Crowd Flow Analysis for Measuring the Impact of Urban Transformation Actions in City's Heritage Areas

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1 ABSTRACT

In the past years, cities have become more and more interested in shifting from the traditional ideology-based approach to an evidence-based process of policy and decision making. Subsequently, much attention has been given to new tools and technologies for enhancing data collection on the urban transformation practices. With the help of these new tools and technologies, big social, economic and spatial data are collected which allow a more accurate analysis of urban processes in order to create more livable, inclusive and attractive cities.

This paper outlines a data-guided approach shaped by evidence for cultural-led urban regeneration in creative and knowledge cities, tested in the framework of a H2020-funded project (GA 730280), ROCK (www.rockproject.eu). Its elementary concept is based on developing an innovative, collaborative and circular systemic approach for regeneration and adaptive reuse of historic city centres, transferring the circular economy model to the transformation process of urban historic environments. In this project, transformative actions such as adaptive reuse, temporary structures and events are used to transform public spaces and buildings that have heritage value. By these actions, it is aimed to increase the quality, raise awareness of people and attract more visitors to these places.

This paper focuses on how the large-crowd location-based monitoring tool (LBA sense[1]) is contextualised in two of the Role Model Cities involved in the project: Cluj-Napoca (Romania) and Turin (Italy) in order to understand the impact of transformative actions in heritage districts. In a highly dynamic urban environment, people's flow remain the only constant, expressing the lively dimension of changes in the urban fabric (M. Castells, 2000). The paper is based on a systematic analysis on data collected over time in the two cities, using a set of locally-deployed WiFi sensors and providing real-time insights on activity and mobility patterns within the monitored area. It highlights the accessibility dimension to specific contextual data on crowd flows (during ordinary days and extraordinary/ exceptionally events) in different CH locations in the city, related both to traditional heritage spots, as well as to the empty and underused spaces stock, as potential new locations for creative and cultural purposes.

The method used follows an origin-destination matrix approach, aimed at comparing various crowd flows during different times in the two cities in relation to specific events/ happenings impacting the usual/ conventional use of space. Throughout the comparison, the paper showcases many similarities (such as situational-driven people movement between certain locations), despite the self-evident distinction of hotspots spatial distribution within the two cities and the different urban planning and design background and culture. Finally, the analysis proposes a set of policy measures based on informed documentation of the actual use of the urban space during ordinary and extraordinary events impacting the urban environment.

Keywords: Cultural heritage, urban transformation, data-driven knowledge, crowd monitoring, people flow analytics, sensor data

2 INTRODUCTION

2.1 Theoretical framework

Cultural Heritage (CH) is becoming a key asset for local sustainable development actions. The need of defining sustainable development action in post-industrial contexts finds in CH assets and services an

[1] Large-crowd monotirong tool, developed by DRFC (http://www.dfrc.ch/) – the system combines sensors which allow the reading of the crowd's nature, enabling end-users to access demographics figures and mobility patterns on a wider scale, in ordinary and extraordinary conditions (i.e. festivals and events). It is aimed at determining footfall in real-time and change rate in the crowd size, besides dwell time, revisit and flow patterns and distribution, as well as any abnormality, in the overall area under monitoring (https://rockproject.eu/tools).

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opportunity for creating new employment. In this new role of driver for the local economies, CH has to be conceived and understood more broadly. CH states a closer relation with the places' cultural identity which brings back to a multitude of territorial tangible and intangible elements (Graham et al., 1998), contributing to assert a notion of CH which goes beyond historical and conservative value (UNESCO, 2006). CH, as geographical, economic, functional (UNESCO, 2001) and societal topics (UNESCO, 2014, p. 10) permits to promote CH as driver for sustainable development.

A contemporary understaning of CH unfolds a paradigm shift in approaching CH by transforming it from the condition of "identity and memory repository" to a newly one of "aggregator of contemporary innovative uses and services". This change requires the adoption/ and integration of specific tools and technologies in the heritage environment. In order to make this change possible, it is relevant to orient and equip urban planners with specific tools for measuring the impact of actions and policies related to this new interpretation of the CH. For this reason, Evidence Based Planning (EBP) is relevant when we deal with sensitive assets of CH, as it denotes a planning principle committed to replacing ideologically-driven politics with rational decision making. Moving towards evidence based policy requires skills in data analysis, interpretation of causes and effects, developing policies to correctly address complex urban matters. EBP needs to become a key-capacity of planners, policy designers/ makers working with CH. Using 'evidence' supports the tailoring of policy framework to better respond to urban transformation needs.

The ROCK Project is working on determining the conditions for shaping a methodology that opens new perspective for the integrated use of CH at urban scale. Integration has to be meant not just as the necessary activation of multi-stakeholders planning processes in the places of transformation, but even as opening a dialogue with innovative technologies (e.g. use of emotional data) and other urban critical assets (e.g. public spaces design, nature based solutions assets…) that permit to open a field of reflection and design within the broader concept of cultural landscape.

2.2 ROCK project: general framework and identified knowledge gaps

ROCK is an EU-funded project, through Horizon 2020 programme, under the call SC5-21-2016-2017: Cultural heritage as a driver for sustainable growth, GA no. 730280 (www.rockproject.eu). The project focuses on historic city centres as extraordinary laboratories to demonstrate how Cultural Heritage [CH] can be a powerful and unique engine of regeneration, sustainable development and economic growth for the whole city. ROCK believes that CH should not be perceived as static, a vestige from the past, but instead, it could be a driver for bringing new creative energy into the city, by using the past to help building urban futures. The project conceptualises an innovative circular model as an integrated vision of urban regeneration, based on 6 connected pillars (Creative, Cultural, Regeneration, Knowledge, Security and Green) that interconnect to draw the future of cities.

2.2.1 ROCK Circular approach

The Cultural Model shows a continuous effort to recognise the city and its transformation as a heritage and common good, in which all actors interact with the urban transformations, with various degrees of responsibility and awareness, embodying a collaborative and shared approach. Two key concepts that lay the foundation of ROCK are: creative city and city of knowledge. Hence, creativity and knowledge combined with technological innovation are triggers that fuel the economic and social growth of the city, transforming it sustainably through means of cultural heritage-led regeneration. Likewise, urban regeneration efforts go hand in hand with ROCK attempts to minimize the impact on the environment, leading to environmental sustainability and contributing to the resilience of communities to climate change.

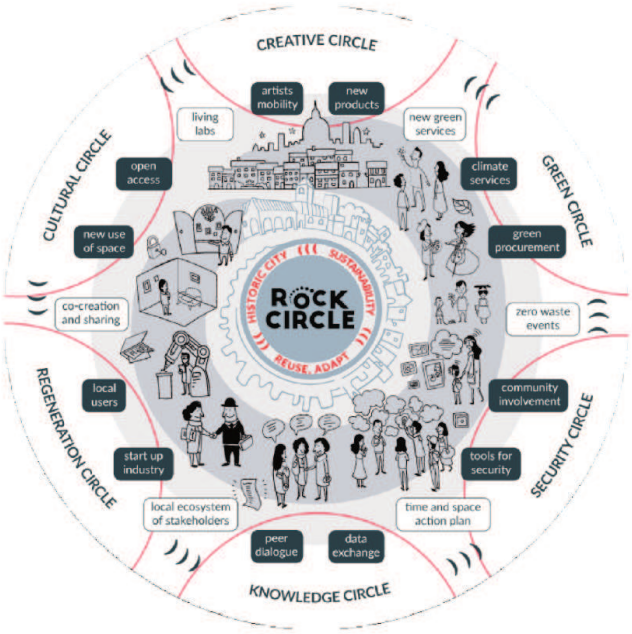

Fig. 1 ROCK Circle

2.2.2 Addressability of knowledge gaps in the policy field of CH-led regeneration through ROCK

ROCK project adopts a vision towards urban transformation of city's heritage areas into Creative and Sustainable Districts through actions such as adaptive reuse, temporary structures and events, aimed at changing public space and buildings with high heritage values. Extending ROCK project's assumption, the present paper addresses two main knowledge gaps: 1) policy field: the demand for more evidence based policy about the impact generated by heritage led-regeneration and urban transformation actions (both permanent and temporary actions); and 2) operational field: the urgent need for adopting new technologies to create novel ways of mapping and measuring the impact provoked by the urban regeneration process and physical transformation actions in the context of heritage areas.

Throughout this paper, we direct our focus on ROCK tools and technologies aimed at improving CH accessibility and public safety perception, namely the large-crowd monitoring tool developed by DFRC.[2] The large-crowd monitoring tools is contextualised in two of ROCK Role Model Cities: Cluj-Napoca (Romania) and Turin (Italy), in order to understand the impact of transformative actions in heritage districts. The tool is used to study users' flows generated by urban transformation actions, on two different circumstances: one related to regular activities and ordinary uses of public space in the monitored areas, while the other one shaped by temporary public installations, structures and happenings related to specific cultural events/ large crowd events. The end goal of testing the large-crowd monitoring tool in the two cities is to collect missing, but essential data for optimizing safety conditions and tailoring urban policies.

The large-crowd monitoring tool is based on the LBASense system, which relies upon a network of sensors placed in both indoor and outdoor areas of the city, later called monitored areas. The sensors provide accurate analysis on spatial-temporal behaviour, based on collected data over time and real-time insights on mobility patterns within and between the monitored areas. The collected data allows the system to perform a comprehensive reading of the crowd's nature, enabling end-users to access demographic figures and mobility patterns during ordinary (during conventional/ average week days) and extraordinary conditions (i.e. cultural-based festivals and events) for the selected locations. The main objective is to determine the footfall in real-time, as well as the change rate in crowd's size, dwell time and data concerning revisits and nationality information for visitors. Additionally, the system provides explicit visualisation for flow patterns and distribution in the monitored areas.

[2] Data Fusion Research Centre (DFRC), a Swiss SME founded in 2006, World leader in WiFi analytics. DFRC is specialised in geospatial data fusion and analysis, delivering powerful end-to-end solutions based on meaningful information about location, movement and flow of people and objects through unique monitoring tools such as its patented LBASense mobile phone detecting sensors, software and platforms. (http://www.dfrc.ch/)

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3 METHODOLOGICAL APPROACH

3.1 Paper objective

The main objective of this paper is to perform a trend analysis within city-flows by investigating data provided through the LBASense and constructing situation awareness pictures in specific heritage areas from two of ROCK Role Model Cities: Cluj-Napoca (Romania) and Turin (Italy). Both cities are currently under the testing phase of the LBAsensors in real urban environments, with the aim of measuring the impact of large-scale events and urban transformations in the city heritage areas. The major contribution of this paper covers two main outcomes: 1) a visual analysis approach to highlight the impact of urban transformation actions, generated from location-based data concerning people movement flows and 2) identification of frequent versus exceptional movement flows and rhythms to highlight changes occured during ordinary (in the sense of conventional/ average days) and extraordinary times (i.e. during particular large-scale events).

3.2 Methodology

The methodology used for investigating the impact of urban transformation actions in city's heritage areas is based on a systematic analysis on data generated from the LBASense (through the locally-deployed WiFi sensors in the two selected cities), collected over three selected moments, as follows: one, covering an ordinary week period with no exceptional event/ particular happening (data gathered over seven consecutive days) and the other two, concerning two different extraordinary/ large-scale events that generate temporary changes in the normal behaviour (data gathered over the entire event period). Therefore, the paper explores real-time data provided by the LBAsense system (raw data transposed into charts) for a limited period of time (chosen moments according to data availability), in order to identify mobility patterns within the monitored areas, which are consequently translated into visual representations (charts and mobility maps).

The performed analysis highlights the accessibility dimension to specific contextual data on crowd flows (during ordinary days and extraordinary/ exceptionally events) in different CH locations in the city, related to both traditional heritage spots and unconventional spaces, outlining urban hotspots and preffered locations.

3.3 Case studies selection

The reasoning behind the selection of the two cities for performing the analysis was the similarity of the conceptual approach towards heritage-led regeneration (both cities have undergone through a transition phase, building a new culture and knowledge-led identity), differentiated through diverse implementation methods and tools, which served to the definition of the city's model framed in ROCK project:

- Cluj-Napoca displays a model of Community-based Design, based on the process of reinventing Cluj-Napoca historical centre and redevelopment of the city's backbone to create a sustainable and equitable solution to address the community's needs, by enabling citizens to become active participants in the life of their own community;
- Turin showcases a model of sustainable re-use of the spaces and Public-Private synergies, based on the reuse of the heritage in the central districts combined with physical regeneration, great international events (e.g. 2006 Winter Olympics) and the development of a strong, long-term publicly-led cultural policy, contributed to boost an overall and wider redevelopment process.

Consequently, the options considered by cities for selecting the areas to be monitored through ROCK project were quite different from two main reasons: on the one hand, due to the particularity of the locations influenced by the large-scale events organised in the city heritage areas, while, on the other hand, considering the specificity of the spatial approaches included in the city's overall regeneration or development strategy. For instance, Turin's city strategy proposes the dispersal of the major urban (cultural) regeneration projects in both the historic core of the city as well as in more peripheral areas surrounding the city centre (like for example San Salvario, Barriera di Milano (Urban Recovery Programme Turin[3]), Porta Palazzo (Colantonio, 2011), etc. Contrarily, the city of Cluj-Napoca concentrates the cultural happenings nearby the central area of the city, with a focus on the old town and the west part of the city center (near Simon Bărnuțiu Park and Someș Riverbanks). Despite the different spatial approaches towards the regeneration process, crowd flow analysis is still dependent on the fact that in a highly dynamic urban

[3] Urban Recovery Programme Turin, available at: http://www.comune.torino.it/rigenerazioneurbana/en/

environment, people's flow remain the only constant, expressing the lively dimension of changes in the urban fabric (M. Castells, 2000). Therefore, identifying crowd flow patterns in the two cities allows us to draw some conclusions regarding the use intensity of certain locations in correlation with particular events (especially in respect to extraordinary events), as well as to determine average mobility flows during ordinary days and diviation trends during extraordinary periods, in order to formulate a set of adequate policy recommendations.

3.4 Criteria for periods selection to conduct the analysis

In the present research, the urban transformation actions are understood as temporary/ extraordinary events that produce variations in the people flows among different city locations, according to the reasoning behind the usage of particular spots, intensity of usage, etc. This analysis allows for the identification of hot-spots inside the urban tissue which could be subject of tailor-made policy interventions or specific measures regarding mobility issues (such as accessibility means, public transportation timetable, etc). The impact of urban transformation actions is measured in three different moments, selected individually for each city, but following the same guidelines, in order to allow for a comparison between mobility patterns between the monitored areas inside the city. The time slots/ periods were selected according to the following criteria:

- First moment: during a large-scale[4] event, following a period of at least three consecutive days, during which large crowd flows differ (between days and between monitored spots);
- Second moment: during a smaller-scale event, but which accommodates temporary installations/ structures in the monitored area, following a period of at least five consecutive days, during which large crowd flows differ (between days and between monitored spots);
- Third moment: during an ordinary week, including the entire weekdays and weekends, from Monday to Sunday, when no particular event is organised within the monitored area.

3.5 Evidence-based results of crowd flow impact during urban transformation actions

In the context of this paper, possible impacts of urban transformation actions in city's heritage areas were grouped in different sub-domains, falling under the three main pillars of ROCK vision: accessibility, sustainability and collaboration (ROCK Deliverable 2.2). Each of these three areas corresponds to specific scenarios and measures considered in the regeneration processes, all impacting the way urban transformation actions bring visible changes in the urban environment. In ROCK acceptance, accessibility is understood both in terms of physical aspects (mobility issues, as well as the access of people with different disabilities) and non-physical/ immaterial accessibility (on the basis of economic accessibility, social equity and digitalisation level). Sustainability (climate/ environmental) and resilience is expressed through the capacity of urban systems and cultural heritage to be sustainable in terms of mitigation and adaptation to climate change (i.e. actions for mitigating and adapting to climate change, greening actions, etc). Lastly, collaboration (for new productions) is used to boost the process of creating new ways of collaboration among stakeholders and users with the aim to transform them into prosumers/ active producers of new values (i.e. new typologies of unconventional collaborations for adaptive reuse, temporary uses, etc). One limitation of the present study refers to the lack of data availability on certain aspects concerning these pillars in the two analysed cities. Hence, starting from ROCK pillars, for measuring the impact of urban transformation actions in city's heritage areas generated by crowd flows, the study has defined a limited number of impact areas, as shown in the table below.

The process of data collection and interpretation aims at identifying people flows related to chosen periods of time in order to correlate the effect they produce over these identified impact areas. This corelation allows us to make evidence-based reccomendations for improving the policy framework in different domains, all affected more or less by spatial-temporal behaviour connected to specific extraordinary events/ happenings. In this respect, the differentiation of the selected times for analysing data reflects important changes in the mobility patterns produced by fleeting large crowd flows between city's heritage areas and hotspots.

[4] Large-scale event has been interpreted as an event whose people flow exceeds 90k visitors per day, while the smaller-scale event has been interpreted as an event whose people flow exceeds 25 visitors per day. The number of days for each type of event varies.

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ROCK Pillar	Sub-domains/ Themes	Impact area	Policy domains
Accessibility	Physical accessibility	Public transportation means/ timetable Routes management and signage Physical access for people with different disabilities (sight, hearing, movement)	Mobility (including services for disabled people) Urban design/ signage
	Non-physical accessibility	Awareness/ communication of action Price for use/ consumption of the event	Communication and advertising
	Safety	Police and security Health/ First aid Perception/ Lighting system	Security Health Urban Lighting
Sustainability	Environmental aspects	Traffic and air pollution Waste management Energy efficiency	Environmental protection
	Physical environment	Noise and vibrations Physical degradation of built heritage	Heritage protection
	Socio-economic environment	Short-term housing price speculation Social conflicts over the use of space	Site management
Collaboration	Services and facilities (commercial, cultural, leisure and entertainment)	Adaptive reuse of buildings Temporary use of urban space	Space provision and use
	Events/ festivals organisation	Partnerships for event organisation Incentives for event organisation	Public-private partnership

Table 1: Impact areas and related policy domains grouped under the three key ROCK pillars

4 TECHNOLOGY ENABLERS FOR DATA-DRIVEN URBAN TRANSFORMATION ACTIONS

Cultural heritage-led regeneration represents a sectoral part of the city's urban regeneration strategy, which is typically a spatial component of a wider policy program addressing social deprivation in inner-city areas (McCarthy, 2007), but also a means to improve physical fabric of urban areas to stimulate economic growth (De Magalhães, 2015). No matter what the tackled policy goal is, urban regeneration remains, even nowadays, an important tool for dealing with the urban transformation process. In this context, ROCK project assumes a regeneration process oriented to go beyond the physical transformation by assuming the city as a common heritage, with the end goal to ensure social equity and community cohesion.

One of the most frecquent policy challenges cities are facing in relation to cultural heritage regeneration lies in finding the right balance between conservation and modernisation/ valorisation measures. The regeneration measures are considered at two main levels in respect to the urban transformation intervention actions: 1) permanent physical transformations (projects concerning physical operations such as rehabilitation/ conservation of heritage buildings, public spaces, etc) and 2) organisation of temporary events for cultural purposes. In either case, the outcomes lead frequently to the intensification of mass tourism, over crowdedness, leading, eventually, to spatial overuse and environmental degradation. The rationale behind the pressing need for acquiring evidence-based policies in the heritage regeneration processes comes, alongside urban management questions, also for bridging the existing gaps in the policy framework in relation to the identified challenges (i.e. management plan based on spatial-temporal analysis; diversification of culture-connected services and facilities offer in the area; spatial redistribution of uses and flows, etc). Therefore, ROCK envisions regeneration measures as being part of a process managed through a complex regulatory framework with complementary governance and policy instruments, in order to avoid touristification and

gentrification phenomena, without constraining the enjoyment and accessibility of heritage areas and sites (ROCK Deliverable 6.4).

In this context, technology plays a fundamental role in providing evidence-based analysis related to the aforementioned pillars of cultural heritage-led regeneration processes. However, technology integration into the heritage environment and the urban regeneration process of heritage areas is not an easy task. Throughout ROCK project, the involved cities adopt a data-driven approach for progressive transformation of CH in creative and knowledge cities, collecting data generated by iterative transformation actions, analysing and interpreting it, and assimilating the feedback into the regeneration process through corrective or adjusted actions or specific measures. Within this paper, we are examining a particular typology of data (concerning Cultural Heritage and Safety issues), resulted from the deployment of the LBASense system in the two selected cities (Cluj-Napoca and Turin), which provides real-time insights on activity and mobility patterns within the monitored areas.

4.1 Technology integration into heritage areas

Technology integration into heritage areas is one of the biggest provocation of the project so far, since the authorisation processes for the deployment of particular sensors is more complicated and requires a longer approval period. However, the LBA sensors come in different forms (short-range and long-range sensors), in order to make their usage possible both indoor and outdoor, but none of them generates any interferences with the heritage, being non-invasive for heritage building's structure and image. For this reason, ROCK project paid special attention to acquire an optimal integration between new technologies and the historical centre, with no disruption or disturb for people, historic buildings and areas, the LBAsensors being carefully placed in areas which do not affect in any way the historical buildings or other components of heritage areas. As such, the deployment of the Large-Crowd Monitoring Tool did not raise unexpected issues for the cities experimenting with this specific technology.

4.2 Technicalities and functionalities of the LBAsense: expected outcomes

The Large-Crowd Monitoring Tool used for generating the necessary data to carry out the impact measurement of urban transformation actions in city's heritage areas is represented by the LBASense system, which performs location-based analytics through a comprehensive reading of the crowd's nature, enabling end-users to access demographics figures and mobility patterns on a wider scale, in ordinary and extraordinary conditions (i.e. festivals and events). The LBAsense system comprises a network of mobile devices scanning sensors, which converts human traffic data into powerful and versatile analytical and profiling services through innovative algorithms. The sensors determine footfall in real-time and change rate in the crowd size, besides dwell time, revisit and flow patterns and distribution, as well as any abnormality, in the overall area under monitoring, with an additional focus on selected key-locations[5] (DFRC reports).

The networked system of the LBASense is composed of two complementary sensors types: 1) long-range sensors, providing full coverage of the monitoring area on a citywide scale, but generating low accuracy mobility patterns and 2) sensors located at specific points of interest within the coverage of the wider system, providing high accuracy location specific data for those locations. The mixture between the sensors supports high accuracy measurements of footfall and mobility patterns within the entire monitored area. Specifically, the LBASense mobile phone sensors are capable to monitor, using both cellular and Wi-Fi signals, crowd dimension for monitored spots and people flows between the monitored spots (the area where the sensor is placed, with a radius of approximately 100 m radius around the sensor location). The compiled data is delivered through the LBA Dashboard, which allows end-users to retrieve various analytics on request under the form of raw numbers and aggregated graphics. The LBASystem installation comes with a set of requirements from the city side for the selected areas to be monitored, including the definition of concrete installation points, supply of power/ connection to the grid, access to the Internet/ local server, min/ max temperature threshold.

5

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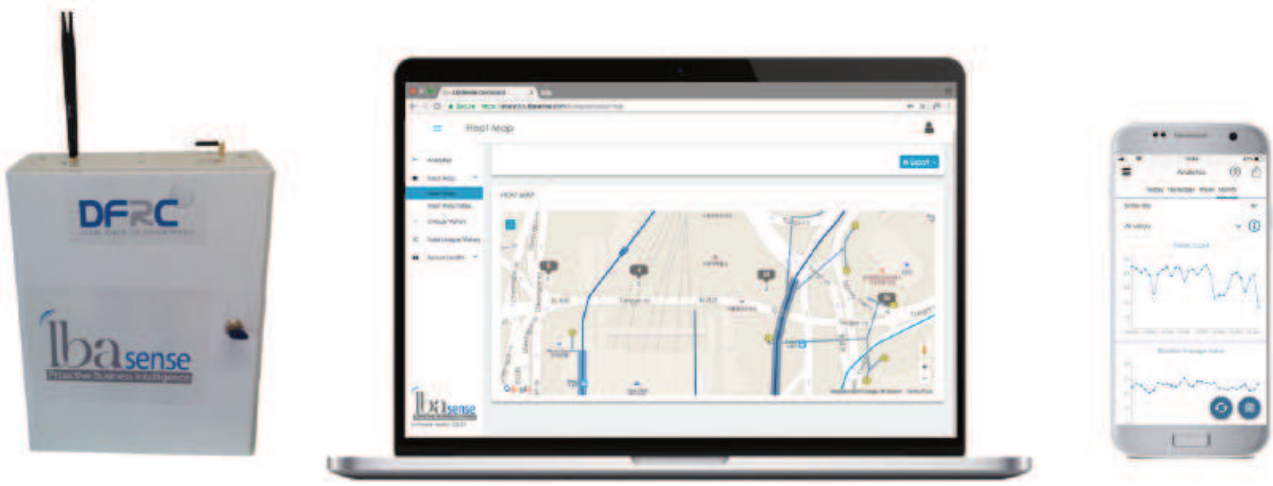

Fig. 2 Crowd Analytics Monitoring Tools: Outdoor Box, LBASense Web Dashboard and Mobile App6

4.3 Data description and processing

The LBASense system generates Big Data, which is analysed through the Analytics Builder Service and translated into visitor movement track through the Track Builder. Specifically, the data employed in the present analysis falls under visitor track data, which is periodically read from database, processed into visits analytics (including site, flow, mobility, link, behavioural analytics) and stored back into the same database. The data collected comprises the following information: a) visitors count per hour/ day, b) duration of the visit, c) mobility of visitors among city areas (measured through in/ out flows for specific target spots where the sensors are placed), d) new visitors versus returning visitors.

4.4 Criteria for periods selection for the analysis

In the present research, the urban transformation actions are understood as temporary/ extraordinary events that produce variations in the people flows among different city locations, according to the reasoning behind the functional usage of particular spots, intensity of usage, etc. This analysis allows for the identification of hot-spots inside the urban tissue which could be subject of tailor-made policy interventions or specific measures regarding mobility issues (such as accessibility means, public transportation timetable, etc).

The impact of urban transformation actions is measured in three different moments, selected individually for each city, but following the same guidelines, in order to allow for a comparison between mobility patterns between the monitored areas inside the city. Therefore, the time slots/ periods were selected according to the following criteria:

- during a mega-event[6] (Valentino P., 2011), following a period of at least three consecutive days, during which large crowd flows differ (between days and between preferred spots) – two different events selected for each city;
- during an ordinary week, including the entire weekdays and weekends, when no particular event is organised within the monitored area – senven consecutive days from Monday to Sunday for each city.

The selected events for each city varies on many levels, starting from the length (measured in number of days), frequency (annually), location (measured in number of venues, sites activated), attendance level (measured in number of visitors). Nevertheless, temporary impacts caused by these events are often associated with negative externalities, among which we mention the displacement of people and short-term gentrification phenomenon, the commercialisation of public space or environmental deterioration.

[6] Mega-event is defined as "a large-scale special event that is high in status or prestige and attracts a large crowd and wide media attention" (Jago L.K, Shaw R. N. (1998), p. 30). Hence, a mega-event in the present articles has been interpreted as a large-scale event whose people flow exceeds 25k visitors per day. Unlike the commonly accepted understanding of mega-event, large-scale events referred in this paper do not produce long-lasting transformative impacts on the urban fabric.

5 CROWD FLOW ANALYSIS IN THE TWO CITIES: CLUJ-NAPOCA AND TURIN

In order to perform the analysis on the flows generated by people movement between hot spots of the city in different moments/ periods of time, a short background on the city profile is required for understanding the particularities that lay behind distinct spatial patterns and, particularly, the reasoning behind the sensors' setting within the urban tissue. A short descriptive contextualisation of the city's background and cultural profile eases the understanding of the expected

5.1 Cluj-Napoca (Romania)

5.1.1 City profile and contextualisation

Cluj-Napoca is the second largest city in terms of population, located in the heart of Transylvania. The city is labelled as one of the most important university centres in Romania and a knowledge node of EU significance (ESPON 1.1.1). Among the main strengths of Transylvania's capital, Cluj-Napoca benefits from an advantageous geographical position near the western borders of the country and it is recognised as an emergent economic centre, developing economies with a diversified structure and proving a high clustering potential in many domains. In terms of demographics, the city has a significant increase of young population, being one of the few cities in Romania with a positive natural growth and population growth at a steady pace (SIDU, 2017).

Over the past ten years, the internationally renowned university environment favoured a transition towards a knowledge-based economy, with a strong orientation to innovation and ICT sector. In consequence, the city witnessed a flourishing cultural dynamic and registered the highest urban vitality index after Bucharest, the capital city, considering the following indicators: cultural sector infrastructure, specialised human resources, budget spent on cultural-related activities/ services, participation in cultural activities, creative economy, NGO sector, medium income, number of students and investment per capita (World Bank, 2017).

Since creative industries and the university sector are among Cluj-Napoca's growth engines, the city currently focuses on developing its innovative character, increasing the culture of entrepreneurship and providing good training of young workforce in competitive fields such as IT and creative industries. After adopting a more cultural-oriented approach, the transition has been visible especially in the increasing number of cultural events, with over 100 annual festivals offering theatre, literature, dancing, musical experiences. Cluj has a specific cultural vitality defined by a wide range of events throughout the year. It has also been the Youth Capital of Romania in 2015 and shortlisted for Cultural Capital of Europe 2021 title (European Capital of Culture Candidate City, 2016).

One of the major festivals is called Untold, the largest electronic music festival held in Romania yearly, reaching its 5th edition in 2019, is organised in the very centre of the city (Cluj Area location), but highly impacts the surrounding areas (Central Park, Unirii Square, etc). Together with Untold Festival, Transylvania International Film Festival (TIFF) attracts a significant number of visitors at both national and international level, contributing to the enhancement of the tourism sector as a key pillar in the economic, spatial and cultural development of the city. In the past 5 years, Cluj has been appointed European Youth Capital in 2015 and shortlisted for Cultural Capital of Europe 2021 title, which also strengthens the city's cultural and vibrant profile. All of the fast changes occured in Cluj dynamics in terms of demography, economic development and specialisation are inevitably speeding the urban transformation processes as they are generating changes both in terms of new spatial configurations (secondary centres for diffusing the cultural interest within the city, new interest spots, etc), flows and mobility patterns within the city.

Considering the city's background, the option for using the crowd analytics instrument for monitoring large-crowd events was without any doubt, the best choice for measuring the impact produced by temporary installations and events in the heritage areas in the city, specifically the historic city centre. The crowd analytics instrument has been placed in strategic areas and spots in the Unirii Square surrounding areas (Unirii Square (1), Central Park (1), Cultural institutions: Casino Building Rooftop (1), Magyar Opera House (1), Polyvalent Hall (2), Cluj Arena (1)) for a period of 2 years (August 2018 - June 2020). By using this instrument, the city of Cluj-Napoca aims at examining people's flow among various locations, based on information collected about the visitors' habits, period of usage of the space, visitors' returning rate during large cultural events, such as Transylvania International Book Festival, Transilvania International Film Festival, Cluj Days, Cluj Never Sleeps, etc.

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5.1.2 Data interpretation and results

In the following lines we will briefly describe the main results of the data analysed for each particular event and will link the conclusions to the impact areas listed above.

For Cluj-Napoca, the graphic representing the number of visitors by daily footfall shows an increase of almost 200% of total visitors during the large-scale event (UNTOLD), with a total number of new visitors almost 2.5 times bigger than the number of new visitors at TIFF, and 5 times bigger than the number of new visitors in an ordinary day of the year. In what concerns the most crowded periods, the peak hour during the UNTOLD festival was 10pm, gathering a maximum number of around 25k visitors, followed by the interval from 12 to 6 am with around 20k visitors. These big figures have a big impact on the physical accessibility of the surroundings of the festival's area, as crowd flows put a lot of pressure on both pedestrian routes and roads, thus bringing the necessity for a good traffic management and a well-organized public transport system, especially during the peak moments of the event. The big amount of people also impacts the natural environment, which is of particular importance in Cluj's case as UNTOLD area includes the biggest park in the city, and, on the other hand, the main venues are very close to Someș River. Another domain which is affected is the area's safety during a large-scale event, which need to be assured through a set of clear measures. On the other hand, in what concerns users preferences for different locations, we have noticed two different types of locations: the ones that keep a moderate number of persons in the same place for a long period of time (from 20 minutes to one hour) and the ones that attract mainly transitory flows (1-5 minutes). The socio-economic environment is also a challenge especially during large-scale events, as it leads to housing speculation and social conflicts regarding the use of space between residents and visitors, considering the fact that public spaces such as Simon Bărnuțiu park, the single big park in Cluj, cannot be accessed by residents during the event.

During both analysed events in Cluj-Napoca (UNTOLD and TIFF), we have noticed that transitory flows are linked to locations such as Simon Bărnuțiu Park, Cluj Arena and Polyvalent Hall, while Unirii Square, Magyar Opera House and the Casino are keeping the visitors at the location for a longer period. Thus, the statistics showcase several differences between different paces that each location imposes on the users and also reflects how the activities carried out in each location shape their behavior. In what concerns the mobility patterns, we have noticed that users preferences differed from an event to another, thus each event had 2 routes which were more populated - for UNTOLD, the path between Polyvalent Hall and Cluj Arena, and also from the park to the Casino, while during TIFF people moved from Unirii Square to Cluj Arena and Polyvalent Hall, but also from the Hall to the Arena. People movement impacts the non-physical accessibility of the area, bringing the need for particular on-site soft interventions for a better orientation, and also for raising the attractivity of less popular locations. Furthermore, they bring the need for certain services and activities provided by the area, all of these impacting also the natural and the built environment, which need to be protected from noise, pollution and harmful vibrations.

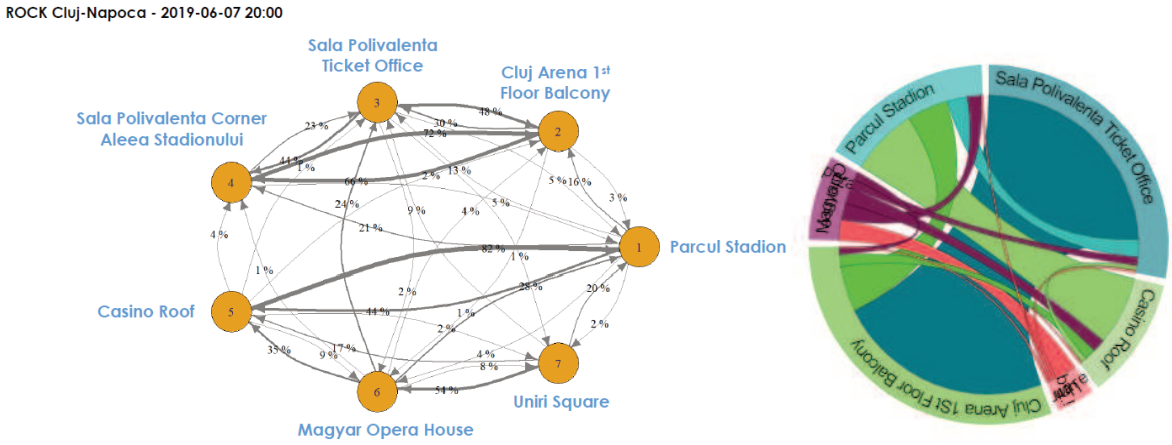

Fig. 3 – Mobility patterns map. Preffered locations/flows distribution in Cluj-Napoca during TIFF festival

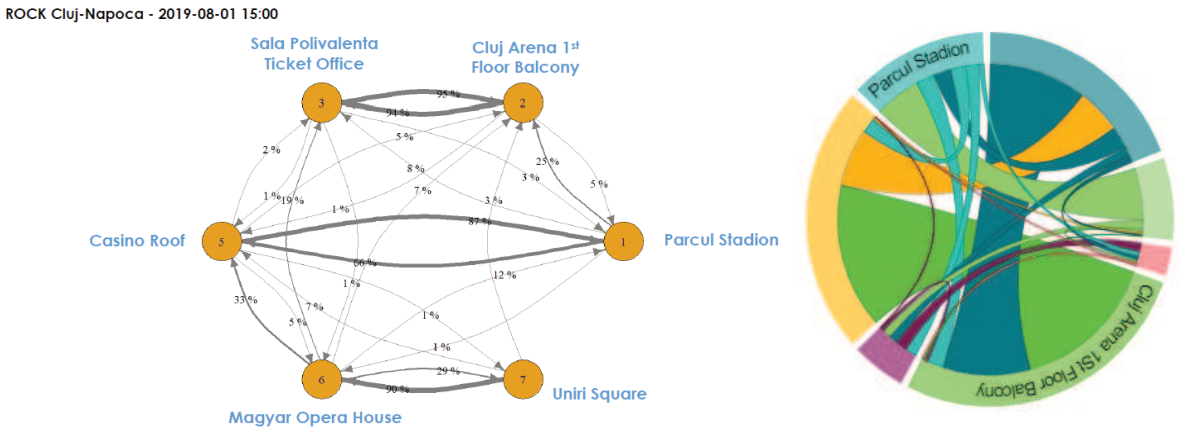

Fig. 4 – Mobility patterns map. Preffered locations/flows distribution in Cluj-Napoca during UNTOLD

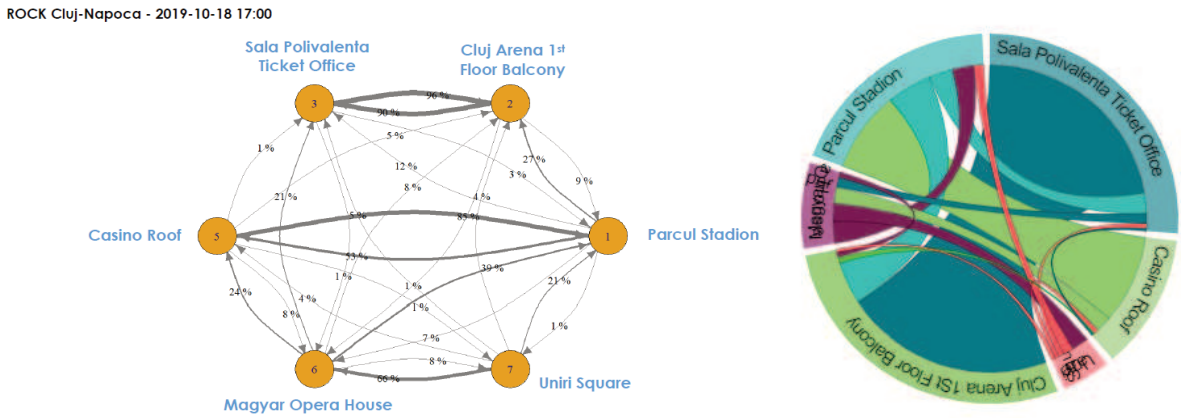

Fig. 5 – Mobility patterns map. Preffered locations/flows distribution in Cluj-Napoca during ordinary week

5.2 Turin (Italy)

5.2.1 City profile and contextualisation

Turin is an important economic pole located in the northern part of Italy, in the Piedmont Region. Ranked as the third richest Italian city, after Rome and Milan and it used to be one of the main industrial centers of Italy, being part of the so-called “industrial triangle” together with Milan and Genoa (Carter, 2016). The industrial past has brought the city a significant challenge in repositioning in the national and global economy, but also a valuable legacy of former industrial buildings that have been partly reconverted with new functions, partly being still vacant. Therefore, the cultural heritage of the city is characterised by different historical layers, developed from the Roman times to the post-industrial years. However, the consequences of the de-industrialization process were heavy both economically and socially, questioning the identity of a whole city. As a major university centre, with 7 prestigious universities (among which Polytechnic of Turin and University of Turin being particularly focused on developing technical and creative competencies), Turin embraced this strength and overcame the post-industrial crisis by leveraging on the social capital.

Pressured to reinvent itself, the city of Turin made tremendous efforts to orient its industrial reputation towards business and creative sectors, by leveraging on its rich culture and history, as well as on the well-prepared workforce, whose primary asset lies in the extensive knowledge of design and production processes due to their industrial background. Currently, according to UNESCO, around 9.1% of the active bodies and companies are represented by creative and cultural industries, counting around 100.000 employees (UNESCO Creative Cities Network, 2014).

In this context, the city administration channeled its efforts not only onto the reconversion of post-industrial areas into new service areas, but also on urban and cultural regeneration, with a particular focus on cultural heritage areas within the city. Beside physical infrastructure projects, the city also embraced and encouraged the implementation of several major cultural events such as Contemporary Art Week, Turin International Book Forum and others, which bring annually hundreds of thousands of visitors to the city.

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Considering Turin's background, the use of LBAsense system under the ROCK project framework tackled two main issues. On the one side, the city needs to better understand the connection between the permanent heritage (museums, UNESCO locations, historic city centre) and temporary events attracting large amount of visitors, which, in many cases, are organised in areas outside the city's centre, areas under development or in transition, therefore the potential in terms of attractiveness of neighborhoods in the process of regeneration needs to be better investigated and understood. The second need is related to the negative side effects of the fruition of CH and cultural events such as the management of large crowds in terms of security, noise, mobility and waste. As such, the strategy for choosing the areas under sensors' monitoring follows a two-fold approach: permanent locations for tracking large crowd flows (Museo Arte Orientale, Galleria Arte Moderna, Borgo Medievale, Palazzo Madama, Museo del Risorgimento Italiano, Palazzo Reale, Giardini Reali, Courtyard Palazzo Carignano and Appartamenti dei Principi) and temporary locations, which follow the most popular locations during the large-scale events (Salone del Libro Pad 2, Salone del Libro Pad 3, Salone del Libro Pad OVal, Da Lisa Via Baretti 2, Palazzo Carignano - Cortile (x2), Office Test 1, Office Test 2). One of Turin's intents is to enable wider knowledge about existing cultural heritage in the city, beyond the conventional and institutionalised heritage assets, its condition and usability perspectives, to which the crowd flow analysis during certain temporary events can input with relevant quantitative data sets.

5.2.2 Data interpretation and results

In Turin, the conclusions resulted from analysing the figures during extraordinary events are the following: there are 3 times more visitors in the peak day of Turin International Book Fair (90k people on 11.05.2019) in comparison with the Contemporary Art Week (37k people on 2.11.2019). Compared with an ordinary week, TIBF figures are 11 times higher, while CAW figures are 4 times higher than during an ordinary day. (90k, respectively 37k versus 8k). Considering the very big differences occurring between extraordinary events and ordinary days regarding crowd flows, the highest impact in the city is probably related to the physical accessibility of the area and its safety. Even if it does not imply a natural area (as in Cluj-Napoca's case), the environmental impact is another matter of concern during particular events, as issues such as waste management and traffic must be very well organized.

The mobility issues are another tensioned point during extraordinary events, but in this case the figures resulted from hourly footfall and also the schemes on mobility patterns can lead to a good management. For Turin, both events are showcasing the same popular periods, as there are two main peak time intervals preferred by visitors: from 10am to 4 pm (9-10 May 2019, around 5k visitors) and from 12pm to 4 pm in the following days. An interesting fact about people patterns during CAW is the curve showing visitors flows, which is very similar from one day to another. It shows every day the same two peak moments (12pm and 16pm), with Palazzo Reale and Giardini Reali being the most preferred locations. On the other hand, both events are bringing a big number of new visitors in all festivals days, with TIBF bringing the highest percentage (70%) during the second day of the event, on a Friday (10.05.2019), while also showing a gradually decrease until the last day of the event (10% new visitors). On the other hand, the Contemporary Art Week, even if it brings a smaller total number of visitors in comparison with TIBF, brings a higher percentage of new visitors during the whole period of the festival. These figures describe a huge need for a good public transportation system, and also require special attention given to assuring physical access and safety measures for vulnerable social categories (disabled, elderly and children). In what concerns the mobility patterns, there are big differences between user preferences during each event, showing major flows between book salons organized in the central area during TIBF, while during CAW the most popular paths are Museo Dei Risorgimento – Palazzo Carignano – Cortille and Palazzo Reale – Giardini Reali. This results can impact the urban transformation processes related to the temporary use of urban space (temporary installations), public awareness and indications related to a certain action/event and also measures related to noise and vibrations.

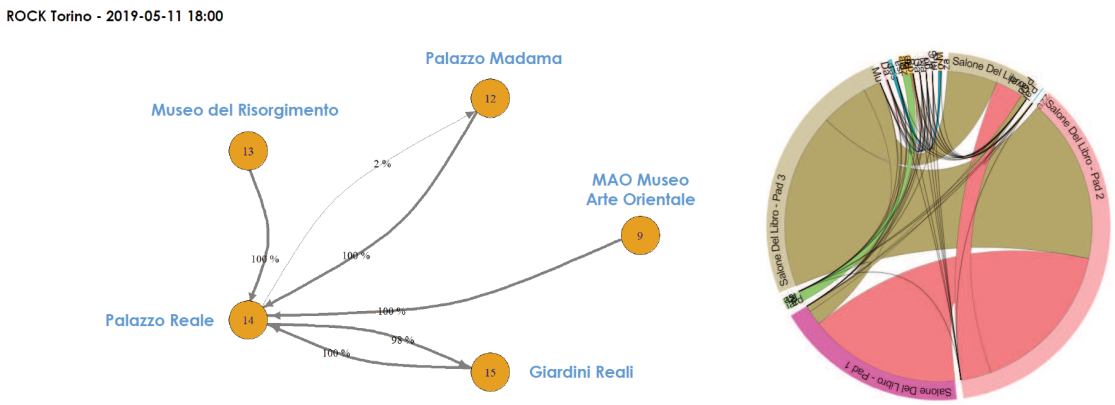

Fig. 6 – Mobility patterns map. Preffered locations/flows distribution in Turin during International Book fest

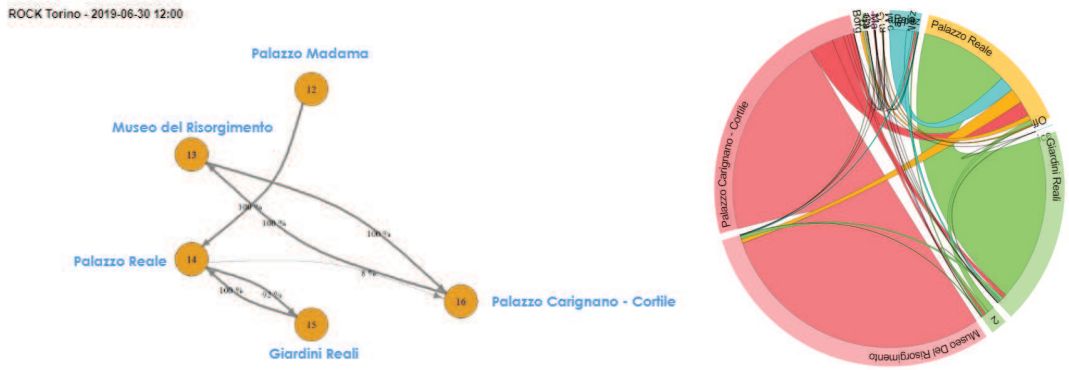

Fig. 7 – Mobility patterns map. Preffered locations/flows distribution in Turin during ordinary week

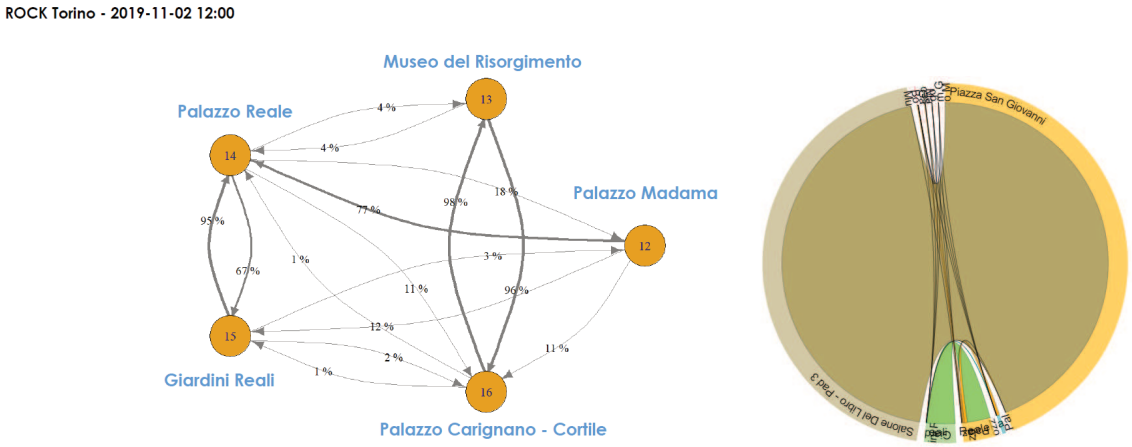

Fig. 8 – Mobility patterns map. Preffered locations/flows distribution in Turin during Contemporary Art Weekend

6 EVIDENCE-BASED POLICY RECOMMENDATIONS

To conclude, the sensors deployment strategies in Cluj-Napoca and Turin are quite similar, being mainly oriented towards collecting data on people's flow among various locations among the city and identifying movement patterns related to cultural assets and events for a period of approximately 2 years (from August/ October 2018 to June 2020). Nonetheless, the spatial approach (location of sensors) and partially the expected outcomes vary to some extent. The data analysis carried out in Cluj-Napoca and Turin within the three selected moments of 2019 (two large-scale event and an ordinary week of seven consecutive days), resulted in a set of relevant conclusions regarding different types of impact that crowd flows dynamics has on both studied cities.

As an overall consideration, the monitored areas of the two cities outline a similarity in terms of accentuated “festivalization” phenomenon of culture, as well as a concentration of events in the same spots of the city, which eventually leads to short cultural experience duration. Besides, this tendancy creates an unbalanced distribution of people flows between different spots in the city, leading to high polarisation and attractiveness

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of certain spots, the so-called hotspots. However, one limitation of the present study has to be considered here – conclusions have been drawn based on the monitored area in each city, determined by the places where the sensors have been located. Therefore, we are reffering to specific parts of the city which have fallen under the monitoring process. While the city of Turin struggles to distribute the cultural happenings and events outside the concentrated city centre, the city of Cluj-Napoca is still lagging behind in terms of the cultural offer, which is still reduced outside the city center.

Taking into consideration also other study constraints (such as the availability of qualitative data regarding the selected events – perceptions, emotional mapping, as well as the lack of preliminary policy framework analysis), a set of policy recommendations has been formulated in respect to the three main ROCK pillars (accessibility, sustainability and collaboration), considering the identified subdomains in relation to urban transformation actions on which crowd flows impact. The table below summarises the policy recommendation on the ROCK pillars:

ROCK Pillars	Policy recommendations	
	Explicit (directly resulted from raw data analysis)	Intuitive (requiring further analysis of compementary data)
ACCESSIBILITY **Subdomains:** Physical accessibility Non-physical accessibility Safety	• Limitation of number of people visiting certain areas • Develop thematic routes in order to help different types of users to orientate in crowded areas (vulnerable social categories, visitors, etc) • Increased safety services (police, first aid) during extraordinary events, especially during peak hours/periods in certain locations	• Diversification of offer in regards to economic and leisure activities, in relation with the events/ Encompassing different parts of the city to minimize the pressure on existing hotspots • Strenghten and widen urban connections/ paths in different points, especially from events area to key points such as airport, railway station
SUSTAINABILITY **Subdomains:** Environmental aspects Physical environment Socio-economic environment	• Develop specific measures and regulations regarding to car access and parking during the extraordinary events • Integration of another valuable elements (natural/built) in the festivals circuit, through temporary uses, art installations, etc	• Assure a well developed waste management infrastructure, especially in the proximity of natural areas such as parks, lakes • Find methods for softening the social conflicts regarding the use of public space during the events
COLLABORATION **Subdomains:** Services and facilities Cultural production Events/ festival organisation	• Polarization/ distribution of smaller events/ facilities in other areas to lower the impact on a certain location • Highlight and improve less popular CH locations through developing cultural, leisure and entertainment offers	• Adaptive reuse of buildings, Temporary use of urban space (easy permits for temporary installations) • Provide incentives for event organisation in order to help the local economy • Strenghten the PPPs regarding the festivals organization, accommodation during the festival and other goods and services provision during the events

Table 2 – Impact areas grouped under the main three ROCK pillars

7 CONCLUSION

A specialised institutional setup is highly required for identifying and addressing properly the policy challenges through regulatory framework and measures for creating a balance between conservation issues and modernisation/ valorisation ones (i.e. overcoming the touristification phenomenon without constraining the enjoyment of heritage areas value). Therefore, according to ROCK vision, data evidence is mandatory for ensuring appropriate impact assessment in cultural heritage valorisation projects, assumption which stands as a key cross-policy recommendation in the course of the implementation of cultural heritage valorisation project (ROCK Deliverable 6.4). In this sense, the rationale for performing a crowd-flow analysis stays at the

basis of measuring the impact of urban transformation actions in city's heritage areas, through a clear evidence on movement patterns between and within monitored areas, allowing the comparison between people flow distribution at different momentums.

The results of data analysis and interpretation were correlated with qualitative information regarding the nature of the urban transformation action (temporary character of the transformation actions studied in the present paper, in the context of large-crowd events and ordinary week days). Based on the outcomes, a set of recommendations have been proposed, with the final goal of tailoring the local policies to respond to dynamic changes in the flow distribution and usage of space in the city's heritage areas. The proposed recommendations have been structured based on the same format and logics as the established impact areas, grouped under ROCK pillars.

We would like to express our gratitude for the support and contribution received from the teams involved in ROCK project, representing the two Role Model cities Cluj-Napoca and Turin, as well as DFRC.

8 REFERENCES

Carter D. (2016), Remaking Post-Industrial Cities: Lessons from North America and Europe, Routledge Taylor & Francis Group, NY and London.

Cluj-Napoca 2021 European Capital of Culture (2016), Candidate City, Cluj-Napoca 2021 European Capital of Culture Association, no. 58, 21.

Cristea Marius, Codruța Mare, Ciprian Moldovan, Andreea China, Thomas Farole, Adina Vințan, Jane Park, Keith Patrick Garrett, Marcel Ionescu-Heroiu (2017), Magnet Cities: Migration and Commuting in Romania, Washington, DC: World Bank.

De Magalhães, C. (2015). Urban Regeneration. International Encyclopedia of the Social & Behavioral Sciences

ESPON 1.1.1 (2005), Potentials for Polycentric Development in Europe, ESPON Final report, NORDREGIO, Sweden + Annex report A – Critical dictionary of polycentricity European urban networking revised version.

McCarthy, J. (2007), Partnership, Collaborative Planning and Urban Regeneration. Ashgate, Aldershot

SIDU CLUJ-NAPOCA (2017), Strategia Integrată de Dezvoltare Urbană pentru Zona Metropolitană Cluj-Napoca, available here: https://issuu.com/urbasofia/docs/sidu_cluj_2017_030717.

UNESCO Creative Cities Network, 2014, available at: https://en.unesco.org/creative-cities/torino

Colantonio A., Dixon T (2016) - Urban Regeneration and Social Sustainability: Best Practice from European Cities

Valentino, Pietro (2011) – A Definition Mega Event

ROCK Deliverable 2.2 - ROCK Circular Urban System, 2018 (intermediary version)

ROCK Deliverable 6.4 - Regulatory Framework, ROCK Procurement and Policy Recommendation, 2019 (available at https://rockproject.eu/documents-list#384)

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