Defensible Smart Cities:

A System-of-Systems approach for vertically integrated spaces

Scientific coordinator:

Prof. Dr. Eng. Adrian V. GHEORGHE

PhD Candidate:

Eng. Ulpia-Elena BOTEZATU

September 2022

Executive summary

Smart cities of the West are as vulnerable to disruptions and failures in outer space as are nation-states. This PhD research challenges the traditional conventional discipline-based academic thinking about governance of (in)security in both urban studies and outer space politics, in an attempt to enhance it and update it in line with the “spatial turn” in social sciences. This research develops a relational, multi-, inter- and trans- disciplinary understanding of security governance that implies both outer and urban space elements, in order to better understand security as socio-spatial processes through practices of critical infrastructure protection. In particular, the research attempts to convey recommendations at city level with regards to how events in outer space could affect them. By means of reconstructing few very disruptive events in outer space, namely the collision between Iridium 33 and Cosmos 2251, the ASAT tests of Cosmos 1408 and FY-1C, as well as the reentry into the atmosphere of Long March-5B rocket body, the research sheds light upon the complex interconnections between cities and outer space infrastructures and services.

Governance of security, defined as a process of interactions through the laws, norms, power and language of an organized society, is a socio-spatial process that binds systems-of-systems of material and non-material bits and pieces, institutions and practices, with various logics, intentions, perceptions, languages, and with different histories, that the current research attempts to disentangle and highpoint. By using the security practices associated to the concept of critical infrastructure protection that connects both urban sphere and the outer space, the research un-blackboxes the complexities of contemporary governance of security in order to identify solutions for improvement. Thus, the research contributes to the ongoing debates on the spatialization of security practices by complementing the academic scholarship in the field of urban governance. Urban security, as a new spatial logic based both on flow and connectivity on the one side, and disconnection and interruption as the other side of the same coin, represents a process where urbanized forms of outer politics and more spatialized forms of urban governance are mutually constitutive. In other words, built-in resilience relies heavily on these mutual relationships between cities and outer space.

Chapter 1

The research starts with setting the context and adding an emphasis on definitions, context, theories, and applied concepts with relation to the governance of security and critical infrastructure protection. Imaginations of developed cities as a giant system-of-systems composed of networks of humans, technicalities, institutions, of interconnections and intersections of system infrastructures, and interests, raises critical questions on what is happening if all these ‘smart’ systems fail?

Outer space starts right in our cities. Physically, every place or individual on Earth is just 100 kilometers away from it. Operationally, space technology significantly enhances the facets of our life, with about 2,000 operational satellites provide a wide range of services that augment our environment in a variety of ways, from the GPS systems in our automobiles to the daily weather prediction. In the event of an unintentional or natural interruption, these critical services, or rather the lack thereof, also serve as a representation of our collective fragility.

At the same time, the global urban population is now increasing by 60 million people annually. Nearly 61% of the 8.1 billion people on the planet are anticipated to live in cities by the year 2030. By 2050 that number will increase to 9.7 billion and by 2100, it will reach an astounding 11.2 billion. Cities are becoming more populous and as a result, the utilities' networks that now sustain contemporary living get increasingly wide and complex. Researchers and decision-makers are being forced to innovate at a much quicker rate as a result of the relationship between urbanization, improving living standards, and technological advancement. Urban areas are becoming "smartified," a process that uses digital technologies to make existing networks and services more effective for both residents and businesses, in order to address the challenges of contemporary urbanization.

The other side of increased connectivity is increased vulnerability. Subsequently, the danger of all sorts of attacks, including cyber, is unavoidable in the technologically advanced urban environment we presently inhabit. Similar to other components of the digital essential infrastructure, also satellites and other space assets are susceptible to cyber-attacks. Because of this, key infrastructure on Earth could be seriously at danger, and as a consequence of insecurity issues in the space environment, cities could be impeded in their economic growth in addition to mounting societal concerns. Attacks on satellites might target their missions, command and control systems, or terrestrial infrastructure like satellite control centers. Networks used for communication may be jammed, spoofed, or hijacked by these assaults. State-to-state military operations, well-funded organized criminal elements seeking financial gain, terrorist groups looking to further their causes, even up to the fatal stage of cascading satellite collisions, as well as lone hackers looking to showcase their abilities are some examples of potential cyber threats against space-based systems.

But in addition to the electronic means of warfare, also physical attacks to vital space infrastructures. One example is testing anti-satellite weaponry, i.e., when a nation launches a ballistic missile into space with the intention of hitting one of their assets in order to gauge the asset's redundancy and robustness. The target gets fragmented into many parts of various sizes which then could potentially hit other critical space infrastructure, inducing failures in the functioning of urban services that could potentially cascade into even more disruptions in the complex urban system-of-systems.

Thus, this research claims that the governance of security in urban areas should be enriched with a layer that addresses critical infrastructures and services in outer space and their impact at the city level, in order to create a smart and resilient city. Furthermore, urban security and space security are mutually constitutive in smart cities of the West, due to high level of integration and interconnectedness. Therefore, "defensible" areas in Western cities should incorporate aspects of space security.

In terms of their interconnections and interactions, there is a study gap when security in cities and in outer space are discussed together. Although, as separate topics, these areas of study have a large literature of reference, the merging of the two, starting with the perceptive level, terminology and syntax in the definitions, levels of analysis, and ending with the ways in which the relationship between these systems-of-systems is understood, is understudied.

Urban security has been historically associated with criminology, delinquency, and other types of deviance that attack urban areas. On the other side, arguments on space (in)security are presently based on differentiating between "militarization" and "weaponization" of outer space. As a result, this research found its fertile land in this gap between urban and space security. There is not enough literature connecting a highly domestic form of security and defense (city level security) and an antipodal national and global approach to military operations in outer space. In the end this research argues that an urbanized form of outer politics and a more specialized form of urban governance is needed for building a better, a more sustainable and a more resilient urban future for humanity.

This PhD research attempts to upgrade the current understanding of urban governance by bringing disruptions and breakdowns in the essential infrastructures of outer space to the center of urban security policy. This is needed because of the long-standing traditions of academic 'silo' thinking and thus the need to improve security governance in line with contemporaneous transformations.

Space is one of the vertical aspects of security governance, along with underwater infrastructure and other hidden assets. For the ongoing protection of crucial assets and their connections, it is essential to include the vertical dimension when talking about security. Space security is directly related to local communities' well-being, much as cyber security is. The consumers are often immediately impacted when even one component of this spectrum of space service fails. We may use the loss of essential surveillance capabilities that occurs while a natural catastrophe unfolds as an example. This component of security is crucial in modern security strategies due to the speed and scope of system operational deterioration.

Now is the moment to broaden our perspectives in both multidisciplinary and trans-disciplinary approaches. Though traditionally thought of as the domain of astrophysicists, the present day's risks and the interconnectedness of contemporary civilization, which combines ground-based vital infrastructures with those in space to provide essential services, make space a domain for security specialists. Since many domains are interconnected and interdependent, it is crucial to get used to a more holistic way of thinking that is not limited to certain academic disciplines or living spheres.

Today, complexity permeates every aspect of our lives. Understanding strategy and tactics at all levels—from the global consensus to the local sector, from governmental to commercial enterprises everywhere—seems to need an increasingly "complex" perspective of reality. Yet, the purpose of this debate is to bring up the notion of complexity in conversations about critical infrastructures in smart cities and in outer space, rather than to theorize about complexity management approaches.

Chapter 2

Chapter 2 summarizes the literature review on the governance of security in both cities and outer space.

Due to its multidisciplinary, transdisciplinary, and interdisciplinary nature, this research examines a number of literary strands. However, because the administration of security in smart cities is the primary area of research, the literature review is divided into three categories and provided in this chapter: The historical development and the meaning of urban security will be discussed first, after which the tradition of 'defensible space' in urban studies and the governance of security will be addressed. Secondly, the evolution of space security has been discussed, paying special emphasis to how space security is governed by highlighting the concept of Space Situational Awareness. Finally, the research employs the idea of critical infrastructure to connect the two separate scales of analysis because, from a governance perspective, cities and outer space are at different planes of political decision-making.

A single discipline cannot possibly encompass the idea of a "smart city" since it is just too broad. All academic fields, including engineering, urban studies, sociology, economics, law, and computer science, have a role in the success or failure of the "smartification" of cities, from economic, research and development, and cultural interactions to livability, environment, and accessibility. In actuality, idealistic rankings are what fuel smart cities, and at the moment, one can see a whole industry of organizations comparing and contrasting cities, which inspires action, ambition, and progress.

Historically, urban security has been connected to the concept of defensible space. Coined by Oscar Newman as "a residential environment whose physical characteristics—building layout and site plan—function to allow inhabitants themselves to become key agents in ensuring their security", the three design components that make up the defensible space each work alone and together to help make cities safer:

- Territoriality: the ability of the built environment to supposedly define zones of territorial influence;
- Natural Surveillance: The ability of the built environment to offer opportunities for natural surveillance for residents and their agents;
- Image and Milieu: The ability of design to affect how a project is viewed in terms of its singularity, seclusion, and stigma.

In its initial understanding, Defensible Space has been used to redesign those neighborhoods that were considered to be problematic for the authorities. Subsequently, it generalized in the major cities of the West, from New York to London and Paris in the 1980s, and eventually gave rise to different theoretical approaches, such as Crime Prevention through Environmental Design, Situational Crime Prevention, and Secured by Design, in criminology. Especially in Great Britain, the defensible space theory became influential during Margaret Thatcher's era of extensive housing policy and later on it constituted the basis for Alice Coleman's controversial book Utopia on Trial: Vision and Reality in Planned Housing (1985). Defensible space elements have been inserted into broader urban renewal policies that were initiated in 2004. The paradigm of “situational prevention” became embedded into the planning choices made in sensitive urban areas. The French “situational prevention” emerged from the work of Ronald V. Clarke (1995) on crime prevention through environmental design.

The work of Oscar Newman at the time helped to close the gap between pre-1970s criminological theories and preventive measures and today's more practical and policy-driven approaches. Nevertheless, as Jacobs and Lees argue, defensible space is more than a concept, it is also “a knowledge-production method replicated across space and time through localized instances”. The theory is performative as it operates to produce the reality it propagates, i.e., if bad urban design promotes crime, good urban design contributes to reducing it.

Nevertheless, given the complexification of urban areas, both in terms of infrastructural networks and propagation of threats and cascading disruption, how could cities of the West upgrade their fundamental theories of secure city-building? As authorities in charge of public safety and security must adapt to more sophisticated and high-tech crime, data from outer space will play an increasingly vital role in ensuring the safety and security of smart cities. Where can the defensible space theory be enriched with outer space elements? How can the threats that circulate through the invisible networks that connect contemporary critical services and infrastructures be defined, rendered visible and contained?

Cities, as the densest settlements both in terms of number of people but also from the perspective of dense infrastructural networks, have been always exposed to numerous environmental, social and economic crises that have significantly affected our societies. Thus, attempts to protecting settlements translated with time in finding more efficient solutions, more digitalized, more intelligent in this regard and, of course, subjected to different threats and risks. Protection thus became with time congruent with sustainability and more recently with resilience.

As opposed to the domestic space of cities, outer space security has always been seen as largely a military concern. However, this perspective has lately been broadened to encompass the following three aspects of space security: space for security (i.e., military and security operations in outer space), security in space (i.e., the security of space assets), and security from space (i.e., protecting infrastructures on the ground from the complex outer space environment).

As more nations use space assets to support various military operations, such as surveillance, reconnaissance, and intelligence gathering; precise positioning, navigation, and timing; strategic and tactical communications; and missile early warning and tracking, the likelihood of war in space is rising. Currently, some countries view space as a battlefield. Despite the lack of hostile antisatellite strikes against an adversary, the ability to physically destroy or interfere with space technology is being developed and proven quickly.

Despite the fact that the majority of the world's population today lives in urban areas and that most of the technologies employed in the so-called smart cities rely on space infrastructure and technology, the relationship between the urban and the outer spaces is not readily apparent. This relationship is especially pertinent and crucial when talking about concerns of (in)security.

The adverse space environment as well as the inability to technically intervene in case of space systems failure, among other factors, is to be taken into account when discussing the protection of space infrastructures. In consequence, this section looks at the specific risks of outer space in an attempt to map the impact on critical infrastructures.

The solar wind, which is made up of particles traveling from the Sun to the Earth, may have an impact on the ionosphere, the magnetic field of the planet (which may result in auroras), telecommunications, and the electrical grid (especially at high latitude). Additionally, the intense particle flow and magnetic effects have an impact on various flight schedules and routes as well as radio communications. Additionally, the sun continually emits solar wind, which is made of plasma. Winds from various parts of the sun have varying speeds and densities, which have varying impacts. High-speed winds often result in geomagnetic disruptions. Other geomagnetic turbulences may also happen when fast solar winds overtake sluggish solar winds or when the magnetic field of the solar wind reverses polarity.

From the sun's surface to the Earth's surface, space weather may occur everywhere. A space weather storm departs the sun and enters the solar wind after passing through the corona. By the time it gets to Earth, it has energized the magnetosphere and has accelerated electrons and protons to the magnetic field lines, where they, especially at high latitudes, crash with the atmosphere and ionosphere. Various technologies are impacted by different aspects of space weather. Therefore, a natural occurrence has the potential to have a significant negative impact on the economy and well-being of society on Earth.

Satellites may be in danger from the environment in space itself in addition to potential collisions with other space objects. The magnetic field, atmosphere, and surface of the Earth are ultimately affected by a variety of solar-based physical and electromagnetic phenomena referred to as "space weather." These occurrences, which may be harmful to operations in orbit and on the surface of the Earth, include solar flares, solar wind, geomagnetic storms, and coronal mass ejections.

The solar wind phenomenon is brought on by the solar system's ongoing creation of electrically charged particles from the sun. Radio, infrared, visible light, ultraviolet, and X-rays are only a few of the electromagnetic radiation wavelengths that the sun releases. Sunspots, which may result in higher solar wind emission, are one of the several impacts known as space weather events that are caused by fluctuations in the intensity of these emissions. The next stage is a geomagnetic storm, which may create aurora borealis and australis in more severe circumstances and, in less intense ones, destroy electrical equipment.

Aside space weather events, also near-Earth objects have been discussed from the perspective of their impact on Earth. Although there is an extremely minimal probability that a huge object may strike the Earth, it might nonetheless cause havoc and casualties. Even just looking at the Solar System's asteroid population, gravity has split it up into several subpopulations. Because of this, although though all planets orbit the sun, the Main Belt, which is situated between Jupiter and Mars, contains the great majority of them. Jupiter's gravity shapes and stirs up the Main Belt, causing some asteroids to completely depart the Solar System and others to be pointed in the direction of the Sun to interact gravitationally with the inner four planets. Some of them enter Earth's atmosphere once they reach orbits that bring them near to the planet.

Finally, the last part of this section looks at space debris. Over the course of 65 years of human space activity, a considerable quantity of space debris—which is defined as the non-operational satellites, spent rocket stages, and other bits created during the launch and operation of satellites—has been produced. Old satellites, spent rocket stages, pieces from disintegration, erosion, and collisions, including those brought on by debris itself, are just a few examples of abandoned man-made things that may be discovered in space. More debris is created when two pieces collide.

Natural phenomena like solar radiation, asteroids, other spacecraft, and of course space debris can have an impact on space systems at any time. International space policy is starting to pay more attention to the risk posed by space debris. This is a prudent course of action given the growing amount of space junk. The creation of a Space Situational Awareness system is one of the most crucial tools for enhancing the security and safety of space systems in these conditions. One of such a system's primary duties would be to keep an eye on and track crucial space infrastructure as well as on trackable space debris.

Critical space infrastructures are more vulnerable to criminal exploitation because of their inherent complexity. Even though national governments and the general public understand the importance of protecting crucial space infrastructure, the advantages of existing actions are comparatively limited as long as there are no formal agreements. Generally speaking, political authorities in the U.S. and the EU were aware of this issue and began CI protection activities, albeit in a very restricted manner with regard to space applications and systems.

It is challenging to completely comprehend the current security risks to space systems due to a dearth of academic study in the area and the frequent secrecy or classification of information concerning events harming vital infrastructure. Nevertheless, this thesis discusses responsible actions in space in relation to smart city governance. While, according to the current international law, responsible actions in space are the prerogative of nation-states and smart cities governance requires a local level approach, this research is attempting to make this connection visible.

Undoubtedly, the information and services offered by space technology are crucial to the success of smart cities. However, the specifics of this complex relationship and the degree of this dependency are the main subjects of this study. The capacity to describe the space environment and activities is known as space situational awareness (SSA), which entails monitoring space objects using both ground- and space-based sensors, such as radars or optical telescopes. The orbits of space objects are ascertained and future courses are predicted using a combination of tracking data from various sensors. Characterizing space objects, space weather, and pre-planned on-orbit operations are other crucial SSA elements.

Currently in use space assets are at risk of a variety of dangers, such as collisions with space debris and the full amount of energy unleashed by space weather events. Over the last 25 years, a variety of models for the causal chains connecting solar wind and geomagnetic disturbances, geomagnetic induced currents, and the sensitivity of the electrical grid have been investigated. However, this part focuses only on natural hazards (mostly the occurrences grouped together under the syntagmatic word "solar weather," as well as the effect of NEOs), whereas the next chapter will concentrate on space debris, or dangers to vital infrastructure caused by humans.

Satellites, airplanes, and power grids are among the technological infrastructure systems that are impacted by space weather occurrences. The contemporary economy is particularly vulnerable to solar storms due to a web of interdependencies. Thus, improving our understanding of the root causes of space weather and our capacity to anticipate it are critical goals.

Chapter 3

The methodology of the study is explained in Chapter 3, along with the research design, and conceptual lenses. The analysis of governance of security in smart cities of the West is informed by Complex System Governance in the academic literature. Complex System Governance (CSG) is dedicated to the planning, implementation, and development of (meta)system functions that result in the management, coordination, and integration of complex systems, with the aim increasing the chances of properly addressing the society's complex systems and challenges.

Moreover, as embodied in spatial practices, security practices necessitate a methodological approach that considers reality as being always partial and under construction, socially constructed both by the researcher and the researched. Additionally, as the research investigates questions of agency, power and representation in modern political life, it would fit the label of ‘poststructuralism’, i.e. an interpretive analytic of ‘postmodernism’, with a critical attitude towards thinking the present historically.

Poststructuralism is primarily concerned with how meanings are created, attached, and circulated, in respect to structures, institutions, actions, ideas, people, places, things, spaces, et cetera. Therefore, the material properties of these structures/people/places are not as important as the way in which we interpret and understand them.

This PhD project employs the genealogy technique as a special inquiry of those components that “we tend to feel without history”. The components of daily living are present in this setup. A linear quest for roots or the formation of a linear progression are not characteristics of genealogy. Instead, it aims to depict the complex and perhaps conflicting history that shows signs of how power has shaped the truth.

Following the path of genealogy presented above, this doctoral research has a forensic approach to several events in outer space that have happened in the past, in order to highlight the impact on smart cities’ critical infrastructures.

Firstly, few events have been identified – it has been chosen one singular Collision event (Iridium 33 x Cosmos 2251), two Fragmentation events (all ASATs from Russia, China) and one RE-Entry event (Long March). Documentation from academic and operational open sources, news, reports, et cetera complemented the general picture on these chosen events.

Secondly, once the events have been identified and understood, the satellite orbital coordinates (TLEs) from various data based have been procured. In this way, the outer space environment has been keeping the same configuration as it was at the time of the events. Given the importance of the CA, FR and RE events, there were several platforms that simulated these already. However, none of them did not reach the year 2022 – in this sense, the scenario analysis has also been transversal research. The database for TLEs was SOCRATES. Nevertheless, as a database for orbital elements I have also used space-track.org, only for CA and FR. Moreover, for FR events I have also used the ESA's DISCOS database, i.e., a database specialized on FR event database statistics: https://fragmentation.esoc.esa.int/home/statistics.

Regular updates on upcoming orbital conjunctions are made available by SOCRATES. It is intended that this service would assist satellite operators in avoiding unwanted near encounters via early mission planning due to the potentially disastrous repercussions of such conjunctions going undetected.

Using a database of all unclassified NORAD two-line element sets (TLEs) that have been made available to the public, CelesTrak searches for satellite conjunctions during the period of the following seven days by comparing a list of all satellite payloads in orbit with a list of all objects in orbit. In order to allow satellite operators ample time to plan—or hire planning services—to shift their spacecraft away from danger (if their satellite is mobile), or to take other necessary precautions, the search has been restricted to conjunctions with payloads. All payloads are taken into account because it is currently impossible to tell whether payloads are still active.

The runs are carried out using STK's SGP4 propagator and STK/CAT (STK's Conjunction Analysis Tools). At the time of closest approach (TCA), when a conjunction is within 5 km, STK/CAT is set up to look for it and provide the minimum distance and possibility that it will happen. According to CSSI, the minimal distance approach ignores position covariance information and may lead to an overestimation of the underlying risk, whereas the maximum probability technique gives a more acceptable (albeit still cautious) evaluation of the genuine risk.

For scenario building I have used both CelesTrack and STK, as these two were available interchangeably for the analyzed events. STK requires much memory and, in order to obtain natural environments, the application often accesses various add-ons, available upon purchasing licenses. In this regard, CelesTrack was preferable, when available.

After compiling the list of possible collisions (from Space-track.org), I have searched every piece of payload in ESA satellites catalogue. Some payloads proved to be large pieces of debris, and so these have been disregarded from the analysis. However, for the active satellite at the time of the analyzed events, I have searched in few other databases dealing with smart city projects, possible applications that use the services provided by the potential affected satellite, in order to determine the possible interruptions in space services. These databases can be accessed at:

- https://earth.esa.int/eogateway
- https://gras.earth.esa.int/
- Infrastructure & Smart Cities | ESA Business Applications

Observing and simulating past events is very helpful in understanding the ways in which very rare singular occurrences withstand time. Moreover, such a transversal analysis help predict and forecast possible events in the future, not in terms of their timing and localization, but rather in terms of their impact on ground infrastructures and critical services.

Chapter 4

In Chapter 4 are presented the simulations of some events in outer space and the analysis of these simulations, i.e., the impact of these events to the critical infrastructures in smart cities.

The collision between Iridium 33 and Cosmos 2251 not only that it destroyed a communication satellite fact that led to a short-term destruction of the satellite telecommunication of the Motorola company, but, 13 years after, the impact on Landsat, Demeter and Iridium could have affected the continuity of critical infrastructure sectors in various smart cities. The analysis of the event has demonstrated that a number of critical infrastructures have been impacted indirectly by the collision between Iridium 33 and Cosmos 2251. If more collisions were to happen, transportation, IT&C and energy sectors would have been more impacted. At the other pole, the health sector, especially the emergency services, would have been less affected due to the fact that this sector has already built-in redundancies.

The accidental collision between Iridium 33 and Cosmos 2251 not only that it led to the loss of a satellite and a temporary failure of the communication network it was serving, but, over the time, almost all critical services could have been subjected to disruption. These results prove that there is a direct correlation between collisions in outer space and vital services that make the contemporary smart cities.

The fragments resulted from the Russian ASAT testing (Cosmos 1408) could have impacted a series of vital satellites. The military ISR, communications and EO satellites could have registered the most disruptions of service. At the other pole, environment monitoring could have been the least impacted. In addition to the interruptions of critical functions, the disruptive nature of the Chinese ASAT (FY-1C) test offers a rare chance to research the development of debris clouds over longer periods of time.

The analysis of the two ASAT tests revealed that a great number of critical infrastructures could have been impacted by fragmentation of objects in orbit. If those fragments were to crush the analyzed, critical services such as reconnaissance, communications and Earth Observation, the corresponding services in smart cities would have been impacted, disrupted or even interrupted.

In the end, it worth mentioning that re-entry event of the Long-March 5B Rocket Body that could potentially affect all critical infrastructures and services. This could happen while travelling through the layers of atmosphere, as well as at the impact with the ground.

The four cases studied in this doctoral research highlights the fact that almost all critical sectors could have been impacted by events in outer space associated to the concept of SST. Not only these critical infrastructures could have been affected at the city-level, but generally, these infrastructures could have been disrupted globally.

Chapter 5

The analysis is concluded in Chapter 5 with a discussion of how the highlighted issues relate to the governance of security in smart cities.

This research came to a few conclusions and recommendations as a result of the intersection of the two perspectives on the governance of security, on the one side in smart cities of the West, and, on the other side, in outer space.

Firstly, this double-layered perspective, urban and global, is fresh in the literature and it opens up the potential to develop a full scholarship around the problematics of smart cities and outer space. At city level, understanding better where possible disruptions come from could be a useful information for operational authorities. At the same time, for operational stakeholders related to activities of ensuring security from space, understanding the ways in which failure propagates systemically may help them build more resilient systems.

Secondly, the concept of 'defensible space' is being updated in the light of this research that connects cities and outer space. In order to achieve resilient cities, humanity needs to expand its understanding towards nonlinear perspectives of space, time and speed.

Thirdly, the research's results revealed the fact that an intermediate level of governance is needed. While outer space politics constitute the object of global and national policymakers, the urban level is being addressed locally.