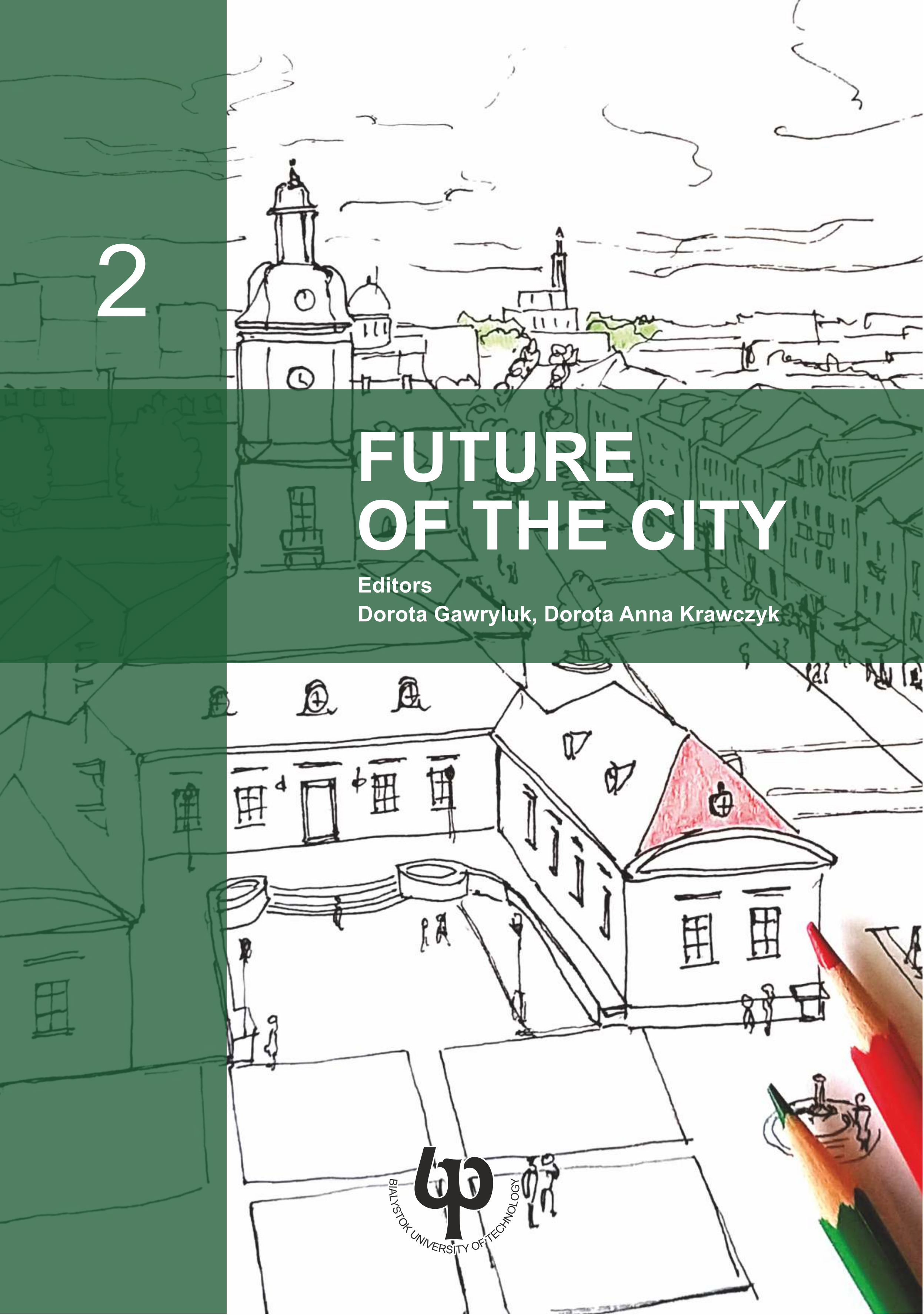


2

FUTURE OF THE CITY

Editors
Dorota Gawryluk, Dorota Anna Krawczyk

BIALYSTOK UNIVERSITY OF TECHNOLOGY

A series of books representing the intellectual results of the Glocal project, Erasmus +:
volume 1: SMALL GLOSSARY OF TECHNICAL TERMS
FOR ENGLISH-POLISH-SPANISH-LITHUANIAN LANGUAGES, 2020
volume 2: FUTURE OF THE CITY, 2021
volume 3: coming soon

All books are available in electronic form free of charge
on the website of the project glocal.pb.edu.pl

EN	**This project has been funded with support from European Commission. This publication [communication] reflects the views only of the author, and the European Commission and Erasmus+ Programme National Agency cannot be held responsible for any use which may be made of the information contained therein.**
PL	**Ten projekt został sfinansowany przy wsparciu Komisji Europejskiej. Niniejsza publikacja [komunikat] odzwierciedla wyłącznie poglądy autora, a Komisja Europejska oraz Narodowa Agencja Programu Erasmus+ nie ponosi odpowiedzialności za jakiekolwiek wykorzystanie informacji w niej zawartych.**
LT	**Šis projektas finansuotas remiant Europos Komisijai. Šis leidinys [pranešimas] atspindi tik autoriaus požiūrį, todėl Europos Komisija ir Erasmus+ programos nacionalinė agentūra negali būti laikoma atsakinga už bet kokį jame esančios informacijos naudojimą.**
ES	**Este proyecto ha sido financiado con el apoyo de la Comisión Europea. Esta publicación [comunicación] es responsabilidad exclusive de su autor, y la Comisión Europea y la Agencia nacional del Programa Erasmus+ no es responsable del uso que pueda hacerse de la información contenida en el mismo.**

INNOVATIVE TRAINING OF FUTURE ENGINEERS
RESPONDING TO PROBLEMS OF CONTEMPORARY CITIES
2019-1-PL01-KA203-065654

GLOCAL PROJECT COORDINATOR
GLOCAL@PB.EDU.PL
WWW.GLOCAL.PB.EDU.PL

Erasmus+

FUTURE OF THE CITY

Editors
Dorota Gawryluk, Dorota Anna Krawczyk

Publishing House of Bialystok University of Technology
BIAŁYSTOK 2021

Reviewers:
dr hab. inż. arch. Adam Nadolny, prof. PP
dr hab. inż. Marek Kalenik

Science editor in the discipline of architecture and urban planning:
dr hab. inż. arch. Grażyna Dąbrowska-Milewska, prof. PB

Science editor in the discipline of environmental engineering, mining and energy:
dr hab. inż. Izabela Anna Tałałaj, prof. PB

Copy editor:
Trevor Coldron

DTP:
Publishing House of Bialystok University of Technology

Cover of a book:
Dorota Gawryluk, Marcin Dominów

Photo on the cover:
Dorota Gawryluk

ISBN 978-83-66391-61-1
ISBN 978-83-66391-62-8 (eBook)
DOI: 10.24427/978-83-66391-62-8

Free copy

Printing: Agencja Reklamowa TOP Agnieszka Łuczak

Publishing House of Bialystok University of Technology
Wiejska 45C, 15-351 Białystok
e-mail: oficyna.wydawnicza@pb.edu.pl
www.pb.edu.pl

CONTENTS

Authors

Flórez de la Colina Maria Aurora – Universidad Politecnica de Madrid

Gawryluk Dorota– Bialystok University of Technology

Ivavičiūtė Giedre – Klaipeda State University of Applied Sciences

Izquierdo Gracia Pilar Cristina – Universidad Politecnica de Madrid

Jankauskienė Dainora – Klaipeda State University of Applied Sciences

Kłopotowski Maciej – Bialystok University of Technology

Krawczyk Dorota Anna – Bialystok University of Technology

Kučinskienė Jurga – Klaipeda State University of Applied Sciences

Kuklienė Lina – Klaipeda State University of Applied Sciences

Kuklys Indrius – Klaipeda State University of Applied Sciences

Matys Wojciech – Bialystok University of Technology

Rawski Kamil – Bialystok University of Technology

Ruzgienė Birutė – Klaipeda State University of Applied Sciences

Spiriajevas Eduardas – Klaipeda State University of Applied Sciences

Vaicekauskienė Vilma – Klaipeda State University of Applied Sciences

Valiente Mercedes – Universidad Politecnica de Madrid

Vidales Barriguete Alejandra – Universidad Politecnica de Madrid

PREFACE

The future of the city is the point of interest of many researchers in different disciplines, and also other groups like citizens, state administration, producers, engineers of various industries, designers and contractors.

The monographe "The Future of the City" is the result of scientific cooperation between lectures and researchers from three European universities: Bialystok University of Technology (Poland), Universidad Politecnica de Madrid (Spain) and Klaipedos Valstibine Kolegija (Lithuania).

The authors collaborated in the GLOCAL project (Glocal – Innovative training of future engineers responding to problems of contemporary cities. Erasmus+ 2019-1-PL01-KA203-065654) and carried out a Strategic Partnership of Erasmus+ programme.

The group of 17 authors included professors with recognized scientific achievements, as well as doctoral students starting their scientific career. Authors representing various disciplines such as architecture, urban planning, landscape architecture, environmental engineering, civil engineering, building structures, geodesy, prepared in interdisciplinary teams eight chapters devoted to their current research of modern cities' needs. The topics covered were: the protection of cultural heritage, city accessibility and the use of green and blue infrastructure to improve the standard of living, solutions supporting the energy efficiency of facilities, the circular economy and the use of recycled building materials for resources protection (including cityscape) and the reduction of energy consumption, and finally, smart city solutions.

Cultural heritage protection is one of the key elements of urban sustainable development. This topic was discussed in the chapter devoted to cityscape cultural values of the three European cities: Bialystok, Madrid and Klaipeda. The authors have shown that architecture, urban structure of public places and art are a way to highlight the history of place. They provide opportunities to – better understand cities, past and future, in order to build their more sustainable and resilient development.

Historical heritage is a carrier of local cultural values and universal content. The methods of its protection and the forms of availability thanks to digitalization (e.g. 116 sculptures in the Sculpture Park in Klaipeda, Lithuania), freehand drawing and various technologies for building 3d models of historic objects are presented in the next chapter.

The experience of shaping the cultural values of the cityscape and the protection of the heritage of Bialystok, Madrid and Klaipeda should be shared on the European forum. In the authors opinion, it can be useful to other cities.

Social Conditions, including issues related to the availability of public space are an important point of cities sustainable development. The authors of the next chapter postulate minimizing the difficulties in navigating in public spaces for people with special needs, including the elderly and the disabled. They indicate design solutions based on their own research and analiysis of good practice examples from around the world.

The adaptation of small architecture and green infrastructure in public urban space research issues is presented in the next chapter. The authors analysed the solutions used in Madrid and Vienna. They indicated sustainable design strategies of public space in the context of green and blue infrastructure, integration of public space with greenery to improve the well-being of residents and the idea of "placemaking" – creating places with the participation of the local community.

The principles of the circular economy in relation to the certification and furnishing of an urban public space is the subject of the next chapter. The author indicates propositions of use by cities and producers. There are proposed solutions such as the use of solar and wind energy, recycled building materials, multi-functional designing, rainwater retention, et cetera, they significantly reduce the amount of waste and energy consumption.

Modern solutions supporting Energy Efficiency of buildings and the development of Renewable Energy sources in the form of photovoltaic panels use are presented in the next chapter. The authors presented interdisciplinary research on the impact of panels location on their efficiency and form of building as well as their impact on cityscape. The conclusions regarding the cooperation of designers of various industries in relation to existing and newly designed objects were given.

The study of contemporary cities requires aerial mapping which is the most advanced method of obtaining information about the Earth's surface and other objects using remote sensing. These issues were presented in the next chapter in which the authors defined the conditions for obtaining the cartographic products and 3d models quality in relation to remote sensing ("Unmanned Aerial System") and a laser system in LiDAR technology.

The problem of the smart city in relation to urban transport and its structural elements in Klaipeda was discussed by the authors of the last chapter. The researchers conclude that the development of logistic centres is conducive to the development of Klaipeda, and the intelligent technologies and buildings materials used for their construction meet the quality requirements and affect the high quality and durability of the facilities

The large and international authors team and presented research problems reflect the state of interest of the multidisciplinary researchers community in the subject of sustainable urban development and its future. The results of this published research serve the exchange of knowledge of the scientific community, as well as the dissemination of its results among multi-sector groups of designers, engineers, contractors and producers, state administration of supra-, regional and local level, social, scientific and professional associations, as well as strengthening the standard of education in engineering faculties.

Dorota Gawryluk, Dorota Anna Krawczyk, Editors

Białystok, March 2021

DOI: 10.24427/978-83-66391-62-8_1

1. CULTURAL VALUES OF CITYSCAPE

Maria Aurora Flórez de la Colina, Dorota Gawryluk, Jurga Kučinskienė,
Pilar Cristina Izquierdo Gracia, Giedre Ivavičiūtė

1.1. INTRODUCTION

1.1.1. Cityscape and cultural values

What are the values of modern cities? And are some of those values located within an ancient historic origin? Difficult questions to answer, but relevant as most of the world population lives in cities and the tendency is that the actual percentage will increase (United Nations, 2014). The attraction of urban settlements is in the basis of human culture and modernity has increased its attraction, creating a lack of balance between small rural towns and megacities. To re-establish a new sustainable approach, we need to know what are those urban values and to reach a better understanding with our environment.

Most dictionaries (Merriam-Webster, Collins English Dictionary, 2020) consider that cityscape can be:

1. A city view, as a scene.
2. An artistic representation of a city, an urban landscape (printing, drawing, photograph).
3. An urban environment, a configuration of built forms and interstitial space.

The urban cultural landscape is formed because of human intervention with its scenery, which is a specific and unique urban landscape. This shape creates an urban image that can be used as its identity. Urban cultural landscape is a reflection of the physical and cultural conditions in the region, which occurs due to political, economic and social influences starting from the past, and continuing in the present and future. So it can be said that urban morphology occurs because of urban cultural landscape (Rosmalia, Martokusumo, 2012).

We would like to trace back the values that are represented as a symbolic form in the material built spaces of European cities, with a similar methodology to that used by Kevin Lynch (1960) to study three American cities. Kevin Lynch established that urban images were linked to: "landmarks", as points of reference and memories for most of its citizens, usually buildings or public open spaces near them; "nodes", between areas or neighbourhoods; "districts", medium or large areas in the city, with common features; "edges" either real such as city walls or shorelines, or just perceived by inhabitants; "paths", as streets, railways, canals or other spaces through which people move or travel (Lynch, 1960).We will add some other basic elements that have been established in the 21st century by UNESCO, as part of the concept of "Historic Urban Landscape, HUL" (UNESCO, 2011).

We will try to give an approach to those values, relating our studies to three European cities, with different sizes and locations: Bialystok (Poland), Madrid (Spain) and Klaipeda (Lithuania).

1.1.2. The buildings, public spaces and artistic representation of a city as a way of transmitting its values

Urban public space adopted a very relevant role both in city planning and in culture, essentially in contemporary 20th century European cities. In the last two decades of the beginning of the 21st century, dramatic issues have changed the view we have of open spaces that have been the core of occidental city life: terrorist attacks, but also illnesses such as Covid-19 are making us think about public spaces design. As "public space appears to be under threat (Voices of Culture, 2016)", we need to identify its values for citizens.

Cultural values are linked with identity, as established by many studies and research. When thinking of a European historic city image, most of us remember some construction element, such as the Eiffel tower in Paris or the Big Ben tower in London, but also a city view from a lookout point. From the 17th century many painters utilized this, as the famous View of Delft (1660–1661) by Jan Vermeer. Landscape paintings become popular in 18th and 19th century Europe, and collections of views of cities were kept in palaces. Impressionist painters made urban landscape as a subject, popular. During the 20th and 21st centuries, photography and figurative painting was also interested in urban settings. We might use these artistic representations of cities as a tool to understand its history and values, as well as its identity.

1.1.3. The Case of Poland, Spain and Lithuania

The aim of this chapter is to show the importance of cultural values in shaping European cities in last 300 years and why public spaces should be adapted and designed to convey new values such as sustainability, capacity of change to adapt to new technologies over time as well as historic continuity, plurality and diversity as well as identity and sense of a place. Understanding these values may help decision makers better prioritize actions to be done, and a more transparent process of decision making.

1.2. Cultural values and public urban spaces

Thinking about the new material layers on the historical urban pattern of our cities is more important that we realize. They are related to the memories of its inhabitants and sometimes linked to events of their lives. As an example, **public squares are "landmarks" that can be the scenery of everyday lives**, when used as markets, one of the more common uses in Europe. As explained by Bob Giddings, James Charlton and Margaret Horne (2011):

"Of all types of urban space, squares are the most representative of the values of the societies that created them – the agora, forum, cloister, mosque courtyard are examples. Traditional functions included:

- Trade: buying and selling, depository and manufacture;
- Information: dissemination of news – place of social activity;
- Recreation: games, teaching, lunch and conversation;
- Protection: militia, training and drill, gathering in times of danger;
- Piety: holy inspiration and prayer, open space before a church for worship (French, 1983)" (Giddings, Charlton, Horne, 2011)

We will analyse and explain the uses and values of one selected public square in each of the three European cities in our study, and how those historic public spaces have changed. Ancient photos and paintings show how they were used, some existing/non existing objects in them, including or excluding greenery, monuments or statues, changing pavements and building's facades…

1.2.1. City square in Bialystok, Poland: Kosciuszko Square "Rynek Kościuszki"

The most important square in the centre of Białystok is Rynek Kościuszki. It was the main space of the residential, private town connected with the Baroque Branicki's palace and garden residence since the second half of the 18th century (Dobroński, 2012). The market square had traditional trade but also representative functions, with a rich symbolic program at that time. Everyday life of the market was surrounded by a beautifully composed set design of the urban and architecture. The dominant tower of the town hall towered over Białystok (Dolistowska, 2018) (Fig. 1.1a). During World War II, the town hall was pulled down by the Soviets, who wanted to erect a monument to Stalin in its place. Nearly 90% of the centre of Białystok was destroyed during World War II. The town hall, some of the historic buildings around the market square and the Branicki's Palace were rebuilt or largely reconstructed after the war, similar to the Old Town in Warsaw (Wicher, 2009). These activities were aimed at rebuilding the identity of the place and the sense of social identification.

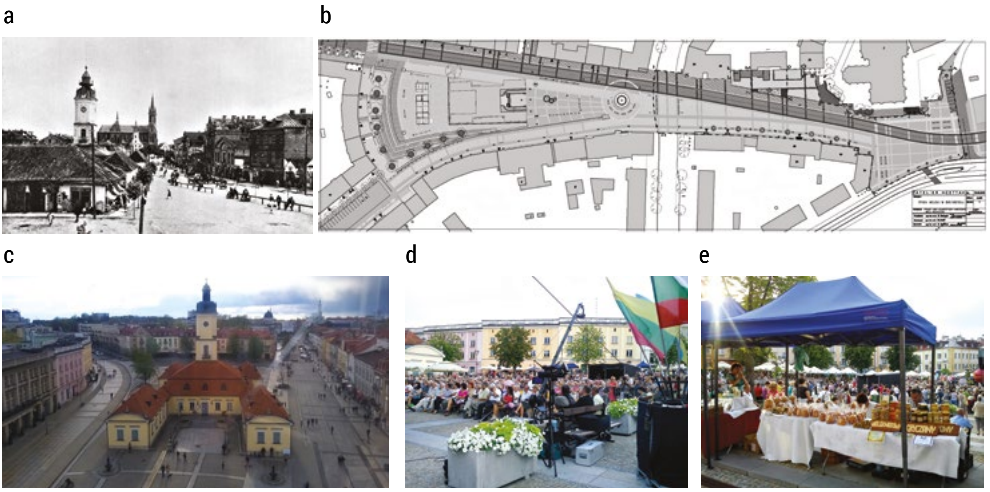


FIG. 1.1. "Rynek Kościuszki" square in Bialystok, Poland a – Market Square 1915–1920 (Source: WEB-1), b – Project of revaluation 1st decade of 20th c. (Source: D. Gawryluk, 2011), c – Kościuszko Square, estern part, the 2nd decade of the 21st c., d-e – Events on Kościuszko Square (Source: c, d, e photos by D. Gawryluk)

There was a square with flowers, bushes and trees established on Kościuszko Square in the 1960s of the 20th century. It was an important central point of public transport there too. Over decades, plants grew up and made the shape and buildings around the area of Kościuszko Square, invisible. The diregarded greenery area has become even a dangerous place. Historical values of this cityscape place were destroyed in that time.

The latest revitalisation of Rynek Kościuszki in the 1st decade of the 21st century (project by Atelier ZETTA) (Gawryluk, 2011) (Fig. 1.1b). The readability of the market square scale (big trees from after war in the square were transplanted to another part of the city) and space's functionality (change in traffic organisation) were restored. The cultural values of Białystok are confirmed by contemporary elements, such as showcases exhibiting old views of Rynek Kościuszki, a drawing on the square's floor showing the plan of the former town building and the course of the Choroski route, a sculpture of little Ludwik Zamechoff (author of Esperanto language) (Fig. 1.1c). Nowadays, the market serves as a city lounge – a meeting place where numerous events (cultural, social, state, traditional markets...) take place – a place of social activity, a place where an increasing number of residents spend their time, a place that is intentionally visited by tourists too. Rynek Kościuszki is one of the main landmarks in Białystok due to its cultural values (Fig. 1.1d, e).

1.2.2. City square in Madrid, Spain: “Plaza Mayor”

The name of “Plaza Mayor” can be translated as Main Square and it is, as well as “Puerta del Sol”, one of the essential “landmarks” of the city. It has kept most of the traditional functions established by French (French, 1983) (Giddings, Charlton, Horne, 2011), including trade (with its shops under its arcades and as a popular temporary winter market, even today), recreation (also maintained with its restaurants, cafes and terraces, cultural open air events, occasionally teaching (Valiente López, Izquierdo Gracia, Florez de la Colina, García López de la Osa, González Rodrigo, Martínez Pérez, Llauradó Pérez, 2017), information (both as a place of social activity and an important municipal information point).

Built in the sixteenth century, it was originally outside of the Madrid city walls. The “Plaza Mayor” space was used as a marketplace where the Madrilenian people could find products cheaper than inside the village, as the latter ones were taxed with the “portazgo” – literally, the “gate tax” – that all merchants must pay if they want to sell inside the walls.

The village transformation after it was nominated as capital of Spain, and the resulting population increase, motivated the village authorities to build a new line of walls and so the Plaza Mayor was going to be integrated within the village urban fabric; the “edge” perception of this “landmark” changed. Aside from being the main marketplace centre, something reflected on singular buildings, like the “Casa de la Panadería” -Bakery House-, it became the scenario of the Crown and the Church for solemn acts (like public executions, canonization processes, Inquisition “autos de fe”) and festive activities (bullfighting, tournaments, celebrations) (Fig. 1.2).

a b c

FIG. 1.2. **Oil Paintings of “Plaza Mayor” square in Madrid, Spain.** a – ca. 1623, b – 1634, c – between 1675 & 1680 (Source: WEB-3)

Many Monarchy power symbols can be found there (memorial plaques and inscriptions, crests, statues) which remain in place even with the large transformations suffered by the city.

Perception of the shape of this square was significantly changed with greenery in its middle or with the "paths" established in the 20th century by public transport inside it, as we see in postcards from the 1950s (Fig. 1.3). People's movements had a circular pattern, following tramway lines, which was even more evident due to the statue in its middle inside the rectangular shape of the square.

a b c

FIG. 1.3. **Ancient photos of "Plaza Mayor" square in Madrid, Spain (Source: a, b – WEB-3, c – WEB-4)**

Today it has recovered its importance and symbolic meaning for its citizens. One of the most interesting tourist landmarks for our visitors, it is still an important meeting point not only for tourists, but also for the capital inhabitants, the Madrilenians, and a recreational space (Fig. 1.4).

FIG. 1.4. **"Plaza Mayor" square in Madrid, Spain (Source: photo by M.A. Flórez de la Colina, 2016)**

The terraces and restaurants of the square offer a unique way to enjoy our cuisine and the space is frequently used for concerts and other cultural events or sports activities, being an important municipal information point. It is also a place for shopping in the stores that you can find under its arcades. There is still the tradition of the Sunday stamps & coins market and in December we have the famous Christmas market, the traditional place to buy ornaments and figures for the family manger.

1.2.3. City square in Klaipeda, Lithuania

In the 17th century the *Theatre Square* was known as a venue for traveling theatres, there was a market, which together with other markets formed a long and rather wide market, where there were bustling traders and attractions (Tatoris, 1994). The first public squares and green squares were constructed in Klaipeda in the first half of the 19th century. In 1819 after filling part of the castle ditches, the new market was opened in the irregularly shaped square, on the edge of which a hall was built and the current *Theatre Square* was located between two marketplaces and became part of a long marketplace itself (Tatoris, 1994). In 1850 a square was planned on the site of the current *Theatre Square*, but soon the site was used for trade (Fig. 1.5).

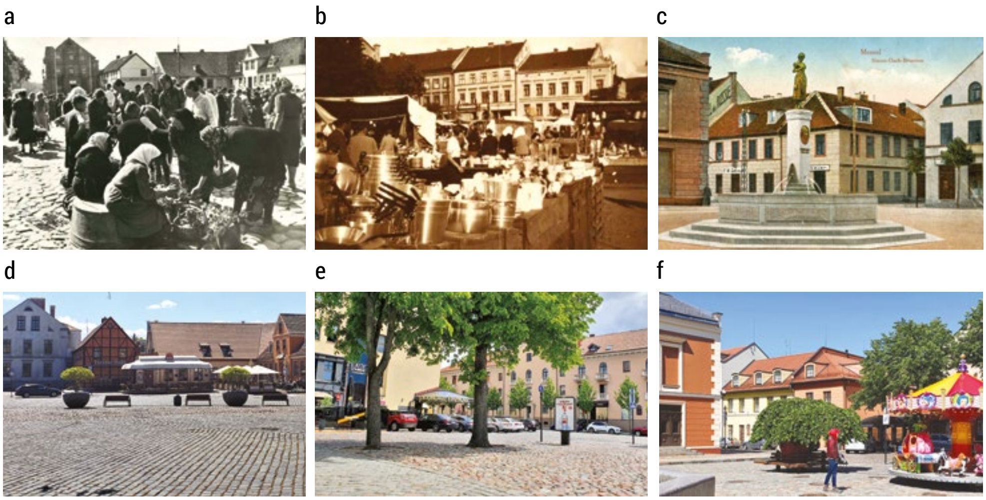


FIG. 1.5. **Theatre Square from 19th century till now, Klaipeda, Lithuania (photo from Klaipeda County Public Ieva Simonaityte Library (Source: a, b – WEB-5, c – WEB-6 and d, e, f – photos by Martynas Vainorius)**

For long time, the old town ended up to the street, and after the theatre was built in front of it, a square was formed. The square became a completed spatial element of the city in the second half of the 19th century (Fig. 1.5). In the 20th century the magistrate considered how to make better use of the *Theatre Square*. Part of it was considered to be turned into a green square, and the other part left free for public gatherings. It was decided to build a fountain in the middle of the square and a triangular square around it, but although the fountain was built in 1912 (Fig. 1.6), the green square was abandoned (Tatoris, 1994). The monument created by A. Künne in memory of the poet Simon Dach (1605–1659), a poet born in Klaipeda and a professor at the University of Karaliaucius, stood in the *Theatre Square* until 1939 with a sculpture Tarava Anike.

FIG. 1.6. The Tarava Anike sculpture with a fountain in Theatre Square, Klaipeda, Lithuania (Source: a, b – WEB-6, c – Klaipėdos architektūra, 2020)

The buildings that formed the square during World War II were badly damaged. Warehouses behind the theatre, a trade hall, a block in the lower part of the square were demolished. In 1963, in the reconstruction project of the old town, prepared by V. Jurkstas, S. Cerskute and V. Parciauskas, it was proposed to increase the space in front of the theatre by demolishing the existing buildings in the lower part, planting, installing a parking lot, adding an extension to the bank. As a result of these alterations, the planned and functional nature of the square has changed. Although the theatre was the most important building in terms of composition and function, the new layout of the square did not represent it anymore (Butkus et al., 2015). The only path that crosses the square diagonally seems to emphasize that its main purpose is to pass transit pedestrian traffic to the pier. After planting with bushes and trees it became a green square. The *Theatre Square*, which functioned as a green square for a long time after the war, did not take on its shape until the very end of the 1990s. Closing it from the busy Sukileliu (now Pilies) Street as a theatre annex and the restoration of the Tarava Anike sculpture with a fountain, it has become a new emotional attraction of the city (Butkus et. al., 2015) to the present day (Fig. 1.6).

1.3. Integration of historic cultural values and contemporary city requirements

Many cities in Europe have been destroyed by war at different periods of our history. The European Community, after the Second World War, was created to try to avoid this destructive threat of human beings: "*As of 1950, the European Coal and Steel Community begins to unite European countries economically and politically in order to secure lasting peace. The six founding countries are Belgium, France, Germany, Italy, Luxembourg and the Netherlands*" (European Union, 2020). Cultural values are essential to build peace or as Jean Monnet stated: "*If I had to do it again, I would begin with culture*" (cited by Jahier, 2016).

1.3.1. A city with signs of former religious communities: Bialystok, Poland

Białystok was a multicultural and multi-religious city before World War II. There were Jews (about 40%), Catholics (30%), Orthodox Christians (15%), Protestants (4%) and others (Dobroński, 2012). Their diversity was marked in the city landscape with objects related to religion: temples and cemeteries. Jews were the most numerous part of Białystok society which had about 60 synagogues in the area of the city (Dobroński, 2012; Dolistowska, 2018). Today, the denominational structure in Białystok is as follows: Catholics (60%), Orthodox Christians (15%), Protestant churches (less than 1%) and others.

a b c

FIG. 1.7. **Monument of Great Synagogue in Białystok, Poland: a – former graveyard Square on Bema street, b – monument of Great Synagogue, c – memory board with view of former Great Synagogue (Source: photos by D. Gawryluk)**

The Jewish community was almost completely destroyed during World War II. In the contemporary landscape of Białystok, the evidence of the former Jewish diaspora are selected objects adapted to new functions (synagogue Piaskower – Universal Podlaski now, Synagogue Beit Szmuel – unused now, Synagogue of Cytrons – Slendzinski Gallery now), landscaped green areas established on former Jewish cemeteries (Central Park realised as community action in the 60/70s of the 20th c. on the place of the Old Jewish Cementary, square by Bema street designed by Jerzy Grygorczuk in the 1st decade of the 21st c. on the place of the former cementary) (Fig. 1.7a), more and more monuments, signs and information boards in the city space, e.g. the Monument of The Great Synagogue with the square and the model of the building restoring the memory of the location of the largest synagogue in Białystok (author of conception Michał Flikier, design and realisation artists: Maria Dżugała-Sobocińska, Stanisław Ostaszewski, Dariusz Sobociński, 2008) (Fig. 1.7b, c). The monument is not easy to find, the urban structure was changed after War Wold II and area of the former Jewish district is almost not visible in the city scape.

The followers of the Evangelical-Augsburg Church were numerous in the 17–19th century. Now they are almost absent in Białystok's community. Areas of two former evangelical graveyards are signed in cityscape: 1) in the form of the lapidarium

(1994–1996 designed by Jerzy Grygorczuk) with a collection of tombstone elements near Wasilkowska street (Fig. 1.8a) and 2) a new sculpture and greenery composition on Sienny Square (Rynek Sienny) realised according to the conception of sculpturer Jarosław Perszko in 2020 (Fig. 1.8b). The crossed lines of monument and square are a symbol of the intersection of different cultures and communities in Białystok (Fig. 1.8c).

a b c

FIG. 1.8. Former Evangelical cemetaries in Białystok, Poland: a – Lapidarium on Wasilkowska street b – monument on Sienny Square, c – Sienny Square, Sienny Rynek (Source: a, b, c photos by D. Gawryluk)

The religious graveyards were absorbed by the city and their fuctionality was changed. Białystok projects are based on the integration of greenery and history in the places of former Jewish and Evangelical graveyards.

1.3.2. An historic city with "international spirit": Madrid, Spain

An historical Egyptian temple was moved from Egypt to Madrid, but not many of its inhabitants know the importance of this "landmark".

The construction of the Assuán dam in the beginning of the 1960's was going to flood a number of heritage buildings of the Nubian Valley. The First international rescue collaboration was launched by UNESCO. Spain was rewarded by Egypt for its contribution with Debod temple, transferred to Madrid from Alexandria and installed in the Prince Pio Mountain.

Work for reconstruction and restoration in Madrid was done by Manuel Herrero Palacios and Martín Almagro Basch (archaeologist), but not until 1970–1971. Restitutions were made with Sotomayor sandstone ashlar masonry and two residual pylons of the three initial ones were mounted on an axial route immersed in a gentle slope, inside an artificial pond integrated into the remodelling of the park where it is located (Fig. 1.9, 1.10).

FIG. 1.9. “Templo de Debod” in Madrid, Spain (Source: photos by M.A. Flórez de la Colina, 2020)

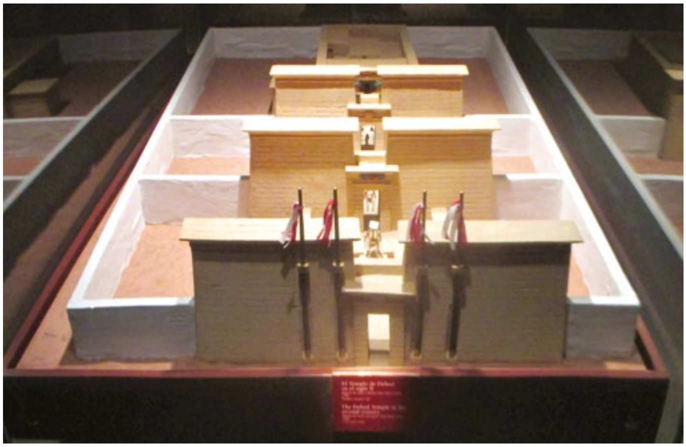
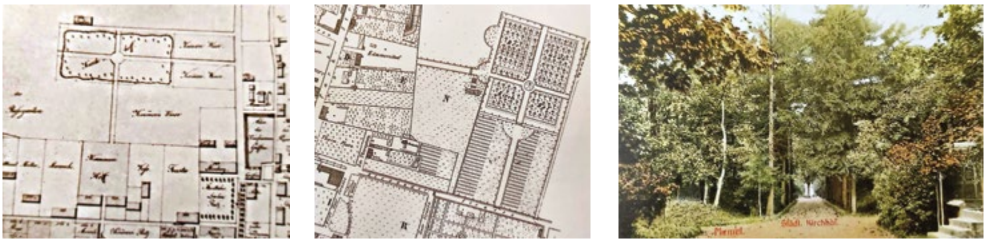


FIG. 1.10. Model of “Templo de Debod” as it was in 2nd century, located inside the museum (Source: photos by M.A. Flórez de la Colina, 2020)

Recent studies report the progressive deterioration of the temple due to environmental problems, generating a controversy about future actions for better conservation (Arquitectura de Madrid, 2020).

1.3.3. A city that integrates greenery and history: Klaipeda, Lithuania

The greenery of Klaipeda city and suburbs had a utilitarian and aesthetic significance. Strong sea winds and blowing sand value the creation of protective barriers. To make the city more beautiful, the magistrate installed squares and green squares in the city, demanded to arrange them, and to decorate the cemetery with bushes and flowers. Already in the second half of the 18th century by the order of the Prussian government, the streets of Klaipeda were planted with trees (Tatoris, 1994). In the middle of the 19th century planting in the promenade began. This promenade was five km long. There were English-style parks on the edge of this alley. Over time, city gardens and squares are installed. In the 19th century larger railway stations had to have squares, two of them were installed near Klaipeda station. In the 20^{th} century planning of parks and squares becomes stricter forms – geometric. Urban and suburban greenery was supplemented by a cemetery. In addition to respect for deceased ancestors, they also had an important aesthetic educational significance (Tatoris, 1994). During the history of Klaipeda, there were many cemeteries, each community had its own cemetery. In the 1820 a new City Cemetery was opened in which everyone could find a place for themselves. It was decided in advance to plant trees in the cemetery (Demereckas, 2014). The carefully maintained cemetery became a quiet place, which was considered the pride of Klaipeda. The plan of 1840 already shows the new City Cemetery, designed in the classicist style (Fig. 1.11), which was divided into four rectangles of equal size. After the great fire of 1857, a new wide path to the cemetery was installed (Demereckas, 2014) (Fig. 1.11).



1840 1857 1920

FIG. 1.11. City Cemetery from 19^{th} till 20^{th} century, Klaipeda, Lithuania (Source: photos from Demereckas, 2014)

The cemetery has been redesigned: a semi-circular square has been formed in the western part in front of the cemetery. The town cemetery was park-style, so it was great for walks (Fig. 1.11). At the junction of 19^{th} – 20^{th} centuries, an expanding city began to approach these cemeteries. On the 1944–45 Klaipeda lost most of its population, so this cemetery no longer performed a memorial function. For the new owners of the city, the cemetery has become a place to profit from. In the late 1960s, metal gratings and crosses were stolen in the cemetery, marble tombstones were removed, and residents planted potatoes. In the 1957 it was decided to close the cemetery and turn it into a city greenery. But it took time. In the seventies, when the city management was able to revive and implement the idea of creating a park in the former cemetery, the name of M. Mazvydas was chosen for this park (*Klaipėdos skulptūrų parkas ir jo tapatumų iššūkiai*, 2012). This park had to become a sculpture park, have not only a recreational but also an exhibition purpose, and the sculptures had to be created in Klaipeda and donated to the city. Today, 116 sculptures of various themes are exhibited in Klaipeda Sculpture Park, created by 67 sculptors during the sculptors' symposiums in Smiltyne (1977–1991) (Fig. 1.12).

FIG. 1.12. City Cemetery from 19th till 20th century, Klaipeda, Lithuania (Source: photo by Žygimantas Gedvilas)

The sculptors' symposia took place during the summer and were the most significant cultural initiative of the time, not only in the city but throughout the country. In the 1986 Klaipeda Sculpture Park was declared as a natural monument of local significance. Each sculpture in the park tells its own story, has a certain meaning, meaning or thought. In the sculpture park you can also find the first half of the 19th – 20th century's tombstones remembering the history of Klaipeda city (Fig. 12). Today, the territory of the Sculpture Park includes and unites several dimensions (*Skulptūrų parko istorija*, 2017): 1. historical memorial legacy, commemorating the memory of famous people buried in the City Cemetery; 2. the artistic legacy of modern decorative sculpture, which is currently well preserved and maintained; 3. the use of this place as a public space for a cultural event.

1.4. Conclusions

The cultural values of these three European cities can be an example of what is already being done, but also of the possibilities this can have of a better understanding both of our past and present, to build a future more sustainable and resilient future, sharing and communicating them to new European citizens.

References

1. Arquitectura de Madrid (2020) Templo de Devod. Online article in *Fundación Arquitectura COAM* website. Retrieved from: http://guia-arquitectura-madrid.coam.org/#inm.F2.1 [Accessed: 16.10.2020]
2. Butkus, T. S., Safronovas, V., Petrulis, V. (2015) *Klaipėdos urbanistinė raida, 1945–1990.* Vilniaus dailės akademija. [ISBN 978-609-9546-469]
3. Demereckas, K. (2014). *Klaipėdos istoriniai parkai ir želdynai*. Klaipėda. [ISBN 978-609-8094-11-4]
4. Dobroński, A. Cz. ed. (2012) *Historia Białegostoku,* Wydawnictwo Sąsiedzi, Białystok [ISBN: 978-83-934373-0-6]

5. Dolistowska, M. (2018) *W poszukiwaniu Tożsamości miasta. Architektura i urbanistyka Białegostoku w latach 1795–1939*, 2nd ed. Wydawnictwo Uniwersytetu w Białymstoku, Białystok [ISBN 978-83-7431-530-2]
6. European Union (2020) *The history of the European Union*. Online article in European Union website. Retrieved from: https://europa.eu/european-union/about-eu/history_en [Accessed: 16.10.2020]
7. Gawryluk, D. (2011) Contemporary building technologies used to reconstruction and modernisation of historical places and architectural monuments in Białystock. Technical Transaction. Architecture. Czasopismo Techniczne. Architektura, R. 108, Z. 11, 2-A1, 57–64 [online: https://repozytorium.biblos.pk.edu.pl/resources/32239]
8. Giddings, B., Charltone, J., Horne, M. (2011), Public squares in European city centres, *Urban Design International*, 16 (3), 202–212. ISSN 1357–5317. And, cited by them: French, J.S. (1983) *Urban Space – A Brief History of the City Square*, 2nd ed. Iowa: Kendall Hunt Publishing
9. Jahier, L. (2016) "Foreword". Citation of Jean Monnet. In: European Union, European Economic and Social Committee (2016), *Culture, Cities and Identity in Europe*. P. iii [Online Study carried out by Culture Action Europe and Agenda 21 for Culture – UCLG]. Retrieved from:https://www.eesc.europa.eu/sites/default/files/resources/docs/qe-01-16-463-en-n.pdf. [Online: ISBN 978-92-830-3199-4] [Accessed: 16.10.2020]
10. *Klaipėdos architektūra*. (2020). Retrieved from: https://www.vle.lt/Straipsnis/Klaipedos-architektura-125278
11. *Klaipėdos skulptūrų parkas ir jo tapatumų iššūkiai*. (2012). Klaipėda. [ISBN 978-609-404-134-1]
12. Lynch, K. (1960) *The Image of the City*. The MIT Press. [ISBN 0-262-62001-4]
13. Merriam-Webster (2020), *Cityscape definition*. [Online dictionary]. Retrieved from: www.merriam-webster.com › cityscape. Collins English Dictionary (2020) *Cityscape definition*. [Online dictionary]. Retrieved from: www.collinsdictionary.com › cityscape. [Accessed: 16.10.2020]
14. Rosmalia, D. Martokusumo, W. (2012) The Notion on Urban Cultural Landscape from the Perspective of Landscape Architecture Case Study: Cirebon City, West Java, *Arte – Polis 4 International Conference – Creative Connectivity and the Making of Place*.719–728
15. *Skulptūrų parko istorija*. (2017). Article from History Museum of Lithuania Minor, Klaipėda, Lithuania website. Retrieved from: https://www.mlimuziejus.lt/lt/skulpturu-parkas/klaipedos-m-skulpturu-parko-istorija/skulpturu-parko-istorija/
16. Tatoris, J. (1994). *Senoji Klaipėda. Urbanistinė raida ir architektūra iki 1939 metų*. Vilnius. [ISBN 5-420-00510-7]
17. UNESCO (2011) *UNESCO Recommendation on the Historic Urban Landscape*. And *Second Consultation on the 2011 Recommendation on Historic Urban Landscape Implementation by Member States, 2019*. Retrieved from: https://whc.unesco.org/en/hul/ [Accessed: 16.10.2020]
18. United Nations (2014) *World Urbanization Prospects (Revisions)* Department of Economic and Social Affairs. Retrieved from: http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf. In: European Union, European Economic and Social Committee (2016), *Culture, Cities and Identity in Europe*. P.2 [Online Study carried out by Culture Action Europe and Agenda 21 for Culture – UCLG]. Retrieved from: https://www.eesc.europa.eu/sites/default/files/resources/docs/qe-01-16-463-en-n.pdf. [Online: ISBN 978-92-830-3199-4] [Accessed: 16.10.2020]

19. Valiente López, M., Izquierdo Gracia, P.C., Florez de la Colina, M.A., García López de la Osa, G., González Rodrigo, S., Martínez Pérez, I., Llauradó Pérez, N. (2017) The enchantment of pencil drawing in Madrid: gamebased learning and architectural sketches of "Plaza Mayor" square, *ICERI 2017 Proceedings*, 2017, 355-362 [doi: 10.21125/iceri.2017.0149]
20. Voices of Culture (2016), Promoting Intercultural Dialogue and Bringing Communities Together Through Culture in Shared Public Spaces. Brainstorming report (to be published). *European Union, European Economic and Social Committee (2016), Culture, Cities and Identity in Europe*, 8 [Online Study carried out by Culture Action Europe and Agenda 21 for Culture – UCLG]. Retrieved from: https://www.eesc.europa.eu/sites/default/files/resources/docs/qe-01-16-463-en-n.pdf. [Online: ISBN 978-92-830-3199-4]
21. WEB-1: Website https://polska-org.pl [Online] Old photo by H. Poddębski: *Market Square 1915–1920, Bialystok, Poland.* (1915–20), Retrieved from: https://polska-org.pl/8100356,foto.html?idEntity=7143859 [Accessed: 10.10.2020]
22. WEB-2: Website https://www.portalsamorzadowy.pl [Online] Fig. 1.1c) Photo: *Kościuszko Square, estern part, the 2nd decade of the 21st c.* Retrieved from: https://www.portalsamorzadowy.pl/serwis/top-inwestycje-polski-wschodniej/nominacje/61851.html [Accessed: 10.10.2020]
23. WEB-3: Website Memoria de Madrid http://www.memoriademadrid.es [Online] Oil paintings: Fig. 2 a) De la CORTE, J. (ca. 1623) *Fiesta real en la Plaza Mayor* (Oil painting). Inv. 3422. Casa de la panadería, Plaza Mayor. Retrieved from: http://www.memoriademadrid.es/buscador.php?accion=VerFicha&id=9990&num_id=10&num_total=210. Fig. 2 b) Unknown author (1634) *Perspectiva de la Plaza Mayor, con la comitiva de Felipe III camino de la calle Mayor* (Oil Painting) "Segobiana / El Alcazar". Inv. 3152. Casa de la Panadería, Plaza Mayor, Ayuntamiento de Madrid. Retrieved from: http://www.memoriademadrid.es/buscador.php?accion=VerFicha&id=10006&num_id=108&num_total=210. [Accessed: 16.10.2020] Fig. 1.2c) Unknown author (between 1675 & 1680), *Vista de la plaza Mayor en fiesta de toros* (Oil Painting). Inv. 4004. Casa de la Panadería, Plaza Mayor, Ayuntamiento de Madrid. Retrieved from: http://www.memoriademadrid.es/buscador.php?accion=VerFicha&id=140406&num_id=33&num_total=210 [Accessed: 16.10.2020] Fig. 3 a) Unknown author (1916–1923). Museo Historia: Inv. 1991/1/590. Retrieved from: http://www.memoriademadrid.es/buscador.php?accion=VerFicha&id=10403&num_id=15&num_total=568. [Accessed: 16.10.2020] Fig. 1.3b) Lacoste, J. (1906–1914). *Museo Historia:* Inv. 31234 Retrieved from: http://www.memoriademadrid.es/buscador.php?accion=VerFicha&id=10581&num_id=105&num_total=213. [Accessed: 16.10.2020]
24. WEB-4: Website www.delcampe.net [Online] Ancient photo of "Plaza Mayor" square in Madrid, Spain" (Old postcard). [Accessed: 16.10.2020]
25. WEB-5: Website http://adm.klavb.lt/de/adm// [Online] *Fig. 1.5a, b – Theatre square history, Klaipeda County Public leva Simonaityte Library (AdM archive)* [Accessed: 28.09.2020]
26. WEB-6: *Website* http://www.krastogidas.lt/objektai/5-paminklas-simonui-dachui-skulptura-taravos-anike [Online] *Fig. 1.6a, b – Tarava Anike* [Accessed: 09.10.2020]
27. Wicher, S. (2009) *Żyć architekturą. Życie i twórczość Stanisława Bukowskiego.* Białostockie Zakłady Graficzne S.A., Białystok [ISBN 978-83-89231-10-9]

DOI: 10.24427/978-83-66391-62-8_2

2. 3D MODELING AND DIGITALIZATION IN HERITAGE

Birutė Ruzgienė, Lina Kuklienė, Indrius Kuklys, Dainora Jankauskienė, Mercedes Valiente, Wojciech Matys

2.1. Fundamentals of Cartography and Photogrammetry

Cartographic products in digital public environment can be seen more than ever before. An interactive map product embedded in many digital cartographic systems become ubiquitous. A map is a visual representation of an entire earth area or a part of an area where 3D space, usually is presented on a horizontal plane/ flat 2D surface.

There are several types of surface models: two-dimensional, three-dimensional, four-dimensional, dynamic and even web. The maps show various objects: physical features, roads, topography, population, climate changes, natural resources, economic activities, small architectural monuments, political boundaries, etc.

Cartography is the art and science of graphically representing a geographical area, usually on a map or chart. It may involve the superimposition of political, cultural or other nongeographical objects onto the representation of a geographical area. Modern cartography largely involves the use of aerial and satellite photographs as a base for any desired map or chart. The procedures for translating photographic data into maps are governed by the principles of photogrammetry and yield a degree of accuracy previously unattainable. The remarkable improvements in satellite photography since the late 20th century and the general availability on the Internet of satellite images have made possible the creation of *Google Earth* and other databases that are widely available online (WEB-1). In addition, the use of geographic information system (GIS) has been indispensable in expanding the scope of cartographic subjects. Cartography is related to three assumptions: 1. Cartography is relevant assuring the quality of geospatial information; 2. Cartography is attractive constructing interactive, collaborative maps; 3. Cartography is modern generating 3D and 4D realtime models (WEB-2). Fig. 2.1 shows example of modern cartography application.

FIG. 2.1. Modern cartography: 2D, 3D images and photograph of sculptures – park in Klaipeda city (Source: WEB-3)

Photogrammetry is the science of making reliable measurements by the use of photographs and especially aerial photographs (as in surveying). The definition of photogrammetry can be extended: photogrammetry is the art, science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena. The main product created by the use of photogrammetry science is the orthophoto map. An orthophoto (also known as an orthophotograph) is an aerial image that has been geometrically corrected (ortho rectified) so that the image is uniform from edge to edge. Orthophotos are corrected to remove terrain effects (what happens when you convert a 3D real surface into a 2D product) and distortions that result from the camera's lens and the angle the photo was taken from the plane.

FIG. 2.2. Fragment of orthophoto map: Klaipeda city (Source: WEB-5)

The goal of ortho rectification is to create an image where distance measurements are the same across the entire image. A digital orthophoto map typically has a geographic reference to the Earth, such as a UTM or State Plane coordinates, so each pixel in the photo can be accurately located (Manual, 2004; Linder, 2009; WEB-4). Many of the digital aerial photographs available through GIS are orthophotos. Fig. 2.2 shows rectified aerial photography: fragment of orthophoto map of Klaipeda city.

2.2. Generation of spatial models of small architectural objects located in public space

The mapping of protected cultural heritage objects is relevant today and in the future. The idea is to commemorate cultural heritage objects, protecting them from degradation, to ensure the preservation of information, to increase the relevance and visibility, and to realize more convenient access to geoinformation. Various institutions are involved with the common goal of promoting cultural heritage to Lithuanian and foreign residents by using information technologies.

Digital maps, constructed by the use of various technologies (e.g., TLS) are becoming public and accessible at the website to anyone who is interested. Terrestrial laser scanning (TLS) is referred to terrestrial Light Detection and Ranging (LiDAR) technology, acquiring XYZ coordinates of numerous points on surfaces by emitting laser pulses toward these points and measuring the distance from the device to the target. Software packages are generally required for managing and analyzing the data because of the large amount of data stored in a TLS point cloud. A point cloud may be converted into a grid DEM to facilitate topographic mapping and spatial analyses. TLS instruments are commonly of three categories based on the distance the laser light can travel to record a point in a field-of-view: short, medium and long-range scanners. A potential limitation to TLS approaches is the weight of the instrument (>20 kg including the battery) length (Ruzgienė, Berteška *et al.* 2015, Kraus, 2007).

2.2.1. The instruments and technologies

The new multi-station *Leica Nova MS60* enables surveying with one instrument, combines fast 3D laser-scanning capabilities, GPS/ GNSS connectivity and digital imaging (WEB-6). The *Nova MS60* features includes a fast laser speed of up to 30,000 points per second, optimized scan area definitions, adapted scan managements, and an improved scanning path for zenith scans. Measurement professionals can make decisions directly in the field, performing point-cloud analysis such as flatness analysis, etc. Scan data of the *Nova MS60* can graphically show in real time, collecting the points positions in the field.

Laser scanner *Stonex X300* made in Italy is a 3D scanner designed to deliver effective results every day, on any project. This scanner has a dedicated line of accessories to work better, scanning process is controlled by smartphone or tablet, allows to work where others fail, regardless of dust, humidity, heat or bumps (WEB-7).

3D Reshaper is a scanner software dedicated to surveyors and can execute processing of point cloud (manual and automatic filters, merge, color), 3D meshing (smoothing, holes filling, borders improvement), 3D inspection of data, polylines, CAD surfaces, to compute a digital surface model, longitudinal profiles, classify points, etc. terrestrial scanning (WEB-8).

JRC 3D Reconstructor is the multi-platform powerful software to handle LiDAR point cloud: import, process and manage terrestrial scanning data, handheld, mobile, airborne laser scanner and easily integrate UAV and 3D imaging data in a single platform.

For realization of 3D modelling of architectural small objects located in cities/ public space, apply up-to-date mapping/ geoinformation technologies:

- Remote Sensing (RS) – imagery from satellites in *Google Earth* (simultaneously *Street View*) application usable for overview general situation of study object (WEB-3).
- Terrestrial Lidar Scanning (TLS) – the scanning sculptures with laser scanners (*Nova MS60*, *Stonex X300*), 3D modelling by the use of software (*3D Reshaper, JRC 3D Reconstructor*). Laser scanning speeds up workflows by combining technologies (imaging, scanning capabilities and GNSS connectivity) in this all-in-one instrument. With the use of specialized software, all measurement and scanning data can be visualized in 3D environment for quality and completeness corrections (WEB-9).
- Geoinformation Systems (GIS) – the use of software application (*ArcGIS*) for thematic map construction, classification of topographic elements and coordinates from other data sources, e.g., city municipality.
- Aerial Photogrammetry – the use of orthophoto map for presentation of sculptures positions and infrastructure of cities parks for public needs.

2.2.2. The results of sculptures mapping

The sculptures park located in Klaipeda city, Lithuania is the open-air art gallery with 116 works of art of various thematic and 6 historical objects, situated on area of 10 ha. This object was selected because of great significance as nature and art monument combining historical memorial legacy, modern decorative sculptures and the use of public space for cultural events. The mapping of sculpture park objects is important activity for obtaining information that can be used for construction state-of-the-art data base, disseminating for everyone's needs by the use of smart devices.

Data acquisition and processing. 116 sculptures and 6 historical objects were scanned by the use of terrestrial scanning technology (TLS) with laser scanner *Leica Nova MS60*. The photographs of all sculptures by the use of high-resolution camera were gained from four stations (at the sides, front, rear of the sculpture) and sometimes from additional stations depending on the complexity of the sculpture. These photographs were used for 3D modelling. Software *3D Reshaper* was applied for 3D modelling of all sculptures in a virtual environment (WEB-8). The virtual geoinformation data base can be taken from the platforms of http://www. mlimuziejus.lt/park (WEB-10) and can be used by everyone. 3D modelling was fulfilled step by step: importation of points cloud gained from laser scanning of sculptures; TIN creation, filling of gaps; creating real image; shading of invisible areas, generation of three-dimension model. The example of 3D modelled sculpture named “Bangpūtys” by software *3D Reshaper* is presented in Figures 2.3 and 2.4.

FIG. 2.3. **Extraction of a real image model: orientation of sculpture “Bangpūtys” model, used 4 photographs (Source: own elaboration, 2020)**

FIG. 2.4. **3D model of sculpture „Bangpūtys“ generated from TLS data (Source: own elaboration, 2020)**

Thematic map construction. The spatial data set was created with software application *ArcGIS*. The orthophoto map of study area and topographic survey with sculptures planimetric coordinates was provided by Klaipeda city municipality. These data were imported in *ArcGIS* overlaying positions of sculptures onto the orthophoto map and constructed map (Fig. 2.5).

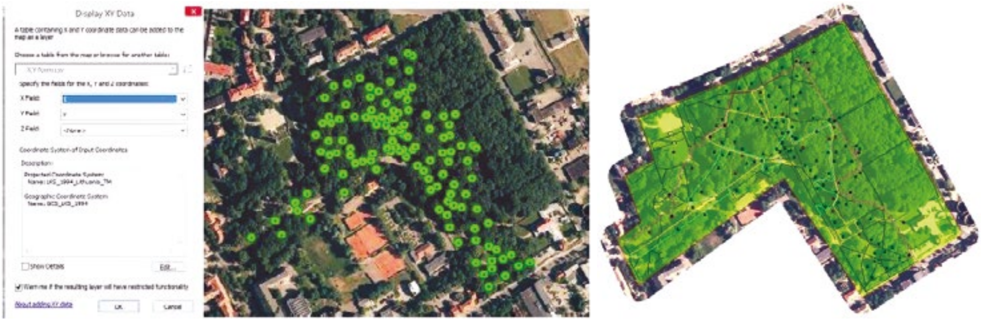


FIG. 2.5. **Sculptures position onto orthophoto map and the map of sculpture park constructed by the use of GIS technology (Source: own elaboration, 2020)**

Another object of study – 3D modelling of architectural heritage objects "Baubliai", located in Dionizo Poskos antiquities field museum, Bijotų village, Lithuania have been performed. Oaks, that are about a thousand years old, are called "Baubliai" (Baubles). The museum shed oak stalk with straw roof, coated by ribbons cementitious foundations; there writer and historian, enlightener of culture D. Poška rested and worked at the end of XIX century. Baubles, has been declared as important historical, cultural, ancient monument of Lithuanian culture with no analogue. Nowadays Baubles are covered by glass roof.

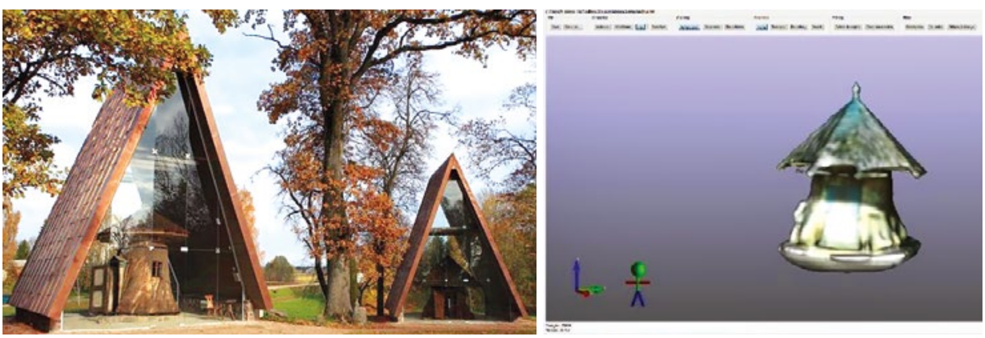


FIG. 2.6. **The field museum with cultural monuments and generated 3D model of Bauble by the use of TLS technology (Source: own elaboration, 2020)**

Two Baubles were scanned with laser scanner *Stonex X300* using TLS technology. Because both Baubles were under a closed glass and enclosure with a roof, the scanning procedure becomes complicated. For both Baubles, due to the trapezoidal roof, it was decided to measure from six different positions outside and also inside with scanning angle 75–90 angles. Measuring conditions were more difficult concerning of the tapering roof, therefore the laser scanner had to be raised higher. Due to the difficult measurement conditions mentioned above, the measurements took five hours. 3D modelling of Baubles was performed by the use of software *JRC 3D Reconstructor* processing, unifying, correcting of the point cloud. Generated 3D model of one Bauble is presented in Figure 2.6.

2.3. Classic methods of 3D modelling

Understandably, new technologies are replacing the old ways of 3D modelling cultural heritage. However, one cannot forget about the classic methods of visualizing objects. When constructing them, we base methods of measurement: traditional (manual meters) and modern (electronic meters). However, when creating them, an equally important or even more important role is played by the "feeling" of the object by the author of the model, his/her knowledge, experience and imagination. The author decides about the hierarchy of importance of the elements included in the object. Some of them are detailed, others are blurred or even deleted. That kind of 3D modelling, unlike digital methods, is heavily influenced by subjectivity and humanity.

2.3.1. 3D drawings made by hand

This kind of 3D modelling is usually faster and simpler than others, and also can be created always and everywhere.

Two methods are used to create 3D drawings: parallel projections and perspective projections (Ducki, Rokosza, Rylke, Skalski, 2003).

In the first method (simpler), lines are projected in parallel along three different axes (x, y, z) with different angles in conjunction with a horizontal baseline. We distinguish isometric projection, elevation oblique and axonometric projection/plan oblique.

This type of 3D drawing is easily understood even by laypersons and can be constructed at all scales. It is often used both to present urban and planning layouts as well as small architectural spaces (gardens, atriums, etc.) (Fig. 2.7).

Perspective projections are characterized by the parallel lines convergence at the vanishing points usually placed on the horizon line (the viewer's eye level). The most used are one-point and two-point perspectives.

a b

FIG. 2.7. Examples of the use of parallel projection (Source: a – axonometric projection of the center of Bialystok, graphics by Wojciech Matys; b – 3D street – art by Marek Kierklo, Kartuzy, photo by Bartłomiej Gruby, WEB – 11)

These kinds of 3D drawings are usually created in two mains types of perspective: linear perspective and atmospheric perspective.

Linear perspective has all converging lines which seem to move towards a common vanishing point (or points) placed on an eye-level of the viewer's line (horizon line) (Fig. 2.8).

a b

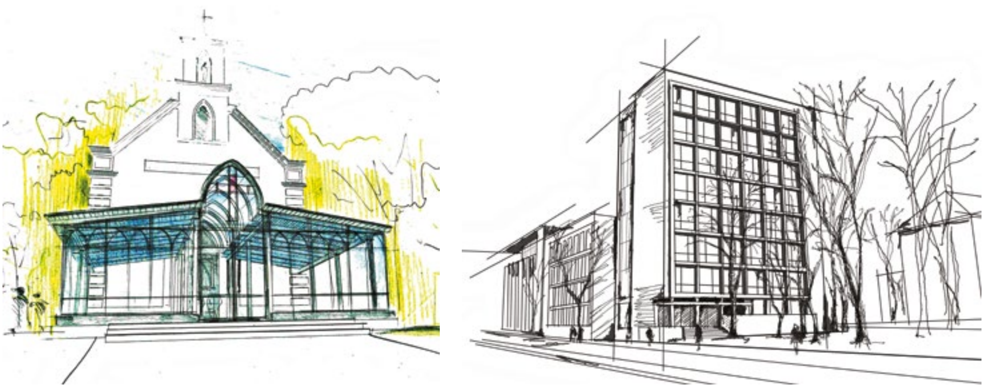


FIG. 2.8. Linear perspective projection – examples (Source: a – graphics by Marta Baum, b – graphics by Wojciech Matys)

The atmospheric perspective projection is based on landscape painting. The space shown is not "constructed" (Wilk, 2014). It is often impossible to determine the location of vanishing points and depth is shown by varying object sizes (larger seem closer, smaller farther) (Fig. 2.9).

a b

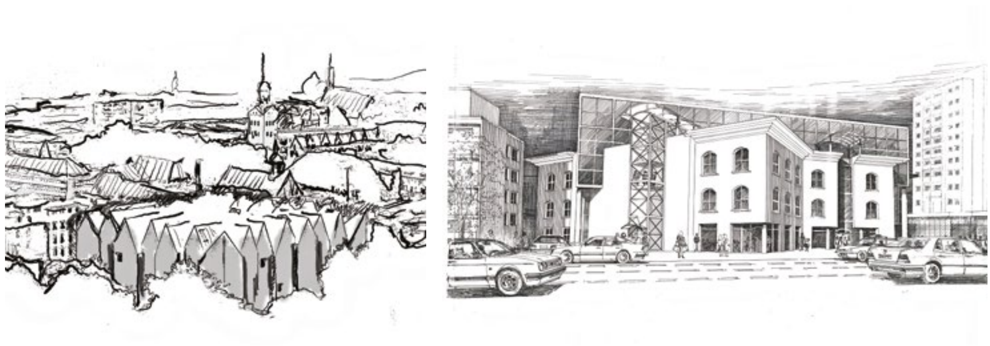


FIG. 2.9. Atmospheric perspective projection – examples (Source: a – graphics by Wojciech Matys b – graphics by Marta Baum)

2.3.2. Manual models

A model is a conventional three-dimensional "image" of space made in a given scale or in appropriate proportions. The conventionality of the model is achieved, among others, thanks to the use of homogeneous materials, the use of non-obvious, undefined elements, or simplification of the presented spaces.

This kind of 3D modelling is often used when creating models of sculptural objects or also tactile models intended mainly for the blind (Fig. 2.10).

a b

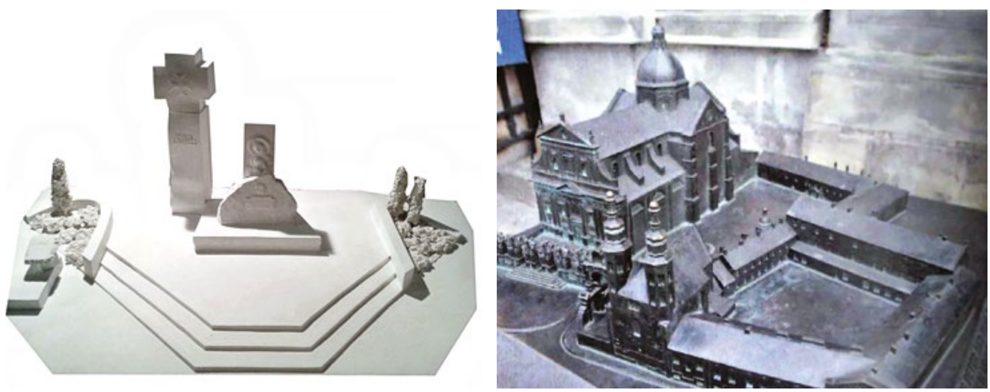


FIG. 2.10. Examples of the manual models (Source: a – Manual model by Jerzy Grygorczuk, photo by W. Matys, b – photo by M. Kłopotowski)

Model views are digitized by photos. The same is true of hand-drawn drawings that are also scanned (also by large-format scanners). Digitized objects can be used in visualizations using photo processing software.

2.4. Drawing by computer is a different way to draw

The importance of Architectural Drawing as a means of communication between professionals is unquestionable. That is why one of the essential objectives of technical schools in the Plan of Study, is to provide students with a means of communication that is essential for their future professional activities. What is clear is that virtually no important architect has dispensed with the intermediate language that is the graphical representation. Therefore, it is safe to say that the graphic medium, architectural drawing, really offers the greatest potential for the study of the entire set of issues related to the architectural discipline. At the same time it is taught, or at least that has been the focus throughout our years of teaching at this school, the precise rules to master the different techniques, both conventional and newest, those have been used or are used in Architectural Drawing execution and knowledge necessary for their restructuring.

Nowadays not only conventional techniques are taught, but attempting, at least experimentally, to show each student more innovative ways in Architectural Representation. This is the case of the use of computers, and the new language BIM.

New ways of drawing the BIM (Building Information Modelling – modelling building information). For BIM applications, with programs such as Revit, architecture is more than a three-dimensional model with different representations; it is not enough to represent the building in a realistic way, it is a simulator of buildings under real conditions. Many words have been spent in comparing AutoCAD – AutoCAD Architecture – Revit, but if we do, we will always fall into the simplistic comparison as tools to represent reality, forgetting the most important thing of Revit, which is to simulate reality. Simulating reality can make better choices in the design phase, as well as provide many of the problems that arise in the life cycle of the building.

The computer drawing was projected in 2D and 3D, but with BIM new concepts were incorporated:

- 4D-BIM: incorporation of the time factor in the project
- 5D-BIM: construction costs related to time and durability of the building
- 6D-BIM: building maintenance throughout its lifetime.

The BIM (Building Information Modeling – modeling building information), is a new revolution as with the advent of computer drawing.

2.4.1. 3D print introduction

A 3D printer is a machine capable of generating print designs in three dimensions and in different materials ranging from mud, dust, some plastics and even metals. The result is being able to create volumetric parts previously designed on a computer.

3D printers use multiple manufacturing technologies and we will try to explain simply how they work. With 3D printers what you do is create an object with its 3 dimensions and this becomes built on layers until the finished desired object.

What a 3D printer really does is to produce a 3D computer design created with a physical 3D model. In other words, if we have designed on your computer, for example a simple cup of coffee (by any CAD program – Computer Aided Design) we can print it in reality through the 3D printer and produce a physical product that would be our own cup of coffee. With this we can generate through physical documents electronic documents. Generally, the materials used to manufacture metal objects can be, nylon, and about 100 different types of materials.

2.4.2. 3D print uses of 3D printers at different sectors: research in the UPM

The models are made with a 3D printer model MARKETBOT REPLICATOR TM 2 DESKTOP 3D PRINTER Fig. 2.11. In the images you can see some examples. In Fig. 2.12. and Fig. 2.13. you can see the models.

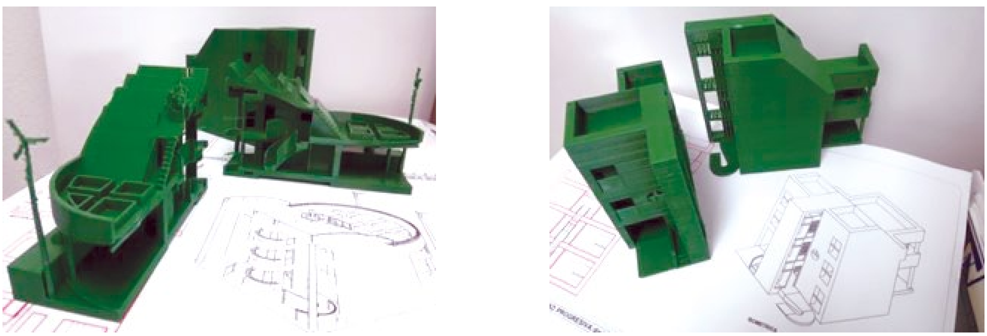


FIG. 2.11. Models were made with a 3D PRINTER MARKETBOT REPLICATOR TM 2 DESKTOP 3D PRINTER (Source: own elaboration, 2020)

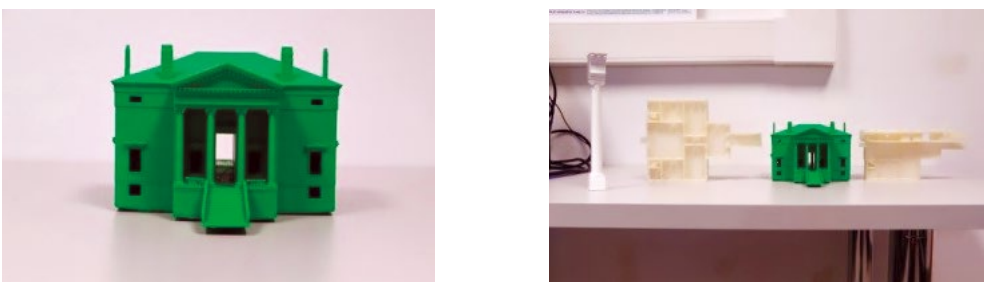


FIG. 2.12. Models were made with a 3D printer MARKETBOT REPLICATOR TM 2 DESKTOP 3D PRINTER PALLADIO HOUSES VILLA CHIERICATI (Source: own elaboration, 2020)

FIG. 2.13. MakerBot Replicator 3D printer (Source: own elaboration, 2020)

For a long time 3D printers have been one of the greatest inventions that has reached its peak in this 21st century, due to a lot of companies that are innovating in their production and in application uses that can be given. The marketplace in 3D printers reveals many different purposes, sizes and prices, opening millions of possibilities for easy production even allows trial and error without excessive costs.

References

1. Ducki, J., Rokosza, J., Rylke, J., Skalski, J. (2003) *Hand Drawing for Landscape Architects (in Polish)*, Warsaw, Publishing House SGGW
2. Kraus, K. 2007. Photogrammetry: Geometry from Images and Laser Scans. Berlin: Walter de Gruyter. 459
3. Linder, W. (2009) *Digital Photogrammetry. A practical Course*, Springer – Verlag, Berlin, Heidelberg, 33–73, 121–131
4. *Manual of Photogrammetry* (Edited by J. Chris McGlone), (2004) American Society for Photogrammetry and Remote Sensing, Maryland, USA, 959–963
5. Ruzgienė, B.; Berteška, T.; Gečytė, S.; Jakubauskienė, E.; Aksamitauskas, V, Č. 2015. The surface modelling based on UAV Photogrammetry and qualitative estimation. Measurement. Oxford: Elsevier Ltd. Vol. 73, p. 619–627
6. WEB-1:*Cartography*, (2020), [Online] Available from: https://www.britannica.com/science/cartography [Accessed: 18.02.2020]
7. WEB-2: *Modern Cartography*, (2020), [Online] Available from: http://www.gsdi. org/docs 2004/ Cookbook/cookbookV2.0.pdf [Accessed: 18.02.2020]
8. WEB-3: Google Earth, Street View application (2020), [Online] Available from: https://earth.google.com /web/@55.69191266,21.17681752,11.67728544a,6495.67834488d,35y,0.00000121h,0t,0r / [Accessed: 20.10.2020]
9. WEB-4: *Geospatial technology*, (2020), [Online] Available from https://mapasyst. extension.org/what-is-an-orthophoto/ [Accessed: 18.02.2020]
10. WEB-5: Maps.lt (2020), [Online] Available from: https://beta.maps.lt/?c=2362412.9%2C7500077. 6&r=0&s=72223.819286&b=orto / [Accessed: 20.10.2020]
11. WEB-6: Smart Office, (2020), [Online] Available from: https://www.soffice.lt/ produktas/technine-iranga /tacheometrai/daugiafunkciniai/MS60.html [Accessed: 10.03.2020]

12. WEB-7: Stonex (2020), [Online] Available from: https://www.stonex.it/ project/x300-laser-scanner/ [Accessed: 15.03.2020]
13. WEB-8: Reshapter 3D, (2020), [Online] Available from: https://www.3dreshaper. com/ en/software-en/download-software/current- release-software [Accessed: 22.03.2020]
14. WEB-9: Terrestrial Laser Scanning, (2020), [Online] Available from: https://www. sciencedirect. com/ topics/earth-and-planetary-sciences/terres- trial-laser-scanning [Accessed: 20.01.2020]
15. WEB-10: Mažosios Lietuvos istorijos muziejus (2020), [Online] Available from: http:// www. mlimuziejus.lt/park/ / [Accessed: 20.10.2020]
16. WEB-11: Kartuzy (2020), [Online] Available from: https://kartuzy.info/zdjecie/3631957 [Accessed: 20.10.2020]
17. Wilk, S. (2014) *Construction and Design Manual Drawing for Landscape Architects,* Dom Publisher, Berlin

DOI: 10.24427/978-83-66391-62-8_3

3. ACCESSIBILITY OF PUBLIC SPACE

Kamil Rawski, Maciej Kłopotowski

3.1. Public space users

Space accessibility should be considered in the context of its users because accessibility is such a property of an environment that allows those users to use the space in an equal way. From the point of view of public space accessibility, people who benefit from the accessible environment are not only the elderly or disabled persons. It is estimated that up to 30% of society may have permanent or temporary limitations in mobility or perception. These include people moving with the help of assistive equipment, with manual and cognitive difficulties, with hearing and sight impairment or even people with heavy luggage, as well as pregnant women, physically weaker people, or experiencing difficulties in moving. Many of these people do not have the status of a disabled person. Therefore, it can be said that accessibility concerns all of us, but in everyday life its lack is noticed mostly by people with special needs (including individual ones), resulting from the lack of full functionality. The accessibility mainly concerns (MIiR, 2018):

- people in wheelchairs and with reduced mobility;
- blind and partially sighted people;
- deaf and hard of hearing people;
- deaf-blind people;
- people with mental and intellectual disabilities;
- elderly and weakened people;
- people who have difficulties communicating with the environment (also with a lack of knowledge of the language);
- people with unusual height (including children);
- pregnant women;
- people with young children, including prams;
- people with heavy or unwieldy luggage.

Not all universal design beneficiaries are continuously disabled. Space users can have special needs towards moving around only temporarily and after some time they can return to the full capacity.

Planning of accessibility makes life easier for all of society members, in particular for people with special needs, including the disabled. Accessibility can be achieved not only by planning new spaces but also in the way of removing spatial barriers and making rational improvements (e.g. utilizing assisting technologies) to already existing ones. Such actions give many benefits. Accessible public spaces reach with its offer to a greater amount of different space users and are more user friendly and attractive. For many people leading an independent life may be fully conditional on the accessibility of public spaces. Through accessible places, such people have a chance to participate in the social and economic life of the country or local society.

3.2. Design of accessible space

The trend of thinking in terms of planning space accessibility, taking into account people with special needs (including disabled), began only in the 1960s. The first ideas slowly, gradually began to be reflected in new laws over the next 40 years. At first, provisions including rules about applying correct solutions to spatial problems can be found in the United States, Australia and Western Europe. The important thing is that such provisions had started to oblige designers to implement prepared solutions. Earlier, as Ewa Kuryłowicz (2005) describes in her publication about universal design, one had only attempts to organize the space on the basis of an average, unified model of man (Grandjean, 1978). Initially, such theories were studied in the Renaissance, where some prominent individuals as Leonardo da Vinci or Bernini had tried to draw up the ideal proportions of the human body. It is also worth quoting the work of Vitruvius entitled De Architectura libri X, in which he treats, inter alia, about aesthetics, space planning and interior design. He also emphasized the statement that the location of buildings can affect human health and described the canon of human proportions that should be used during the design process. The next breakthrough in this field was made much later by one of the greatest architects of his time Le Corbusier – the creator of Modulor. The next step was the creation of anthropometric models, thanks to which it was possible to develop individual elements of space fitted to people with different characteristics (Ujma-Wąsowicz, 2005). Over time, such patterns have also been developed for people with disabilities.

Universal design is the trend in design that is strongly connected with the ergonomic. The first time this term was used in the 1970's, but the idea was developing since the early 1960's by architect Ronald L. Mace. Initially in North America and later on in Western Europe and other parts of the world (Antoniszczak, 2020). Universal design arose from the earlier barrier-free concepts (Rawski, 2019). Main assumptions of this idea was stated by The Center for Universal Design at North Carolina State University as seven principles (Centre for Excellence, 1997):

1. **Equitable use** (providing the same means of use for all users),
2. **Flexibility in use** (providing a choice in methods of use),
3. **Simple and intuitive** (eliminating unnecessary complexity and providing consistency with user expectations and intuition),
4. **Perceptible information** (using different modes for additional presentation of essential information and increasing its legibility),
5. **Tolerance for error** (arranging elements of design to minimize risk and errors and providing fail-safe features),
6. **Low physical effort** (allowing the user to maintain a neutral body position with minimum fatigue while using the design),
7. **Size and space for approach and use** (independently from user's body size or mobility provide adequate access, reach and use).

It can be stated that a given place is accessible if we can get to it easily, whether we are fully functional, move in a wheelchair or with a white cane. The essence of the accessibility of a every space is also influenced by the perception of individual places, i.e. the possibility of seeing them from a distance, as well as the way of the arrangement of various objects inside (e.g. shops, public institutions, etc.). On the other hand, the amount of effort that should be put into moving around a given area directly translates into the comfort of its use. Also, whether the elements of equipment such as benches, litter bins or bicycle stands are located so that they do not interfere with the main communication routes. Another element that is worth paying attention to is the way of overcoming height differences. Designers should consider the need of planning landings for stairs or driveways, and the use of escalators, platforms or lifts when the situation requires it. A suitable amount of resting places as well as safety of a place has big a influence on the comfort of its use. Large enough and well-planned parking facilities are also important. This affects the efficient rotation of vehicle traffic. This directly results in increasing the accessibility of a given space. Other crucial aspects are the number of entrances (preferably clearly visible) to a given space and the level of convenience to access public transport.

3.3. General barriers and guidelines

In order to understand the issue of accessibility planning in the process of designing public places, it is necessary to know what elements constitute obstacles. Such barriers can make it hard to carry out many activities for people with special needs that are very normal for fully functional people According to interpretations of the Office of the Government Plenipotentiary for Disabled People[1], such obstacles can be divided into three categories (eBIFRON, 2012):

1 Translated name of Polish institution „Biuro Pełnomocnika Rządu do Spraw Osób Niepełnosprawnych"

- **architectural barriers** – means obstacles inside the building and in its direct vicinity, which, due to technical or constructional solutions prevent or hinder the freedom of movement for disabled people,
- **technical barriers** – are those caused by the lack of application or non-adaptation of items or devices appropriate to the type of disability. The elimination of these barriers should result in the more efficient functioning of disabled persons in society and enable them to better function,
- **communication barriers** – are limitations that prevent or hinder persons with special needs from freely communicating and/or transmitting information.

In some sources[2] one can find slightly different definitions of the concept of "architectural barriers". Despite some divergences, their thematic scope is similar, but they are not sufficient in the context of universal design. Initially, the term was used to refer to people with disabilities, identifying them only with people in wheelchairs. Explanations of this expression were also limited to physical obstacles only, so some elements were not taken into account in the context of the meaning of architectural barriers. A. Zając (2012) proposed a broader view at this definition for the project Warsaw Map of Barriers[3]. According to him, any object in public space that causes mobility problems or limits access for any group of users with special needs, as well as the lack of appropriate amenities, can be a barrier. Thanks to the wide range of the topic, such a definition fits perfectly into the idea of universal design.

For this paper, only outdoor places were taken into account, so interior spaces were excluded from the considerations. Thanks to the appropriate recognition of spatial barriers, it is possible to design new, more accessible spaces or improve already existing ones to be more suited for people with different needs. It can be noticed that in many cases outdoor barriers force people to stay in their houses. Design of public spaces requires having in mind that they should be devoid of architectural and technical barriers. Among them are elements mostly related to the technical conditions of sidewalks, their width as well as aspects that refer to overcoming height difference and placement of space equipment (small architecture). It should be taken into account that many users of public spaces can also drive a car or move around by public transport. For that reason, aside from the availability of the vehicles, a very important thing is the accessible design of bus stops as well as special places at parking lots.

Identifying the elements that may constitute barriers is very important in the context of designing accessible spaces. Thanks to this, it is possible to design alternative spatial solutions or accurately transform places that were not created in accordance with the idea of universal design. Therefore, it is important to have a holistic approach that takes into account all users of the space, not only seniors or disabled people. Barriers in public spaces may be related to communication paths, vertical

[2] e.g. Polish Encyclopedia PWN, Wikipedia, niepelnosprawni.pl, Encyklopedia WIEM – zapytaj.onet.pl, mapabarier.sisko.waw.pl

[3] Authors' translation from Polish 'Warszawska Mapa Barier'

communication (moving between different heights), space equipment, and elements related to road infrastructure (Zając et al., 2013). By recognizing them and applying appropriate design guidelines (developed on the basis of anthropometric patterns), one can design a barrier-free space. The table 3.1. below lists typical barriers and spatial solutions that increase accessibility.

TABLE 3.1. Typical barriers and spatial solutions (Source: own elaboration based on Rawski, 2017)

Type	Typical barriers	Solutions
Communication paths	• bad technical condition; • unhardened surface; • uneven or too slippery surface; • too narrow sidewalks; • lack of tactile paving for blind people.	• the transverse slope should not exceed 2%, and the longitudinal slope should not exceed 6% (preferably 5%)(Kowalski, 2010); • the surface should exclude the possibility of stumbling or slipping (Czarnecki & Siemiński 2004); • used materials should be durable and ensure the good technical condition of sidewalks; • tactile surfaces (directional or warning) should be used for the blind in functional places; • main pedestrian ways should be planned straight and turns should be as close to right angles as possible; • the width of the routes with greater traffic in both directions should be at least 200 cm (Kowalski, 2011); • the width of sidewalks should be 150 cm (due to the size of wheelchairs), segments 120 cm wide should not exceed 20 m in length (Kowalski, 2018).
Vertical communication	• lack of ramps or elevators at stairs; • too steep wheelchair ramps; • unmarked lower and upper edges of stairs; • no handrail at stairs; • construction of steps in areas with a slight difference in terrain; • bad technical condition.	• it is good practice to design (if possible) long slight slopes instead of stairs (single steps should be avoided if stairs are necessary); • the flight of stairs should be min. 1.2 m and the first and last step should be marked with a contrasting stripe; • it is recommended to design a 0.5 m wide zone of touch surface (warning field) 0.6 m – 0.8 m before and after the flight of stairs (PZN, 2009); • if the stairs have more than 10 steps, landings should be used; • the recommended height of the steps is 12 – 15 cm and the width is 35 cm; • if the stairs have a height of more than 0.5 m, railings must be applied; • ramps should be applied near the stairs on the main routes; • the usable width of the ramp should be 120 cm; • if the ramp is longer than 9 m, landings should be designed; • at the end and the beginning of the ramp there should be an even manoeuvre area 1.5 x 1.5 m; • on both sides of the ramp, a handrail should be designed at a height of 75 cm and 90 cm, parallel to its surface (Budny, 2009).

Type	Typical barriers	Solutions
Space equipment	• placement of elements within the sidewalks gauge; • insufficient manoeuvring space nearby the devices or lack of that; • badly designed height of usable elements (too low or too high); • wrongly placed or too weak lighting.	• equipment elements should be grouped in rows parallel to the main axis of the path so that they do not narrow its width (NDA, 2002); • information boards should be placed outside the usable width of pavements; • functional parts of devices should be placed at a maximum height of 130 cm (Nowak & Budny, 2008); • useful information should also be written in Braille, and the space in front of it should be marked with the attention field; • fountains should be separated from pedestrian routes by a green belt or by means of warning elements; • parking meters should be positioned so as to be accessible to disabled people (including manoeuvring spaces for wheelchairs).
Elements related to road infrastructure	• narrow bus stops; • bus stops with unpaved platforms; • badly designed bus bays (access to the edge of the platform is impossible); • lack of low curbs; • unspecified passage through the road; • no warning tactile fields at the pedestrian crossings; • pedestrian crossings without refuge islands on two-way multi-lane roads; • lack of parking places dedicated to the disabled.	• car parks should include wider (3.6 m) parking spaces for disabled people; • curb higher than 2 cm should contain a ramp with a maximum slope of 5% (Kowlaski, 2010); • blind and visually impaired people need tactile warning fields against pedestrian crossings (in a contrasting colour and placed along the street) at least 0.5 m wide; • traffic lights should give an audible signal and include buttons activating green light located at a height of 0.9 m to 1.1 m (Wysocki, 2010); • a warning tactile zone along the entire length of the platform should be 30 or 40 cm wide and 80 cm from the edge of the bus stop; • it is recommended to raise the platform to a height of 20 cm to make it easier for people in wheelchairs to board the bus; • the edge of the platform should be marked with a 7 or 10 cm wide contrasting strip (preferably yellow) along the entire length of the platform (Wysocki, 2012); • the bus stop shelter (approx. 150 – 180 cm deep) should be situated from the warning tactile surface min. 80 cm away to allow the passage of a wheelchair.

3.4. Good practices

Following design guidelines developed by ergonomics specialists is necessary for designing accessible spaces, but often such guidelines are intended to ensure only minimal functionality of individual places. Respecting legal requirements alone is currently not sufficient to design fully accessible spaces. Therefore, the important aspects of this process are the experience and knowledge of the designers themselves. The search and study of realizations that take into account the needs of people with different abilities expand the range of design solutions for every professional. As a result, designers can be able to provide higher-level accessibility – not only for security but also for the functionality of the places. Selected examples of good practices that show how to approach accessibility design in public spaces will be discussed below.

FIG. 3.1. Beach in Bondary near Siemianówka reservoir with accessible feature (Source: photos by K. Rawski, 2018)

As recreational areas, beaches are places that, due to their natural structure, are inaccessible to many people with special needs, in particular for wheelchair users. As shown by the example of one of the Turkish beaches (Fig. 3.1), it is possible to develop the area in such a way that there are additional platforms and ramps enabling easy access to the water. Another example is the device presented below (Fig. 3.2) located on one of the playgrounds in Warsaw. It has been constructed so that it can be used by people who are moving using various aids (including wheelchairs).

FIG. 3.2. Accessible platform and carousel on the playground (Source: WEB-1)

Another good practice related to the design of small architecture is a picnic table with a reserved space for a person in a wheelchair (Fig. 3.3). Thanks to this, such a person will not be excluded from joint participation in a meal or rest.

FIG. 3.3. Accessible picnic table with space for wheelchair (Source: WEB-2)

The relevant issue that was raised in the previous considerations was also the accessibility of public transport. However, in addition to the proper arranged space – the width of the platform, the marking of its edges, and the location of the bus shelter, it is also important to ensure that such a place is properly lit after dark (Fig. 3.4).

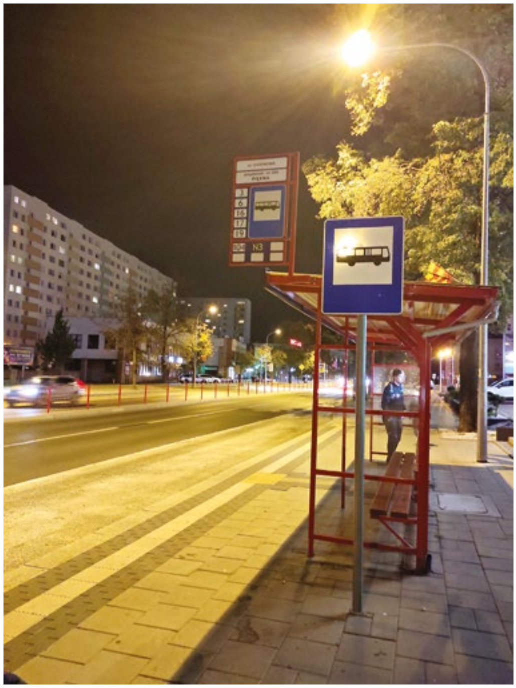


FIG. 3.4. **Well illuminated bus stop at night with tactile surface (Source: photos by K. Rawski, 2020)**

3.5. Summary

There is a noticeable increase in the awareness of the needs of people with various abilities related to their functioning in public spaces. Thanks to this, one can notice a gradual change in the surroundings, in particular in public buildings, as well as in the generally understood urban space. One can also find many places that require further transformations so that they can be freely used by such people. But still there are many remedies which solve the problem only partly for economic reasons (Kowalski, 2013).

Good practices included in this publication show that a properly designed communication system and compliance with the appropriate guidelines (contained in the law and literature of the subject) results in planning a well accessible space. Making public space more accessible contributes to improving the quality of life for people with different abilities and that have mobility problems with normal everyday functioning.

References

1. Antoniszczak M. (2020) *Wpływ ruchów społecznych na rozwój projektowania uniwersalnego*, Formy, nr 4/2020 [Online] https://formy.xyz/artykul/wplyw-ruchow-spolecznych-na-rozwoj-projektowania-uniwersalnego [Accessed: 8.10.2020]
2. Budny J., (2009) *Dostosowanie budynków użyteczności publicznej – teoria i narzędzia*, Stowarzyszenie Przyjaciół Integracji, Warszawa
3. Centre for Excellence in Universal Design, 1997, *The 7 Principles of Universal Design*, [Online] http://universaldesign.ie/What-is-Universal-Design/The-7-Principles/ [Accessed: 11.10.2020]
4. Czarnecki B., Siemiński W. (2004) *Kształtowanie bezpiecznej przestrzeni publicznej*, Difin, Warszawa
5. eBIFRON NUMER 1/2012 - ABC osoby niepełnosprawnej, *Bariery do pokonania*, [Online] http://www.pfron.org.pl/ebi/poprzednie-wydania/numer-12012-abc-osoby/pomoc-osobie-niepelnos/53,Barierydopokonania.html [Accessed: 21.09.2016]
6. Grandjean E. (1978) *Ergonomia mieszkania, aspekty fizjologiczne i psychologiczne w projektowaniu*, Arkady, Warszawa
7. Kowalski K. (2013) *Planowanie dostępności – polskie uwarunkowania prawne i praktyka*, Niepełnosprawność – zagadnienia, problemy, rozwiązania. Nr I/2013(6). s. 77
8. Kowalski K. (2010) *Projektowanie bez barier – wytyczne*, Stowarzyszenie Przyjaciół Integracji, Warszawa
9. Kowalski K. (2011) *Planowanie dostępności – prawo w praktyce*, Stowarzyszenie Przyjaciół Integracji, Warszawa
10. Kowlaski K. (2018) *Włącznik – projektowanie bez barier*, Fundacja Integracja, Warszawa
11. Kuryłowicz E. (2005) *Projektowanie Uniwersalne. Uwarunkowania architektoniczne kształtowania otoczenia wybudowanego przyjaznego dla osób niepełnosprawnych*, Warszawa, Stowarzyszenie Przyjaciół Integracji, s. 20–40
12. Ministerstwo Inwestycji i Rozwoju (2018) *Program rządowy „Dostępność plus*”, Warszawa
13. NDA (2002) *Building for Everyone: Inclusion, Access and Use*, National Disability Authority, Dublin
14. Nowak E., Budny J. (2008) *Mieszkanie dostępne dla osób z dysfunkcją narządu ruchu*, Stowarzyszenie Przyjaciół Integracji, Warszawa
15. Polski Związek Niewidomych (2009) *Osoby niewidome i słabo widzące w przestrzeni publicznej*, Warszawa
16. Rawski K. (2017) *Public space without architectural barriers as friendly and accessible for people with disabilities*, Teka Komisji Architektury, Urbanistyki i Studiów Krajobrazowych PAN, 45–52
17. Rawski K. (2019) *Postawy społeczne wobec osób niepełnosprawnych a projektowanie przestrzeni dostępnej*, Architektura Krajobrazu, 1/2019, s. 34–51
18. Ujma-Wąsowicz K. (2005) *Ergonomia w architekturze*, Wydawnictwo Politechniki Śląskiej, Gliwice, s. 23–28
19. WEB-1: bo.um.warszawa [Online] photo of Maksymilian Chołuj Retrieved from: bo.um.warszawa.pl [Accessed: 10.10.2020]

20. WEB-2: havinghome [Online] Retrieved from: http://havinghome.com/ [Accessed: 10.09.2020]
21. Wysocki M. (2010) *Projektowanie otoczenia dla osób niewidomych. Pozawzrokowa percepcja przestrzeni*, Wydawnictwo Politechniki Gdańskiej, Gdańsk
22. Wysocki M. (2012) *Standardy dostępności dla miasta Gdyni*, Gdynia
23. Zając A. P. (2012) *Miasto barier. Bariery architektoniczne na podstawie projektu Warszawska Mapa Barier*, Instytut Socjologii UW, SISKOM, [online] http://mapabarier.siskom.waw.pl/wp-content/uploads/2012/05/Zajac_bariery_architektoniczne_KMS2012.pdf [Accessed: 12.10.2020]
24. Zając A. P., Dębska M., Kowalski R., Pietrzyk P., Rak. A., Zakrzewski M. (2013) *Diagnoza głównych barier architektonicznych w przestrzeni publicznej Warszawy* – Raport *SISKOM*, SISKOM, Warszawa

DOI: 10.24427/978-83-66391-62-8_4

4. ADAPTATION OF SMALL ARCHITECTURAL OBJECTS AND GREEN INFRASTRUCTURES FOR SUSTAINABLE DEVELOPMENT IN URBAN PUBLIC SPACES

Alejandra Vidales Barriguete, María Aurora Flórez de la Colina

4.1. Sustainable development

The alarming data on the massive population increase and pollution and waste generation alerted the international community so much that, in 1972, the United Nations Conference on the Human Environment convened in Stockholm, Sweden (United Nations, 1972).

From that moment, there began the implementation of criteria and common principles surrounding environmental matters which require collaboration between nations, as well as the adoption of international measures in order to serve the public interest. Not until 1987, with the publication of the Brundtland Report – *Our Common Future*, did the concept of **sustainable development** be defined as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (United Nations, 1987). The report outlines the relationship between environment, economy, and society and the need to find effective procedures to reverse the negative environmental consequences of industrialization, globalization, and population growth (Vidales Barriguete, 2019).

Based on this, we can consider there to be 3 fundamental pillars of sustainability: environmental sustainability, economic sustainability, and social sustainability (WEB-1) (Fig. 4.1).

- Environmental sustainability: supports the reasonable use of natural resources and the protection of nature. It is committed to the conservation of water, use of renewable energies, reduction of pollution, promotion of recycling, extension of green areas, implementation of sustainable mobility and construction, etc.

- Economic sustainability: focuses on the promotion of equitable wealth whilst also taking care of natural resources.
- Social sustainability: promotes not only the development of people but also of communities and cultures; trying to improve quality of life achieve gender equality and adequate and fair health, labor, and education systems.

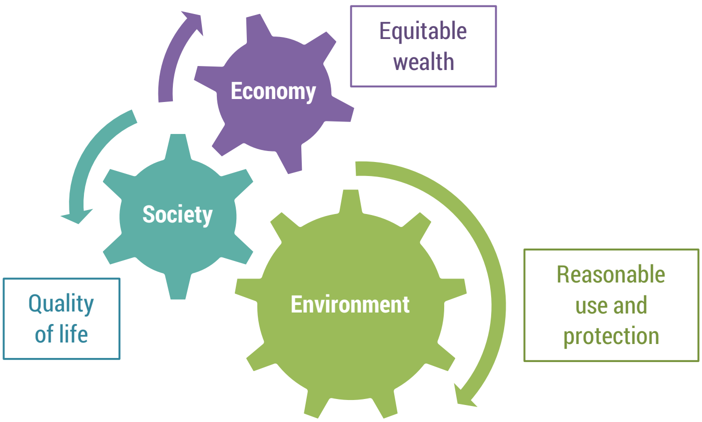


FIG. 4.1. **The pillars of sustainability (Source: A. Vidales, 2020)**

The Sustainable Development Goals, or Global Goals, adopted by all Member States, were created as a call to all countries *to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030* (United Nations, 2020).

4.1.1. 2030 Agenda

On September 25, 2015, 193 countries signed the agreement to fulfill, by 2030, the 17 Sustainable Development Goals (SDGs) formulated by the United Nations (Fig. 4.2) (Ministerio de Derechos Sociales y Agenda 2030, 2020).

For the duration of 15 years (2015–2030), countries involved must undertake the necessary means to achieve the implementation of the SDGs. They must not only rely on public administrations (responsible for basic and common structures), but also on the private sector (creator of shared value) and civil society (responsible for the legacy of a prosperous future) (Comunidad Por El Clima, 2020).

As such, each country implements its own political strategies to achieve the SDGs in order to protect the common good and ensure the well-being of its people. For example, promoting energy efficiency and renewable energies; creating new regional regulations, strategic frameworks and action plans to the boost circular economy; developing new Urban Agendas with more sustainable social and environmental models; raising the minimum inter-professional wage; creating social bonds; establishing equal opportunities; etc.

FIG. 4.2. **Sustainable Development Goals. (Source: United Nations Development Programme, ...)**

The 17 SDGs are all inter-related. Moreover, they are divided into 169 objectives in such a way that the successful completion of one is intrinsically linked to the achievement of others. These goals are reflected in the following summary (WEB-1):

- Elimination of poverty and hunger, improving quality of life.
- Increase in access to basic services such as water, sanitation, and sustainable energy.
- Advocacy for inclusive education and fair work.
- Promotion of innovation and generation of reinforced infrastructure in communities and cities with sustainable consumption and production.
- Minimization of inequalities in the world (social, gender, economic...).
- Protection of the environment, combating climate change, and caring for the oceans and terrestrial ecosystems.
- Creation of a peaceful environment and sustainable development with the collaboration of the different social agents.

4.1.2. Sustainable cities

There is no doubt that cities are the key to achieving many of the Sustainable Development Goals. Approximately 56% of the world's population lives in large cities (over 4 billion people), and it is estimated that this number will increase by a further 10% in just 25 years. In many cases, this has led to the uncontrolled expansion of urban areas, with basic services and the infrastructures necessary for development and a good citizen quality of life not being taken into account. For example, it is worth noting that even though cities only occupy 3% of the world, they are responsible for up to 70% of all greenhouse gases and account for between 60% to 80% of energy consumption (Iberdrola, 2020).

It is, therefore primordial that we rethink urban management models and their planning in order to create spaces that are more in line with the **eleventh Sustainable Development Goal: "Sustainable Cities and Communities".** This involves ensuring cities be safer, more inclusive, and have resilient models in which production and consumption are sustainable and in which the real needs of citizens and their socio--cultural relations, etc. are analyzed (Fig. 4.3).

FIG. 4.3. University area in Vienna – Austria (Source: photos by A. Vidales, 2020)

There is a Sustainable Cities Index, created by ARCADIS in collaboration with the United Nations Program Human Settlements Programme (UN-Habitat), whose biannual report is based on the analysis of the 3 fundamental pillars of sustainability mentioned in section 1.1:

- Environmental: factors for pollution, emissions, energy used, recycling and composting rates, mobility, etc.
- Economic: factors for the business environment, possibility of starting a business, health of the economy, tourism, employment rates, etc.
- Social: factors for quality of life, life expectancy, dependency, crime, obesity rates, etc.

This index considers that a city is sustainable when the 3 requirements are met. There is no point in having a very "green" city with good relations between neighbors if the city does not also have any possibility of creating business or finding work, since there would not be an adequate quality of life for the inhabitants and long-term sustainability would not be possible. Among the most sustainable cities are Zurich, a solid, liveable city that is committed to urban ecology; Singapore, which despite its almost 6 million inhabitants has focused on mobility and aims to have 80% of its buildings sustainable; Stockholm, which stands out for the Hammarby Sjöstad neighborhood, a former industrial area now reconverted, which also has a sustainable water, energy and waste management system; London, for its great economic opportunities and its environmental initiatives; and Amsterdam, for its continuous investment in improving the quality of life of its inhabitants and reducing emissions (Arcadis, 2018).

4.2. Sustainable trends in public places

The main purpose of the eleventh Sustainable Development Goal "Sustainable Cities and Communities", is to achieve public spaces that contribute to ensuring that all citizens have *access to safe and affordable housing and basic services* (Pont, 2020). In general, cities have better opportunities related to these basic services (education or health), better communication and technology systems, and more job opportunities. However, this does not mean that improvements in these fields are not needed.

Public spaces in cities are a very important part of our daily lives. We use them constantly and they support many social and cultural activities and meetings. Therefore, it is necessary to reflect on these spaces, on their needs, on their shortcomings (Fig. 4.4), on the factors that give them identity, and on the elements that make them up (Bonells, 2016). All this should be considered with the future of the next generations in mind.

FIG. 4.4. **Left: Bicycle "resting" on a park bench. Right: Backpacks "sitting" on a park bench (Source: photos by Alejandra Vidales; in Vienna – Austria, 2020)**

This is where sustainability becomes important as a mechanism for the development of public spaces. Water, vegetation, energies used, accessibility, and materials used in the creation of public areas must be related to, and interact with, life.

4.2.1. Green and blue infrastructures

The European Commission's Communication *Green Infrastructure* (*GI*) – *Enhancing Europe's Natural Capital*, refers to these infrastructures as a *strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. It includes green spaces (or blue spaces in the case of aquatic ecosystems) and other physical elements in terrestrial (natural, rural, and urban) and marine areas*" (Comision Europea, 2013).

The concept of green and blue infrastructure is targeted at making the concept of gray infrastructure disappear. The latter includes traditional transport structures such as roads or airports; the distribution of services such as water and gas networks or solid waste facilities; social spaces such as schools and hospitals or sports areas; and commercial facilities such as quarries, factories, or offices (Magdaleno Mas, Cortés Sánchez, Molina Martin, 2018).

Moreover, the objective of the green and blue infrastructure is to improve the environment in order to obtain improved goods and services in the ecosystem. **Green infrastructure** offers solutions not only to environmental problems (environmental conservation, adaptation to climate change) but also to social problems (water distribution, pollution reduction, green areas in urban spaces) and/or economic problems (job creation).

Blue infrastructure is related to water, its planning and management, and the ecosystems related to it (Fig. 4.5).

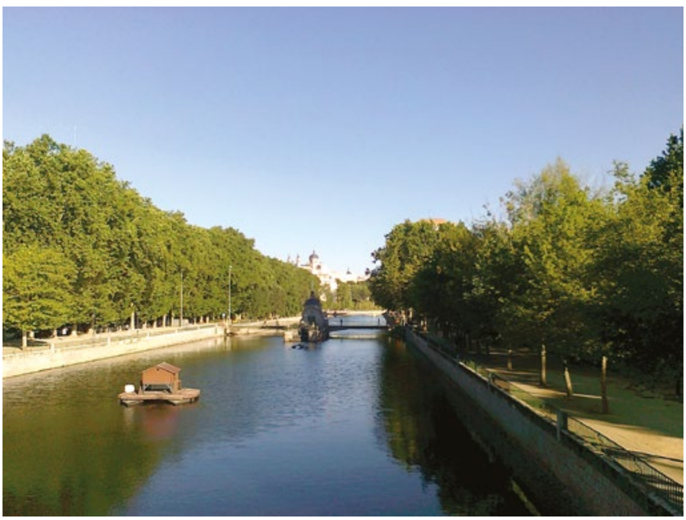


FIG. 4.5. The river corridor 'Manzanares' in Madrid, Spain (Source: photos by Mª A. Flórez de la Colina, 2012)

4.2.2. Biophilia

Direct contact with elements of nature produces great benefits for human mental, physical and emotional health. There are many studies that have shown this fact. There are also many practices that have been based on this: from recovery rooms overlooking a wooded area having been found to help with quicker recovery in their patients, and stays in hospital rooms with more sunshine leading to a reduction in the time spent hospitalized, to indoor gardens making children forget that they are hospitalized (Rosales Pérez, 2019).

The concept of **biophilia** may be defined as the integration of elements of nature in interior or exterior areas, with the goal of evoking the essence of being in nature (Fig. 4.6). The objective is to ultimately make individuals feel better and allow them to find new connections with their space through the use of their senses (smell, sounds, humidity, temperature...) (Seguí, 2020).

However, as with any green area being utilized by humans, it needs to be maintained. An example of this is the refurbishment of the main lobby at the long-standing Atocha station in Madrid which saw the installation of large plants and trees in addition to a pond. The refitting illustrates the problems that can occur: from the lack of acclimatization of some species that had been initially selected for the green zone, to other more unpredictable problems such as the need to periodically remove some abandoned pets from the pond.

FIG. 4.6. **Left: Green Wall, Caixa Forum. Right: Inside Atocha railway station, Madrid, Spain (Source: photos by Mª A. Flórez de la Colina, 2017)**

The strategy is to incorporate, in the space, elements of nature, such as water, natural light, vegetation, wood, or stone. Moreover, in the creation of such spaces, biophilia looks to use as many possible shapes that living or inert beings can create so that there is also a direct visual connection with the environment (Stouhi, 2019). For example, tree trunks, butterfly wings, mountains or the movement of water, are references commonly used in this philosophy.

4.2.3. Placemaking

Placemaking consists of transforming a space into an area. It is done for and by local residents (artists, activists, entrepreneurs...) and in collaboration with the public administration and private sector (Fig. 4.7).

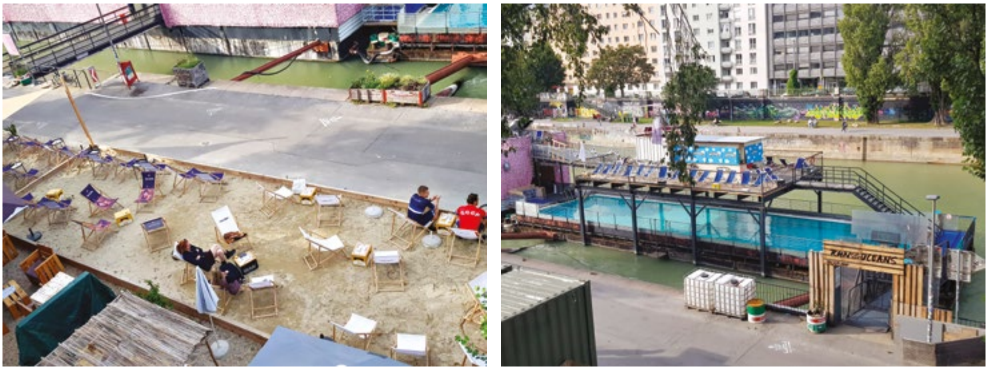


FIG. 4.7. Beach area (left); pool area and drinks area (right) – Vienna Donaukanal, Austria (Source: photos by Alejandra Vidales, 2020)

Firstly, an urban strategy is established, in which the thematic focuses are identified, the proposal and the objectives of the project are made clear, the ideas for the areas of intervention are developed and, of course, the actions are coordinated with public and private organizations. Secondly, the project is implemented, with an open call for people, projects, and cooperation workshops.

This strategy maintains that design and architecture alone do not create large public spaces. The support of bureaucracy is needed to allow innovation and activation in public areas (Krebs, 2020) and the participation of public and private entities, as well as the spaces' users is also needed.

4.3. Sustainable design strategies for small urban architectural objects in public spaces

The previously mentioned approaches are reflected in the wide variety of elements that occupy urban public spaces. The design of these spaces has been the incorporation elements linked to the technical needs related to the different types of infrastructure required in a modern city. However, it has also been adhering to other criteria, such as the potential for greater use, the extent of the spaces' functionality, its energy-saving potential, the use of recyclable materials, and the incorporation of more green elements to them.

The creation of new urban green spaces is fundamental in reducing the carbon footprint caused by cities. In Madrid, the Madrid-Rio project made a large financial investment to improve basic infrastructure in the city, which had been damaged by the creation of an urban freeway, the M-30. A very important section of this expressway was buried in the south of the city, freeing up a large amount of space near the Manzanares river, most of which was refurbished to be green areas, or to be used for sports or leisure. The cultural recovery of historical spaces whose image had been damaged by the creation of this main urban road, was not initially supported by some social groups who estimated that the cost of intervention would be very high. However, with the passing of time and the eventual use of these historic spaces, many changed their minds (Flórez de la Colina, 2016).

Prior to this intervention, the riverbanks had already been cleaned and treated, with there also being the establishment of a floodgate system which allowed water to be dammed. This subsequently created a very convenient microclimate on the banks, since part of the water evaporated due to the very dry climate of Madrid, which became especially dry in the summer months. The reflection of the water also improved the aesthetic appeal of the engineering and architectural work found along the riverbank (Fig. 4.8).

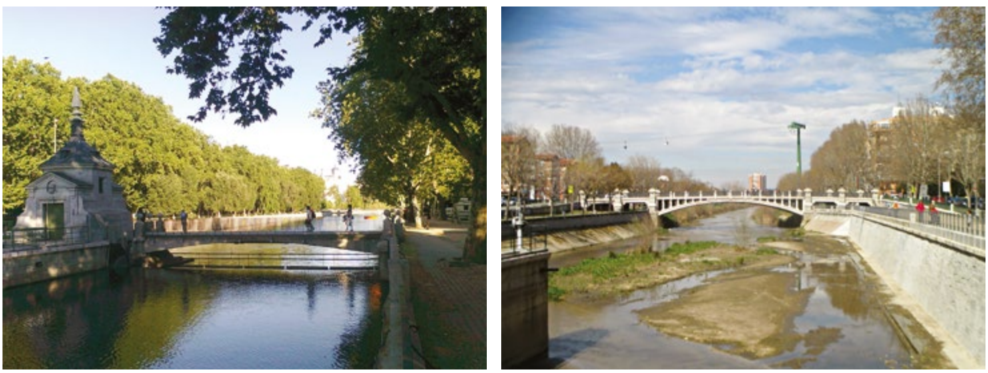


FIG. 4.8. **Riverbanks of the Manzanares river, near Queen Victoria bridge, Madrid, Spain. Left: 2012, with the reflection of the water. Right: 2019, with sandbanks in the riverbed (Source: photos by Mª A. Flórez de la Colina, 2012 and 2019)**

The lack of maintenance of the floodgates due to a motivation to save money and a municipal policy that promoted a "greater naturalization of the river", changed the river's image. Now, the riverbed has sandbanks and small islands with reeds that contribute to the increasing presence of birds and insects, even in this urban area.

Special care has been taken in the design of objects that are used to refurbish this new urban green space in Madrid. The new infrastructures vary with the biggest being the new bridges and pedestrian walkways, like the one created by French architect Dominique Perrault in Arganzuela, inaugurated in 2011 (WEB-2) or the "Shell Bridge" in Matadero, by West 8 and Burgos+Garrido, Porras+LaCasta, and Rubio & Álvarez-Sala, with mosaics by Daniel Canogar (WEB-3) one of the two new twin footbridges that join both banks of the river Manzanares (Fig. 4.9).

FIG. 4.9. **New bridges and footbridges in Manzanares river, Madrid, Spain. Left: Bridge designed by D. Perrault. Right: Bridge with mosaics near Matadero (Source: photos by Mª Aurora Flórez de la Colina, 2019)**

Smaller objets in these public spaces consist of playground equipment, information panels, and the evacuation and ventilation systems used for the tunnels (Fig. 4.10 and 4.11). For these smaller objects, sustainable materials have been used: steel, granite from the mountains near Madrid, as well as wood, are the most commonly used. They contrast, for example, with the plastic that was previously used in children's playgrounds and which is currently being reduced.

FIG. 4.10. **Madrid-Rio Project, small objects located in the new public space, in Madrid, Spain. Left: Infrastructure and fountains with granite stone. Right: Emergency exit from underground tunnel (Source: photos by Mª A. Flórez de la Colina, 2019)**

FIG. 4.11. **Madrid-Rio Rio Project, small objects located in the new public space, in Madrid, Spain. Left: Children playground: information panel. Right: Children playground: steel and wood (Source: photos by Mª A. Flórez de la Colina, 2019)**

References

1. Arcadis, Centre for Economics and Business Research (2018) Citizen Centric Cities. The Sustainable Cities Index 2018, *Arcadis design and consultancy for natural and built assets*, UK. Available: https://www.arcadis.com/media/1/D/5/%7B1D5AE7E2-A348-4B6E-B1D7-6D94FA7D7567%7DSustainable_Cities_Index_2018_Arcadis.pdf
2. Bonells, J. E. (2016) Arquitectura y espacio público urbano, *Jardines sin fronteras*, Available: https://jardinessinfronteras.com/2016/12/10/arquitectura-y-espacio-publico-urbano/ [Accessed: 12.10.2020]
3. COMISIÓN EUROPEA (2013) Infraestructura verde: mejora del capital natural de Europa, Bruselas, 6.5.2013. *Comunicación de la Comisión al Parlamento Europeo, al Consejo, al Comité Económico y Social Europeo y al Comité de las Regiones,* p.3, Available: https://eur-lex.europa.eu/resource.html?uri=cellar:d41348f2-01d5-4abe-b817--4c73e6f1b2df.0008.03/DOC_1&format=PDF. Cited in: Ministerio para la transición ecológica y el reto demográfico (2020), *Estrategia Estatal de Infraestructura Verde y de la Conectividad y Restauración Ecológicas* [Accessed: 12.10.2020]
4. Comunidad Por El Clima (2020) ¿Qué es la Agenda 2030? Available: https://porelclima.es/equipo/2592-agenda-2030 [Accessed: 12.-10.2020]
5. Fernández, R. (2019) Porcentaje mundial de población residente en áreas urbanas de 1985 a 2050," *Statista,* Available: https://es.statista.com/estadisticas/635368/porcentaje-de-poblacion-areas-urbanas-del-mundo/ [Accessed: 12.10.2020]
6. Flórez de la Colina, M.A. (2016) Sustainable Development of Historic Cities: Rediscovering Madrid's Urban Facade from its River, *Procedia Engineering* 161:1965–1970. World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium 2016, WMCAUS 2016. DOI: 10.1016/j.proeng.2016.08.787. Available: https://www.sciencedirect.com/science/article/pii/S1877705816330168 [Accessed: 12.10.2020]
7. Iberdrola, (2020) *Te descubrimos las ciudades más sostenibles del mundo* Available: https://www.iberdrola.com/medio-ambiente/ciudades-sostenibles [Accessed: 12.10.2020]

8. Krebs, R. (2020) Transform from ‘ space’ to ‘place,’ *Training School COST RESTORE*, Vienna (Austria)
9. Magdaleno Mas, F., Cortés Sánchez, F. M. and Molina Martín, B. (2018) Infraestructuras verdes y azules: estrategias de adaptación y mitigación ante el cambio climático Green and Blue Infrastructures: Adaptation and Mitigation Strategies to Climate Change, *Ing. Civ.*, 191, 105–112. Available: http://193.145.71.12/index.php/ingenieria-civil/article/view/2350 [Accessed: 12.10.2020]
10. *Ministerio de Derechos Sociales y Agenda 2030, Objetivos de desarrollo sostenible* (2020) Available: https://www.agenda2030.gob.es/objetivos/home.htm [Accessed: 12.10.2020]
11. Pont, E. (2020) En marcha hacia unas ciudades y comunidades más sostenibles, *La Vanguardia*
12. Rosales Pérez, N. de J. (2019) *Arquitectura y Biofilia. Percepción del espacio laboral universitario*, Tesis Doctoral, Universidad Autónoma de San Luis de Potosí (México)
13. Seguí, P. (2020) El diseño biofílico. El poder de la arquitectura y la naturaleza., *Ovacen*, vol., p.. [Online]. Español / Spanish. Available: https://ovacen.com/el-diseno-biofilico-el-poder-de-la-arquitectura-y-la-naturaleza/ [Accessed: 12.10.2020]
14. Stouhi, D. (2019) Aire y naturaleza en el interior: beneficios de la biofilia en la arquitectura, *Plataformaarquitectura*, Available: https://www.plataformaarquitectura.cl/cl/927694/aire-en-el-interior-beneficios-de-la-biofilia-en-la-arquitectura [Accessed: 12.10.2020]
15. UNITED NATIONS (1972) International Conference, *Report of the United Nations Conference on the Human Environment*, Stockholm, 5–18 June 1972. Available: https://www.un.org/ga/search/view_doc.asp?symbol=A/CONF.48/14/REV [Accessed: 12.10.2020]
16. UNITED NATIONS (1987) General Assembly, *Part I. Common Concerns. 2.Towards sustainable development. The concept of sustainable development.* In *Brundtland Report: Our Common Future,* Report of the World Commission on Environment and Development, Governing Council of the United Nations Environment Programme, Fourteenth session held at Nairobi from 8 to 19 June 1987. Available: https://undocs.org/en/A/42/427 [Accessed: 12.10.2020]
17. UNITED NATIONS (2020) Development Programme, *Sustainable Development Goals*, Available: https://www.undp.org/content/undp/en/home/sustainable-development-goals.html [Accessed: 12.10.2020]
18. Vidales Barriguete, A. (2019) *Caracterización fisicoquímica y aplicaciones de yeso con adición de residuo plástico de cables mediante criterios de economía circular*, Tesis Doctoral, Universidad Politécnica de Madrid (España)
19. WEB-1 Acciona, “¿Qué es el desarrollo sostenible?,” Article in Acciona website, 2020. Available: https://www.acciona.com/es/desarrollo-sostenible/ [Accessed: 12.10.2020]
20. WEB-2 Ayuntamiento de Madrid, “Puente Monumental Parque de Arganzuela”. [Online]. Spanish / Español. On line article in *Bienvenidos a Madrid (página oficial de turismo)* Website. Available: https://www.esmadrid.com/informacion-turistica/puente-monumental-parque-dearganzuela?utm_referrer=https%3A%2F%2Fwww.google.com%2F [Accessed: 12.10.2020]
21. WEB-3 Arquitecturaenacero, “Puente Cáscara Matadero Madrid Rio”. *Simón García, fotografía de arquitectura* Available: https://www.arqfoto.com/puente-cascara-matadero-madrid-rio/ [Accessed: 12-10-2020]; Acciona, “Proyecto de Pasarelas Gemelas sobre el río Manzanares en Madrid, España” Available: https://www.youtube.com/watch?v=GVLo1oGJJHA/ [Accessed: 12.10.2020]

DOI: 10.24427/978-83-66391-62-8_5

5. THE CIRCULAR ECONOMY APPLIED TO ARCHITECTURAL ELEMENTS IN PUBLIC AREAS

Alejandra Vidales Barriguete

5.1. Background of the circular economy

From the dawn of humanity up until the onset of the Industrial Revolution, the use of existing natural resources from the surrounding world caused very little environmental impact. Raw materials were extracted and waste returned in quantities that nature itself was capable of absorbing through natural cycles (Vidales Barriguete, 2016).

The problem began to take on an alarming scale in the 20th century, and more specifically from the final quarter of the century onwards, with *"the emergence of an economy based on consumption, a throwaway culture"* (UNED, 2016). Alongside the major changes brought about by technological progress, this has caused a serious environmental impact. *"The use of materials around the world has multiplied tenfold since 1900, and could double again by 2030"* (San juán-Barbudo, 2016).

Following the World Commission on Environment and Development (WCED), which in 1987 presented what is known as the Brundtland Report, "Our Common Future", the EU changed its approach with regard to sustainable development. This idea represents a radical change in the perception of sustainability, understood as a balance between society and its surroundings, providing the initial basis for efforts through a series of programmes, agreements, activities, partnerships, etc., which have arisen in an attempt to provide solutions to existing environmental problems.

Having moved into the 21st century *"we face one of the greatest challenges of humanity: to achieve a truly sustainable global model"* (Barrón Ruiz, 2016). Our environmental awareness is awakening, with constant commitments *"to new ideas, to different formulae which will, when combined with imagination, fairness and resilience, plot courses towards another possible world"* (Novo Villaverde, 2006). This involves a change in attitude with regard to our predominant economic model.

The transition towards the model of a circular economy is a priority in European Union policies. The idea is to make our society efficient in the use of resources, generating less waste, while wherever possible reusing any waste that cannot be avoided as a resource (Secretaría de Estado y Medio Ambiente, 2016). It is here that innovation becomes a key element, not only in the incorporation of new technologies and business models, but also in integrating the circular economy within education, one of the factors responsible for shaping the consciousness of new generations (Espaliat Canu, 2017).

5.1.1. The circular economy model

Right now *the linear system of our economic model (extraction, manufacturing, use and elimination) has reached its limits, or is about to do so, hence the need to find alternatives* (Moraño Rodríguez, 2016). In response to not only environmental but also social and economic problems which have gradually built up over recent years, we are seeing a change in our economic model, giving rise to a circular economy (Fresneda, 2014).

In the 1990s two figures from the USA, the architect McDonough and chemist Braungart, introduced the concept of "cradle to cradle". This involves the materials used in industrial and commercial processes being considered as nutrients, allowing them to be easily regenerated or returned to the earth (Hermida Balboa, Domínguez Somonte, 2014). Such an archetype proposes the foundations for a new paradigm of intelligent design based on closing the product life-cycle, just as we see in nature: the circular economy (Braungart, McDonough, Bollinger, 2007) (Fig. 5.1).

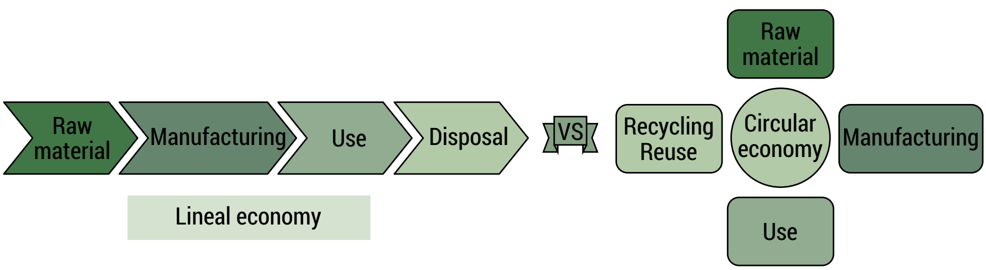


FIG. 5.1. **Linear economy versus circular economy (Source: A. Vidales Barriguete, 2020)**

The circular economy is a concept which aims to rethink how companies manage the production of their goods and services, while at the same time optimising the use of raw materials, water and energy sources. They are encouraged to achieve not only sustainable benefits for themselves, but also for society as a whole.

The key champions of this approach, such as Ellen MacArthur, a leading figure behind the model, point out that it goes far beyond recycling. The circular economy involves design and innovation, repurposing resources, opening up new markets, value creation, and even to a great extent job opportunities (Fresneda, 2016).

This philosophy emphasises 3 basic principles (Enciclopedia economica, 2018):

1. Preserve and enhance natural capital: the least possible amount of natural resources should be selected, or renewable resources used, in an attempt to manage finite reserves.
2. Optimise resource performance: the need is to achieve the longest possible product life-cycle. Eco-design plays an important role here, with products not simply being manufactured, but also repaired and/or recycled efficiently.
3. Promote the eco-efficacy of systems: negative external factors in the design must be detected and eliminated, in pursuit of harmony among the agents involved.

Many social and business benefits can be obtained by applying the circular economy model in any field. From the preservation of ecosystems in general, to cost-cutting and energy savings in the production of goods in particular.

5.1.2 The circular economy in construction

The construction sector is no exception. José Ignacio Tertre, the President of RCD Asociación (the Spanish Construction & Demolition Waste Recycling Association), points out that *given the considerable volume produced, the environmental impact and ease of recycling, CDW represents one of the five priority sectors for the EU circular economy Action Plan* (Tertre Torán, 2016).

It is a fact that the way we build has slowly adapted to the needs of each era, in response to a social and economic reality, which now also incorporates "ecological" factors as simply a further requirement (Baño Nieva, Vigil-Escalera del Pozo, 2005).

A circular economy focus in construction represents an opportunity for the design and innovation of new materials (Fig. 5.2). Given the need to maintain the added value of products for as long as possible, it is essential to propose long-lasting materials which also avoid waste generation and landfill (Argiz, 2016).

FIG. 5.2. **Left: Plasterboard with plastic cable waste additives. Right: Cement mortar with mineral wool waste (Source: photos by A. Vidales Barriguete, 2020)**

The circular economy in construction needs to be focused as a new strategy involving all parties:

- Designers: to design projects that extend the useful life of buildings and construction elements as far as possible; incorporate recycled and/or reused materials within such projects; and take into account their maintenance and/or deconstruction.
- Manufacturers: to incorporate recycled materials as a secondary raw material within their products; and provide information about their useful life, and how they can be reused or recycled once this comes to an end.
- Contractors: to play an active part in generating less waste during the construction process; and select suppliers that are committed to sustainability.
- Users: to raise awareness in opting for sustainable solutions.

5.2. Contribution of the circular economy in cities

One effect of following a linear economic model is that cities generate the greatest consumption of natural resources and produce the largest volume of waste and greenhouse gas emissions. The shift in cities to a circular economy awakens and activates the city, contributing not only in environmental terms, but also socially and economically, by making the city:

- Prosperous, with new business opportunities that serve to minimise waste and provide social decongestion.
- Habitable, with a reduction in urban pollution and improvements in the health of the population and their interactions.

FIG. 5.3. Bus stop in the city of Bialystok, Poland (Source: photos by A. Vidales Barriguete, 2020)

- Resilient, by extending the useful life of materials and reducing the use of natural resources. There is also a commitment to the production and distribution of local materials, supported by digital technology (Fenollar, 2020).

This is achieved through a radical change in the way we plan, design, use and convert public spaces (Fig. 5.3). Meanwhile, such an operational approach in cities helps to resolve problems connected with mobility and development, and works towards the 2030 Sustainable Development Goals (SDGs).

It is down to public authorities, by applying the policy mechanisms and instruments available to them, to enable this transition towards a circular economy, since they have in their hands the tool of leadership capable of engaging all other public or private sectors (Ellen Macarthur Foundation, 2019).

5.2.1. Cradle to Cradle (C2C) certification

The term C2C (Cradle to Cradle) refers to the certification mark evaluated and issued by the Environmental Protection Encouragement Agency (EPEA), a German scientific institute (Fig. 5.4). It promotes the circular economy or "closed circuit" concept in business, with the aim that everything should be reused. In the case of a product that is a biological nutrient, it returns to the earth, while technical nutrient products are recycled again and again, to be used as a secondary raw material.

FIG. 5.4. **C2C (Cradle to Cradle) certification mark (Source: WEB-1)**

It all begins with a product (re)design applying the Cradle to Cradle® design protocol, to ensure that products are designed so they can in all cases be recovered through biological or technical cycles. In other words, consideration must be given to the raw materials used in the product manufacturing processes, aiming to select those of a biological nature (nutrients returned to the earth) and optimising these (reducing waste generation); evaluating what can be done with them when they reach the end of their useful life; analysing reduced water and energy usage in manufacturing, and modifying the company's social responsibility strategies. All of which is done without overlooking the conditions that products need to fulfil in terms of usage, health, safety, comfort, appearance, environmental protection, etc. (Tarkett, 2020).

In order to manufacture a product in accordance with the C2C standard, consideration must be given to the three fundamental principles proposed by McDonough and Braungart:

- Waste: the waste obtained when a product has reached the end of its useful life can be converted into a biological nutrient which will again nourish the earth, or be converted into a technical nutrient which is fed back into a new production process.
- Renewable energies: use must be made of the natural energy we have available.
- Diversity: just as the planet has done for millions of years, energy and materials cycles must be closed through interaction among the different agents (industrial operators, consumers and governments), placing value on the diversity of the natural world in order to benefit from it (Prieto-Sandoval, Jaca, Ormazabal, 2017).

C2C certification provides an eco-label demonstrating an organisation's commitment and effort to design eco-products from the perspective of human and environmental health, recyclability or compostability, and manufacturing characteristics (Fig. 5.5).

FIG. 5.5. **C2C certification criteria (Source: WEB-2)**

C2C certification establishes five levels: Basic, Bronze, Silver, Gold and Platinum, thereby allowing applicants to improve their classification in subsequent evaluations. The evaluation criterion take five factors into account (Estévez, 2014):

- Material Health: assessment of the use of positive chemical components, in other words confirmation of the elimination and/or replacement of any component classified as *high-risk* or *non-classifiable*.
- Material Reutilisation: identification of the flows of material generated when the product has reached the end of its useful life. Materials can be reused as a raw material to be fed back into the manufacturing process (technosphere) or as biological nutrients (biosphere).

- Renewable Energy: confirmation that energy use during the life-cycle is as far as possible renewable.
- Water Stewardship: analysis of responsible and efficient water use, and discharge into drainage networks as cleanly as possible.
- Social Fairness: verification that the staff of the organisation are committed to this philosophy, along with companies in the supply and distribution chain.

The effort required to obtain this certificate for a product involves acknowledging not only its functionality or aesthetic appearance, but also its contribution to planetary sustainability.

5.2.2. Biological cycles and technical cycles

It is not always possible for products to be returned to the earth through biological cycles when they reach the end of their useful life, and on occasions, depending on the nature of the material itself, reuse via a technical cycle might be required (Fig. 5.6).

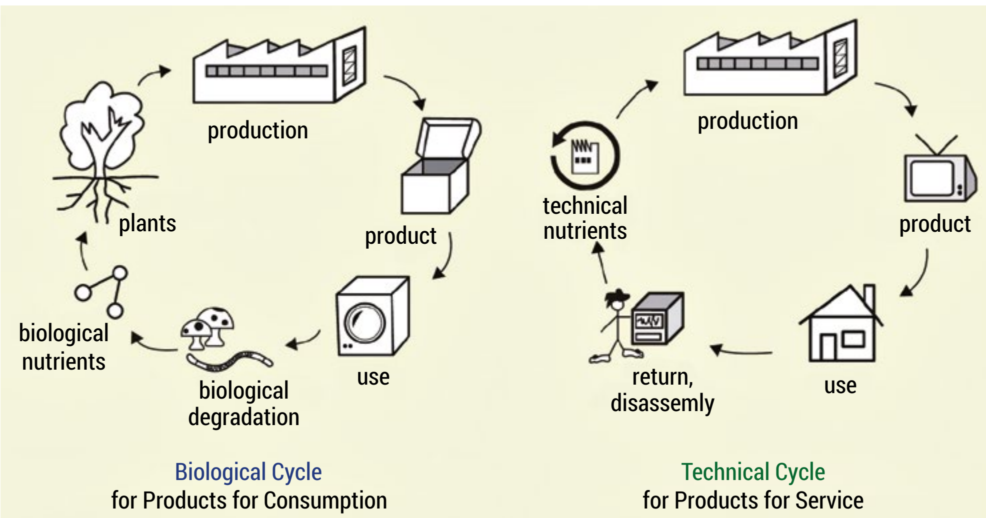


FIG. 5.6. **Biological cycle and Technical cycle (Source: WEB-1)**

In biological cycles, designs are created for biologically based materials such as wood, allowing them to return to the system through processes of composting and/or anaerobic digestion. These cycles regenerate living systems, such as the soil (Ellen Macarthur Foundation, 2017).

In technical cycles, meanwhile, the materials are not suitable to be returned safely to the system, such as plastics or metals, and the design is therefore conducted in order to return them over and over again to the production process for reuse, repair or recycling (Ellen Macarthur Foundation, 2018).

5.3. Circular economy applied to architectural elements in public areas: opportunities

The Urban Agenda of the United Nations, the Urban Agenda for the European Union and the Urban Agendas of each signatory country all aim to achieve the goal of sustainability in urban development policies. Working methods are defined to this end, involving all relevant public and private actors in cities in pursuit of sustainable resource management and support for a circular economy.

The commitment involves fulfilling the 17 Sustainable Development Goals (SDGs) proposed by all the Member States in 2015 in order to achieve a future bringing poverty and inequality to an end, protecting the planet and guaranteeing justice, peace and prosperity by 2030 (ONU, 2020).

The eleventh SDG specifically refers to cities, in pursuit of their sustainability, inclusiveness, safety and resilience.

Public spaces are playing an increasingly important role in society. They serve as a factor identifying a city, and provide platforms for socialisation, gatherings and activity, and so must fulfil suitable conditions for urban living, while successfully maintaining or enhancing the quality of life for their users (Goncalvez, 2011).

On this basis, the urban elements that make up such spaces must also be governed by the same principles as referred to above: resource use and management in selecting these elements, optimal energy efficiency, minimal impact on ecosystems, mobility, accessibility, etc.

FIG. 5.7. **Urban elements in the city of Vienna, Austria (Source: photos by A. Vidales Barriguete, 2020)**

A wide range of urban elements (rubbish bins, panels, street lamps, bus stops, benches, parking meters, etc.) need to be replaced, and should fulfil not only functional criteria, but also sustainability criteria, so as to be able to achieve the goals which have been set.

Companies, designers and users are increasingly committed to this, to protecting the environment, no longer seeing this as an expense, but viewing it as a strategy for savings and corporate social responsibility (Dirección General de Industria Energía y Minas de la Comunidad de Madrid, 2009). Examples would include the use of photovoltaic or wind energy rather than electrical energy, the use of recycled materials, multifunctional design, rainwater collection, etc. (Fig. 5.7). We must remain committed to this approach, since as Leonardo da Vinci said, *"all those that do not find their model or mentor in the natural world are destined to strive in vain"*.

References

1. Argiz, C. (2016) La economía circular en el contexto de las futuras normas de especificaciones de cementos, *Cem. Hormigón*, vol. 976, no. 8
2. Baño Nieva, A., Vigil-Escalera del Pozo, A. (2005) *Guía de construcción sostenible*, Madrid
3. Barrón Ruiz, Á. (2002) Ética, ecología y educación ambiental en el siglo XXI, *La educación y el medio ambiente natural y humano: libro homenaje al profesor Nicolás S. Sosa*, Universidad de Salamanca, 21–38
4. Braungart, M., McDonough, W., Bollinger, A. (2007) Cradle to cradle design: creating healthy emissions – a strategy for ecoeffective product and system design, *J. Clean. Prod.*, vol. 15, no. 13, 1337–1348
5. Dirección General de Industria Energía y Minas de la Comunidad de Madrid (2009) *Guía de mobiliario urbano sostenible con eficiencia energética*, Avaliable: madrid.org.
6. Ellen Macarthur Foundation (2017) Economía circular, *Ellen Macarthur Foundation*, Available: https://www.ellenmacarthurfoundation.org/es/economia-circular/concepto.
7. Ellen Macarthur Foundation (2018) Glossary circular economy, *Ellen Macarthur Foundation,* Available: https://www.circulardesignguide.com/resources#glossary.
8. Ellen Macarthur Foundation (2019) *Economía circular en ciudades: guía de proyecto*
9. Enciclopedia economica (2018) Economía circular, *Encicl. económica*
10. Espaliat Canu, M. (2017) *Introducción a los principios de la economía circular y de la sostenibilidad.* Itelspain, 99
11. Estévez, R. (2014) Registra tus productos con la certificación Cradle to Cradle, *Ecointeligencia*, Available: https://www.ecointeligencia.com/2014/05/certificacion-cradle-to-cradle-c2c/
12. Fenollar (2020) Economía circular en ciudades: pavimento descontaminante Available:https://alfredofenollar.com/economia-circular-pavimentodescontaminante/.
13. Fresneda, C. (2014) La economía circular, *El Mundo*, Londres, 08-Mar-2014
14. Fresneda, C. (2016) Las ciudades serán el motor de la economía circular, *El Mundo*, Barcelona, 26-Nov-2016

15. Goncalvez, P. (2011) Espacios urbanos sustentables, *Apunt. Rev. Digit. Arquit.*
16. Hermida Balboa, C., Domínguez Somonte, M. (2014) Economía circular como marco para el ecodiseño: el modelo ECO-3, *Inf. Técnico*, vol. 78, no. 1, 82–90
17. Moraño Rodríguez, A. J. (2016) Hormigón estructural térmico. Economía circular, *Cem. Hormigón*, vol. 976, no. 8
18. Novo Villaverde, M. (2006) *El desarrollo sostenible: su dimensión ambiental y educativa*. Madrid
19. ONU (2020) Objetivos de desarrollo sostenible, *Programa de las Naciones Unidas para el Desarrollo*, Available: https://www.undp.org/content/undp/es/home/sustainable-development-goals.html.
20. Prieto-Sandoval, V., Jaca, C., Ormazabal, M. (2017) Economía circular: Relación con la evolución del concepto de sostenibilidad y estrategias para su implementación, *Mem. Investig. en Ing.*, no. 15, 85–95 Available: https://www.circulardesignguide.com/resources#glossary
21. Sanjuán-Barbudo, M. Á. (2016) Cemento y hormigón en la economía circular, *Cem. Hormigón*, vol. 976, no. 10
22. Secretaría de Estado y Medio Ambiente (2016) *Plan Estatal Marco de Gestión de Residuos 2016–2022. Ministerio de Agricultura, Alimentación y Medio Ambiente*, 192
23. Tarkett (2020) ¿Qué es cradle to cradle?Available: https://profesional.tarkett.es/
24. Tertre Torán, J. I. (2016) Realizaciones con áridos reciclados, *Cem. Hormigón*, vol. 976, no. 8
25. UNED (2016) *Gestión y tratamiento de los residuos urbanos* Available: https://www2.uned.es/biblioteca/rsu/pagina3.htm
26. Vidales Barriguete, A. (2019) *Caracterización fisicoquímica y aplicaciones de yeso con adición de residuo plástico de cables mediante criterios de economía circular,* Tesis Doctoral, Universidad Politécnica de Madrid doi: 10.20868/UPM.thesis.57437
27. WEB-1 https://2012books.lardbucket.org [Accessed: 10.10.2020]
28. WEB-2 https://www.ecointeligencia.com [Accessed: 10.10.2020]

DOI: 10.24427/978-83-66391-62-8_6

6. PHOTOVOLTAICS AND CONTEMPORARY ARCHITECTURE IN CITYSCAPE

Dorota Gawryluk, Dorota Anna Krawczyk

Introduction

Since ancient times, technologies for building installations have influenced the architectural form. Roman aqueducts in the form of kilometre-long engineering structures shaped the natural, rural and urban landscape. The architectural form of the aqueducts and their exposure in the landscape was motivated by the function of bringing water from springs, usually located in the mountains, to distant cities. The Vitruvian triad: the form, the function and the structure united in an aqueduct testified to their beauty in ancient times. Nowadays, this beauty is also confirmed by the fact that their former functionality of a water supply system has already disappeared (Böhm, 2016).

New installation technologies affect the architectural form in different ways. A distinction should be made between their application to newly designed and existing civil structures. The impact is also different with regard to the scale and location of civil structures. It is of paramount importance that modern technologies and installations should also have, by increasing the functionality of civil structures, a positive impact on their beauty and display in the landscape. It may also be the case that it is selected technologies that determine the shape of the architectural form. When it comes to the logical unification of functions understood by modern installations, appropriate for their optimal operation of the structure ensuring durability and safety of the civil structure and the form determining the aesthetics, the contemporary Vitruvian triad also works.

Today, photovoltaic installations deserve special attention due to their ecological, economic and social importance, including their impact on the city landscape. It is important to be able to install them on a variety of civil structure scales. Numerous investments are being carried out in newly designed or adapted buildings, landscaping elements and public spaces in cities. The work is carried out by designers and engineers of various disciplines. They act alone or in multidisciplinary teams. This has a significant impact on the final result of the project.

It is not difficult to find examples of projects using photovoltaic panels. The energy standard of buildings has been improved, but at the same time their architectural form has been destroyed. In other cases, it happens that the aesthetics of a building overshadows the functionality of the new installation and ultimately reduces its efficiency. The conflicts that have arisen need to be resolved. To this end, it is to be found in the cooperation of designers from various industries, consisting in maintaining compromises of the best conditions for the civil structure (its functionality, structure and beauty).

New and renovated buildings exist in the constructed landscape. Using the "technological" exposure they simultaneously influence their exposure in the city landscape. Hence the need for a design that meets the conditions of both categories of centripetal and centrifugal exposure. This chapter proposes an algorithm of cooperation between an architect and an environmental engineer based on the analysis of the theory of perception, technological conditions for photovoltaic panel installations and selected examples of contemporary projects.

6.1. Contemporary architecture

The Centre Pompidou in Paris is a flagship example of late modernism architecture "talking about structure, technology and movement". The building erected in the 1970s, designed by Richard Rogers and Renzo Piano, became a manifesto of the use of technology and building installations as its essence and therefore the main element of the structure. The form of the building is an orderly emanation of the applied technological solutions. The installations formerly understood as the viscera of the building, have been brought outside and have defined the architectural aesthetics. The architects presented a new approach to design in which the technological sphere of the building was presented in the city landscape as its aesthetic value.

Today, we also find positive examples of modernised and newly designed projects in which the photovoltaic installation plays a significant role in their form, aesthetics and influence on the landscape of public space in the city.

The solutions are implemented on different scales: from the size of the city (e.g. Masdar) or its part (e.g. World Exhibition Pavilions EXPO 2020 in Dubai or Parc del Forum in Barcelona), through individual public or residential buildings, to the scale of landscaping elements

EXPO 2020 in Dubai will open late in 2021 due to the Covid-19 epidemic. Among its numerous pavilions, the Sustainability Pavilion (Fig. 6.1), designed by Grimshaw Architects, will be one of its main, themed ones. The building surrounded by a forest of solar trees will be used as a science museum after the exhibition. Elliptical roofs: the pavilion (120x90m) in the form of a giant funnel and the tree roofs (15x22m) spinning to follow the sun are covered with trapezoidal photovoltaic panels. The spectacular architectural forms designed are a consequence of optimal adaptation to climatic conditions and exposure to the sun. At the same time, they represent an important value for the landscape of the EXPO 2020 exhibition in Dubai (Harrouk, 2020, WEB-1).

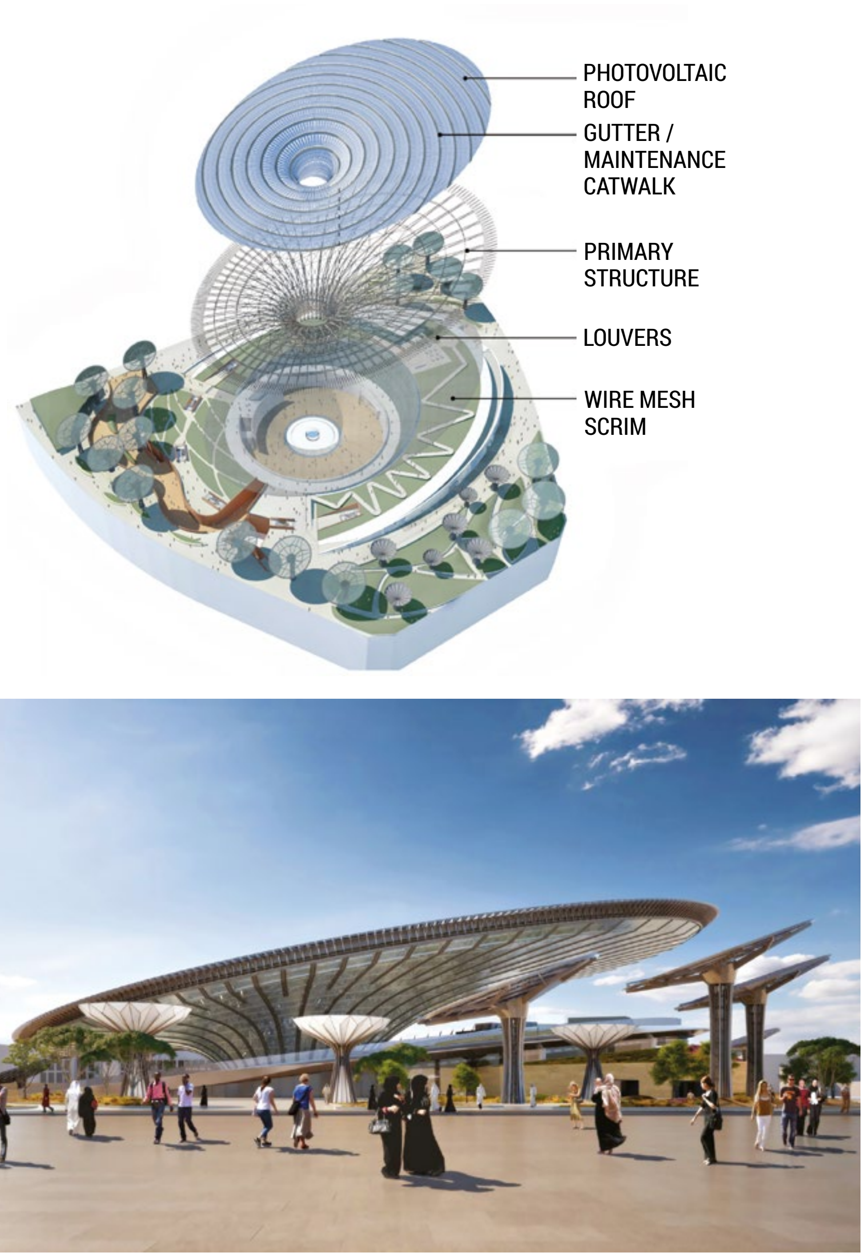


FIG. 6.1. The Sustanability Pavilion, EXPO 2021 (Source: WEB-1, Harrouk, 2020)

Placa Fotovoltaica is a giant pavilion whose roof (approx. 1700 sqm) is fully covered with photovoltaic panels (Fig. 6.2a). The pavilion has become the landmark of Barcelona, due to its unique exposition closing the viewing axis of the square against the sea. The pavilion is a distinctive feature of Parc dela Forum, which was founded in 2004 according to a design by Elias Torres and José Antonio Martínez Lapeña (WEB-1). It is a place for organising various cultural events (e.g. performances, concerts) and spending free time. The complex also includes Bosc de columns ("Forest of Columns") – a civil structure with an area of approx. 15000 sqm consisting of two roofed parts (Fig. 6.2b). It is used to hold various events. Its roof is almost half covered with photovoltaic panels. Significant photovoltaic surfaces of both civil structures have become a characteristic feature of their architectural form.

a b

FIG. 6.2. Parc dela mForum in Barcelona: a – Placa Fotovoltaica, b – Boscde columns "Forest of Columns" (Source: WEB-2)

The Powerhouse Telemark office building (by Snøhetta) built in Porsgrunn is the most energy-efficient building in Norway. It has the form of a diamond, designed to capture and retain solar energy. On the walls of the building 1400 sqm of photovoltaic panels are installed. They are also placed on car and bike shelters. The unique, modern shape of the 11-storey building is the landmark of the city (Bryła, 2020). Selected projects deserve attention mainly because photovoltaic panels have been used in them as an innovative building material with special properties, and not as an element added to finished structures. These are, for example, the bathing pavilion on an island on Lake Steinhuder Meer (Germany) covered with photovoltaic cells on arched roofs (architect Randal Stout, 2006), or the Archaeological Museum in Herne (Germany) by architect Von Buse Klapp Bruning, where skylights have whole roof slopes covered with solar cells (Kuczia, 2020).

An interesting example of the use of photovoltaic panels is the Kawelin Hotel in Białystok (designed by architect Piotr Łodziński and architect Zbigniew Baum). The building is located in a prominent place on Legionowa Street (Fig. 6.3a). Its corner location makes it visible from a considerable distance (Fig. 6.3b). The photovoltaic panels were evenly and radially distributed on the semi-circular roof. The photovoltaic installation placed in the optimal direction for its operation was at the same time linked in terms of composition with the architectural form of the building already at the design stage.

a b

FIG. 6.3. **Białystok, the Kawelin Hotel (Source: photos by D. Gawryluk, 2019)**

The Decathlon chain shop in Olsztyn or KPK (Municipal Transport Company) buildings in Białystok are examples where photovoltaic panels were placed on façades. The modernisation of the buildings in order to reduce electricity costs was carried out with care to preserve the aesthetics of the façade and its legibility in the city landscape. The Decathlon shop in Olsztyn has also created a green wall as an accent of the main entrance. Modern, sustainable technological solutions influence economic benefits and at the same time build a positive corporate image.

a b

FIG. 6.4. **Urban benches: a – Białystok, b – Siemiatycze (Source: photos by D. Gawryluk, 2018)**

Photovoltaics is also a domain of landscaping elements or urban furniture. Benches with photovoltaic panels (e.g. Kosciuszko Square, Bialystok, Siemiatycze) (Fig. 6.4a,b) or roofed stands and lanterns equipped with panels (e.g. Prague Park, the Czech Republic, Sokółka) are pieces of equipment which enable the residents to draw energy obtained by this way free of charge. They are an incentive to spend time in public spaces. At the same time, they are aesthetic pieces of equipment, positively shaping the landscape of a given place.

Solar structures are designed and implemented also for educational purposes. A structure of this kind, presented at the China International Import Expo 2019 in Shanghai, is to be set up in a city park and make the public aware of the possibilities of using solar energy. Similar importance is also attached to the designs of solar walkways for Beijing (WEB-4). The concept of architect Piotr Kuczia was recognised at many competitions (first place at ICONIC Awards, Architecture Masterprize, A'Design, European Product Design Award, MUSE Design Awards). The plan provides for covering the railings of several hundred existing pedestrian walkways with photovoltaic panels. The author proposed solutions ranging from simple to complex parametric forms which could identify city districts. They would become their landmarks. At the same time, they would have an educational function in the use of clean energy in a metropolis struggling with smog (Kuczia, 2020).

6.2. Analysis of spatial conditions in various industries of design

The harmonious equipping of a civil structure with photovoltaic panels requires the cooperation of designers from the architectural and environmental engineering industries. Their work, based on the analysis of various spatial conditions for the industries, should lead to the placement of panels in a way that is optimal in terms of the function of the device (efficiency of its operation) and the aesthetics of the entire civil structure. Hence the need for a compromise between the centrifugal analysis (concerning the efficiency of the solar installation – environmental engineering) and the centripetal analysis (concerning the architecture of the building and its exposure in the landscape – architecture, landscaping).

6.2.1. Conditions for the aesthetic exposure of photovoltaic panels (landscape architecture)

Landscape (aesthetic) exposure of civil structures is examined using tools and methods used in landscaping. In Poland, analyses originating from the Krakow School of Landscaping (Bogdanowski, 1990) are used, such as: sightseeing analysis (Forczek-Brataniec, 2018), landscape absorbency studies and digital land analyses (Ozimek, 2019), passive and active perception of a site in determining for example. the conditions of cultural parks in cities or historical military structures (Böhm, 2016). The research is also conducted on the scale of internal sights, city skyline and panoramas (Czyńska, 2017).

Such analyses and research are intended to prevent the devastation of the landscape and, at the same time, to allow for optimal locations for enclosed building projects. The basic principles they apply to vast panoramas also work well for internal sights of urban public spaces. They are based on ergonomic conditions of the human being and their possibilities of observing the landscape related to the construction of the human eye. The range of view defined by the vertical (30°) and horizontal (10° – sharp viewing angle, 60° – normal viewing angle, 120° – blurred viewing angle) of human vision affects the boundaries of the area of the landscape under analysis (Wejchert, 2009).

6.2.2. Conditions for the functional exposure of photovoltaic panels (environmental engineering)

Proper location of photovoltaic panels has a major impact on the effective acquisition of solar energy. While in the case of large photovoltaic farms, the usage of two-axis trackers, which enable the change of the direction and angle of the inclination of the panels in relation to the sun, depending on the time of day and year, ensures optimal system efficiency, in the case of permanently installed, immovable modules – the choice of their exposure must be carefully considered in advance. The research conducted in this technical point (Wacławek, Rodziewicz, 2011) has shown that optimal radiation absorption can be obtained at the angle of incidence of sunlight to normal to the module within the range of 60–70°. Moreover, in order to maintain a homogeneous current-voltage characteristic of the modules, it is necessary to ensure the operation of the interconnected cells in similar conditions, avoiding shading of some of them by, for example, surrounding buildings or trees. This is often difficult to achieve in urban developments, so at the planning stage it is necessary to analyse the length of the shade at different times of the year. It should also be noted that it is necessary to keep the surface of the panels clean, which may be difficult due to leaves falling on them, dust settling on them, or snow remaining on the surface.

6.2.3. Comparison of conditions

Optimal location of photovoltaic panels on a civil structure should be a compromise of technological and landscape conditions. The functional (centripetal) exposure of photovoltaic cells is related to the cardinal directions of the world (from the east, to south and west) including shading civil structures. The aesthetic (centrifugal) exposure of a civil structure with photovoltaic panels is conditioned by the possibility of observing it in the city landscape. It applies to all the cardinal directions. The limitation is the obscuring structures. The overlap between the different industries is shown in the diagram in Fig. 6.5.

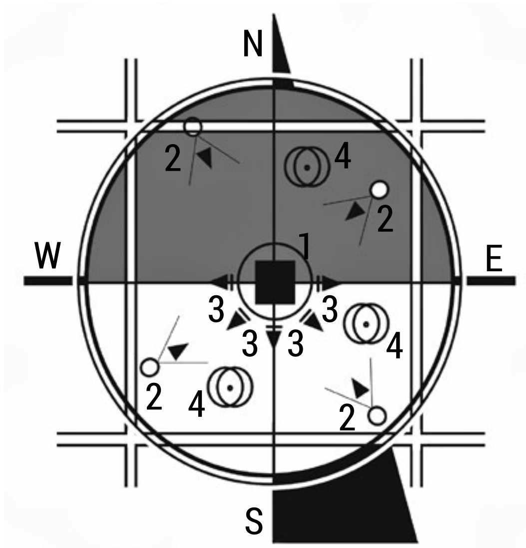


FIG. 6.5. Schema of object's exposition in cityscape: 1– analised object, 2 – location of observer (observation of es-thetical exposition / centripetal exposure, 60°-horizontal viewing angle), 3 – functional exposition of object (centrifugal exposure), 4 – obscuring objects (Source: own elaboration by D. Gawryluk, 2020)

6.2. Method of cooperation

Cooperation between designers from different industries should be correlated with the scope of the project.

The location of a sufficient number of photovoltaic panels on an existing building should be pre-determined by the installation engineer. In the next step, it should be analysed by means of exposure in the city landscape (landscape architect). Its results will lead to a correction in the distribution of panels so that they do not adversely affect the form of the building and its clarity in the landscape (joint design decisions). There may also be a case where the compromise conditions for the location of panels are not achievable. Then, the solution is to abandon the placement of photovoltaic panels in favour of looking for another technology using renewable energy sources and improving the standard of operation of the civil structure.

A newly designed civil structure gives a chance to use photovoltaic panels as an innovative building material with special utility, construction and aesthetic properties. The right approach will be to treat it as an integral element shaping the architectural form and not to add it to the existing structure. Then the impact on the landscape of the entire building shape should be studied at the design stage (on the scale of the architectural and landscape interior, urban composition, and even the city skyline). The solution is to consciously integrate the panels with façades or canopies or to deliberately expose them in an architectural form.

Summary

Photovoltaic panels, apart from their utilitarian purpose, are increasingly used as an integral part of the architectural form. They meet all the criteria of the Vitruvian triad. They influence the functionality, form and structure of the building. They influence its beauty, and on a higher scale they also influence the landscape of the modern city.

Optimal use of photovoltaic panels requires the cooperation of designers from various industries. The presented algorithm of interdisciplinary cooperation will help to avoid the destruction of the form of civil structures and the city landscape. The presented method indicates the need for continuous further education of designers in their discipline, related industries and the ability to cooperate in an interdisciplinary way. Academic centres are an appropriate place for theoretical and practical research and training of students and practising engineers.

References

1. Bogdanowski, J. (1976) *Kompozycja i planowanie w architekturze krajobrazu*. Ossolineum, Wrocław, Warszawa, Kraków, Gdańsk
2. Böhm, A. (2016) *On the factor of composition in the planning of space.* Wydawnictwo PK, Kraków
3. Czyńska, K. (2017) Assessment of tall buildings visual impact on selected landscape interiors using the vis method. *SPACE & form*, 32/2017, 237–256, [Online] Available from: http://pif.zut.edu.pl//images/pdf/pif-32/DOI%2010_21005_pif_2017_32_D-01_Czynska.pdf
4. Forczek-Brataniec, U. (2018) *Visible space – A visual analysismin the landscape planning and designing.* Oficyna Wydawnicza Politechniki Krakowskiej, Kraków.
5. Whalley, A. (2020) Expo 2020 Dubai's Sustainability Pavilion [Online] Available from: Expo 2020 Dubai's Sustainability Pavilion – Andrew Whalley – Journal – GRIMSHAW [Accessed: 30.11.2020]

6. Harrouk, Ch. (2020) *One Year to Go: Expo 2020 Reveals Latest Pavilions as the Event Moves Forward* [Online] Available from: https://www.archdaily.com/948967/one-year-to-go-expo-2020-reveals-latest-pavilions-as-the-event-moves-forward?utm_medium=email&utm_source=ArchDaily%20List&kth=3,566,204; Photos Avaliable from: Grimshaw Architects Dubai Expo 2020 Sustainability Pavilion | Floornature [Accessed: 30.11.2020]
7. Kuczia, P. (2020) Fotowoltaika i architektura. *Architektura Murator,* 2020/11 https://architektura.muratorplus.pl/krytyka/fotowoltaika-i-architektura_10771.html?utm_source=eloqua&utm_medium=email_n_architektura&utm_campaign=newsletter_arch [Accessed: 30.10.2020]
8. Ozimek, A. (2019) *Measure of the landscape. Objectificationof view and panorama assesment supported with digital tools.* Wydawnictwo PK, Kraków
9. Wacławek, Rodziewicz, (2011)
10. Wejchert, K. (2009) *Elementy kompozycji urbanistycznej*, Arkady, Warszawa
11. WEB-1: Sustainability Pavilion (Dubai): Expo 2020 Dubai's Sustainability Pavilion – Andrew Whalley – Journal – GRIMSHAW [Accessed: 30.11.2020]
12. WEB-2: https://commons.wikmedia.org: Fif 2a https://commons.wikmedia.org/wiki/File:BarcelonaFotovoltaica.JPG – Wikimedia Commons; Fig 2b Bosc Urbà, parc del Fòrum (Barcelona): https://commons.wikmedia.org/wiki/File:071_Bosc_Urb%C3%A0,_parc_del_F%C3%B2rum_(Barcelona).jpg [Accessed: 30.11.2020]
13. WEB-3: Bryla.pl (2020) Powerhouse Telemark. Snøhetta zaprojektowała najbardziej energooszczędny budynek w Norwegii [Online] Available from: Powerhouse Telemark. Snøhetta zaprojektowała najbardziej energooszczędny budynek w Norwegii – Bryła (bryla.pl) [Accessed: 30.11.2020]
14. WEB-4: Property design (2020) *Kładki dla pieszych* [Online] Available from: https://www.propertydesign.pl/architektura/104/kladki_dla_pieszych_produkowac_beda_prad_piotr_kuczia_o_obsypanym_nagrodami_projekcie,29558-109444.html#img [Accessed: 30.11.2020]

DOI: 10.24427/978-83-66391-62-8_7

7. ADVANCED TECHNOLOGIES IN AERIAL MAPPING

Birutė Ruzgienė, Lina Kuklienė, Indrius Kuklys, Dainora Jankauskienė

Aerial mapping is one of the most advanced methods to obtain information about the surface of the Earth and other objects using remote sensing technology. The quality of cartographic products and 3D models mainly depends on the success of aerial photography/ scanning mission, qualified guidance of photogrammetric workflow, appropriate realization of aerial mapping requirements.

7.1. Concept of Remote Sensing

Remote Sensing (RS) is defined as the acquisition and analysis of remotely sensed images to gain information about the state and condition of an object through sensors that are not in physical contact with it and discover relevant knowledge for decision making. Remote sensing for environmental monitoring and Earth observations can be defined as: it is the art and science of obtaining information about the surface or subsurface of the Earth without needing to be in contact with it. This can be achieved by sensing and recording emitted or reflected energy toward processing, analyzing, and interpreting the retrieved information (Chang, Bai, 2018)

Remote sensing technology is used for the mapping of the Earth's surface and objects. Data are obtained from different sensors arranged at different platforms (unmanned aerial vehicles, airplanes, spacecraft and satellites, ships and submarines), ground stations, without touching the objects to be mapped. The usage of different platforms has its own advantages and disadvantages (Tab. 7.1).

In capturing imagery in remote sensing, the following factors should be considered: flight restrictions, image resolution and coverage. Sensors, equipped at satellites, capture data at a global scale, unmanned aerial vehicles better to use for flying over small areas, airplanes and helicopters take the middle position.

TABLE 7.1. Evaluation the usage of different platforms (Source: WEB-1)

Platforms	Unmanned aerial vehicles (UAVs)	Airplanes and helicopters	Low Earth orbit satellites
Advantages	Very high-resolution imagery programmable flight paths; LiDAR capabilities.	High resolution imagery; pilot-flown flight paths; LiDAR capabilities.	High to coarse resolution imagery; large coverage extent.
Disadvantages	Very small coverage extent; visual line of sight.	Small coverage extent; flight operation.	Coverage limited to orbital path; cloud obstructions.

Types of remote sensing and their some features are presented in Figure 7.1.

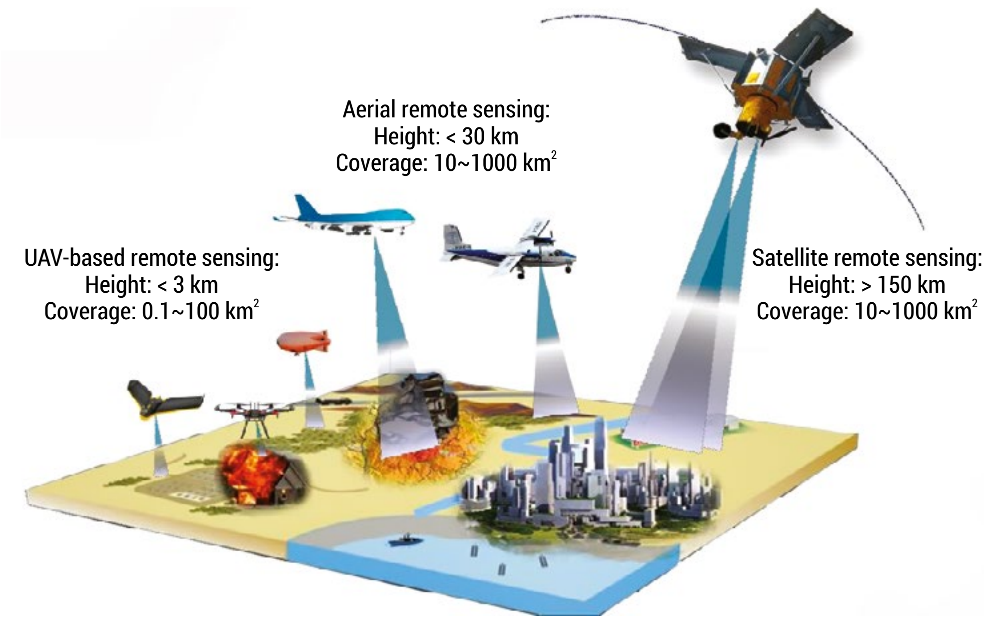


FIG. 7.1. Types of remote sensing/ platforms (satellite, manned aviation and low-altitude UAV) (Source: Xiang, Xia, Zhang, 2019)

Two types of sensors are used in remote sensing:

1. Passive, when photographing with optical photography systems – electromagnetic energy reflected or radiated from the Earth's surface is collected. This method involves the production of an aerial photograph.
2. Active, when electromagnetic energy is generated in the system itself. The Earth's surface is scanned with radar (RADAR – Radio Detection and Ranging, IFSAR – Interferometric Synthetic Aperture Radar) or laser (LiDAR – Light Detection and Ranging) systems (Ruzgiene, 2008).

Figure 7.2 shows principle of passive and active sensors, equipped at unmanned aerial vehicle, operation.

FIG. 7.2. **Principle of passive and active sensors operation (Source: WEB-2)**

Data from remote sensing are used for: the construction of small-scale topographic and thematic (geological, tectonic, geobotanical, landscape, etc.) maps; updating the cartographic material; mapping of rapidly changing objects (for example, agricultural land, minerals, cities, roads and hydraulic equipment, construction sites); mapping under-explored and hard-to-reach areas; creating operational maps; monitoring the dynamics of various processes and phenomena; determining the type of crop, crop area or condition; monitoring the growth process of agricultural land, forecasting the yield; determining the thickness of snow cover in large areas; studying the seasonal movement of ice in the oceans, etc.

Remote sensing technology continues to be developing and improving, with the appearance of more uses and opportunities to create value in new industries and fields of study – from environmental science to public safety, to telecommunications. Several different remote sensing methods are available today, and each comes with strengths and limitations.

The most popular remote sensing type is UAV-based remote sensing with application of UAV-Photogrammetry and Light Detection and Ranging (LiDAR) technologies.

7.2. Remote sensing with Unmanned Aerial System

The use of the Unmanned Aerial System (UAS) for the mapping of objects with varied form of topography leads to a new level of surveying technology. UAS defined as Aerial Imaging solution is designed for the reduction of time and cost collecting aerial cartography data as well guarantees the reliability of mapping products.

The typical components of the mobile segments are as follows (Armenakis, Patias, 2019):

- the vehicle platform (UAV), which enables motion and houses the engine and all other systems;
- the navigation module, which guides and controls the motion of the platform and includes the onboard, autopilot, global navigation satellite system (GNSS), inertial measurement unit (IMU), altimeter, compass and navigation cameras;
- telecommunication links (command and control, downlink telemetry and sensor data);
- the propulsion system and power generation system, including batteries and fuel tank;
- mapping sensors (still/video optical cameras, thermal, multispectral and environmental sensors, and laser scanners).

7.2.1. Substantial features of UAS

The past few decades have witnessed great progress for Unmanned Aerial Vehicles (UAVs) in civilian fields, especially in remote sensing and photogrammetry. In contrast with manned aircraft and satellites, platforms flying at low altitude have many promising characteristics: flexibility, efficiency, high spatial/ temporal resolution, low cost, easy operation, and so forth, that make them an effective complement to the other remote sensing platforms and a cost-effective means for remote sensing.

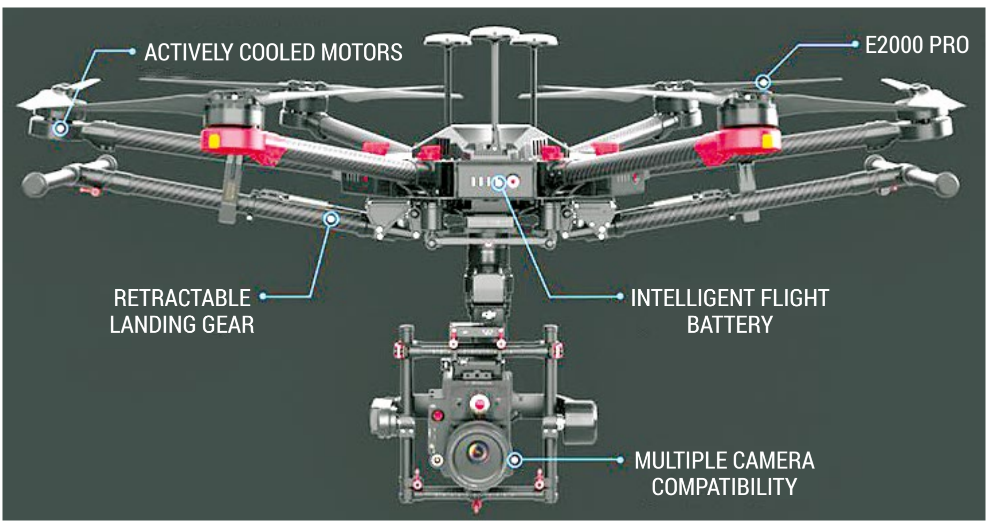


FIG. 7.3. Basic components of UAV (Source: WEB-3)

Unmanned aerial vehicles of different models, classification and categories can be used for aerial mapping, for example, helicopters with four or six wheels, the fixed-wing *UX5* from the company Trimble, etc. The company Dà-Jiāng Innovations (DJI), China, rapidly turns to a new standard in mapping of territories combining a robust and highly user-friendly system. The standard technical means from DJI used for surface data acquisition are: the platform *MATRICE 600 PRO* with a custom-designed camera *ZENMUSE X5*, thermal camera *ZENMUSE XT*, laser scanner *MAPPER LITE 2*, GPNS. The *MATRICE 600 PRO* is a hexa-copter specifically designed for professional and industrial applications. It features an enhanced flight performance with the capability to carry a heavier payload. The vehicle also comes with pre-installed arms and antennas that reduce set up time. The *MATRICE 600 PRO* features six rotors for added redundancy and stability in the air. The vehicle also features six batteries for added safety and an extended flight time. Basic components of UAV are presented in Figure 7.3.

Main features of DJI *MATRICE 600 PRO*:

- Weight (with six TB47S batteries) – 9,5 kg.
- Max wind resistance – 8 m/s.
- Max speed – 65 km/h.
- Hovering accuracy (P-GPS) – vertical: ±0,5 m, horizontal: ±1,5 m.
- Hovering time (with six TB47S batteries and scanning equipment) – 32–35 min.
- Max service ceiling above sea level – up to 2500 m.
- Max takeoff weight – up to 15,5 kg.
- Operating temperature – –10°C to 40°C.

The gimbal light camera *ZENMUSE X5* mounted at DJI *MATRICE 600 PRO* can be successfully used for the photogrammetric data acquisition. The main features of the camera *ZENMUSE X5* is presented in Figure 7.4.

Sensor:
Size – 17,3 × 13,0 mm
Type – CMOS
(complementary metal-oxide semiconductor)
Pixels – 16 M
Resolution – 4608 × 3456 px
Optics:
Focal length – 15 mm / 30 mm
Video:
Resolution – 4096 × 2160 px
Format – MP4 / MOV

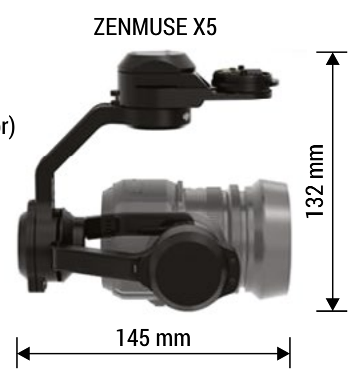


FIG. 7.4. Main features of gimbal camera *ZENMUSE X5* (Source: WEB-3)

A 3D laser scanning system of special type can be mounted quickly on any UAV when the requirement is the use of LiDAR (Light Detection and Ranging) technology. One of the most popular laser scanners is *YellowScan MAPPER LITE 2*, that has an easy-to-handle, easy-to-use and accurate system. This scanner is fully autonomous, has direct georeferencing workflow for increased accuracy and efficiency of mapping from UAVs. The main features of laser scanner *YellowScan MAPPER LITE 2* is presented in Figure 7.5.

MAPPER LITE 2

Weight – up to 2,2 kg
Navigation systems:
GPS, GLONASS, Beidou, Galileo1, SBAS
Optimal scanning height – 10-75 m
Scanning precision – 10 cm (XY), 5 cm (Z)
Shots per second – 18500
Laser scanning technology – up to 3 echoes per shot

FIG. 7.5. Main features of laser scanner *MAPPER LITE 2* (Source: WEB-2)

The 3D laser scanning system is fueled by the needs of surveyors, researchers, asset managers and all people requiring LiDAR data.

7.2.2. UAV-Photogrammetry

The modern technology of UAV-Photogrammetry is used for remote sensing of surfaces, acquiring a huge number of images and processing of the photogrammetric data. Photogrammetry is one of the most advanced methods to acquire information about the surface of the Earth and other objects using photographic images. The use of unmanned aerial vehicles (UAVs) with the integrated camera for image capturing, GPNS, the management equipment and specialized software for the processing of images has been rapidly expanding for aerial mapping. The orthophoto maps of high accuracy (quality) and three-dimensional surface models are the main products generated by the use of aerial photogrammetric technology.

The UAV-Photogrammetry technology contains the use of UAV with integrated photographic equipment for gaining images of surfaces, flight planning and control, photographic image processing by specialized software.

A typical workflow for the use of UAV-Photogrammetry technology is presented in Figure 7.6. Main steps are: mission planning → image acquisition → UAV image processing (triangulation and DTM/ DSM generation).

The image data processing software *Pix4Dcapture* and *Pix4Dmapper* developed at Computer Vision Lab in Switzerland is the main tool for the application of modern technologies with the use of UAV. *Pix4Dcapture* is the flight planning and image acquisition module involved in the software *Pix4D.*

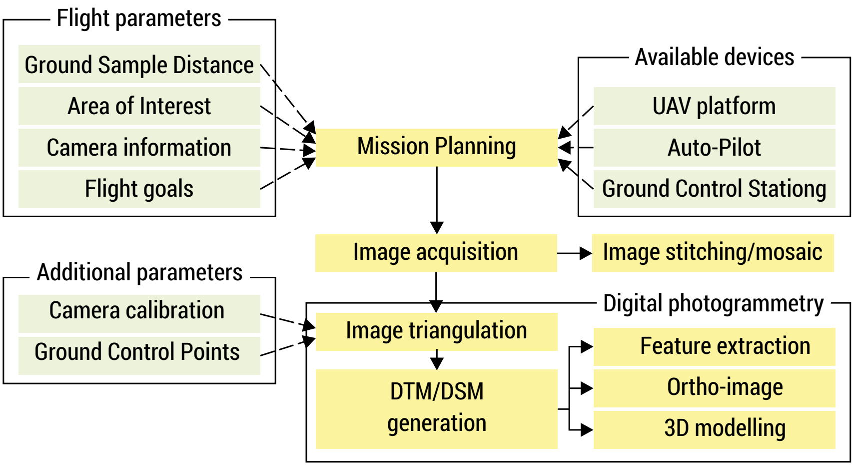


FIG. 7.6. **Typical workflow applying the UAV-Photogrammetry technology (Source: Nex, Remondino, 2014)**

Pix4Dmapper is an image processing software that is based on automatically finding thousands of common points between images. Each characteristic point found in an image is called a *keypoint*. When 2 *keypoints* on 2 different images are found to be the same, they are *matched keypoints*. Each group of correctly *matched keypoints* will generate one 3D point. When there is high overlap between 2 images, the common area captured is larger and more *keypoints* can be matched together. The more keypoints there are, the more accurately 3D points can be computed. Therefore, the main rule is to maintain a high overlap between the images.

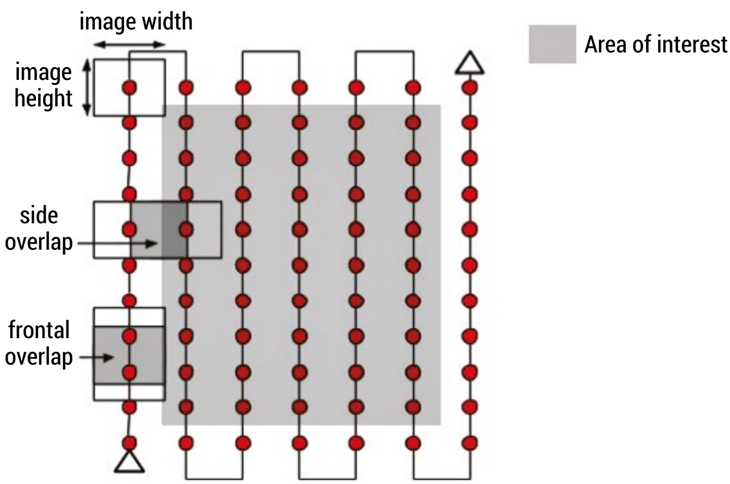


FIG. 7.7. **Ideal image acquisition plan – general case (Source: WEB-4)**

As the image acquisition plan has a high impact on the quality of the results, it is important to design it carefully. The recommended overlap for most cases is at least **75% frontal overlap** (with respect to the flight direction) and at least **60% side overlap** (between flying tracks). It is recommended to take the images with a regular grid pattern (Fig. 7.7). The camera should be maintained as much as possible at a **constant height** over the terrain/ object to ensure the desired ground sample distance (GSD).

The module *Pix4Dcapture* offers the possibility to fly four different kinds of autopilot missions and one manual but semi-automatic mission (Fig. 7.8). To get the best results out of the image acquisition plan, the type of mission has to be chosen depending on the terrain/ objects that need to be reconstructed.

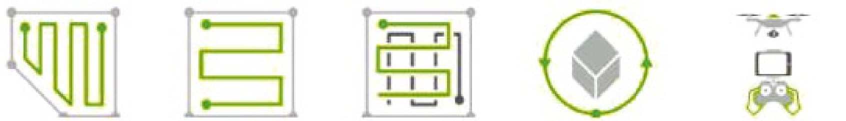


FIG. 7.8. Different kind of autopilot missions (Source: WEB-4)

In an aerial mapping survey, are using ground control points (GCPs) are used which the surveyor can precisely pinpoint: with a handful of known coordinates, it is possible to accurately map large areas. A GCP is a point of known coordinates in the area of interest. Its coordinates can be measured using traditional surveying methods measuring with GPS or total stations; obtaining by other sources (LiDAR, older maps of the area, web map service, even from Google Earth application). Ground control points can be anything that can be easily recognized in the images. Typically, they look like a small section of a checkerboard. The shape leaves very little ambiguity about where the 'point' of a ground control point is. They're almost always black and white because it is easier to recognize high contrast patterns. In order to obtain more precise aerial mapping products, the points/ targets are distributed in a specific order: projecting points at the edges of an object considering configuration, but not so close to the margins because they will not be seen in several images; one point in territory center, as well as points in the areas of a complicated relief (Fig. 7.9). Recommendation for GCPs number – 5 points, minimum – 3, usually – 5–10. Each of GCPs should be seen in 2 images as a minimum, if relief is complicated – 5 GCPs should be seen in 5 images.

The *Pix4Dmapper* software is supplied with computer-vision algorithms combined with proven state-of-the-art photogrammetric techniques to produce outputs with the highest accuracy and with minimal manual interaction. This software is a new concept extending the stereo view triangulation and increasing the accuracy of 3D modelling. Aerial images are imported in consideration with their locations, orientations, and camera calibrations parameters. The use of photogrammetric algorithms allows correction of the image orientations. The software at first performs the adjustment with photo tie points, automatically matching the tie points in all images. Tie points are usually distributed densely, even in low terrain texture. *Pix4Dmapper* software has efficient possibilities for orthophoto generation, surface modelling, etc. Operations with this package are fully automated and flexible, data input is scalable, output data are easily editable and on-site quality assessment is instant.

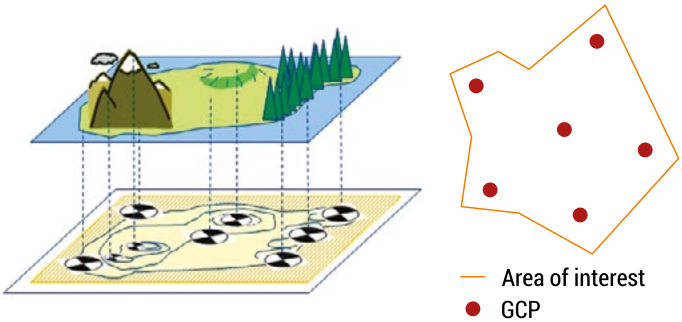


FIG. 7.9. **GCPs and their typical distribution (Source: WEB-4)**

Using different platforms and sensors for capturing the images, the main photogrammetric procedures remain as follows: aerial triangulation, images orientation, generation of point cloud for surface modelling, production of orthophoto map and vector data collection for GIS or cartographic needs. The relation between images and object coordinates can be establish, when the coordinates of ground control points are determined.

Figure 7.10 shows aerial mapping products generated by the use of UAV-Photogrammetry technology; image processing has been performed with software *Pix4Dmapper*.

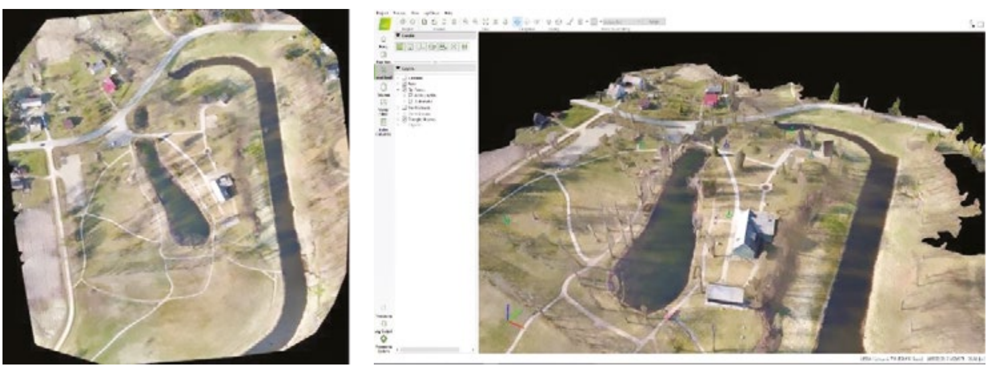


FIG. 7.10. **Aerial mapping products: orthophoto map and DSM (Source: own elaboration, 2020)**

7.3. Remote sensing with laser systems: LiDAR technology

LiDAR, which stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses, combined with other data recorded by the airborne system, generate precise, three-dimensional information about the shape of the Earth and its surface characteristics (WEB-5). Pulses of light are emitted from a laser scanner, and when the pulse hits a target, a portion of its photons are reflected back to the scanner. Because the location of the scanner, the directionality of the pulse, and the time between pulse emission and return are known, the 3D location (XYZ coordinates) from which the pulse reflected is calculable. The laser emits millions of such pulses, and records from whence they reflect producing a highly precise 3D point cloud (model) which can be used to estimate the 3D structure of the target area.

A LiDAR instrument principally consists of a laser, a scanner, and a specialized GPS receiver. Airplanes and helicopters are the most commonly used platforms for acquiring LiDAR data over broad areas. Two types of LiDAR are: topographic and bathymetric. Topographic LiDAR typically uses a near-infrared laser to map the land, while bathymetric LiDAR uses water-penetrating green light to also measure seafloor and riverbed elevations.

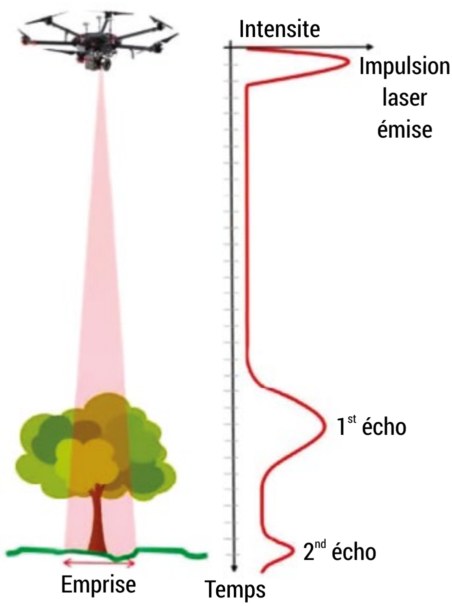


FIG. 7.11. Principle of LiDAR operation (Source: WEB-2)

The principle of LiDAR operations (Fig. 7.11):

1. Emitting a laser pulse on a surface;
2. Catching the reflected laser back to the LiDAR pulse source with sensors;
3. Measuring the time laser travelled;
4. Calculating the distance from source with the formula:
   Distance = (Speed of light × Time elapsed) / 2.

The equipment needed to measure a million distances from sensors to surface points is installed in a LiDAR system. This advanced-technology operates really fast as it is able to calculate the distance between LiDAR sensors and target. LiDAR systems integrate 5 main components whether they are used on automotive, aircrafts or unmanned aerial vehicles:

1. Flying vehicle.
2. Scanning laser emitter-receiver unit.
3. Differentially-corrected GPS.
4. Inertial measurement unit (IMU).
5. Computer.

LiDAR systems pulse a laser light from various mobile systems (automobiles, airplanes, unmanned aerial vehicles) through air and vegetation (aerial laser) and even water (bathymetric laser). A scanner receives the light back (echoes), measuring distances and angles. The scanning speed influences the number of points and echoes that are measured by a LiDAR system. The choice of optic and scanner influences greatly the resolution and the range in which you can operate the LiDAR system.

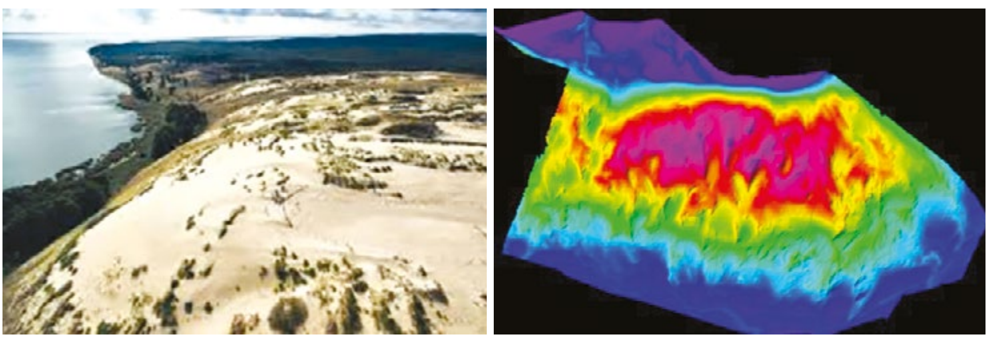


FIG. 7.12. **3D model generated from LiDAR data (Source: own elaboration, 2020)**

Whether a LiDAR sensor is mounted on an aircraft, car or UAV (Unmanned Aerial Vehicle), it is crucial to determine the absolute position and orientation of the sensor to make sure data captured are useable data. Global Navigation Satellite Systems (GNSS) provide accurate geographical information regarding the position of the sensor (latitude, longitude, height) and an Inertial Measurement Unit (IMU) defines at this location the precise orientation of the sensor (pitch, roll, yaw). Data recorded by these devices are then used to generate data into static points: the basis of the 3D mapping point cloud.

In order to collect the data, computation is required to prepare the LiDAR system to work by defining precise echo position. It is required for on-flight data visualization or data post-processing as well to increase precision and accuracy delivered in the 3D mapping point cloud.

LiDAR data – acquired dense point cloud can be processed using the software *MicroStation*, Bentley. This software is an innovative and integral technology of today providing possibilities for 3D surface modelling. Properly generating a digital surface model, it is necessary to add the *TerraScan* and *TerraMatch* toolbars (WEB-6). Figure 7.12 shows 3D models of a surface, generated from LiDAR data.

References

1. Armenakis C., Patias, P. (2019) *Unmanned vehicle systems for geomatics: towards robotic mapping. Scotland*, UK: Whittles publishing, 2
2. Chang, N., Bai, K. (2018) *Multisensor data fusion and machine learning for environmental remote sensing.* Taylor & Francis group, 2
3. Xiang T., Xia, G., Zhang L. (2019) Mini-Unmanned Aerial Vehicle-Based Remote Sensing: Techniques, applications, and prospects. *IEEE geoscience and remote sensing magazine,* pp. 29–63
4. Ruzgienė, B. (2008) Fotogrametrija. *Vilnius. Technika*. pp. 15
5. Nex, F., Remondino, F. (2014). UAV for 3D mapping applications: a review. Appl Geomat 6, pp. 1–15 https://doi.org/10.1007/s12518-013-0120-x
6. WEB-1: GIS Geography. What is Remote Sensing? The Definitive Guide (2020) [Online] Available from: https://gisgeography.com/remote-sensing-earth-observation-guide/#chapter1 [Accessed 8.10.2020]
7. WEB-2: LiDAR (2020) [Online] Available from: https://www.yellowscan-lidar.com/knowledge/how-lidar-works/ [Accessed 14.10.2020]
8. WEB-3: Dji Enterprise. Light detection and ranging (2020) [Online] Available from: https://www.yellowscan-lidar.com/knowledge/how-lidar-works/ [Accessed 8.10.2020]
9. WEB-4: Pix4D (2020) [Online] Available from: https://www.pix4d.com/ [Accessed 13.10.2020]
10. WEB-5: What is LiDAR? (2020) [Online] Available from: https://oceanservice.noaa.gov/facts/lidar.html [Accessed 12.10.2020]
11. WEB-6: Bentley MicroStation [Online] Available from: https://www.bentley.com/en/products/product-line/modeling-and-visualization-software/microstation [Accessed 14.10.2020]

DOI: 10.24427/978-83-66391-62-8_8

8. SMART CITY INNOVATION: URBAN TRANSPORT AND STRUCTURE ELEMENTS

Vilma Vaicekauskienė, Eduardas Spiriajevas

8.1. The Concept of Sustainable Urban Mobilit'ies and Their Practically Applied Outcomes

8.1.1. Peculiar SUMP

A Sustainable Urban Mobility Plan (hereafter SUMP) is a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life for inhabitants living in urban and suburban areas. The purpose of SUMP is comprised of five following principles:

- Ensurance to all citizens to offer transport options to key destinations within urban and suburban areas;
- Improvement of safety and security of public and freight transportation systems;
- Reduction of air and noise pollution, greenhouse gas emissions and energy (fuel) consumption;
- Improvement of the efficiency and cost-effectiveness in transportation of persons and goods;
- Contribution to enhancing the attractiveness and quality of the urban environment for urban and suburban inhabitants;
- Ensurance of diversified modes for urban daily mobility needs based on principles of sustainability.

The SUMPs tackles transport-related problems in urban areas more efficiently. Thereon it is considered a result of a structured process, which comprises the status analysis, urban and transport planning policy and selection of the measures, active communication, monitoring and evaluation, identification of learnt lessons. The basic characteristics of the SUMPs are distinguished as following:

- Long-term vision and clear implementation plan;
- Participatory approach of local inhabitants (social groups), stakeholders, urban planners, transport companies, private companies, port authorities, research institutes etc.;
- Balanced and integrated development of all transport modes (public transport, cycling, combined, alternative etc.);
- Horizontal and vertical integration of different communication levels between institutions, social groups;
- Assessment of current and future performance of traffic flows and mobility of passengers as well as pedestrians;
- Regular monitoring, review and reporting;
- Consideration of external costs for all transport modes.

The SUMPs are based on a long-term vision for transport and mobility development for the entire urban area (town, city, agglomeration) which covers all modes and forms of transport: public and private, passenger and freight, motorized and non-motorized, moving and parking etc. The SUMPs focus on people and meeting their basic daily mobility needs. It follows a transparent and participatory approach, which brings citizens and other stakeholders on board from the outset and throughout the plan development and implementation process. Participatory planning is a prerequisite for local inhabitants and stakeholders to approach, i.e. social awareness and acceptance on implementation of SUMP and its relevant policy. In this issue, the SUMP fosters a balanced development of all relevant transport modes, while encouraging a shift towards more sustainable modes. The following topics are typically addressed to public transport, non-motorized transport (walking and cycling), intermodality and door-to-door mobility, urban road safety, flowing and stationary road transport, urban logistics, mobility management, and smart transport systems (STS). The development and implementation of SUMP follows an integrated approach with high level of cooperation and consultation between the different levels of government and relevant authorities. The SUMP also identifies specific performance objectives, which are realistic in view of the current situation in urban and suburban areas and it sets measurable targets. These targets are being measured in the framework of indicators.

Table 8.1 presents in a simplified manner some of the main differences between traditional transport planning and sustainable urban mobility planning.

TABLE 8.1. Comparison of aspects of traditional transport planning and sustainable urban mobility planning (Source: authors' systematized material, 2020)

Traditional Transport Planning	Sustainable Urban Mobility Planning
Focus on traffic	Focus on inhabitants
Primary objectives: traffic flow capacity and speed	Primary objectives: Accessibility and quality of life, as well as sustainability, economic viability, social equity, health and environmental quality
Modal-focused	Balanced development of all relevant transport modes and their shifts towards cleaner and more sustainable transport modes
Infrastructure focus	Integrated set of actions to achieve cost-effective solutions
Sectorial planning document	Sectorial planning document that is related to policy areas (such as land use and spatial planning; social services, etc.)
Short and medium-term delivery plan	Short and medium-term delivery plan embedded in a long-term vision and strategy
Related to an administrative area	Related to a functioning area based on travel-to-work patterns
Domain of traffic engineers	Interdisciplinary planning teams
Planning by experts	Planning with the involvement of stakeholders using a transparent and participatory approach
Limited impact assessment	Regular monitoring and evaluation of impacts to inform a structured learning and improvement process

Hence the need for detail sustainable and integrative planning, it deals with the complexity of urban mobility, which has been recognized since 2013. Due to the willingness of municipal authorities to adopt new modes of transport, e.g. electro bikes, shared bikes, combined modes (by private cars and by public transport alike), and thus comprising 8 basic principles of sustainable mobility to be implemented in urban and suburban areas:

- Prepared, adjusted and approved SUMP for the relevant urban area (possibly involving and suburban areas);
- Definition of a long-term vision and a clear implementation of plan;
- Ensured cooperation between different institutions;
- Development of all transport modes in an integrated manner;
- Involvement of citizens (different social groups) and stakeholders;
- Arrangement for monitoring and evaluation;
- Assessment of current and future performance;
- Quality assurance.

In fact, a good planning of the SUMP helps to select and plan the right measures, which implement the basic principles of sustainable urban mobility.

The European Commission strongly recommends that European towns and cities of all sizes should implement the concept of SUMP. These can improve the quality of life for inhabitants by addressing major challenges such as congestion, air/noise pollution, climate change, road accidents, unsightly on-street parking and the integration of new mobility services. Congestion in cities is a major source of delay for commuters and inhabitants. It also increases air pollution and affects the air quality in urban and suburban areas (Green Transportation …, 2016). The planning of freight transport movement using smart IT decisions has become essential, recently. Hence, there many different inventions and innovative solutions based on IT technologies and smart soft-ware are being implemented such as:

- Distribution of freight using e-cargobikes within the area of inner cities;
- Assurance of smart traffic management process;
- Smart mobility solutions;
- E-car-sharing pool;
- Promote shared use of electric cars and reduce number of parking spaces;
- E-cargobike pool;
- Promote shared use of e-cargobikes by residents;
- Mobility stations for multiple travel alternatives;
- Car-sharing to expand range of car;
- Bike-sharing alternatives;
- Bike-storage constructions;
- Smart taxi stand system;
- Prioritization of public transport on the lane giving sign aged priority for public transport;
- Creation of the „Green corridors“ for freight and public transport by management of smart traffic lights (Fig. 8.1).

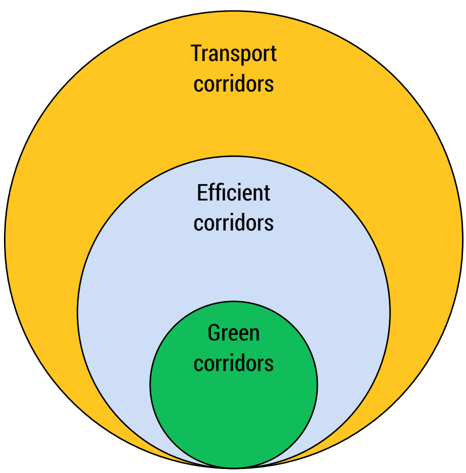


FIG. 8.1. **The structural place of Green corridor within the structure of transport corridors (Source: G. Panagakos, H. Psaraftis, 2012)**

In urban areas the Green green corridor concept was introduced in 2007 by the Freight Transport Logistics Action Plan of the European Commission (European Commssion, 2007). According to this document the following principles are distinguished:

- Green transport corridors are marked by a concentration of freight traffic between major hubs and the logistics centres, port areas, industrial areas;
- Flows of public transport and freight are being encouraged along Green corridors to rely on smart technology related to regulation of traffic lights in order to reduce the cross-urban travel time;
- Green transport corridor also can be used for trans-shipment facilities and supply of goods and materials;
- Green corridors could be used to experiment with environmentally-friendly, innovative transport units, and with advanced Smart Transport Systems (ITS) applications in urban areas in particular (Faste´n & Clemedtson, 2012).

Also, the Green corridor aims at reducing environmental and climate impact such as:

- Implementation of sustainable logistics solutions with documented reductions of CO_2 emissions;
- Implementation of logistics concepts with optimal utilization of all transport modes called intermodality;
- Creation of platform for development and demonstration of innovative logistics solutions, including IT based smart technologies.

Herein, it is possible to distinguish two definitions of Green corridor:

- A corridor which is economically efficient and environmentally sustainable;
- A corridor which takes a central position in transportation of freight and passengers by public transport.

A holistic policy approach is needed to deliver on wider sustainable development objectives. Thus, the public awareness and acceptance in behavior of daily mobility are very important social factors. Society (as local inhabitants, social groups) plays an important role in the process of the implementation of sustainable urban mobility principles. Social behavior is a key determinant in assurance of sustainable mobility processes. Addressing a broader range of policy objectives can help forming consensus among key political and societal actors.

8.1.2. Implementation of Sustainable Urban Mobility Principles: a Case of Klaipeda City

Adapting good practices in SUMP was designed to support the SUMP preparation process by collecting and presenting experiences of other European countries and other interested bodies, on purpose to promote public awareness about different mobility patterns. Adapting good practices in SUMP is a complex process, which has to be implemented in the application of an interdisciplinary approach, involving cooperative activities between different municipal and public institutions, active social groups and stakeholders as well. For Klaipeda city, the structural share of modal split of mobility foreseen until 2030 means as follows: 35 percent of population use public transport, 33 percent – walking, 25 percent use private cars, 7 percent – cycling. During the period of 2017–2020 shifts of modal split are moving towards the planned structure with some exceptions. These exceptions depend on the behavior of different social groups, weather conditions in autumn and winter, the reconstruction of infrastructure, when due to different individual obstacles the preferences, are given more to private cars and less to alternative means and public transport. This is the most important issue of public awareness and acceptance (Table 8.2).

TABLE 8.2. Summary of the main impact results of SUMP implementation in Klaipeda city (Source: authors' s research material, 2020)

Sustainable mobility principle	Indicator	Results		
		Indicator mean before, % 2017	Indicator mean after, % 2020	Impact as change, %
Shape more integrated transport infrastructure and mobility systems	Dynamics of modal split: Public transport Walking Private cars Cycling Combined Other alternatives N=258	 22,9 11,7 45,7 9,1 10,1 0,5	 20,5 11,8 51,2 2,8 11,5 2,5	 –2,4 +0,1 + 5,5 – 6,3* +1,4 +2,0
Public awareness and acceptance of SUMP implementation	Awareness level Acceptance level 1–5 (low-high) N=258	2,82 4,32	3,0 4,44	+0,18 +0,01
Improve efficiency of urban and freight transport	Increased time accuracy of public transport during the rush hours Decreased cross-urban travel time for freight	76,0 –5,0	88,0 –8,0	+12,0 (+1,5 min) –13,0 (–2,0 min)

*Due to changed habits in usage of public transport, affected by Covid-19 pandemic.

**Due to increased popularity of electro bikes as opposite to cycling.

During the period of 2017–2020 4 units of smart traffic lights installed (out of 21 planned until 2021) for creation of the Green corridor along the port‘s zone, and CO_2 emissions decreased along the port‘s zone up to –7,5 percent. Due to developed bike-sharing service by public enterprise CityBee, local inhabitants started to use the bike-sharing system as newly a developed system for daily mobility purposes and as an alternative to private cars in particular for shorter distances of daily commuting. In addition the bike-storage system started to develop by constructing units of bike-sheds related to smart technologies of their usage. The brand new bike-sheds installed in a proximity to public schools and in densely populated residential districts, where socially active local communities are active with a higher level of social responsibility towards the implementation of SUMP‘s principles. Hence the public awareness and acceptance on implementation of sustainable urban mobility principles changed positively since the SUMP started to be implemented. Social advertisement of the SUMP among different social groups gave the outputs in better social understanding of the SUMP's importance in the processes of daily urban mobility. Supporting activities are very significant in the beginning of SUMP principles implementation in order to approach public attention, which is important in public awareness and acceptance while SUMP was under the first stages of implementation. Supporting activities were applied in the form of scientific and practical events, a public presentation of conducted urban study on daily mobility in the city for different social groups in Klaipeda.

The implementation of a traffic management system for the creation of a Green corridor in relation to the prioritisation of public transport. These two actions are considered as technical ones with IT based technologies and related to the creation of a traffic management a data system as data server and installation of smart traffic lights. The system of smart traffic lights related to traffic data created a Green corridor for the movement of freight and prioritisation of public transport in Klaipeda. After the implementation of sustainable mobility principles, the following drivers were distinguished and summoned:

Strategic: implementation of SUMP regarded by the administration of the Klaipeda municipality. The implementation process has political support due to the expectation that good practices of SUMP will be applied to the city.

Planning: the strategic planning of SUMP and its practical application match the objective to implement the principles of sustainable movement in order to reduce the use of private cars and increase the use of public transport facilities in the city. These planning objectives are highly supported by the central government of the Republic of Lithuania.

Sustainable development: the implementation of the principles of sustainability in the development of the systems of transport and communication is a priority in a national document of "White Book on Regional Development in Lithuania". This priority was approved in October2017 on a national level.

Publicity: the inhabitants of the city and its suburban areas acquired knowledge on the significance of sustainable mobility principles in daily mobility, which affected a raised public awareness and acceptance of sustainable urban mobility principles.

Institutional: a cooperation between different institutions leads towards a better inter-institutional dialogue for discussion on the implementation of sustainable mobility principles in the city, also taking in account cooperation between the city and the port.

8.1.3. Conclusions

During the period of 2017–2020 the following key impact findings were detected on:

1. The dynamics of the modal split is moving towards the planned structure of modal split in SUMP with some exceptions. These exceptions depend on the behavior of different social groups, weather conditions in autumn and winter, the reconstruction of infrastructure, when due to different individual obstacles, the preferences are given more to private cars and less to alternative means and public transport;
2. The public awareness and acceptance on implementation of sustainable urban mobility principles changed positively since the SUMP started to be implemented;
3. Social advertisement of the SUMP among different social groups output in better social understanding of the SUMP's importance in the processes of daily urban mobility;
4. Supporting activities are very significant in the beginning of SUMP principles implementation in order to approach public attention. Supporting activities were applied in the form of scientific and practical events, such as the public presentation of a conducted urban study on daily mobility in the city;
5. Locals introduced to different scenarios on sustainable urban mobility models, focused on the meanings of improvement of pavements and roadways in the city. It helped to find out the opinion of inhabitants, stakeholders about current mobility situation in order to improve urban environment for pedestrians and cyclists;
6. Development of a Green corridor for freight movement in relation of prioritization of public transport, both are considered as technically and IT based actions for efficient regulation of freight and public transport traffic in order to decrease cross-urban time of freight movement, increased time accuracy of scheduled public transport commuting, decreased CO_2 emissions in the city, i.e. in areas of city and port interaction.
7. Cooperation platform between the city and port authorities is also considered as a focal point which plays a significant role to assure the sustainable urban mobility principles in Klaipeda.

8.2. Smart city innovation: structure elements

Klaipeda Seaport operating in Lithuania is one of the most important transport logistics centers in the country. The importance of logistics centers in the state and Klaipeda has a significant impact on the country's economy (Fig. 8.2).

FIG. 8.2. Picture BLC logictics center (Source: own elaboration, 2019)

All logistics transport centers were built using a variety of construction technologies or construction materials. Smart construction is an information modeling of buildings, it is better known as three-dimensional construction, i.e. BIM – building information model. The 3D model includes all the information about the building. The model covers the entire life cycle and the entire process during which a building is designed, built and even maintained. All data is digitized and available to different professionals (WEB-1).

8.2.1. Smart materials

The most popular building material used in the construction industry is concrete, which at first glance is relatively friendly to human and the environment. The production process of structures made of concrete and reinforced concrete elements uses chemicals which improve properties of concrete material. Many unique concrete production technologies have been developed that, at first glance, give concrete "magical powers".

Electrically conductive concrete is used for structures operated in cold climates, generally for roads and bridge pavements. Concrete is heated through electrically conductive fillers in it, preventing the formation of an ice layer on the surface and making pavements user-friendly.

Carbon concrete (Furuya, 2000) is the new composite material, which has the potential to revolutionize the entire architecture. The high-performance material is a combination of concrete and carbon fibers. It has more strength, durability and lightness than conventional concrete.

Load-bearing wood concrete. A further innovation in the field of concrete production was recently presented by researchers of the Swiss research program "Resource Wood" (NRP 66), who were using the innovative, sustainable building material "Wood Concrete". The gravel and sand content is replaced by finely ground wood, i.e. sawdust is mixed into the cement instead of fine aggregate. In some mixtures, sawdust has a proportion of more than 50 percent by volume. This makes concrete significantly lighter than conventional concrete.

Self-healing concrete (WEB-2) was created byDutch civil engineer, Dr. Schlangen at Delft University (WEB-3). In presentation, he demonstrated the effectiveness of the material by breaking it in two pieces, then putting them back together, and heating concrete in the microwave oven. Once the melted material cools down, element becomes solid. This method requires heating the concrete construction.

Construction material – Luminous cement. The construction industry is evolving and one of the main trends is to move towards more resource and energy efficiency ways of creating and manufacturing structures. Therefore, the application of the cement acting as a 'light bulb' is very broad. We can use it in swimming pools, parking lots, road safety signs and in many other situations.

8.2.2. Tilt-up method

The Tilt-Up construction technology is a method whereby building elements (walls, columns) are formed on a construction site, then lifted and placed in the design position by the crane (WEB-4) (Fig. 8.3).

The method is a cost-effective and have a shorter completion time. Tilt-up construction technology is a common method usedthroughout North America. However, it is not very popular in Europe. Concrete elements can also be formed at factories. Tilt-up differs from prefabricated or formwork cast constructions, because all elements are constructed on the job site. This eliminates the size limitation imposed by transporting elements from the factory to a construction site.

The chronological steps that need to be taken for a tilt-up project are: site evaluation, engineering, footings and floor slabs, forming tilt-up panels, reinforcement placement, embeds and inserts, concrete pouring, panel erection and finishing (WEB-4) (Fig. 8.3, Fig. 8.4).

FIG. 8.2. **Tilt-up panel (Source: own elaboration, 2018)**

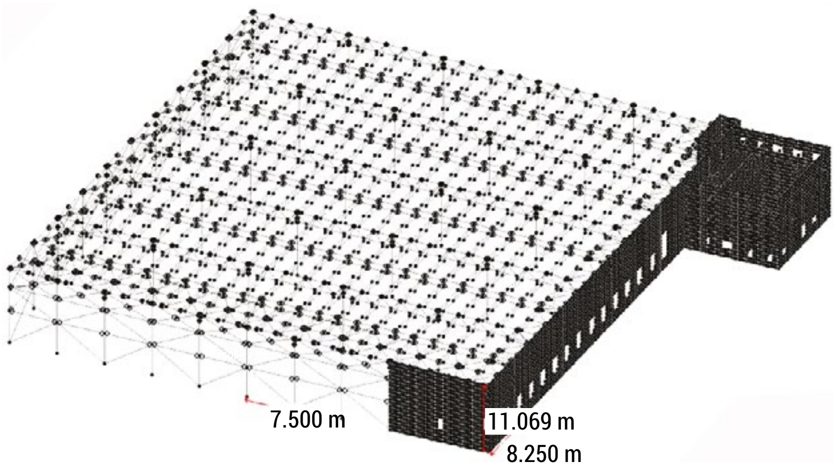


FIG. 8.3. **Analytical model of wearhouse (Source: own elaboration, 2019)**

This method of construction technology requires the installation of a reinforced concrete slab in the construction site for the formwork of elements. If there is no possibility or enough space, then the building floor is installed. Once the formwork has been done, all the necessary inserts (for lifting, supporting, trusses, etc.) are put together and filled with the concrete. When the concrete reaches required strength, element is placed in the design position with the crane. After that, panels are temporarily braced, until they are joined to other supporting structures (roof, floor) (WEB-5). The Tilt-Up construction technology is mostly used for the construction of low-rise storage buildings (Fig. 8.5).

FIG. 8.4. **Tilted Tilt-up panels in Stariskes str 9, Laistai (Source: own elaboration, 2019)**

8.2.3. Conclusions

1. The rapid emergence of logistics centers and the continuous development of the existing ones is one of the signs that a favorable environment has been created for logistics processes in the Klaipeda Region.
2. The smart technologies and materials used in the development of Klaipeda logistics centers are successfully applied and operated. According to the initial characteristics of operation, all quality requirements have been met, and in general, we can state that the objects created with materials will be of high quality and long-lasting.

References

1. Electrically conductive cement-based materials, D. D. L. Chung*(2004) University of Buffalo, The state university of New York
2. Fastén, G., Clemedtson, P. O. (2012) Green Corridor Manual. An East West Transport Corridor II Report. NetPort.Karlshamn
3. Green Transportation Logistics. The Quest for Win-Win Solutions (2016) Editor H. N. Psarafis. Springer
4. Panagakos, G., Psaraftis, H., Moyano, H., Holte, E-A. (2012) Green Corridors handbook (Vol. II). SuperGreen project, Document number: 07-20-PP-2012-05-02-3.
5. Supporting EU's Freight Transport Logistics Action Plan on Green Corridors Issues (2007). Seventh Framework Programme. The European Commission (2007).
6. https://trimis.ec.europa.eu/sites/default/files/project/documents/20120405_225725_78542_D2%205_WP%202_Super%20Green_FINAL%20PUBLIC.pdf
7. WEB-1 https://www.thalesgroup.com/en/markets/digital-identity-and-security/iot/inspired/smart-cities [Accessed: 10.10.2020]
8. WEB-2 https://www.sciencedirect.com/science/article/pii/S1110016815000447 [Accessed: 10.10.2020]

9. WEB-3 https://www.letsbuild.com/blog/10-innovative-construction-materials [Accessed: 10.10.2020]
10. WEB-4: https://tiltwall.ca/blog/tilt-up-construction-the-past-the-present-and-the-future/ Tilt-Up Construction: The Past, The Present, And The Future [Accessed: 06.03.2020]
11. WEB-5 The basics of Tilt-Up construction: https://www.korteco.com/construction-industry-articles/basics-tilt-construction/ [Accessed: 06.03.2020]. Yasubumi Furuya, in Comprehensive Composite Materials, 2000

LOCAL

BIALYSTOK UNIVERSITY OF TECHNOLOGY

Erasmus+