and fiber, or running new fiber overhead: this phase is highly capital intensive and is characterized by long payback periods. Being so capital-intensive, it is considered as a natural monopoly. Private investment in new broadband infrastructure in "white" areas constitutes a challenge because of:

- **High risks** - infrastructure deployment outside urban/high income areas by private sector operators or resulting from public-private co- operation, are perceived as high risk investment, which requires a higher return on investment
- **Longer pay-back periods**, incompatible with the short-term return horizons of service providers and telecom operators (especially if public companies);
- **Insufficient size**: promoters may be too small to attract the interest of large financial institutions or to attract cheap financing;
- **Lack of evidence** substantiating the viability of the business model – broadband is still an emerging asset class as opposed to transport and energy sectors (especially in non-urban areas.
- **Open wholesale access** may be imposed by ex- ante regulation (for incumbents only)

7 Practical applications

The goal of this analysis is by no means limited to mapping the existing infrastructural gaps for the connectivity of the Alpine Region. More ambitiously, this feasibility study wants to identify at least some examples of possible options for leveraging on technological innovations in order to exploit the competitive advantages of the Alpine Region with respect to the rest of Europe, signaling its role as a unique natural and socio-economic context in the entire world. Describing some practical applications that can be developed on the basis of an advanced technological infrastructure specifically for the Alpine Region can help all involved stakeholders, public institution and private players alike, to figure out the many possibilities of sustainable and scalable developments that can be achieved.

The practical applications being described below have been identified with the logic of addressing all the most relevant factors discussed in the study, and namely:

- Development of cross-border connections and interoperability among communication networks, computing resources and digital ecosystems
- Exploitation of specific factors of competitive advantage of the Alpine Region
- Sustainability from both environmental and socio-economic perspective
- Scalability via replication at relatively low marginal costs
- Eligibility for public financing as well as attractivity for private investments

The study briefly addresses four possible practical applications that fit the factors listed above:

1. **Smart & Sustainable Outdoor Sport Areas**
2. **Smart Nature Parks**
3. **Smart Mobility & Logistics**
4. **Smart Village: “dispersed hotellerie”, smart agriculture and digital tourism**

For each of the four possible applications briefly described below, a synthetic table is reported, describing the recommended lines of intervention with respect to the appropriate layer (infrastructural, application and governance) of initiatives to be implemented in order to allow the development of both an initial experiment of “minimum viable solution” – as portrayed in the previous chapters - and the possible replication/scaling-up in order to achieve a desired level of critical mass across the Region. Each layer indicates a preliminary list of technological and organizational issues to be addressed, and is associated a degree of expected priority and a list of possible stakeholders to be involved.

7.1 Smart & Sustainable Outdoor Sport Areas

The Alpine Region has a competitive advantage for outdoor sports and entertainment activities and infrastructures, which attract the majority of the 500 millions of visits coming every year from all over the world, contributing decisively to the economy of the area, as well as representing one of the main “branding” element for general touristic attractiveness.

A significant share of R&D activities and industrial investments related to the production of specific products, tools and solutions for outdoor sports are also naturally clustering around alpine region, from skiing tools to special shoes, from climbing to trail running/hiking tools

and accessories. Therefore, providing a laboratory for experimenting innovation in outdoor activities will not only support sustainable tourism, but also foster private investments in R&D and production.

A technological infrastructure designed to transform alpine zones in “smart areas” for sports and outdoor activities needs appropriate backhauling and high-speed access coverage of specific areas (mountain tracks and trails, domain skiable, etc.), with a focus on specific cross-border options to foster international cooperation. Integration with existing solution of access control (ski passes, e-bikes GPS systems, etc.) and of positioning can improve user experience as well as security and safety of operations, lowering public costs and attracting more traffic, while keeping a strict control on environmental sustainability of tourism.

The outdoor recreation economy is becoming one of the largest sector in modern economies, and incorporates several practices and disciplines, as well as all the associated services, products, accessories and technological solutions. Outdoor recreation contributes vitally to human well-being, but spatio-temporal mapping on large scales of this ecosystem service is rarely addressed in a comprehensive manner. In a study (see U. Schirpke et al., Revealing spatial and temporal patterns of outdoor recreation in the European Alps and their surroundings, Ecosystem Services 31/2018, 336–350) published in 2018 and co-financed by the European Regional Development Fund through the Interreg Alpine Space programme (‘‘AlpES” project, CUP: D52I16000220007) and by the Austrian Federal Ministry of Science, Research and Economy with the HRSM cooperation project KLIMAGRO, one can find an accurate mapping for the Alpine Region of recreation supply, demand, and flow, combining different approaches and data sources, including spatial indicators and crowd-sourced information from social media. The study indicates that mountainous areas provide high ecosystem service supply, while high demand is characteristic of strongly urbanised areas. The spatio-temporal pattern of flow hot spots shows two major trends: recreational landscapes around urban agglomerations are frequented all year round, whereas visitation rates in remote mountain areas depend greatly on the season. Different clusters of municipalities have been defined, distinguishing municipalities with little importance for recreation, prevailing demand, or supply, and flows through highly used areas.

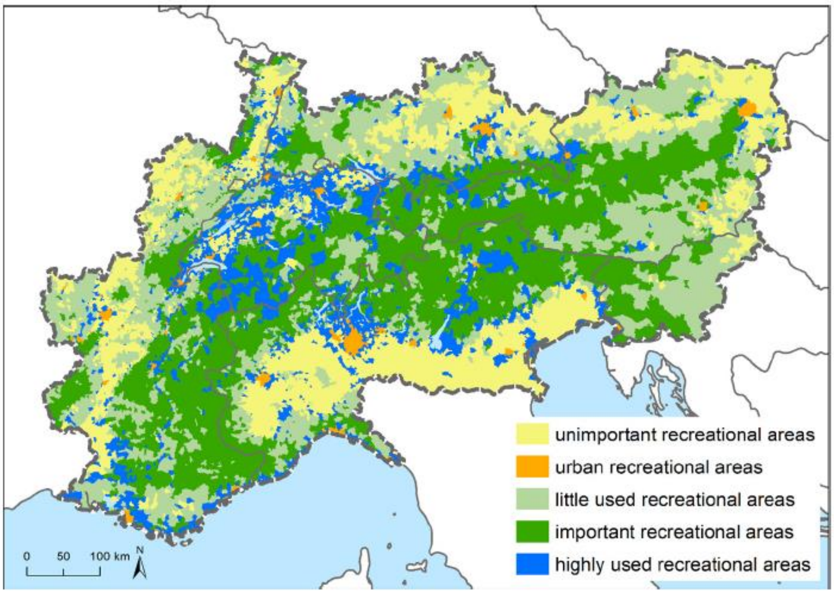


Figure 20: Municipalities in the Alpine Region with similar patterns of supply, demand and flow of outdoor activities

Source: U. Schirpke et al. Revealing spatial and temporal patterns of outdoor recreation in the European Alps and their surroundings/ Ecosystem Services 31 (2018) 336–350

The supply, demand, and flow of outdoor service ecosystem are mapped according to the following criteria:

1. **Supply** includes two aspects: the recreation potential provided by ecosystems and the possibility to benefit from it. Recreation potential is defined as the capacity of ecosystems to provide recreation opportunities due to the natural preconditions without human input and regardless of these being actually used. The service, however, is only provided if people can reach the supply area to carry out recreational activities. Thus, the supply is related to areas providing recreation that are accessible by infrastructure such as roads, trails, public transport and, more recently, digital connectivity.
2. **Demand** for recreational opportunities within the society is mainly expressed through stated preferences and values or direct use, but there is no agreement on measures for assessing recreation demand. Demand can be mapped considering where beneficiaries live or where the use occurs In the study, the demand areas are mapped quantifying local beneficiaries, with consideration of general societal preferences in qualitative terms.
3. **Flow** refers to the actual level of use and can be measured by the number of people practicing outdoor activities in a defined area and time. It is determined by the population density in the vicinity as well as the capacity of tourism accommodation, as the beneficiaries' origin can be from nearby areas or from other countries or continents. Hence, the benefit of recreational outdoor experiences can be connected to very different spatial scales.

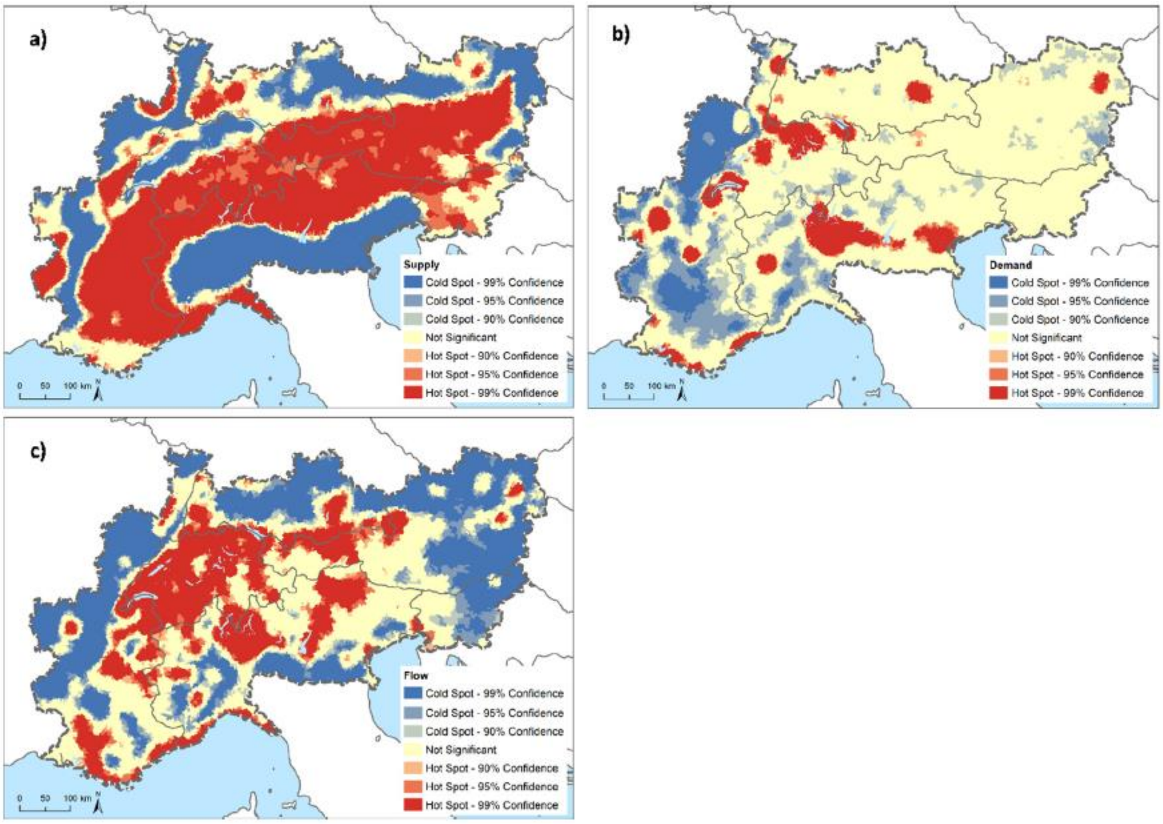


Figure 21: Hot and cold spots of (a) supply, (b) demand, and (c) flow maps at the municipality level for the Alpine area

Source: U. Schirpke et al. Revealing spatial and temporal patterns of outdoor recreation in the European Alps and their surroundings/ Ecosystem Services 31 (2018) 336–350

Empirical results suggest that societal preferences can be explained by landscape attributes and tourism physical and technological infrastructure, providing a useful basis for decision-making on infrastructures and landscape planning regarding recreational ecosystem services. Among the possible options for policy intervention, one shall consider the high level of scalability achievable by defining a pattern of technological infrastructure of specific Alpine areas for outdoor sports and recreation activities.

By defining an architectural blueprint for the technology infrastructure that can attract, monitor and improve outdoor sport activities, seeking both public support and private investment, another important issue can be targeted: environmental sustainability and management of major risk derived from the threats of global warming to the Alpine context.

The economic, social and technological implications of the necessary convergence between digital technologies and environmental sustainability can be seen in the case of ski tourism.

Ski tourism is a multi-billion-dollar international market attracting, on a worldwide basis, between 300 and 350 million annual skier visits. With its dependence on local infrastructures and technical solutions and accessories, as well as its strong reliance on specific climatic conditions, the ski industry is regarded as the tourism market most directly and immediately affected by climate change.

For the Alpine Region, assessing these risks and preventing the possible shortfalls with a coordinated initiative is essential.

A growing and increasingly diverse research and empirical literature has projected decreased reliability of slopes dependent on natural snow, increased snowmaking requirements, shortened and more variable ski seasons, a contraction in the number of operating ski areas, altered competitiveness among and within regional ski markets, and attendant implications for ski tourism employment and values of vacation property real estate values. The extent and timing of these consequences depend on the rate of climate change and the types of adaptive responses by institutions, companies and skiers' communities.

Several empirical researches have been investigating the possible effects of environmental factors on ski tourism. In the most recent years, the coverage of scientific literature has been growing exponentially, providing a robust base for public and private decision-making. The review of scientific contributions on ski tourism and climate changes proposed by Steiger et al. (2017) offers a striking view of the evolution of the debate about outdoor activities and environmental issues.

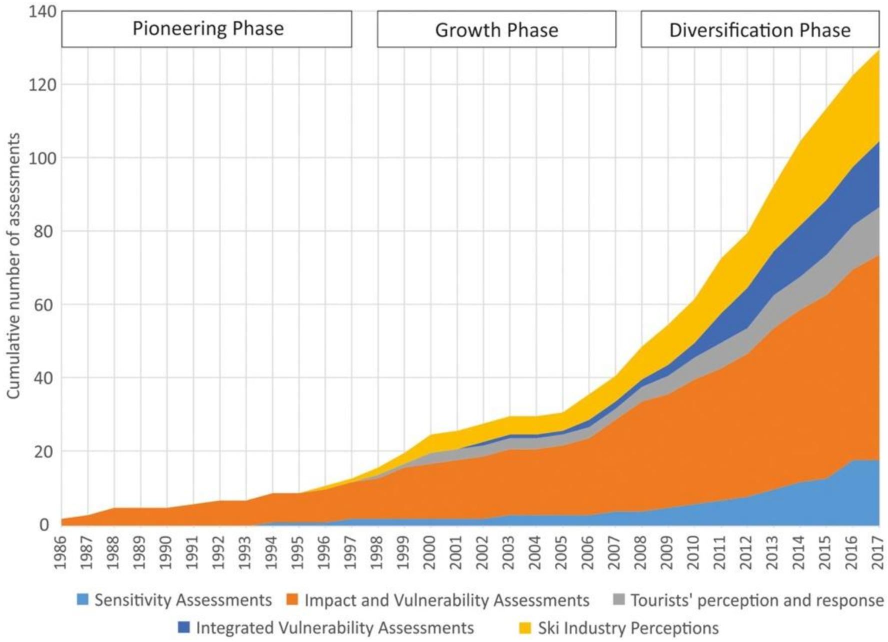


Figure 22: The evolution of peer-reviewed climate change and skiing tourism literature

(Source: Robert Steiger, Daniel Scott, Bruno Abegg, Marc Pons & Carlo Aall (2019) A critical review of climate change risk for ski tourism, Current Issues in Tourism, 22:11, 1343-1379, DOI: 10.1080/13683500.2017.1410110)

Several researchers have pointed out the expected impact of climate change on outdoor activities, especially on ski tourism, which is particularly exposed to increase in average temperatures.

The estimated losses in terms of skier's visits in some areas of the Alpine Region have been calculated for past seasons (see table below) in the range up to -33%.

Authors	Region	Season	Temperature anomaly[a]	Demand change (skier visits)
Steiger (2011aSteiger, R. (2011a). The impact of climate change on ski touristic demand using an analogue approach. In K. Weiermair, H. Pechlahner, A. Strobl, M. Elmi, & M. Schuckert(Eds.), *Coping with global climate change: Strategies, policies and measures for the tourism industry* (pp. 247–256). Innsbruck: Innsbruck University Press. [Google Scholar])	South Tyrol (Italy)	1988–1989	+2.6°C	−33%
Steiger (2011aSteiger, R. (2011a). The impact of climate change on ski touristic demand using an analogue approach. In K. Weiermair, H. Pechlahner, A. Strobl, M. Elmi, & M. Schuckert(Eds.), *Coping with global climate change: Strategies, policies and measures for the tourism industry* (pp. 247–256). Innsbruck: Innsbruck University Press. [Google Scholar])	South Tyrol (Italy)	2006–2007	+2.9°C	−2%
Steiger (2011bSteiger, R. (2011b). The impact of snow scarcity on ski tourism: An analysis of the record warm season 2006/2007 in Tyrol (Austria). *Tourism Review*, *66*(3), 4–13.[Crossref] , [Google Scholar])	Tyrol (Austria)	2006–2007	+3.0°C	−11%

Table 5: Impacts of extraordinary warm winter seasons on supply-side and demand-side indicators

(Source: Robert Steiger, Daniel Scott, Bruno Abegg, Marc Pons & Carlo Aall (2019) A critical review of climate change risk for ski tourism, Current Issues in Tourism, 22:11, 1343-1379, DOI: 10.1080/13683500.2017.1410110)

The evolution of technological solutions to cope with environmental uncertainties and temperature variability has been at the center of different generation of studies. While the first generation of empirical research (2000-2007) has been estimating a significant decrease in the share of snow-reliable ski areas in the Alpine region, more recent studies have identified technological solutions (such as the process of artificial snowmaking) that could substantially mitigate the impact on ski ares (see table below).

Region	Indicator	First generation studies (natural snow)	Second generation studies (including snowmaking)
Tyrol (Austria)	Share of snow reliable ski areas	57% (Abegg et al., 2007Abegg, B., Agrawala, S., Crick, F., & de Montfalcon, A. (2007). Climate change impacts and adaptation in winter tourism. In S.Agrawala (Ed.), *Climate change in the European Alps. Adapting winter tourism and natural hazards management* (pp. 25–60). Paris: OECD. [Google Scholar])	49/90% (without/with sm) (Steiger & Stötter, 2013Steiger, R., & Stötter, J.(2013). Climate change impact assessment of ski tourism in Tyrol. *Tourism Geographies*, *15*(4), 577–600. doi: 10.1080/14616688.2012.762539[Taylor & Francis Online], [Web of Science ®] , [Google Scholar])
South Tyrol (Italy)	Share of snow reliable ski areas	63% (Abegg et al., 2007Abegg, B., Agrawala, S., Crick, F., & de Montfalcon, A. (2007). Climate change impacts and adaptation in winter tourism. In S.Agrawala (Ed.), *Climate change in the European Alps. Adapting winter tourism and natural hazards management* (pp. 25–60). Paris: OECD. [Google Scholar])	55/100% (Steiger & Stötter, 2013Steiger, R., & Stötter, J.(2013). Climate change impact assessment of ski tourism in Tyrol. *Tourism Geographies*, *15*(4), 577–600. doi: 10.1080/14616688.2012.762539[Taylor & Francis Online], [Web of Science ®] , [Google Scholar])

Table 6: A comparison of projected changes of ski season length and snow reliable ski areas in the 2050s

(Source: Robert Steiger, Daniel Scott, Bruno Abegg, Marc Pons & Carlo Aall (2019) A critical review of climate change risk for ski tourism, Current Issues in Tourism, 22:11, 1343-1379, DOI: 10.1080/13683500.2017.1410110)

While the exogenous effects of climate change cannot be addressed by local policies, the empirical research shows clearly the mitigating effects of modern technologies and infrastructures, including digital technologies for monitoring and managing preparation, access, usage e safety of a ski area.

The large-scale and long-term nature of climate change makes it uniquely challenging for tourism research and decision-making. While society remains at the early stages of anthropogenic climate change, researchers are witnessing growing interest from increasingly diverse decision-makers (e.g. from institutional investors, ski area owners, grooming and snowmaking equipment companies, insurance companies, and real estate developers) for climate risk information and expert advice on the implications of climate change for individual ski areas and the ski industry as a whole. This demand will increase as the frequency of warm and snow-poor ski seasons increasingly impacts ski tourism operations and destination reputations.

Many studies demonstrate that technology can improve participation and sustainability in outdoor sports. The Sport and Recreation Alliance, in partnership with Future Foundation, the world’s leading independent global consumer trends and insight firm, has recently published a report (“Innovation Generates Participation”, 2014) exploring key trends that are set to become increasingly important to all involved in the sport and recreation sector.

All these findings show how significant new technology is in increasing participation and environmental consciousness in a huge variety of outdoor recreational activities. In addition to the fast growing development and adoption of individual devices for monitoring and

tracking outdoor activities, it is therefore crucial to provide specific areas with the appropriate land-side infrastructures of connectivity, sensors and computing power to support an ever growing need for conscious participation by final user, market opportunities for private organizations, and responsible governance by institutions.

As a brief set of guidelines for intervention, we include the following scheme. The purpose of this synthetic description is to address, with a very broad and initial assessment, the possible developments of both an initial experiment of "minimum viable solution" – as reported in the previous chapters - and the potential replication and/or scaling-up of the application, with the ultimate goal of achieving a desired level of critical mass across the Alpine Region.

The table identifies 3 different levels of intervention:

- Infrastructural layer
- application layer
- governance layer

Each layer contains a list of technological and organizational issues to be addressed, and is associated a tentative degree of priority (1=High 2=Medium 3=Low) and a preliminary list of stakeholders involved.

Guidelines for intervention	**Priority**	**Stakeholders involved**
Infrastructural layer		
Backbone & backhauling of the Sport Area with 5G-ready infrastructures	1	EU supporting entities & programs / Local institutions / Private Players
Sensorization of the relevant / critical spots	2	Regional authorities / Management of Sport Areas
Localisation of appropriate Edge computing resources for low latency and high performance in user experience	3	Private players / Management of Sport Areas
Application Layer		
Development of a marketplace for vertical applications in order to allow contributions from the widest possible perimeter of players involved	1	EUSALP partners/ Management of Sport Areas/Private players
API-based, open data ecosystem for interoperability with complementary processes (mobility, health care, public services, etc.)	1	EUSALP partners/ Management of Sport Areas/Private players/Local Institutions
Development of a first set of vertical software applications for Sport Management	2	Management of Sport Areas/Private players
Governance Layer		
Coordination with EU-level and national Sport Federations & Associations in order to provide a data-driven laboratory for the development of innovative & sustainable sporting events and training platforms	1	EU Institutions / Regional authorities / Management of Sport Areas / Sport Federations & Associations
Involvement of major media and communication players, including global developers of e-sports applications, for the exploitation of economic potential of the technology infrastructure	2	Management of Sport Areas / Sport Federations & Associations /OTT & Media Players

The involvement of EUSALP partners can provide the identification of the best possible locations /candidate Sport Areas across the Alpine Region to ensure both the realization of a “minimum viable solution” and the development of a scalable implementation blueprint to be applied across the region. If a critical mass of Smart Sport Areas will be achieved in the Alps, this can constitute a decisive factor of stronger attractiveness of the Region for future private investments and for sport, science and management talents as well as for increased media coverage, with consequent substantial contribution to the social and economic development of the Region.

On top of the overall EUSALP involvement, however, each single local institution can develop its own approach to transforming the already existing sport areas into “smart spots” according to the above mentioned guidelines, seeking appropriate financing instruments and working on existing coordination with private players at the local level. EUSALP may discuss and develop a survey and a mapping tool of the potential spots across the Region, in order to better quantify the economic potential and the technological implications. After a first, minimum viable solution is being developed, the scalability of the infrastructural layer at the Regional level will depend on the level of standardization and interoperability of the solutions adopted, with the physical and organizational constraints for each specific territory. The solutions adopted for the application and governance layers, instead, should be as replicable as possible, and can/should be designed in such way as to maximize scalability and portability with minimum level of adaptations. This approach can foster the target of reaching a critical mass of applications across the Alpine Region.

7.2 Smart Nature Park

The Alpine Region shows the highest concentration of nature parks in Europe, and one of the highest and oldest in the world.

These areas represent both a best practice in the protection of natural environment, a place of concentration of applied research on life sciences and environmental disciplines, as well as a strong magnet for sophisticated, demanding and increasingly well-educated tourism.

Most of the Alpine Region nature parks, today, are managed by local institutions with very little economies of scale and interoperability, and limited knowledge transfer, sharing of best practices and lack of critical mass in attracting private investments.

A recent report (2018), called “Smart Parks - Bringing new technologies to national parks and urban greenspaces”, offers a new path to maintaining sustainable national parks through technological innovation. The report was created by lead author, Professor Edward Truch, a Director of the Connected Communities Research Lab at Lancaster University Management School and commissioned by the Lake District National Park Authority. The Smart Parks report suggests that technological innovation, like the Internet of Things, is an ideal way to improve the overall park experience for tourists, while helping care for these natural environments in a financially feasible manner. This kind of tech system can be adopted in national parks around the world.

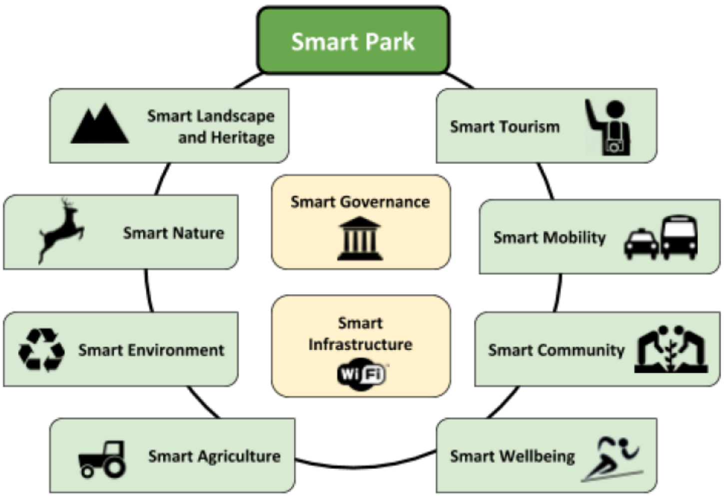


Figure 23: The evolution of peer-reviewed climate change and skiing tourism literature

The model presented in the Figure above describes the key dimensions of a Smart Park

- **Smart Tourism** - Hospitality, attractions, associated visitor services, retail trade, local businesses, and the rural economy as a whole
- **Smart Mobility** - Multi-modal transport integrating trains, uses, cars, boats, cycling and travel by foot including, fell walking and mountain climbing. Smart parking.
- **Smart Community** - Vibrant community of both visitors and residents. Community resilience, emergency preparedness, education for all ages particularly in subjects related to the ecology of the park.
- **Smart Wellbeing** - Physical and psychological wellbeing. Security so that residents and visitors feel safe at all times. Facilities and programs that encourage healthy outdoor recreational activities.
- **Smart Landscape and Heritage** - Enjoyment of the spectacular scenery of the park. Facilitate access to the park in a sustainable and responsible way. Cultural heritage. Land management.
- **Smart Nature** - Enhancement of the natural capital of the park and support of conservation of plants, trees and animals. Conservation of rare species and maintaining biodiversity, wildlife and forests.
- **Smart Environment** - Ensuring a healthy and sustainable environment. Continuously reducing the carbon footprint of human activity in the park. Effective waste management, limiting air, soil and water pollution.
- **Smart Agriculture** - Effective farming that increases productivity and animal welfare whilst reducing use of fertilizers and pesticides. Effective irrigation systems that maximize the use of resources. Farmland management.
- **Smart Governance** - Enhanced management of the park through increased provision of information systems supported by real- me data from many more sources around the park augmented by external data provision. Enhanced information management using latest advances in data science and business intelligence systems. Knowledge management systems.

- **Smart Infrastructure** - IoT technologies deployed throughout the park in systematic ways, fully integrated within a park-wide framework of devices and systems.

The Internet of Things, which in this case is composed by a cluster of sensors and actuators to be installed in a territory and by local computing gateways, would help make parks technologically "smart" by connecting the area through a network which would exchange helpful information. The report points to many examples, such as Bigbelly's Smart Bins and Disney's Magic Band, where this is technology has already been implemented and has been helping with like waste management and personalized service.

IOT Layers		Elements
8	Intelligence	Park-wide organisational intelligence Business model innovation New revenue streams, new efficiencies
7	Cognitive	Visualisation and management dashboards Augmented (AR) and Virtual Reality (VR) Reporting actionable insights
6	Analytics	Data analytics Aggregation from multiple data sources Artificial intelligence (AI)
5	Solutions	Process automation Management Information Systems Smartphone and desktop applications
4	IOT Platforms	Park-owned or co-managed IOT platforms 3rd party IOT platforms Data storage and security
3	Connectivity	Core Platforms & Radio interfaces Mobile networks such as NB-IOT, 3G, 4G, 5G Open source mesh networks; LoRaWAN
2	Data	Real-time data streams Batched data feeds Aggregation
1	Devices	Sensors Actuators IOT Gateways

Figure 24: The "Smart Park" IoT architecture

(Source: Smart Parks, Lancaster University Management School, 2018)

This new way of collecting data would benefit a wide range of people including park visitors, conservationists, nearby communities and park employees. By implementing sensors or collecting information from park visitors, the real-time communication would provide vital information and connect national parks areas quickly and efficiently.

For example, this system could help hikers with valuable updates like safety alerts about oncoming storms. This technology could also let park visitors in non-emergency situations like letting them know where there are open parking spots. This would not only allow people to enjoy the park with less stress but less time spent hunting down open spots means less

CO_2 emissions from cars driving around. Smart Parks could help visitors because they would have access to, better real-time information to avoid traffic jams and queuing on roads, places of interest, attractions and eateries. According to Professor Truch, “Technology can, not only form part of manufacturing of vehicles itself, but also create their own itineraries whereby ever visitor can enjoy a different customized journey that matches their personal preferences or, alternatively, to explore and decide as they go.”

Park employees can also benefit from this tech in many ways. For example, they could be notified when trash bins are full so they’ll know to avoid trips to empty bins which don’t need to be collected yet. This would help keep CO_2 emissions down and allow park employees to focus on other tasks which can keep the park in top condition. The report also points to evidence that the use of smart technologies is on the rise and the time is right for nature parks to take advantage of this system. Research shows this system could critically help parks thrive with a financially feasible system since the cost of these technologies is becoming cheaper. For those who may be hesitant about the idea of connecting national parks, it must be pointed out that this technology is all but invisible and the ability to communicate things like safety alerts would only be there to help people.

Each of the dimensions of the Smart Park concept represents an existing element of today’s nature park that would benefit greatly from enhancement through the deployment of IoT technologies.

Reimagining a national park as a Smart Park requires one to think of a single IoT-enabled ecosystem with its many elements and stakeholders connected interactively in ways that enhance current ways of working. Resulting innovation can bring with it new benefits such as an improved visitor experience, effective sustainable transport, and growth of the local economy.

Achievement of the Smart Park vision would undoubtedly be aided by open discussion of the challenges and unrealized opportunities followed by a systematic review and identification on of ways in which IoT can be deployed to address these and create new value-generating solutions.

Examination of examples from other national parks around the world can encourage new thinking about tomorrow’s solutions and demonstrate the viability of these by presenting ‘pockets of the future’ taken from the continuous flow of early IoT adoption use cases identified and presented by IoT suppliers and market researchers.

Experience from major IT projects in recent years points to the benefits of incremental implementation whereby the risks of each stage are carefully managed. Project management and software development is commonly carried out in an agile manner whereby the detail of each stage is reviewed and refined at the end of each preceding stage. Many IoT technology companies supply their services through reduced risk contract arrangements such as platform as a service (PAAS) which can be scaled up or down as required. This avoids the risks often associated with large one-step projects requiring substantial capital investment upfront. Various payment models and risk sharing arrangements are available.

Thus, it is possible to pilot small-scale prototype projects with relatively small resource commitment. One of the main challenges may be that of persuading businesses to adopt common technical standards and to share IoT platforms and data in order to achieve high levels of systems integration and all the benefits that flow from such collaborative arrangements.

The aim is to identify parks that can become potential candidates for designing and implementing a technological infrastructure based on microsensors and appropriate hardware and software solution for 3D mapping and monitoring of territory, wildlife behavior, anthropic access and touristic/didactical experiences. The booming industry of wearable devices and application for outdoor activities, as well as the industrial research on virtual /augmented reality solutions could benefit from this infrastructure, attracting financial and human capital in the Region. Potentially, with the replication of the Smart Park blueprint, the Alpine Region could host a Interconnected Network of natural parks, constituting a unique ecosystem at the global level for any possible future scientific application.

In order to explore development options and envision the creation of a Smart Park a number of potential future scenarios have been developed. Based on the two key uncertainties, namely the degree of IoT adoption (shown on the vertical axis) and the degree of systems integration (horizontal axis), four distinct future scenarios are identified.

Scenario A - Baseline

Some IoT systems already adopted sporadically by organizations, or being used by visitors such as the many smartphone apps. These include use of e.g. Google Maps for navigation, Ordnance Survey apps, and local park apps.

Scenario B - Independent

In this fragmented scenario organizations have adopted IoT technologies independently utilizing different technical standards and with a reduced level of interoperability between systems. These include stand-alone network solutions internal to the organisation such as Wi-Fi, Z-Wave. Examples includes premises security and wireless handheld payment terminals.

Scenario C - Connected

Common IoT infrastructure. Interoperability ensured by commonly adopted standards and central IoT platform managed by the NPA. Other organizations use their own solutions which utilize the park IoT platform.

Scenario D - Smart Park

This represents a fully integrated and functional Smart Park with a central IoT platform as in Scenario C and which enjoys many if not all the benefits of new revenue streams, additional

efficiencies, cost savings, enhanced management information systems, increased capabilities across many operational areas that enhance delivery of the Park's mission. Besides the common functional elements with shared analytics and intelligence, there is room for independent development for organizations who do not actively participate or wish to follow later.

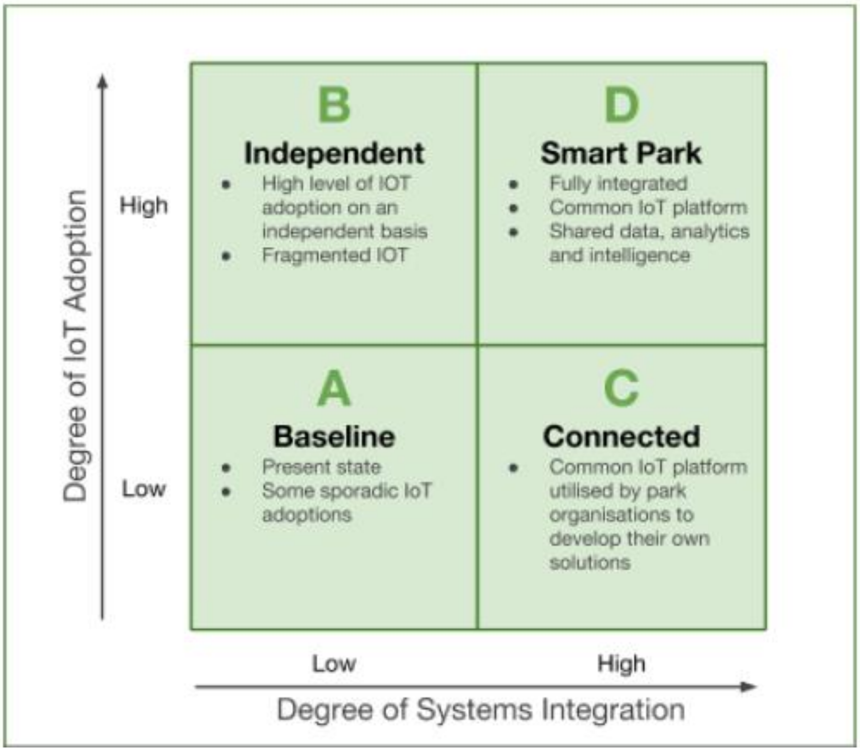


Table 7: "Smart Park" future scenarios

In order to provide a first, tentative scheme for potential future implementation, a synthetic table with possible guidelines for intervention is reported below. The table follows the same scheme already described in the previous section, and therefore includes 3 layers with broadly defined technological and organizational issues, associated to expected degree of priority (1=High 2=Medium 3=Low) and a possible list of stakeholders involved.

Guidelines for intervention	**Priority**	**Stakeholders involved**
Infrastructural layer		
Backbone & backhauling of Park Area and of all main logistic accesses and service buildings with 5G-ready infrastructures	1	EU supporting entities & programs / Local institutions / Private Players
Digital mapping and sensorization of the relevant access path and critical zones	1	Local authorities / Management of Park Areas
Sensorization of selected elements of wildlife and natural resource, for monitoring, protection and scientific observation	2	Management of Park Areas /Scientific institutions

Application Layer		
Development of a marketplace for vertical applications in order to allow contributions from the widest possible perimeter of players involved	1	EUSALP partners/ Management of Park Areas/Private players
API-based, open data ecosystem for interoperability with complementary processes (mobility, education, public services, etc.)	2	EUSALP partners/ Management of Park Areas/Private players/Local Institutions
Development of a first set of vertical software applications for Park Access, Promotion and Scientific Analysis	2	Management of Park Areas/Private players
Governance Layer		
Coordination with EU-level and national authorities for tourism, education and environmental protection to provide a data-driven laboratory for the development of innovative & sustainable ways to leverage on natural resources of Smart Parks	1	EU Institutions / Regional and national authorities / Management of Park Areas
Involvement of major tourism, media and communication players for the exploitation of cultural and economic potential of the technology infrastructure of Smart Parks	2	Management of Park Areas / OTT & Media Players

Also in this case, the involvement of EUSALP partners can be invoked for the identification of applicable nature park areas locations across the Alpine Region, with the goal of fostering both the implementation of a "minimum viable solution" and the development of a scalable blueprint. Taking as example the success story of the US National Nature Parks in terms of quality of environmental protection, scientific research and sustainable tourism exploitation, the target is to reach a critical mass of Smart Alpine Parks connected in a virtual network. This can constitute the biggest example of environmental protection in equilibrium with social and economic development in the entire European continent, representing a fundamental driver of attractiveness for the Region.

Again, side by side with a possible EUSALP involvement, each single local institution can develop its own strategy for the evolution of the existing nature area into "smart parks" according to the above mentioned guidelines, seeking appropriate financing instruments and working on existing coordination with administrative and scientific institutions. EUSALP may support the process by designing and fostering an initiative for mapping the potential natural areas across the Region, in order to estimate the socio-economic options and the technological implications.

7.3 Smart Village: "Dispersed Hotellerie", Smart Agriculture and Digital Tourism

The scattered villages and buildings on the Alpine Region can be transformed in a source of attractiveness for sustainable and smart tourism by transforming their facilities in a digital ecosystem of technologic solutions providing connectivity, surveillance, smart energy & mobility, facilities management for supply, maintenance and care.

The Smart Village approach can be applied locally both for residents and for attracting new investments in smart agriculture, digital & sustainable tourism, thus rebalancing negative demographic trends of mountain areas, attracting new residents and contrasting the

combined effects of ageing and new migration models, by striking a new, positive equilibrium between rural and urban models of citizenship.

An initiative to demonstrate the validity of the Smart Village logic, following the approach of «minimum viable solution», is to target the development of an integrated technological solution for a sub-system of a village, such as the concept of “Albergo Diffuso”. The Albergo Diffuso, an innovative concept of hospitality, was launched in Italy in the early 1980s as a means of reviving small, historic Italian villages and town centres off the usual tourist track. Translated into English as "dispersed hotel", "scattered hotel" or "virtual hotel", it is a hotel that is not in a single block, but converted out of various historic buildings in a small community.

It has to conform to certain conditions: run directly by an individual owner and providing normal hotel services; rooms distributed in existing converted buildings in historic centres; Central reception area with services available; part of a genuine community so that guests can be part of local life. Currently there are more than 40 Italian Alberghi Diffusi, grouped under a national association, and 13 Italian regions had adopted legislation regulating the concept. Interest in Albergo Diffuso has also been shown in other Alpine Regions, such as France, Croatia and Switzerland. The infrastructure to enable the concept is a subset of Smart City technology.

For those who do not love staying at a hotel, an Albergo Diffuso is the right balance between a hotel and a house. Its components are “scattered” in different buildings within the same urban area. “Scattered” indicates a horizontal structure as opposed to the vertical one, typical of condo-like traditional hotels.

The Albergo Diffuso is the right idea for people who are interested in staying in an elegant urban environment together with its residents (instead of other tourists) and it includes regular hotel services such as room service or restaurant. An Albergo Diffuso is the best idea to promote hamlets or towns with historical centres of great artistic and architectural interest. This way old neglected buildings can be readapted to host tourists thus also reducing new construction initiatives.

Hospitality models recognized

a) *Paese Albergo* (Village Hotel)

This category belongs to the Albergo Diffuso one, but it relates to a whole historical centre or even country, through a hospitality network (rooms, houses, bars, restaurants), reception services and common spaces for all guests. Everything is available to the tourists through a centralized booking service, with no unified management. It is not a hotel, but a “Hospitality Network” integrating some services but leaving the single operators independent. According to a resolution by the Sardinia Regional Council (n.28/26 on July 26th, 2007), a Paese Albergo is defined at art. 30 as “*Hospitality operator network established through collaboration agreements between individuals who may or may not be entrepreneurs. The reception activity must be carried out in collaboration, with no unified management, in order*

to provide accommodation and other services in multiple buildings throughout a relevant part of a residential area, in accordance to the requirements of the Regional Council".

b) *Residence Diffuso* (Scattered Residence)

It is defined as a "*Non-hotel reception structure providing accommodation in more than one residential units. They are provided with reception and assistance services, located in one town and integrated by the centralized reception desk". It is a non-hotel reception structure characterized by a centralized booking system and by basic reception and assistance services.*

c) *Albergo Diffuso di campagna* (Country Albergo Diffuso)

Regulated by Molise Region according to ADI's suggestion, the countryside scattered hotel is a real Albergo Diffuso, operating in the countryside instead of villages.

The association between Smart Villages for hospitality and Smart Agriculture must therefore be seen as a way to intertwin two of the most important economic activities of the Alpine Region; Smart Agriculture, on the other hand, is mostly used to denote the application of IoT solutions in agriculture. Although smart agriculture IoT, as well as industrial IoT in general, aren't as popular as consumer connected devices; yet the market is still very dynamic. The adoption of IoT solutions for agriculture is constantly growing. Namely, BI Intelligence predicts that the number of agriculture IoT device installations will hit 75 million by 2020, growing 20% annually.

At the same time, the global smart agriculture market size is expected to triple by 2025, reaching $15.3 billion (compared to being slightly over $5 billion back in 2016). According to the report (Zion Market Research, "Smart Agriculture Market- Global Industry Analysis, Size, Share, Growth, Trends, and Forecast 2016 – 2025") the global smart agriculture market was valued at around USD 5,098 million in the year 2016 and is expected to reach approximately USD 15,344 million by the end of 2025, growing at a CAGR of more than 13.09% between 2017 and 2025.

Because the market is still developing, there is still ample opportunity for businesses willing to join in. Building IoT products for agriculture within the coming years can set you apart as an early adopter, and as such, help you pave the way to success. Technologies and IoT have the potential to transform agriculture in many aspects:

- **Data collected by smart agriculture sensors,** e.g. weather conditions, soil quality, crop's growth progress or cattle's health. This data can be used to track the state of the processes in general as well as staff performance, equipment efficiency, etc.
- **Better control over the internal processes and, as a result, lower production risks.** The ability to foresee the output your production you to plan for better product distribution.

- **Cost management and waste reduction thanks to the increased control over the production**. Being able to see any anomalies in the crop growth or livestock health, one will be able to mitigate the risks of losing yield.
- **Increased business efficiency through process automation**. By using smart devices, one can automate multiple processes across your production cycle, e.g. irrigation, fertilizing, or pest control.
- **Enhanced product quality and volumes**. Achieve better control over the production process and maintain higher standards of crop quality and growth capacity through automation.

A possible scheme for future implementations is reported in the table below. The scheme offers a set of general guidelines for intervention as described in the previous sections. The 3 layers contain preliminary technological and organizational issues, linked to expected degree of priority (1=High 2=Medium 3=Low) and a list of stakeholders to be potentially involved.

Guidelines for intervention	**Priority**	**Stakeholders involved**
Infrastructural layer		
Backbone & backhauling of selected candidate Smart Villages and of all main logistic accesses and service structures with 5G-ready access and connectivity networks, with appropriate level and dissemination of terminal devices	1	EU supporting entities & programs / Local institutions / Private Players
Planning and implementation of a first layer of IOT-oriented sensors on main buildings, roads and territorial elements of the village and surrounding agricultural elements	1	Local authorities / Local Management / Private technology players
Sensorization at the micro-level of a set of buildings, public and private spaces and logistic infrastructures to provide the digital platform for service design and experience management for smart & sustainable hospitality and smart agriculture	2	Management of Smart Village Hospitality Structures/ Local institutions / Private technology players
Application Layer		
Development of a marketplace for vertical applications in order to allow contributions from the widest possible perimeter of players involved	1	EUSALP partners/ Management of Smart Villages /Private players
API-based, open data ecosystem for interoperability with complementary processes (mobility, education, public services, etc.)	1	EUSALP partners/ Management of Village /Private players/Local Institutions
Development of a first set of vertical software applications for Smart Village Access and Promotion	2	Management of Village Areas/Private players
Governance Layer		
Coordination with EU-level and national authorities for tourism, agriculture and environmental protection to provide a data-driven laboratory for the development of innovative & sustainable tourism and agriculture	1	EU Institutions / Regional and national authorities / Management of Village Areas
Involvement of major tourism, media and communication players for the exploitation of cultural and economic potential of the technology infrastructure of Smart Villages	2	Management of Village Areas / OTT & Media Players

7.4 Smart Mobility & Logistics

The current disadvantage of Alpine Region in terms of logistics infrastructure can be transformed in an opportunity for experimenting solutions of smart & sustainable mobility and logistics.

The relative simplicity of the network of routes and the forcefully limited ranges of journeys provides the best potential conditions to test solution of electric mobility, for both people and goods, with increasing level of autonomy in driving capabilities.

Where the marginal cost of each journey is so high, as in Alpine territory, in fact, the economics of e-mobility and autonomous driving becomes more attractive. Moreover, the low level of local traffic reduces the complexity of experiments as well as the minimum level of comparative efficiency with respect to current labor-intensive solutions, allowing the attraction of private investment to replace ate least a part of current local public/private transportation services

Pilot tests can be planned in delimited regions, such as Aosta Valley, where the natural configuration of the territory provides a natural “closed park” for logistic solutions.

The enabling infrastructure requires the sensorization of roads, with appropriate backhauling and local computing power (“fog computing” and/or “edge computing”) to manage near-real-time applications at low latency, supported by a 5G infrastructure of hardware and software applications.

The peculiar features of Alpine Region, where the territory - with its many physical constraints made of peaks, valleys and fragile natural resources – shapes and determines the flows of logistics, calls for a specific attention to the sensorization and digitalization of the relevant assets involved in the telematics approach to Smart Logistics. Telematics provides the technological basis to interconnect means of transportation, trailers and containers to the internet and transmit data that will enable companies to gain deep insights into their operations.

The main goal of telematics is to help identify optimization potential of the combined transport journeys. The trailers and containers get equipped with a sensor device, which offers multiple functions for example tracking and tracing, temperature and light monitoring, impact and acceleration etc. The collected information is then sent from the sensor via communication network and transferred to databases for deeper analysis to support logistic decisions.

The Smart Logistics industry is growing very fast at the global level, almost doubling the market of smart transportation from 2015 to 2020, when it is expected to hit more than 5,500 million US$.

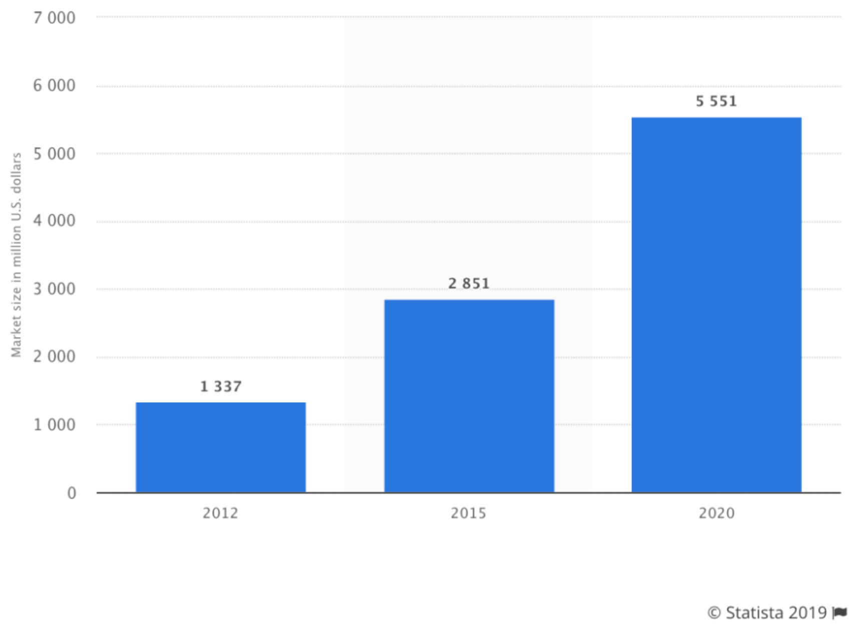


Table 8: Size of the global smart transport market from 2012 to 2020 (in million U.S. dollars)

With a broader perspective, according to a new report by Allied Market Research, titled, "Connected Logistics Market by Technology, and Devices: Global Opportunity Analysis and Industry Forecast, 2016-2023," the global Connected Logistics market was valued at $ 16,774 million in 2016, and is projected to reach at $ 27,722 million by 2023, growing at a CAGR of 7.60% from 2017 to 2023. Bluetooth and sensor nodes segments possess the maximum growth potential and are expected to create valid opportunities for industry players.

In order to make optimal use of the existing infrastructure major goods hubs must optimize their logistics processes from end to end – from unloading at the warehouses to shipping goods to their destinations. It is a matter of ensuring that the right data is in the right place at the right time and of making traffic and infrastructure-relevant information available to all concerned in real time. With the aid of a central, overall smart logistics platform, today the Local Authority of a logistics hub has a constant overview and can control the increasing flows of goods more efficiently, reduce truck downtimes and prevent traffic congestion.

Thanks to integrated software applications, today several logistics managements, trucking companies and forwarders, truckers, filling stations, service areas and port operators receive a role-specific uniform situation pictures that the software enriches with additional information such as bridge opening hours, construction sites or order information. The solution automates traffic route management across all stations. Whether through integrated solutions or through open digital ecosystem, logistics providers can ensure efficient, precise and low-cost transportation processes. Intelligent technologies and cloud-based services help companies to simplify, stabilize and readjust their supply chain management. In practice, real-time traffic data and dynamic route planning reduce both journey costs and carbon dioxide emissions. Unbroken consignment tracking improves distribution planning and delivery reliability.

Several private organizations have already developed their own “walled garden” systems for monitoring and managing their respective fleets of vehicles. Many current telematic solutions often deploy gateways to send encrypted information via mobile messages to the telematic service provider. The telematic service provider holds the customer data in proprietary closed data sinks. That blocks sharing the collected information with suppliers and customers, as well as local public institutions, and to develop new use cases with value added services. To improve the interoperability the data needs to be exchanged in an open, secure and standardized way. Isolated information islands at shipping companies and logistics hubs are no longer up to date.

Combined freight transportation requires mastering of complex logistics processes and frequent, precise communication amongst involved supply chain actors. However a lot of market information is kept non-transparent. For example detailed insights on terminal locations, railway freight lines, over capacities, pricing and costing of operators and last but not least punctuality of shipments are difficult to foster. That is why many logistic firms avoid using intermodal transportation, even though compared to road transportation on longer distances it is less easy to interrupt due to accidents and traffic jams, economically competitive and has a better environmental footprint.

The trend of open data for automotive and intermodal public transportation is very relevant especially for the intermodal freight market. Freight companies can learn how to visualize the flow of information in a complex supply chain and optimize the journey time. Real time tracking can improve and verify the data quality of available routes and capacities. The biggest challenge is to collect and integrate these various sources of data and make them meaningful for all involved stakeholders.

Many academic researches show how open data can be shared for specific use cases (like traffic warnings) in consideration of data privacy, intellectual properties and information security. The European Commission started many R&D programs (e.g. Horizon 2020 and Shift2Rail) with the aim to make intermodal transport more visible and interoperable. As part of the European Commission’s 5G Public Private Partnership, the EU supports 5G cross-border corridor projects for large-scale testing of connected and automated mobility (CAM), which are co-funded under Horizon 2020. Among the projects, launched in November 2018, trial 5G technology applied to CAM includes “5G-CARMEN”: 600 km of roads across an important north-south corridor from Bologna to Munich via the Brenner Pass, through a core alpine area. Within the EUSALP perimeter, a specific workgroup covers the challenges of cross-border mobility: pursuing its objectives will require open access to the widest range of information and digital infrastructures on the territory.

For the Alpine Region, given the high concentration of logistic flows on constrained routes laying on valleys, passes, tunnels and railways, addressing this challenge requires interventions at the infrastructural level, as well as on the application and governance layers.

In order to make the data collection process as comprehensive and independent as possible, without depending on the provisioning of open data by many private logistic organizations, the development of connectivity infrastructures in the Alpine Region shall include the sensorization of the main logistics routes, with the collection and the exposure of open data about logistics flows and information on environmental context. Installing logistic and environmental sensors along the alpine routes while completing the coverage of connectivity

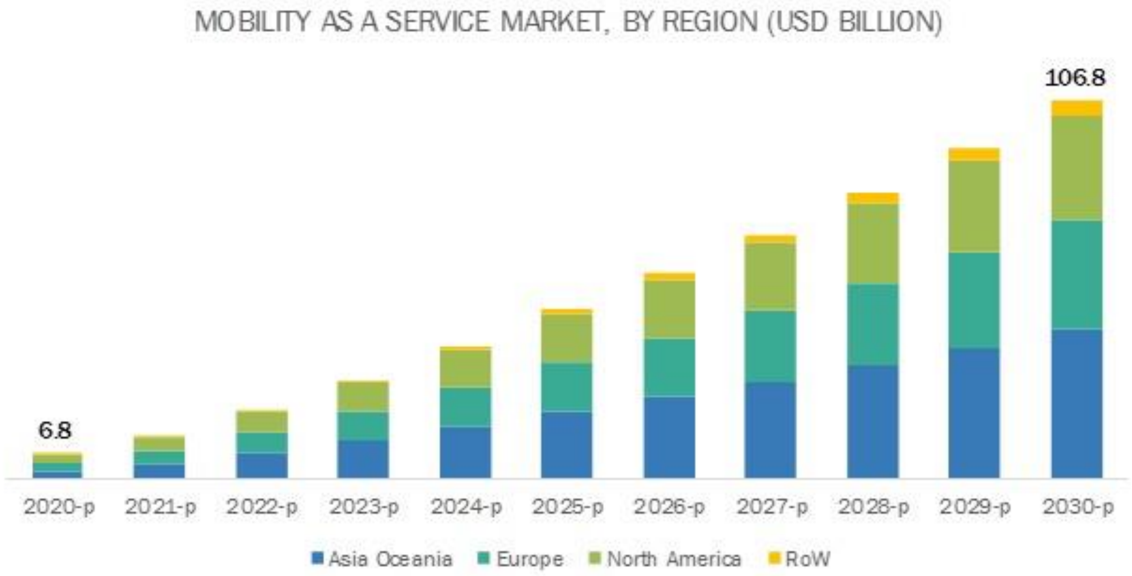
networks on the same physical paths allows higher economies of scope and density, and therefore should be considered in conjunction with any infrastructural program for the installation of cross border connectivity networks. A possible future implementation plan shall also define the specific technical requirements for sensors and devices targeted at tracking asset and logistic flows in the Alpine Region:

- Real-time and event-based geo-localization of assets and flows, using different technologies (wireless, video, sound, infra-red, multi-sensor devices, etc.)
- Long distance and low power communications, with long life battery, solar panel or connection to electrical power supply
- Remote deployment of configuration and rules (geofencing, event-based wake-up & reporting)
- Environmental protection of the tracking device (high range of operating temperature, humidity, dust, etc.) and protection against damage or theft

Sensorization of main logistic routes can be the enabler for advanced use cases for optimized, intermodal freight transport and Smart Logistics, allowing more environmental friendly operations and advanced business models based on value-added services, such as:

- time schedule validation
- journey optimization
- dynamic pricing
- service guaranties penalties
- automatic pay-on-demand, pay-per-use model
- insurance / damage and theft protection

On a wider perspective, planning the sensorization of main logistics routes and infrastructures of the Alpine Region can accelerate the development towards the trend of the so-called “Mobility-as-a-Service” (MaaS). According to recent surveys (see “Mobility as a Service Market”, Published Date: Aug 2019, Report Code: AT 7286, by MarketandMarkets), the MaaS market is projected to grow at a CAGR of 31.7% from 2020 to 2030, and the market size is expected to grow from USD 6.8 billion in 2020 to USD 106.8 billion by 2030.



(Source: MarketsandMarkets,, August 2019)

Europe is expected to account for the largest market size during the forecast period for Mobility as A Service Market. Europe is the largest market owing to the relevant role of some of the leading vendors and the investments by local institutions in smart transportation infrastructure. The Alpine Region shall not miss the opportunity to participate to this fundamental evolution of logistics and mobility, by including in its infrastructural projects the appropriate enabling technologies.

A synthetic scheme for possible future implementations of smart logistics and mobility projects is reported in the table below. The scheme offers a set of general guidelines for intervention as described in the previous sections. The 3 layers contain preliminary technological and organizational issues, linked to expected degree of priority (1=High 2=Medium 3=Low) and a list of stakeholders to be potentially involved.

Guidelines for intervention	**Priority**	**Stakeholders involved**
Infrastructural layer		
Backbone & backhauling of selected logistics routes with 5G-ready access and connectivity networks	1	EU supporting entities & programs / Local institutions / Private Players
Sensorization of logistic infrastructures to provide the digital platform of open data	1	EU supporting entities & programs / Local authorities/ Private technology players
Provisioning of distributed computing resources (edge computing) along main alpine routes as near-real-time information gateways for logistics and mobility services	2	EU supporting entities & programs / Local institutions / Private technology players
Application Layer		
Development of a marketplace for vertical applications in order to allow contributions from the widest possible perimeter of players involved	1	EUSALP partners/ Local institutions/ Private players

API-based, open data ecosystem for interoperability with complementary processes (tourism, health care, education, public services, etc.)	1	EUSALP partners /Private players/ Local Institutions
Governance Layer		
Coordination with EU-level and national authorities for monitoring of cross-border and internal logistic flows, safety and security of citizen and their privacy, for the development of innovative & environmentally sustainable mobility and transportation platform.	1	EU Institutions / EUSALP partners / Regional and national authorities
Involvement of major private players for smart logistics and mobility-as-a-service to organize an ecosystem for public and private transportation in the Alpine Region.	2	EUSALP partners /Private players/ Local Institutions

8 Guidelines for intervention & investment

A final summary of the suggested interventions and investments discussed within this preliminary feasibility study is reported below where infrastructure investments estimations are based on industry average costs. In particular where fiber cables are needed a good reference is US Department of Transports with the list included at link:

https://www.itscosts.its.dot.gov/its/benecost.nsf/DisplayRUCByUnitCostElementUnadjusted?ReadForm&UnitCostElement=Fiber+Optic+Cable+Installation+&Subsystem=Roadside+Telecommunications+)

Intervention	***Priority***	***KPI***	***Estimated investment value***
Close cross-border backbone loops Fiber-optics backbone connection for critical cross-border areas shall be completed across the entire Alpine Region, starting with the segments with higher priority and lower level of current infrastructural resources, as described in the section above. The most urgent areas of intervention are in the North-East and North-West sections of the Alpine Region, and precisely: - Gorizia – Nova Gorica - Great St Bernard - Mont Blanc Tunnel - etc.	High	Availability and length of cable ducts and logistic/passive infrastructures Length, size of bundles and technical features of cables Number, size and features of heavy-duty external cabinets with related hardware resources and configuration	13 K€ per kilometer of cable bundles (including installation) 15 K€ per cabinets, including fiber termination Overall, approx. 0.8 -1.9 ml€ for each cross-border segment, and XX-XX ml€ for the entire Alpine Region in highlighted routes
Improve backhauling coverage and redundancy Replace/integrate radio bridges and wireless links, where present and available, with shared fiber optics connections, providing FO backhauling to 4G and 5G base transmission stations (BTS) and/or antennas for fully redundant, high-speed and low-latency territorial coverage in critical cross-border areas of the Alpine Region, as well as in zone with high socio-economic potential to host some of the proposed technological applications (smart villages & agriculture, smart mobility and logistics, smart park, smart outdoor sports).	High	Availability and length of cable ducts and logistic/passive infrastructures Length, size of bundles and technical features of cables Number, size and features of cabinets with related hardware Number of radio bridges integrated/ replaced Total area covered Total volume of increased data traffic supported	20 - 100 K€ per each radio bridge replaced/integrated 20-80 K€ per each connected BTS/Antenna of wireless networks

Provide distributed resources for sensorization and near-real-time computing Identify, design and implement modular solution of edge computing, fog computing and appropriate sensor devices for monitoring areas/roads/routes and tracking access, presence and transit of vehicles, people and wildlife. The modular solutions for sensorization and distributed computing, including local data centers for low-latency / near-real-time computing, shall be targeted to different types of applications, such as smart villages, smart parks, smart outdoor sports and smart mobility and logistics. A preliminary list of Alpine Region's assets to be targeted may include the followings: - cross-borders ski areas (e.g. Zermatt-Cervinia, La Thuile-La Rosière) and other relevant outdoor sports resorts; - touristic areas of most popular Alpine nature parks; - cross-borders roads and passes (e.g. Monginevro, Tarvisio, Montblanc, Grand St Bernard, Simplon, Spluga, Resia, Bernina, Brenner, Tarvisio, etc.) - mountain villages, alpine refuges and agricultural areas with high touristic and economic potential for hospitality and environmental sustainability	Medium	Number of network nodes / cabinets / processing centers enabled with local computing power Index of computing capacity installed (MIPS) Type, number and extension of assets (roads, parks, buildings, touristic & outdoor sport areas, etc.) equipped with sensorization systems	25 – 75 K€ per node/cabinet 5 – 50 K€ per sensorized asset (depending on its type and extension)
Develop and adopt the software architecture for interoperability and open innovation Define the set of rules for API-based interoperability of public and private data sources, processes and algorithms, terms of use, rights and limitations for access and licensing. Develop a public marketplace for all applications that may require vetted access to public digital assets and/or data sources, providing appropriate technology layers for authentication, security, process continuity and recovery, with reference to a hybrid/multi-cloud oriented IaaS and PaaS solutions. Develop open-format wallets & digital accounts for ticketing, payments, vouchering and other financial/legal transactions, in full interoperability with PDS2 provisions.	Medium	Number of data sources with APIs Number of applications on the marketplace Number of transactions operated Number and type of users, organizations and institutions connected through the software platforms. Volume of accesses and data traffic on the platforms	t.b.d.

Define and monitor the adoption of governance rules for digital ecosystems Establish a EUSALP-based governance table, on a voluntary base, to define rules for the implementation of digital ecosystem involving both public and private organization, incorporating suggested requirements for open data/open algorithms, data portability, privacy protection, free flow of non-personal data. Define a set of recommended terms for all institutional and/or PPP projects that want to have access to public financing and periodically monitor the adoption of the rules. Identify a dashboard with KPI for ecosystem governance and longitudinal/ latitudinal statistical reporting for public scrutiny and communication purposes.	Medium	Type and number of institutional and private players involved Number of applications supervised and monitored Index of performances on portability, security, transactions. Geographical and institutional footprint of the perimeter of coordination	t.b.d.
Implement “minimum viable solutions” for suggested applications and planning for modular replication and scalability Smart & Sustainable Outdoor Sport Areas Identify and implement digital platforms based on connectivity, sensorization and IoT for alpine areas devoted to outdoor sports and entertainment activities, from ski slopes/ infrastructures, to mountain bike riding, climbing, trail running/hiking, rafting, canyoning, kayaking, lake windsurfing, paragliding, etc. including the development and the provisioning of sport tools, outfits and accessories, with the goal of offering an outstanding, safe and enjoyable customer experience, while providing a laboratory for experimenting innovation in outdoor activities to support sustainable tourism and foster private investments in R&D, production and services. Smart Nature Park Technological infrastructuring of selected alpine nature park. Implementation of backbone & backhauling of all main logistic accesses and service buildings with 5G-ready infrastructures. Digital mapping and sensorization of the relevant access path and critical zones. Sensorization of selected elements of wildlife and natural resource, for monitoring, protection and scientific observation. Applying to nature park the logic of Internet of Things is an ideal way to improve the overall park experience for tourists, while helping care for these natural environments in a financially feasible manner.	Medium/ Low	Type and number of Smart outdoors sport areas / Nature Parks / Smart Villages / Smart Mobility/Logistics infrastructures enabled with digital/IoT infrastructures Type and volume of additional touristic traffic generated List of value added services enabled on relevant digital assets Index of sustainability applied to areas/ assets/ nature parks	t.b.d.

Smart Village: Digital Tourism and Smart Agriculture Identification of small villages / alpine refuges with the highest potential in terms of touristic attractions. Planning and implementation of a basic layer of IOT-oriented sensors on main buildings, roads and territorial elements of the village/refuge and surrounding agricultural elements. Sensorization of a critical set of buildings, public and private spaces and logistic infrastructures for service design and experience management, offering smart hospitality and sustainable agriculture. Smart Mobility & Logistics Backbone & backhauling of selected logistics routes (especially cross-border roads, rails and passes) with 5G-ready access and connectivity networks, sensorization of logistic infrastructures to provide the digital platform of open data. Provisioning of distributed computing resources (edge/fog computing) along main alpine routes as near-real-time information gateways for logistics and mobility services. All the examples listed shall be based on modular technological solutions (articulated throughout infrastructural layer, application layer and governance layer) that provide facilitated and efficient replicability for targeting a critical mass, and mid-term modular scalability at the entire Alpine Region level.			

9 Recommendations

There will be a new “mountain chain” across the Alps: digital infrastructures, extending from the peaks of cross-border connectivity to the great data lakes of digital ecosystems. As happened in its orogenic history, the Alpine Region is entering a new Cretaceous Period: like the uplift of tectonic plates, the convergence of high-speed connectivity and digital platforms will raise the heights of Alpine territory to new altitudes. Therefore:

- **It is of upmost importance for sustainable development and competitiveness of the Alpine area to invest in cross-border infrastructure and full coverage of the territory with ultra-broadband and low-latency connectivity networks, integrated with digital ecosystems made of distributed computing resources, architectural platforms, interoperable applications and open data**.
    - This line of intervention will put the Alpine Region back in its original position at the heart of European exchanges, physical and digital. The approach suggested in this study doesn’t look at the Alps under the perspective of a marginal, underdeveloped region to be supported financially as to avoid further backwardness, but rather seeks to use technological infrastructures as a source of differentiation, specialization and competitive advantage. It aims at leveraging on the territorial specificities and the many points of strength of the Alpine Region in a global context that is coming to appreciate more and more the crucial role of its precious natural resources, the historic equilibrium between human presence and environment, the attractiveness of its quality of life and its unrivalled cultural traditions. In a world that, in front of increased environmental risks from global warming, is frantically trying to find a viable solution to pursue sustainable development, the Alpine Region stands firm on its unmatched level of fresh and clean air, water and land, supported by a vast array of renewable energy sources. The Alps are the best place to launch a “Green New Deal”, made of technological infrastructures and digital solutions that may demonstrate, to the rest of Europe and to the world, that a new equilibrium between human development and natural resources can indeed be reached, without compromising neither socio-economic growth nor environmental protection.

- **While several cross-border connectivity «gaps» must still be filled, the required investments may not be difficult to implement but they require to tackle both the «fragmentation problem» in marginal areas and the relevant governance issues, providing neutral facilities and local shared infrastructures.**
    - The analysis has mapped and classified the cross-border connectivity gaps according with four main criteria: Maturity, Access, Ownership, and Governance. The different levels of maturity range from sections where infrastructures are already available and exploitable, to areas where infrastructures can be deployed with little effort and eventually to zones where relatively high investments are required. The level of accessibility to infrastructures is relative to easiness of access to the existing fiber optics and availability/closeness to other neutral facilities; it can be positive when existing fibers are close to locations where PoPs/Towers are already in place and

managed by open and neutral owners or easily buildable by such entities or negative when PoPs/Towers are far away/unreachable or location are owned by entities that do no guarantee openness and neutrality (e.g. vertical integrated telecommunications operators); the fragmentation of ownership is referred to the number of landlords/owners on each physical route; it is considered positive when there is only one owner on each side of borders, and negative with more than two owners; governance is related to the level of complexity of management and control of existing fiber infrastructures; it is considered positive when they are owned by open and neutral players, with no regards whether they are public entities or private companies, while the governance level becomes negative when on both sides there aren't open and neutral owners. Therefore, the feasibility of recommended intervention has been classified with a score: full, when no negative condition is present; partial, when one condition is evaluated to be at an intermediate level and only one condition is negative; low: in other, worst cases. The infrastructural mapping conveniently splits the Alps in three different logical areas: the West Side (from the Ligurian Sea, around Nice in France, to the Simplon Pass included), where 8 routes have been analyzed; the Central Side (from Simplon Pass, excluded, to the Drava River, included), where 6 routes have been mapped; the East Side – Friuli Venezia Giulia to Slovenia, from Drava River, excluded, to the Adriatic Sea near Trieste, where 5 routes have been covered. The most feasible areas of interventions have been identified in 6 routes with Full (so higher) feasibility and 8 routes with Average (so medium) feasibility.

- **To unleash the economic potential of cross-borders areas, and in general of the Alpine Region, the recommended starting point is acting both on enabling infrastructures factors («connectivity/IoT/distributed computing resources» and «digital ecosystems») and innovative strategic applications, such as Smart Mobility & Logistics, Smart Nature Parks, Smart Outdoor Sport Areas, Smart Villages for digital tourism and advanced agriculture, targeting minimum viable solutions that can become replicable and scalable, coordinating with and leveraging on the recommendations and outcomes of the other EUSALP Action Groups.**
    - In the perspective of pursuing a well-balanced and environmentally sustainable social and economic development, connectivity infrastructures shall not be considered as ends in themselves. Rather, they are enablers of many possible strategic applications that can exploit the specific features and the competitive advantages of the Alpine Region to foster growth and increase the local attractiveness of financial and human capital, therefore contrasting the negative demographic trends afflicting the mountain areas. In this view, the recommended interventions are not just targeted at reducing the infrastructural gap that typically is associated to rural areas. The study therefore identifies and briefly describes four possible strategic applications, on top of infrastructural interventions, that can be targeted, developed and implemented in the Region, leveraging on the peculiar characteristics of the

Alpine territory. The four applications suggested in the study range from advanced mobility and logistic solutions, based on availability of digital infrastructures of high-speed, low-latency connectivity and sensorization of roads, passes and railways, to the transformation of the existing residential and touristic assets of the Region in “smart digital zones”: from outdoor sport areas, to nature parks, to smart villages and sustainable, digital tourism and agriculture. The recommendation, hence, is to define a so-called “minimum viable solution” for each one of the listed projects, to be implemented in areas with the highest level of feasibility and growth potential, targeting a subsequent replicability and scalability in order to reach a critical mass across the entire Alpine Region, while granting consistency of institutional and technological governance, as well as the desired level of openness and interoperability in the resulting digital ecosystem.

10 Conclusions

The Alps are not periphery, nor just marginal areas to be catered for. The Alps are the crossroad of European culture: no longer a battled frontier among fragmented nations, but a hinge of social and economic processes, a fulcrum for leveraging integration, an axis to exploit global excellence of its diverse yet converging natural resources and human talents.

The interventions recommended in this study are targeted at reaffirming the unique role of the Alpine Region in the social and economic context of Europe, and not just to cover a infrastructural gap. The financial resources required to address the missing links of cross-border infrastructures are not enormous, nor particularly difficult to implement. But if they have to really contribute not only to the social and economic development of the current residents, but also to attract new human and financial capital in order to exploit the peculiar features of this beautiful, unique territory, then the infrastructural intervention must be combined with the implementation of strategic applications specifically targeted for the Alpine Region. The recommended course of action shall have a long-term, broad and positive impact on the economic potential of the Region, on its global competitiveness and its environmental sustainability.

Alpine natural resources and protected areas, which already represent a unique network of parks constituting a global touristic attraction, will benefit in terms of development, economic sustainability and level of environmental preservation by leveraging technological improvement, monitoring natural resources and wildlife, and carefully supervising closely controlled flows of visitors. Cross-border mobility and logistics, as well as accessibility to remote areas, will be improved by developing a sustainable interconnected network, which meets the needs of residents and tourists alike, for many purposes of mobility, transportation and logistics. The analysis suggest to bring digital connectivity and digital ecosystem approach also to one of the fastest-growing touristic and entertainment activities: outdoor sports in the Alpine areas. These outdoor activities range from skiing to climbing, trail running/hiking, river rafting, canyoning and kayaking, lake windsurfing, paragliding, etc. They also include, in economic terms, the relative touristic inflows, as well as the development and the provisioning of sport tools, outfits and accessories, with the goal of offering a safe and enjoyable customer experience, to be achieved with the extended digital coverage of the relative areas of interest.

Targeting the development of “smart villages” and improving the technological resources for local agricultural activities, the recommendations aim at improving the quality of life of the Alpine population and tourists alike, while giving smart-working professionals good reasons to relocate from metropolitan centers to fresher and cleaner mountain areas, relying on a renewed economic development of the Alpine villages and on the increased digitalization of public services.

These recommendations are therefore addressed not only to authorities at the EU level, but also to local/regional institutions and private organizations that share the same objectives and that can benefit for the standardization and the scalability of the suggested investments in terms of cost saving, increased efficiency and effectiveness. Therefore players at all levels, both international and local, both public and private, should carefully examine the

strategic options set forth in this study. They can access the many different provisions of funds and resources made available by EU programs, such as CEF, as well as refer to local allocation of funding and/or pursue the development of public-private partnership, given the many potential cross-sector effects emphasized for the suggested actions. Finally: this document is not intended to impose new rules or obligations; it just addresses possible common policies to be adopted by the various players involved in the EUSALP strategy.

Glossary

- **5G** - Term used to describe the next-generation of mobile networks beyond LTE. According to ITU guidelines, 5G network speeds should have a peak data rate of 20 Gb/s for the downlink and 10 Gb/s for the uplink. Latency in a 5G network could get as low as 4 milliseconds in a mobile scenario and can be as low as 1 millisecond in Ultra Reliable Low Latency Communication scenarios. Not only will people be connected to each other but so will machines, automobiles, city infrastructure, public safety and more.

- **Backbone network** - A backbone is the part of the computer network infrastructure that interconnects different networks and provides a path for exchange of data between these different networks. A backbone may interconnect different local area networks in offices, campuses or buildings. When several local area networks (LAN) are being interconnected over a considerable area, the result is a wide area network (WAN), or metropolitan area network (MAN) if it happens to serve the whole city.

- **Backhaul network** - Backhaul is the communication and network infrastructure responsible for transporting communication data from end users or nodes to the central network or infrastructure and vice versa. It is the intermediate wireless communication infrastructure that connects smaller networks with the backbone or the primary network.

- **Access network** - An access network is a user network that connects subscribers to a particular service provider and, through the carrier network, to other networks such as the Internet. It can be set up through different technologies, from optical fiber to wireless, providing network services based on ADSL, VDSL, GPON, Ethernet etc.

- **PoP** - Point of Presence (PoP) is the point at which two or more different networks or communication devices build a connection with each other. POP mainly refers to an access point, location or facility that connects to and helps other devices establish a connection with the Internet.

- **Carrier** - A carrier network is the proprietary network infrastructure belonging to a telecommunications service provider. Telecom carriers are authorized by regulatory agencies to operate telecommunications systems. Carrier networks distribute massive quantities of data over great distances.

- **ISP** - An Internet Service Provider (ISP) is a company that provides customers with Internet access. Data may be transmitted using several technologies, including dial-up, DSL, cable modem, wireless or dedicated high-speed interconnects. Typically, ISPs also provide their customers with the ability to communicate with one another by providing Internet email accounts, usually with numerous email addresses at the customer's discretion. Other services, such as telephone and television, may be provided as well.

- **AS** - An Autonomous System (AS) is a network or a collection of networks that are all managed and supervised by a single entity or organization. An AS is a heterogeneous network typically governed by a large enterprise. An AS has many different subnetworks with combined routing logic and common routing policies.

- **CDN** - A content delivery network (CDN) is a system of multiple computers that contains copies of data stored at various network nodes. A well designed and appropriately implemented CDN improves data access by enhancing bandwidth and minimizing access latency. Generally, CDN content can include Web objects, applications, database queries, downloadable data objects and media streams.

- **IoT** - The internet of things (IoT) is a computing concept that describes the idea of everyday physical objects being connected to the internet and being able to identify themselves to other devices. When many objects act in unison, they are known as having "ambient intelligence".

Annex :Cybersecurity Facts and Figures

Cybersecurity issues are becoming a day-to-day struggle for institutions and businesses. The Alpine Region, with its critical role of cross-road of digital exchanges among European nations, shall not underestimate the need to target an adequate level of technological protection and governance process against a growing level of cyber risks, both at the local and at the global level.

Trends show a huge increase in hacked and breached networks and data. The increasing amount of large-scale, well-publicized breaches suggests that not only are the number of security breaches going up – they're increasing in severity, as well.

- Thirty-one percent of organizations have experienced cyber-attacks on operational technology infrastructure. (Cisco)
- According to 2017 statistics, there are over 130 large-scale, targeted breaches in the U.S. per year, and that number is growing by 27 percent per year. (Accenture)
- 100,000 groups in at least 150 countries and more than 400,000 machines were infected by the Wannacry virus in 2017, at a total cost of around $4 billion. (Malware Tech Blog)
- Attacks involving cryptojacking increased by 8,500 percent in 2017. (Symantec)
- In 2017, 5.4 billion attacks by the WannaCry virus were blocked. (Symantec)
- There are around 24,000 malicious mobile apps blocked every day. (Symantec)
- In 2017, the average number of breached records by country was 24,089. The nation with the most breaches annually was India with over 33k files; the US had 28.5k. (Ponemon Institute's 2017 Cost of Data Breach Study)
- In 2018, Under Armor reported that its "My Fitness Pal" was hacked, affecting 150 million users. (Under Armor)
- Between January 1, 2005 and April 18, 2018 there have been 8,854 recorded breaches. (ID Theft Resource Center)

Cybersecurity Costs

Average expenditures on cybercrime are increasing dramatically, and costs associated with these crimes can be crippling to organizations who have not made cybersecurity part of their regular budget.

- In 2017, cybercrime costs accelerated with organizations spending nearly 23 percent more than 2016 — on average about $11.7 million. (Accenture)
- The average cost of a malware attack on a company is $2.4 million. (Accenture)
- The average cost in time of a malware attack is 50 days. (Accenture)
- From 2016 to 2017 there was a 22.7 percentage increase in cybersecurity costs. (Accenture)
- The average global cost of cybercrime increased by over 27 percent in 2017. (Accenture)

- The most expensive component of a cyber-attack is information loss, which represents 43 percent of costs. (Accenture)
- Ransomware damage costs exceed $5 billion in 2017, 15 times the cost in 2015. (CSO Online)
- The Equifax breach cost the company over $4 billion in total. (Time Magazine)
- The average cost per lost or stolen records per individual is $141 — but that cost varies per country. Breaches are most expensive in the United States ($225) and Canada ($190). (Ponemon Institute's 2017 Cost of Data Breach Study)
- In companies with over 50k compromised records, the average cost of a data breach is $6.3 million. (Ponemon Institute's 2017 Cost of Data Breach Study)
- Including turnover of customers, increased customer acquisition activities, reputation losses and diminished goodwill the cost of lost business globally was highest for U.S. companies at $4.13 million per company. (Ponemon Institute's 2017 Cost of Data Breach Study)
- Damage related to cybercrime is projected to hit $6 trillion annually by 2021. (Cybersecurity Ventures)

Cybersecurity Facts and Figures

It's crucial to have a grasp on the general landscape of metrics surrounding cybersecurity issues, including what the most common types of attacks are and where they come from.

- Ransomware detections have been more dominant in countries with higher numbers of internet-connected populations. The United States ranks highest with 18.2 percent of all ransomware attacks. (Symantec)
- Trojan horse virus Ramnit largely affected the financial sector in 2017, accounting for 53 percent of attacks. (Cisco)
- Most malicious domains, about 60 percent, are associated with spam campaigns. (Cisco)
- Seventy-four percent of companies have over 1,000 stale sensitive files. (Varonis)
- Malware and web-based attacks are the two most costly attack types — companies spent an average of US $2.4 million in defense. (Accenture)
- The financial services industry takes in the highest cost from cyber crime at an average of $18.3m per company surveyed. (Accenture)
- Microsoft Office formats such as Word, PowerPoint and Excel make up the most prevalent group of malicious file extensions at 38 percent of the total. (Cisco)
- About 20 percent of malicious domains are very new and used around 1 week after they are registered. (Cisco)
- Over 20 percent of cyber attacks in 2017 came from China, 11 percent from the US and 6 percent from the Russian Federation. (Symantec)
- The app categories with most cybersecurity issues are lifestyle apps, which account for 27 percent of malicious apps. Music and audio apps account for 20 percent. (Symantec)

- The information that apps most often leak is phone numbers (63 percent) and device location (37 percent). (Symantec)
- In 2017, spear-phishing emails were the most widely used infection vector, employed by 71 percent of those groups that staged cyber-attacks. (Symantec)
- Between 2015 and 2017, the U.S. was the country most affected by targeted cyber-attacks with 303 known large-scale attacks. (Symantec)
- In 2017, overall malware variants were up by 88 percent. (Symantec)
- Among the top 10 malware detections were Heur.AdvML.C 23,335,068 27.5 2 Heur.AdvML.B 10,408,782 12.3 3 and JS.Downloader 2,645,965 3.1 (Symantec)
- By 2020, the estimated number of passwords used by humans and machines worldwide will grow to 300 billion. (Cybersecurity Media)

Cybersecurity Risks

With new threats emerging every day, the risks of not securing files is more dangerous than ever, especially for companies.

- 21 percent of all files are not protected in any way. (Varonis)
- 41 percent of companies have over 1,000 sensitive files including credit card numbers and health records left unprotected. (Varonis)
- 70 percent of organizations say that they believe their security risk increased significantly in 2017. (Ponemon Institute's 2017 Cost of Data Breach Study)
- 69 percent of organizations don't believe the threats they're seeing can be blocked by their anti-virus software. (Ponemon Institute's 2017 Cost of Data Breach Study)
- Nearly half of the security risk that organizations face stems from having multiple security vendors and products. (Cisco)
- out of 10 organizations say their security risk increased significantly in 2017. (Ponemon Institute's 2017 Cost of Data Breach Study)
- 65 percent of companies have over 500 users who never are never prompted to change their passwords. (Varonis)
- Ransomware attacks are growing more than 350 percent annually. (Cisco)
- IoT attacks were up 600 percent in 2017. (Symantec)
- The industry with the highest number of attacks by ransomware is the healthcare industry. Attacks will quadruple by 2020. (CSO Online)
- 61 percent of breach victims in 2017 were businesses with under 1,000 employees. (Verizon)
- Ransomware damage costs will rise to $11.5 billion in 2019 and a business will fall victim to a ransomware attack every 14 seconds at that time. (Cybersecurity Ventures)
- Variants of mobile malware increased by 54 percent in 2017. (Symantec)
- Today, 1 in 13 web requests lead to malware (Up 3 percent from 2016). (Symantec)
- 2017 represented an 80 percent increase in new malware on Mac computers. (Symantec)

- In 2017 there was a 13 percent overall increase in reported system vulnerabilities. (Symantec)
- 2017 brought a 29 percent Increase in industrial control system–related vulnerabilities. (Symantec)
- By 2020, we expect IT analysts covering cybersecurity will be predicting five-year spending forecasts (to 2025) at well over $1 trillion. (Cybersecurity Ventures)

This study sets forth the necessity to include cybersecurity issues as a technological and governance layer in any relevant project involving technological infrastructures and digital initiatives across the Alpine Region. An appropriate coverage of cybersecurity tools and processes shall therefore be considered for any future program of public intervention in the area.

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