The Touristic Sector in the 5G Technology Era: The 5G-TOURS Project Approach

Luca Vignaroli*, Marco Gramaglia†, Manuel Fuentes‡, Antonino Casella§, Roman Odarchenko¶, Lorenzo Natale‖, Baruch Altman** and Francesco D'Andria††
*Rai Radiotelevisione Italiana, Italy
†Universidad Carlos III de Madrid, Spain
‡iTEAM Research Institute, Universitat Politecnica de Valencia, Spain
§Telecom Italia, Italy
¶Bundeslab, Hungary
‖Istituto Italiano di Tecnologia (IIT), Italy
**LiveU, Israel
††ATOS, Spain
Email: luca.vignaroli@rai.it, mgramagl@it.uc3m.es, mafuemue@iteam.upv.es, antonino.casella@telecomitalia.it, roman@bundleslab.com, lorenzo.natale@iit.it, baruch@liveu.tv, francesco.dandria@atos.net

***Abstract*—5G mobile networks are designed to fulfill very stringent requirements and support new vertical use cases. This transition to a vertical oriented delivery model will have a strong impact in the touristic sector. In this context, the "touristic city node" of 5G-TOURS, built in the city of Turin, aims at exploiting the potential of the media vertical. The objective is to develop an innovative tourism concept based on complementary and linked trials for five specific use cases. The trials will promote an overall integrated indoor/outdoor immersive experience to the visitors using any possible device, enhancing the accessibility to the technology, especially for disadvantaged and disabled people. They will also utilize 5G to drive "remote tourism" based on augmented/virtual reality (AR/VR) experiences and bridge the gap between the physical and virtual worlds for tourism. This paper provides an overview of the 5G technology deployed in the touristic node, explaining the different services to be provided and discussing the need of 5G technology to support this vision. This work also assesses the business potential of each of the considered use cases, corroborating their potential in the context of future network services.**

***Index Terms*—5G, media, smart tourism, test-beds, trials, demonstrations.**

I. Introduction

Tourism involves the activities of people travelling and staying in a place away from their home environment for leisure, business, or other purposes. Mathieson and Wall in [1] define tourism as "the temporary movement of people to destinations outside their usual places of work and residence, the activities undertaken during their stay in those destinations, and the facilities created to cater to their needs". One can derive from this the concept of *smart tourism*. According to [2], smart tourism is enriching the five As usually associated to touristic services (i.e., attraction, accessibility, accommodation, amenities, and activities), empowered by the use of the most advanced technology. These are major components to be considered in setting the engagement strategy for the services and products of tourism. Smart tourism responds to new challenges and demands in a fast-changing sector, including the evolution of digital tools, products and services; equal opportunity and access for all visitors; sustainable development of the local area; and support to creative industries, local talent and heritage. The use cases proposed in this work even demonstrate how smart and remote tourism can become economical engines in situations such as the global COVID-19 pandemic, which prevents travel and mass visits.

Smart tourism is thus a specific branch of the *smart city* concept, with the objective of enhancing cultural and artistic heritage through digital media (e.g. multimedia, virtual museums, augmented reality, cultural communities on the web, e-commerce), leading the innovation process, especially in this thematic area, with systematic coordination between institutions. The European project 5G-TOURS [3], [4] has a valuable environment for this purpose, in which relevant players such as the city of Turin work in close synergy with Torino Fondazione Musei, a third party of the city, on the development and implementation of the five related use cases presented in this work.

The touristic city of 5G-TOURS is a place where visitors of museums and outdoor attractions are provided with 5G-based applications to enhance their experience while visiting the city. One of the key aspects to consider is the use of virtual reality (VR) and augmented reality (AR) applications to complement the physical visit of the museum with additional content, involving interactive tactile communications. The visitors experience is further enhanced with robot-assisted services and telepresence, to allow for remote visits. Media production and distribution is also addressed, providing visitors with digital content that can further improve the visitors experience as well as live events enabled by mobile communications such as multi-party concerts. All of them require novel functionalities and stringent requirements from the 5G network that cannot be supported by previous generations [5].

This work describes in detail the 5G-TOURS approach to provide a full *smart touristic experience*. It is structured as follows. Section II describes the general verticals point of view and business aspects. Section III describes the use cases implemented in the touristic city, while Section IV focuses on the network deployment aspects. Finally, Section V concludes the paper.

II. The Vertical Perspective

The touristic node use cases will impact both media and touristic verticals in the smart city area of Turin. As smart city, Turin is working on new development models, both social and economic, prioritizing interventions capable of affecting citizens and the life of the city. The city has developed processes and paths aimed at responding creatively to the main territorial problems in some specific areas. Examples are energy, environment, mobility, accessibility, inclusion, social cohesion, culture, and lifestyles. Thus, innovation towards tourism and culture is one segment of the entire mosaic that forms the process and it is considered particularly important by the city.

On the other hand, broadcasters have encompassed a profound transformation in the last years to become media companies and offer, in addition to traditional linear radio and TV programs, a great variety of different services. This includes also non-linear content such as streaming, downloads, podcasts, catch-up, etc., as well as employment of many social media platforms. Introducing remote production over 5G networks for television content can revolutionize the classic workflow of broadcaster and media companies. Its introduction can contribute to the development of cultural events taking place within the territory of the city introducing a new way to cover live events, while at the same time building a more efficient and cost-effective way to produce television content. This aspect will also improve local, national, and international tourism with social and economic utility for cities, as well as "remote tourism".

5G-TOURS, with its use cases, aims to create the framework for innovative tourism, with benefits for the main stakeholders (e.g. tourists, local residents, local government, organizations, accommodation/services providers, and more importantly, technology infrastructure providers). The touristic market context is a very interesting field in terms of possible services that could be exploited and business opportunities, if a very strong partnerships could be done between municipalities, museum foundations and media companies. In this work, services deployed from verticals could be summarized as telepresence, robot assistance, extended reality (XR) in a museum and city walks, and media production and distribution. This way, municipalities, museum foundations and media companies could be the protagonist in the exploitation of main tourism market activities, in which the new 5G network technologies will enable the partnership of involved actors in the value chain.

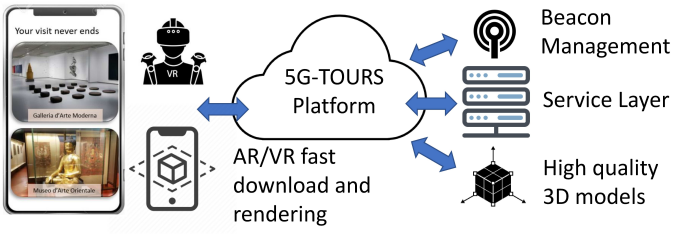

Fig. 1. XR in the museum and city walk.

III. Use Cases

The touristic city node encompasses five different use cases: the augmented tourism experience, the robot assisted museum guide, telepresence, high-quality services distribution, and remote production. The use cases are described below [6], [7].

A. Augmented Tourism Experience

This use case aims to develop a 5G-based XR service platform that provides tourists with an improved and more engaging experience. It is based on the use of an AR/VR mobile application inside and outside the Palazzo Madama museum and on the use of an interactive wall dedicated to children and students in GAM (Galleria d'Arte Moderna) museum. Users experience will be enhanced by using interactive technologies to augment the real-world environment by placing interactive 3-Dimensional (3D) models to interact with, virtual avatars and scenarios, immersive (360 degrees) videos and interactive walls. It also aims to create and test an integrated, immersive visit in the museum and surrounding areas by means of a mobile application that will provide the visitor with additional Internet of Things (IoT)-based information such as a possible tour to run, level of crowding in museum room (by using beacon technology), map of the museum and related points of interest or access to more contents related to specific rooms and artworks.

High broadband capabilities of 5G networks will help to implement a reliable interaction between XR components by enabling an adaptive real-time AR/VR contents streaming and rendering, content sharing management and cloud-enabled storage. Thus, users can interact with (Hi-Res textures) 3D models or participate in a virtual scenario with the aim to improve the visitor knowledge by taking actions. Furthermore, once outside the museum, the mobile application will help visitors suggesting further places of interest or interacting with smart city services. Finally, once at home, the city tourists can retrieve artworks previously stored or explore new ones not seen during the tour. Figure 1 depicts the interaction of service components with the 5G-TOURS.

Another objective of this use case is to allow users to enter lives of artists, directly test the art creation process, and learn about it through *gamification*. It is an educational case study addressed to students or families with children. The experience mixes XR with gamification and will allow children to work on

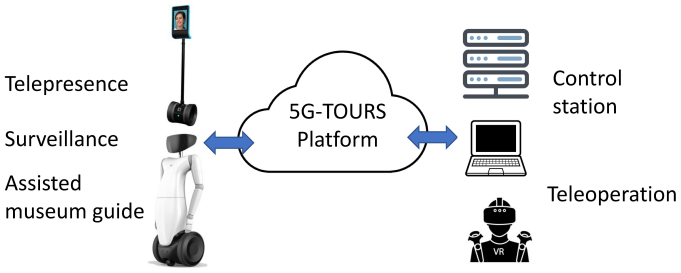

Fig. 2. Robot-assisted museum guide and telepresence.

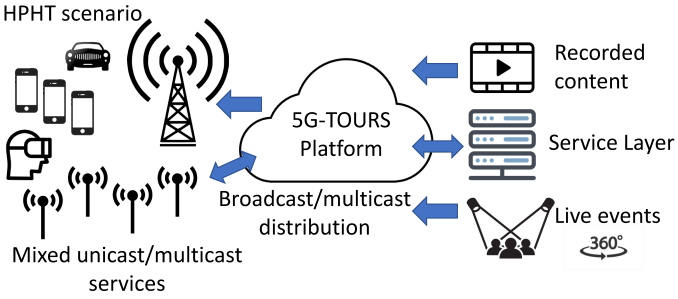

Fig. 3. Broadcast video service distribution.

an interactive wall reproducing the artist canvas by choosing shape and colors contents.

B. Robot-assisted museum guide and telepresence

The main goal of this use case is to test and employ a robot located inside the museum and controlled by a remote user. Telepresence robots have the potential to contribute to accessibility and inclusiveness by extending access to previous excluded audiences. A first idea is to enlarge the public for selected exhibitions to make these experiences more accessible to all for a longer period as well as use virtual exhibition as promotional activity to attract foreign visitors or tourists. The specific sub-use case will be set in Palazzo Madama and will be characterized by two or three curator led visits to the temporary or permanent exhibitions. Another objective of this use case is to offer enhanced educational activities to students at school. The selected location will link students located at the Edulab premised with GAM. The 5G-TOURS platform aims to implement robot-assisted museum guide and telepresence use cases (see Figure 2), using novel 5G network facilities.

Robots will be used for telesurveillance of the museum, both during day and night hours. The selected test beds will be Palazzo Madama and GAM. The use case directly interacts through sensor networks about safety conditions as well as the indoors or outdoors presence of people. The Robot-assisted museum guide use case foresees the use of the robotic technology to provide an enhanced museum visit experience both in Palazzo Madama and GAM. A humanoid service robot (R1) [8] will be able to provide basic information about collection highlights and temporary exhibitions as well as assist visitors during queuing time at ticket desk; guide visitors moving through the museum and describing the artworks. This guided tour will be performed autonomously by the robot following a pre-computed path. The robotic use case will demonstrate the capabilities of the 5G network in scenarios that involve autonomous or partially autonomous systems, in which high reliability and low latency are crucial components.

C. High Quality video service distribution

This use case targets the distribution of enhanced high-quality video and immersive services for tourists, to enhance the user experience when visiting a city. It is directly related to the media and entertainment vertical. In this use case, users will be able to use their smartphones, tablets, or VR devices to receive educational and informative immersive content during their visits to the city and museums. This use case will showcase the advantages of multicast and broadcast technologies as part of a 5G network.

This concept will be showcased, on the one hand, from a mobile operator perspective, in a reduced scenario (using a laboratory network), using a mixed mode where multicast and unicast services share the same resources. With this option, it is possible to distribute high-quality video and immersive content to many users, where part of the downlink content needs to be personalized and where information is also being delivered by the user in the uplink. The network will be able to provide a switch between unicast and broadcast according to the audience size.

On the other hand, the use case also considers a broadcast-centric approach for large scale services. In this option, a video broadcaster facility with a High-Power High-Tower (HPHT) topology will be used (see Figure 3). The use case will use LTE-based 5G Terrestrial Broadcast technology to transmit the video (downlink-only) to all users at once. This technology is independent of the audience size. In this case, the content is broadcast regardless of the number of devices receiving the signal.

Additionally, a third branch of this use case involves the development of a multicast component in the 5G core. That is, in total there are three families of use cases, which encompass different aspects of the network and entail specific deployments in the 5G infrastructure.

D. Remote and distributed video production

This use case tests and demonstrates production of a unique and challenging touristic live event of a multi-site musical concert, where music played by four musicians walking in the street is transmitted over an outdoor 5G infrastructure into a production room inside the Palazzo Madama. In here, it is combined with the music played there by a full orchestra (see Figure 4). A special concert will be composed by a renowned composer, just for this occasion. The transmission uses devices that combine real time adaptive High Efficiency Video Coding (HEVC) audio/video encoding with adaptive transmission over single or multiple-bonded 5G links/modems. Intercom is used to communicate with the cameramen and players. In such productions, highly reliable and high quality audio-visual uplink

TABLE I
MOST RELEVANT KPIS FOR THE PRESENTED USE CASES.

KPI		Use Cases				
		Augmented Tourism Experience	Telepresence	Robot-assisted Museum guide	HQ video service distribution	Remote and distributed video production
Throughput [Mbps] per device	Downlink	200	>15	>10	25-100	∼1
	Uplink	>20	>15	>15	-	>25
E2E Latency [ms]		<15	<10	<10	<10	<10
Density [devices per km^2]		∼50	<5	<5	N/A (broadcast) >100 (unicast/multicast)	>100
Mobility [km/h]		<10	<5	<5	10-100	<5
Reliability [%]		99.999	99.999	99.999	99.999	99 (single camera) 97 (multi camera)
Location Accuracy		<1m	<1m	<1m	N/A	N/A

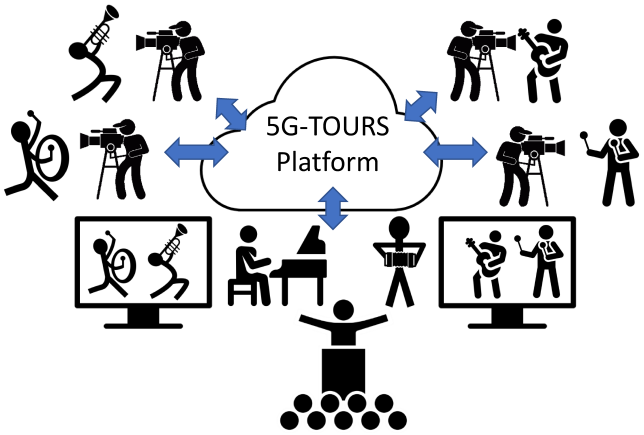

Fig. 4. The itinerant orchestra.

bandwidth is needed, at low and fixed latency, continuously for long time (hours) and while moving outdoors and having the four transmissions tightly synchronized.

IV. NETWORK IMPLEMENTATION

The general scheme on which the 5G-TOURS network deployment is based consists in the provisioning of a network composed by the combination of (i) commercial deployments based on infrastructure owned by the reference network operator in the project and provided by the network manufacturer, and (ii) pre-commercial facilities deployed to test Rel-16/17 equipment as well as 5G-TOURS innovative functionalities, relying mostly on indoor environments.

A. Use case requirements

To deploy the envisaged use cases, 5G-TOURS will exploit the facility provided by the 5G-EVE project [9]. The ultimate goal is to make 5G a reality, enabling touristic sector to validate its advanced use cases, while satisfying increasingly stringent Key Performance Indicators (KPI) (see Table I) and proving their economic viability. Therefore, the first step for setting up the network consists of collecting all requirements coming from the use cases, considering the most stringent ones to design a network that can support all the use cases. This provides an optimized solution in terms of number of radio equipment to be installed, their connections to the appropriate base-band units, etc., as part of the network design activity. All specific requirements for the use cases are collected in Table I.

The network design activity takes care of coverage and position of the radio equipment, which are evaluated by means of simulation based on the maps of the areas and the building plans, corroborated in a second stage by on field measurements. Finally, the needed infrastructure is integrated as part the already deployed one available in the 5G-EVE [9], as discussed below.

B. 5G network deployment

The planned network deployment for the touristic city is depicted in Figure 5. The physical architecture deployment spans different sites in the city of Turin (i.e. the two museums, where the access network and edge facilities will be deployed, plus the laboratory network for the core) and it is fully integrated in the 5G-EVE Italian site.

Most of the use cases will be implemented at the museum. For Palazzo Madama, a mixed outdoor/indoor coverage is required, essentially to support the trial of remote video production use case. The outdoor coverage will rely on the commercial network, while for the indoor will be provided with micro cells in an ad-hoc installation for the 5G-TOURS project. The frequency that will be used is a 80 MHz wide licensed portion in the 3.7 GHz band.

1) Deployment phases: In the touristic city, there is a two-phased approach in which the network is empowered with further releases of the 5G technology:

Phase 1: It foresees that the 5G indoor coverage of the museum is connected to the commercial network, whose core network node is located in Milan (i.e. field core of Telecom Italia). From this perspective, the indoor coverage will be a full-fledged extension of the outdoor coverage for those use case that will require both in an early phase. The network implementation in phase 1 will address only the objective of validating the 5G KPIs for the discussed applications.

Phase 2: It foresees that the 5G indoor coverage of Palazzo Madama and GAM is connected to the laboratory network (as part of the 5G-EVE infrastructure). In this case, the outdoor and indoor coverage will practically be two independent

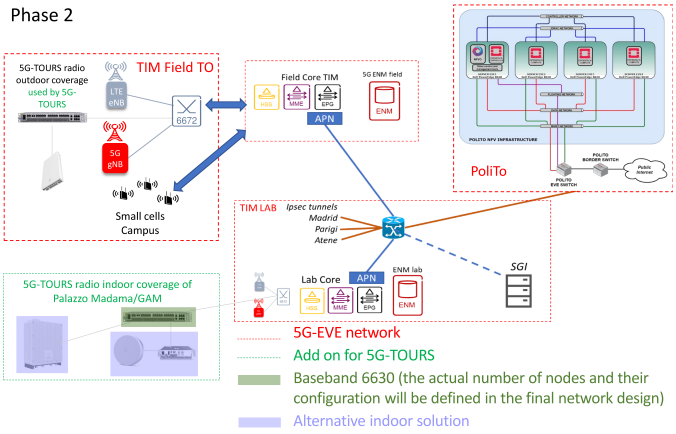

Fig. 5. The network architecture for the touristic city envisioned for the second phase of the Touristic City deployment [10].

networks coexisting in the same area and operating on the same frequency range. The network implementation of phase 2 will address both objectives to validate the need of 5G and demonstrate the benefits of the 5G-TOURS innovations, taking advantage of the 5G EVE laboratory network functionalities that will be made available to 5G-TOURS. Phase 2 will therefore provide an almost full integration with the 5G EVE infrastructure (i.e. laboratory network). In this phase the project will validate its beyond 5G concepts, as discussed in Section IV-C.

2) Backhaul Connectivity: The network infrastructure will also require the support of a broadband wired connection over optical fiber to the museums. An important aspect that must be considered during the design phase of the backhaul network is related to the network coverage planning, which consists in determining the coverage provided by the different cells. An optimal network planning will guarantee a good service provision in terms of connection stability and performances. In case of a mixed outdoor/indoor coverage such as the one that will be deployed at the museums, the network planning plays a fundamental role to determine the boundaries of the respective cells to properly manage the mutual interference that may occurs between the two coverage types.

This aspect becomes even more relevant when the two coverage types refer to two different networks (e.g. core network to which these cells are connected). Concerning the Turin site, such problematic will be more significant in phase 2. Besides the planning aspects, the operational functionalities (i.e. network radio features) are another important factor that contributes to the network radio performances. Handover support as well carrier aggregation (or dual connectivity) are just a couple of examples of such functionalities; the first will guarantee the service continuity when the device will pass from one cell to another (i.e. from the outdoor to the indoor coverage), while the second will improve the throughput by aggregating different carriers of the same or different technologies such as 4G and 5G, as in the case of 5G Non-Standalone (NSA) network architecture.

C. Beyond 5G network deployment

As previously discussed, some of the use cases will require enhanced network functionalities that are not included in 3GPP 5G Rel-15 employed during phase 1, as well as innovative Management and Orchestration (MANO) functions. These functionalities are discussed in this section.

1) Broadcast support: One of the most important network enhancements that 5G-TOURS will bring into the 5G network infrastructure is the use of broadcast. The video service distribution use case requires the presence of broadcast and multicast delivery mechanisms to optimize the wireless channel access in the video distribution. The first part of this use case is a mobile-centric approach that will rely on multicast/unicast switching modules, to be deployed in the TIM laboratory core network as part of the 5G-EVE infrastructure or the TIM proprietary test-plan network. This is a pioneering initiative in the field of 5G broadcast communications in Europe. Partners in the project will also work in the development of multicast capabilities in the 5G Core.

As a second alternative, the broadcast-centric use case will make use of a High-Power High-Tower (HPHT) topology to showcase a bleeding edge technology deployment. It will be structured in two phases: the first phase will showcase enTV Rel-14 capabilities in a fixed reception scenario. The second phase of this trial will employ a fully-fledged Rel-16 deployment, with specific hardware in a mobile-car scenario in Turin. Both trials will be provided using Rais infrastructure.

2) Enhanced Management and Orchestration (MANO): Too often the state-of-the-art MANO solutions employ rigid and static rules during the network operations that risk to not meet the requirements on the usability of the network imposed by the verticals, which will result in a low adoption of the 5G network from them. Thus, in 5G-TOURS we propose to extend the MANO with new functionality to allow the zero-touch management of the network, but also with new interfaces towards the vertical, which will be used for a wiser usage of the network by the vertical service provider. This additional functionality is part of the service layer design.

Several use cases require continuous monitoring of the network services KPIs, such as:

- *VR/XR*: latency and user throughput.
- *Robots*: latency.
- *Broadcasting*: coverage, bandwidth.
- *TV production*: latency and UL trhoughput.

Currently, such kind of monitoring is not possible through the network infrastructure elements. Thus, they will be specifically implemented for the 5G-TOURS use cases and exposed to the verticals, that will use this live feed to check the fulfillment of their network requested network parameters.

3) Dynamic Service-Level Agreement (SLA) management: An additional feature that is requested by verticals is the capability to set up dynamic SLA parameters to the network slice, which will allow flexible decisions on the requested parameters, which may change during the network slice life-cycle. For instance, requirements on the maximum number

of users in the network may vary throughout the day, so the vertical may request rapid changes to such KPI, without going through the usual operations and business support system procedures that are being used nowadays. Specifically, this feature will be enabled on the VR/XR use case, with the following parameters.

- *Number of users.* The verticals will be able to specify a range in the number of active users at any point in time. The enhanced MANO will enforce this rule as long as the minimum Quality of Service (QoS) is reachable.
- *Amount of resources.* The interaction with the network operator and the vertical service provider will be eminently based on monetary interactions (i.e., operators will charge the verticals according to the QoS levels which, in turn, will be based on the amount of resources allocated to the network slice offering the services). The verticals can set up specific values (e.g., such as the number of allocated servers) or let an Artificial Intelligence module handle it (as discussed next).

4) Big Data and Artificial Intelligence: 5G-TOURS will enable zero-touch management of the network, by enabling intelligent management and orchestration decision to be implemented in the network [11]. Specifically, 5G-TOURS will enable this functionality for the VR/XR use case, as part of the enhanced MANO extension envisioned previously (although other use cases such as TV production use case, may also leverage this functionality). Specifically, the Artificial Intelligence (AI) [12] module will use the monitoring information gathered by the orchestration infrastructure (e.g., the infrastructure load, exposed as time series, and the previous re-orchestration events) to generate re-orchestration decisions (on behalf of the vertical) that will be suggested on behalf of the vertical, which can indirectly steer the decision through high level parameter.

D. Evaluation procedures

Besides the deployment of 5G and beyond 5G infrastructure, 5G-TOURS will also take care of quantifying how the requirements imposed by the different use cases are met and the impact on the fulfillment of those requirement on the overall service quality of experience. 5G-TOURS will tackle this form two vantage points: i) by leveraging measurements of network KPIs [13], and ii) by designing specific questionnaire that will probe the satisfaction with the deployed service. Specific questionnaires will be designed for each use case. We remark that specialized versions of these questionnaires will be provided to both final users and verticals, to assess the satisfaction for both, allowing thus a twofold quality of experience evaluation, considering both the pure network performance and the flexibility of the platform.

V. Conclusions

This manuscript provided an overview of the 5G-TOURS network architecture and the deployment strategy to fulfill some 5G requirements to be demonstrated in the city of Turin. The aim of this work is to provide a detailed approach that enables the so-called *smart touristic experience*. The paper presented first a vertical-oriented perspective, as a key aspect to understand the real needs of the market. Related to it, a set of five media use cases, i.e. augmented tourism experience, robot-assisted museum guide, telepresence, high-quality video distribution and remote video production, were briefly introduced and described. The requirements specified for these use cases were set as the basis for our 5G network. In this context, the paper presented its implementation and deployment phases within the project. The key enablers considered within this architecture, i.e. broadcast support, enhanced MANO, dynamic SLA, as well as AI and big data, were also described.

Acknowledgements

This work was supported in part by the European Commission under the 5G-TOURS: SmarT mObility, media and e-health for toURists and citizenS (H2020-ICT-2018-2020 call, grant number 856950). The views expressed in this contribution are those of the author and do not necessarily represent the project.

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