MULTIFACETED RESEARCH IN ARCHITECTURE

Editor **Beata Komar**

VOLUME II

ARCHITECTURE AGAINST THE CHALLENGES OF THE FUTURE – SMART ARCHITECTURE

Editor **Klaudiusz Fross**
Technical editor
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WYDAWNICTWO POLITECHNIKI ŚLĄSKIEJ
GLIWICE 2022

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Klaudiusz FROSS[1]

INTRODUCTION

The considerations undertaken by the authors of this section are a continuation of the interdisciplinary discussion on the quality of the built environment in its various dimensions that started many years ago. This attempt takes on a new meaning, especially nowadays, of defining the quality of the living environment in the face of changing needs, general reconstruction of the world view and new challenges facing mankind. Climate and environmental protection, increasing resource efficiency, the need for energy self-sufficiency of buildings as a standard, protection against pandemics or even living in a pandemic are no longer just theoretical considerations, but the reality in which we function. Architecture is faced with new challenges, opportunities, and social expectations. That is why this section features scientific reflections on the future of architecture - architecture that meets the needs of users in subsequent generations. The group from researchers of the Faculty of Architecture of the Silesian University of Technology, who have been creating the Silesian School of Qualitative Research for over 24 years, is particularly active in this field. A new field that has emerged in this discussion is space architecture. Research in this area was inaugurated by the Faculty of Architecture of the Silesian University of Technology established in 2017. Space Architecture Research Programme, which aims to promote and support scientific work and design concepts related to space. Currently, research is being conducted, among other things, on comical habitats. Solutions tested and implemented in analogue habitats can be implemented not only in space but also on Earth, in projects of self-sufficient buildings, in rescue after natural disasters, and in extreme conditions. They will be useful in solving contemporary problems of mankind, such as growing population and dwindling resources. The next few years may see the need for space architects or astronaut architects, who will fly to other planets to supervise construction. These promises to be interesting times for researchers of the built environment, for new and innovative solutions in architecture and urban planning. At the same time, it is an open invitation to continue and develop this theme.

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Klaudiusz FROSS[2]

WPROWADZENIE

Podjęte przez autorów niniejszej części rozważania to kontynuacja rozpoczętej wiele lat temu interdyscyplinarnej dyskusji nad jakością środowiska zbudowanego w różnych jego wymiarach. Ta podjęta próba nabiera nowego znaczenia, szczególnie w dzisiejszych czasach, określenia jakości środowiska życia wobec zmieniających się potrzeb, generalnej przebudowy światopoglądowej i nowych wyzwań stojących przed ludzkością. Ochrona klimatu i środowiska, zwiększenie efektywności gospodarowania zasobami, konieczność samowystarczalności energetycznej budynków jako standardu, ochrona przed pandemiami czy wręcz życie w pandemii to już nie tylko teoretyczne rozważania, ale rzeczywistość, w której funkcjonujemy. Przed architekturą stoją nowe wyzwania, możliwości, ale i oczekiwania społeczne. Dlatego właśnie w tej części pojawiają się refleksje naukowe nad przyszłością architektury, spełniającej potrzeby użytkowników kolejnych pokoleń. W tym gronie szczególnie aktywna jest grupa naukowców Wydziału Architektury Politechniki Śląskiej, tworzących od ponad 24 lat Śląską Szkołę Badań Jakościowych. Nową dziedziną, która pojawiła się w tej dyskusji, jest architektura kosmiczna. Badania nad tym obszarem zainaugurował utworzony na Wydziale Architektury Politechniki Śląskiej w 2017 r. Program Badawczy Architektury Kosmicznej, mający na celu promocję i wspieranie prac naukowych oraz koncepcji projektowych związanych z kosmosem. Obecnie prowadzone są badania m.in. nad habitatami kosmicznymi. Rozwiązania testowane i wdrażane w analogowych habitatach mogą zostać zaimplementowane nie tylko w kosmosie, lecz także na Ziemi, w projektach samowystarczalnych budynków, w ratownictwie po klęskach żywiołowych, w ekstremalnych warunkach. Są przydatne w rozwiązywaniu współczesnych problemów ludzkości, jak przyrastająca liczba

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ludności i kurczące się zasoby. Potrzebą kolejnych lat być może będą architekci kosmiczni czy architekci astronauci, którzy polecą na nadzory budowlane na inne planety. Zapowiadają się ciekawe czasy dla badaczy środowiska zbudowanego, dla nowych i innowacyjnych rozwiązań w zakresie architektury i urbanistyki. Równocześnie jest to otwarte zaproszenie do kontynuacji i rozwinięcia tego tematu.

Klaudiusz FROSS, Wiktoria DZIADUŁA[3]

QUALITATIVE RESEARCH IN THE LUNARES SPACE HABITAT

INTRODUCTION

Humanity is one step away from manned space missions. The planned mission of the National Aeronautics and Space Agency of the United States of America - the Artemis mission – focuses on achieving the goal of landing a man on the moon by 2024. It assumes sustainable use of the moon by the end of the twenties.[4] The high risk and danger posed by this bold venture is related to the need to test as many potential scenarios, procedures and solutions as possible. Analog habitats have been set up 'because *access to space is so difficult, dangerous and expensive, the disciplines of engineering, operations, and space architecture attempt to simulate every aspect of space habitats they can before finalizing the design.'* [5] The task of simulation research facilities is to render as faithfully as possible all conditions and elements of the environment that are to reflect, for example, outer space, Martian or lunar environment. Marc M. Cohen (2012) pointed out that freehand sketches and computer visualizations are important, however, the key element is full-scale, full-size mock-ups / simulators that provide ample opportunities for research into future space architecture. Prototyping on a scale of 1:1 is a necessary stage of architectural development, it allows the user to experience the space in its full splendor, to touch, smell and hear.

The idea behind these architectural simulations is to create an 'artificial environment' that can serve a variety of purposes depending on the needs. Habitats function, focusing research on the subject of group psychology and isolation

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[4] NASA's Lunar Exploration Program Overview National Aeronautics and Space Administration PLAN September 2020.

[5] M. Cohen, "Mockups 101: Code and Standard Research for Space Habitat Analogues", 2012.

(Mars500, HERA, LunAres) completely cut off from the external environment. Anothee facilities, thanks to their location in terrestrial analogue sites, enable additional extensive research related to geomorphology, geochemistry, and exobiology (e.g., Mars Desert Research Station in the Utah desert; Concordia Research Station at the South Pole). The aquatic environment is a good reflection of the cosmos, which, thanks to its properties, allows the astronaut to undergo advanced training (Aquarius Reef Base). Not all habitats / prototypes are associated with the presence of the crew - some are specific laboratories for research on life-support systems, closed circulation of raw materials, or plant cultivation - aspects of self-sufficiency (CESRF, MELiSSA).

PURPOSE, SCOPE AND METHODOLOGY OF RESEARCH

A term often encountered in the literature is ICE (*Isolated, confined and extreme*), i.e. an environment in which there are physical parameters deviating from optimal for human survival - the task of analog habitats is to enable research on supportive solutions surviving and functioning in an unfavorable, extreme environment. The work below examines these opportunities at LunAres using a qualitative assessment methodology based on the expert judgment that took place in January 2021 during the PANDA – PANDemic Analog simulation mission.

Due to the different purposes and types of analog habitats, it was decided to first match the object with the TRL (*Technology Readiness Level*) level, subjectively assessing the level of simulation of the cosmic environment, and then, taking into account the characteristics for each of these levels, analyze it in individual qualities.

The qualitative research in the LunAres habitat during the PANDA mission was carried out by mgr inż. arch. Wiktoria Dziaduła as part of the work of BK (Faculty of Architecture of the Silesian University of Technology, at the Rar5 Department) under the supervision of dr hab. inż. arch. Klaudiusz Fross, prof. PŚ. Before the mission, the scope of the research was defined, checklists prepared and the methodology discussed.[6] The research team did not know if it would be possible to carry out the full scope of the research. It was prepared for modifications and adaptation to the mission conditions (simulation of conditions on the moon). Due to the limited contact with the outside world, the analog astronaut Wiktoria Dziaduła knew that she would

[6] Fross K., Badania jakościowe w planowaniu, programowaniu, projektowaniu oraz ocenie inwestycji, czasopismo Builder, Biznes, Budownictwo, Architektura, nr 6, PWB MEDIA, czerwiec, 2015, ISSN 1896-0642, s. 14-17.

make decisions about the scope of research on her own in the habitat. At the same time, materials were collected for a thesis related to the architectural concept of space habitat. A difficulty for the research contractor in the facility was the simultaneous performance of all the tasks of the PANDA mission. Immediately after the mission was completed, a meeting was organized to discuss and summarize the results of the research in the form of a report on the stay.

During the research mission, the following was planned (based on theory and practice of this type reaseach)[7]:

A. DAIRY OF THE RESIDENCE

- description of the day, activities,
- own feelings, emerging problems,

Observations about the object, ideas for the diploma project.

B. QUALITATIVE AND OBSERVATIVE TESTS

QUALITATIVE TESTS - EXPERT EVALUATION

Assessment of the facility in terms of quality:

- technical quality,
- functional quality,
- organizational quality,
- economic quality,
- behavioral quality,
- research conclusions,
- guidelines for the diploma project.

OWN OBSERVATIVE RESEARCH OF USERS 'BEHAVIOR.

Observations and conclusions from the observation of the use and behavior of users.

GETTING TO KNOW THE USERS 'OPINIONS ABOUT THE FACILITY – a short voluntary, anonymous interview

- Respondent's mini-certificate: gender, age, time of stay in the facility,
- What do you like about the facility?
- What are any possible shortcomings or what is missing in the facility?
- What will be changed in the facility? Why?

[7] Niezabitowska E., Jakość budynku i narzędzi jej oceny, [w]: E. Niezabitowska (red.) Budynek Inteligentny. Potrzeby użytkownika a standard budynku inteligentnego. Tom I, Wydawnictwo Politechniki Śląskiej, Gliwice 2005.

GETTING TO KNOW USERS'OPINIONS ABOUT THE STAY ONLY - Supplemental (additional) tests – a short voluntary, anonymous interview

- How do you feel here? – What are your impressions? – What do you need? – What is your problem?

- Evaluate individual and teamwork, rest, meals, free time, well-being, interpersonal contacts, other...

TRL LEVEL CLASSIFICATION

To classify and organize thinking about the scale of advancement of projects, NASA and other space agencies adopted the Technology Readiness Scale (TRL) in the 1970s. It is a scale from one to ten determining the maturity of a given project/solution. The scale and the corresponding features are presented in the table below.

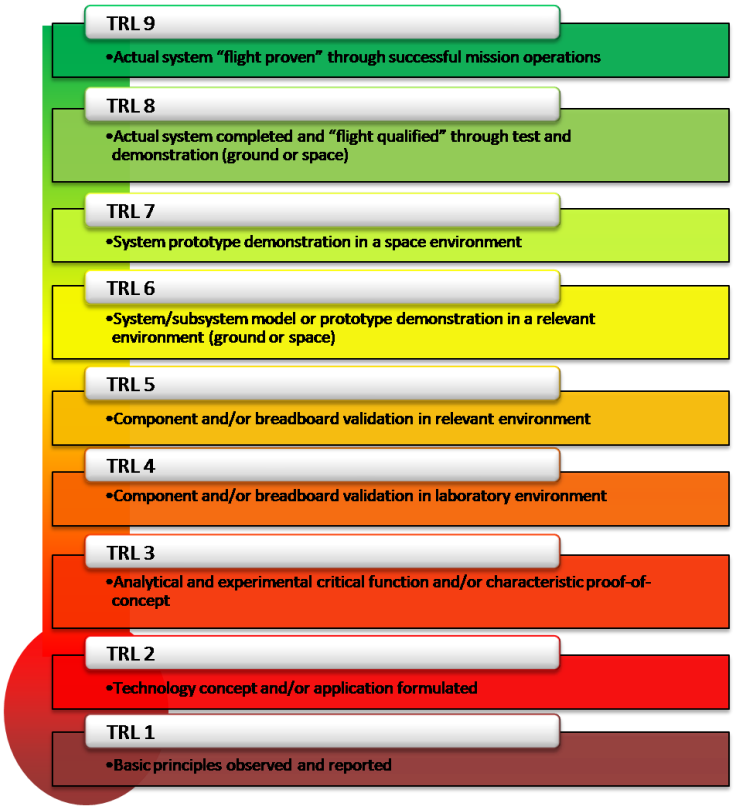

Fig. 1. Table of Technology Readiness Level (TRL). Source: www.nasa.gov
Rys. 1. Tabela - Technology Readiness Level (TRL). Źródło: www.nasa.gov

TRL 1-3 projects are those that focus on initial research, e.g. using computer-aided design or mock-up tests using cardboard, foam, or wood.[8] Additionally, they focus on looking for possible applications of a given technology - the phases involve observation and experimentation. Intermediate levels are TRL 4-6 - they relate to solutions in the target laboratory environment - they are product / design demonstrations. The third category is the higher TRL 7-9 and they are associated with testing or operating in the target environment - space, that is, they reach full maturity and become commercialized. The comparison in the context of mock-ups and habitats was also presented in his publication "*Mockups 101: Code and Standard Research for Space Habitat Analogues*" (2012) by Marc Mitchell Cohen, who analyzed projects, extending them with attributes, typical materials.[9]

TABLE 2. Technology Readiness Levels (TRLs) in Relation to Mockup Attributes

TRL	General Description	Mockup-Specific Attributes	Typical Materials	Remarks
1	Basic Principles Observed	Conceptual Design to show that X can exist with attributes Y & Z.	Foamcore, Cardboard, Sintra board	Scale models usually work as well as full-scale mockups.
2	Concept Formulation, Modeling, and Simulation	Control design variables for dimensions	Plywood, Sintra board, Wood	Architectural Experiments
3	Proof of Concept	Form, Fit, Function, Mechanical Operations	Metal, Plastic, Wood	Engineering Integration Phase
4	Component/ Subsystem Test in a ***Laboratory Environment***	Functional and Operational Research	Electronics, Mechanical Systems	Includes part task flight simulator
5	Subsystem Test in a ***Relevant Environment***	Partial Habitable Living and Working Environment Simulation	Electronics, Mechanical Systems, Atmospheric System	Includes motion-base flight simulator
6	System Test in a ***Relevant Environment***	Full Habitable Living and Working Environment Simulation	Electronics, Mechanical Systems, Hypobaric Atmosphere	Includes high fidelity mission simulator

Fig. 2. Comparison of TRL in relation to prototypes and habitats. Source: Marc Mitchell Cohen (2012)
Rys. 2. Zestawienie TRL w relacji do prototypów i habitatów. Źródło: Marc Mitchell Cohen (2012)

Based on the above lists and my own experience, it was decided to classify LunAres to the TRL 4/5 level, due to the high advancement of the project and the possibility of testing individual subsystems, creating a partially inhabited life and working environment that is a simulation, but still in laboratory (non-target) conditions.

[8] M. Cohen, *Mockups 101: Code and Standard Research for Space Habitat Analogues*, 2012 p. 8.
[9] M. Cohen, *Mockups 101: Code and Standard Research for Space Habitat Analogues*, 2012 p. 8.

ORGANIZATIONAL QUALITY ASSESSMENT

The LunAres is a research facility established in 2017 at the former military airport in Piła and was the first facility of this type in Europe.[10] At LunAres Research Station there are simulated space manned Moon or Martian missions lasting 2 weeks. The main aspect of the mission simulation is based on human factors and technologies related to sustainable development. Due to its characteristics, the base allows for research in full isolation - even during EVA - extravehicular activities - i.e. space walks. They are served by an airline hangar with an area of 250 sq m, equipped with the necessary infrastructure and elements stimulating the lunar surfaces.

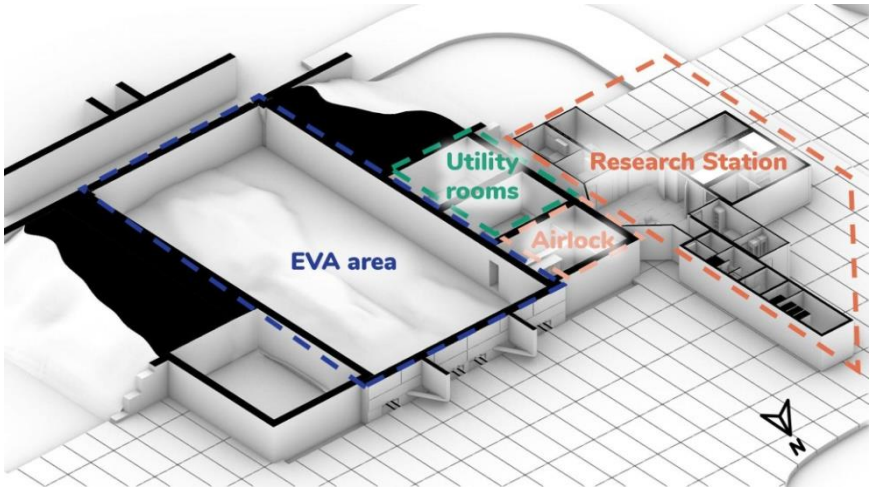

Fig. 3. Functional zones in LunAres. Source: LunAres
Rys. 3. Strefy funkcjonalne w LunAres. Źródło: LunAres

The facility enables tests for:

- Human factor – physical and mental health in isolation, group psychology,
- Growing plants in soilless conditions using hydroponic and aeroponic techniques,
- Prototyping and testing – using modern technologies, e.g. using 3D printing,
- Procedures and safety – during the organization and execution of missions and spacewalks
- Sustainable development – that is, responsible management of resources, reuse of raw materials, use of gray water.
- The use of modern technologies – during monitoring and observation, i.e. telemedicine devices and a monitoring system.

[10] https://lunares.space/about-habitat/ (access: 2.11.2021).

In terms of organization, LunAres Research Station enables advanced research that may affect the development of solutions for manned space missions in the future and improve the quality of life and work on Earth.

TECHNICAL QUALITY ASSESSMENT

Habitat LunAres consists of two parts - an adapted hangar as a lunar surface intended for spacewalks and an added living area connected to the hangar by a lock. The residential part consists of 2.21 x 5.80 m transport containers connected by a dome roof forming an atrium. Due to the materials used, i.e. ready-made containers, despite the thermal insulation of the external walls, the facility has many thermal bridges (photos below), in particular in the corners and at the connection with the dome (no insulation at the connection with the dome). In addition, the atrium is considered the "inner part" of the base, while the outer part is considered "lunar space", although technically the atrium, as the name suggests, is not permanently and tightly connected to the modules - containers. The floor of this inner courtyard is set directly on metal stiffening grids on the concrete base of the airport apron and is finished with foam panels. This results, depending on the external conditions, in a large loss of heat or humidity inside and in poorly developed, incomplete connections with the containers. With the use of the materials used, there is also a problem with the appropriate soundproofing of the rooms; due to the comfort of use, acoustic solutions should be applied (the workplace is next to the gym – exercise on the treadmill interfered with your own work). It is also worth emphasizing the highly advanced "digitization" system of the entire habitat – there are many sensors and intelligent systems inside, which allow for monitoring and adjusting internal parameters, such as the intensity and color of light.

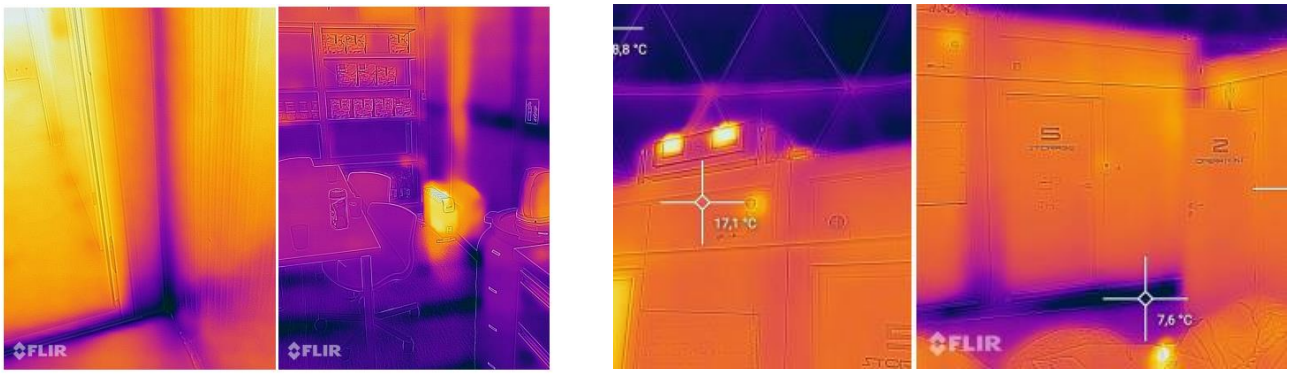

Fig. 4. Thermal images at LunAres. Source: own research
Rys. 4. Zdjęcia termowizyjne w LunAres. Źródło: opracowanie własne

FUNCTIONAL QUALITY ASSESSMENT

Container-modules in LunAres have been arranged in such a way that modules supplied with water are next to each other, silent and separately "dirty". The containers that make up the habitat are mostly monofunctional, responding to individual needs related to living and working in isolation. The functions that are in the habitat are as follows:

- Dormitory, where there are individual sleeping capsules with dimensions of 2x1.2 m equipped with USB and lighting. There is also a place to store the most necessary things.
- A kitchen with basic equipment for preparing meals (kettles, sink, microwave) and a table with space for the entire crew.
- Gym with a treadmill and small equipment for individual or group training.
- Sanitary module, which includes separate rooms such as a toilet with a washbasin and a gray water tank, a walk-through room containing a washbasin and a shower, and a storage space for clean water. In addition, the module is equipped with a wastewater and water treatment and recycling system, which can be monitored and analyzed on an ongoing basis.[11]
- Biolab is a laboratory that has the equipment necessary to perform chemical and biological experiments. There is an infrastructure for the cultivation of hydroponics and aeroponics. At the end of the room there is a small storehouse for medicines and devices.

[11] J. Jurga, N. Cwilichowska, A. Mintus, L. Orzechowski, *Design of hygiene module using closed grey water cycle for LunAres Research Station – main assumptions and applications,* 2020.

- The workshop module consists of two spaces; mechanical workshop and electronic workshop with basic tools, accessories and devices, e.g. 3D printers,
- The management room contains a work area for each crew member and space for storing and documenting.

Everything works properly, there are also no "missing" functions. A good solution is the radial arrangement of modules; the atrium as a central point allows quick access to any room. It is also worth emphasizing the attempts to adapt the facility to the disabled - the bathroom has a driveway, ultimately all differences in levels are to be eliminated.

BEHAVIORAL QUALITY ASSESSMENT AND USER FEEDBACK

During the mission, research was also carried out in the form of a survey to assess the facility by the participants of the mission, which were included in the thesis (author: Wiktoria Dziaduła, supervisor: prof. PŚ, Klaudiusz Fross). Astronauts evaluated individual spaces (containers – kitchen, bathroom, atrium, workshop, gym, studio, bedroom, and laboratory) on a scale of 1-5 for; well being while staying in this space and correctly fulfilling the function of a given room. Additionally, users were asked to state the advantages and disadvantages of a given space and suggest improvements. The graphic below presents a general assessment of individual spaces.

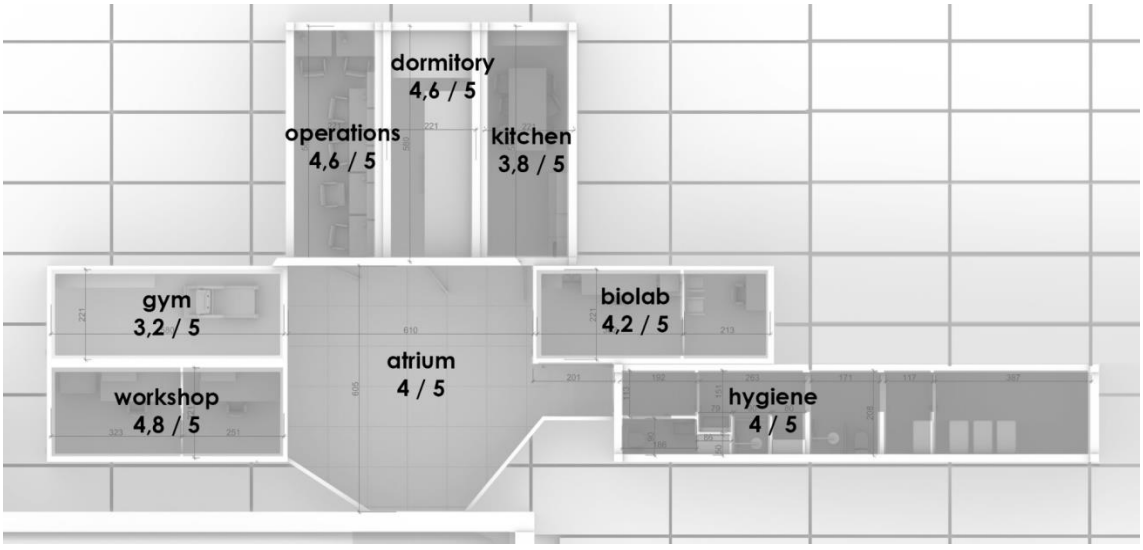

Fig. 5. Graphics showing the average assessment of individual spaces made by astronauts during the mission Source: own research based on the LunAres graphics

Rys. 5. Grafika przedstawiająca uśrednioną ocenę poszczególnych przestrzeni dokonaną przez astronautów podczas misji. Źródło: opracowanie własne na grafice LunAres

The best-rated spaces in terms of space turned out to be a workshop with a 3D printer, followed by a bedroom and a computer lab. This function was best fulfilled by a workshop, followed by a bedroom and a kitchen. The respondents also pointed out that the space is realistic and functions efficiently, but there are no small solutions such as more storage space, mirrors, and equipment that facilitate everyday activities.

As for the interior, they are raw, devoid of unnecessary elements, decorations – they meet the basic needs with a relatively small size (approx. 25 sq m per person). The respondents pointed to the lack of privacy and "coziness" of space, which proves that the internal environment is an additional stressful factor that allows for a reliable reflection of the atmosphere of manned missions, which is an important factor from the point of view of the credibility of research, especially related to psychology. In his book*"Space architecture. Human habitats beyond the Earth"* architect and author Olga Bannova mentioned: *"To live in space is to live in the machine."*

ECONOMIC QUALITY ASSESSMENT

One of the main assumptions of the LunAres habitat is research on the sustainable development and self-sufficiency of the facility. Taking into account the gray water recovery systems and the possibility of its reuse (e.g., for flushing the toilet), as well as the monitored and responsible use of resources, it allowed reducing the daily water consumption below 20 liters/person /day, while the Central Statistical Office data shows that about 100 liters per person are used on average (in Poland). As far as water management is concerned, clean water is stored in special tanks with a capacity of 2000l, when the level was alarming, the tanks were refilled with external interference - the size of the tanks was not large enough to avoid the need to refill clean water. Also due to the uninsulated atrium (mentioned earlier), there was a large loss of heat, especially during winter missions, when the temperature difference is significant. There was a need for additional heating of the entire volume with external heaters most of the time, which significantly influenced the power consumption. The soilless cultivation system in the biolab could also be ineffective, due to the temperature or microclimate - the need for a sterile, dedicated room intended only for experiments with plant breeding was indicated.

SUMMARY AND CONCLUSIONS

In terms of functionality and space, the LunAres habitat fulfills its tasks and roles well. Its advantages include the philosophy of its construction and space, similar to future real cosmic ones, modularity and spatial forms (domes, containers). The course of the mission itself also allows for high immersion and empathizing with the role of an astronaut, which helps to endure difficult conditions. As the only (or one of the few) it allows you to test complete isolation from the outside world (no windows) and at the same time has EVA (spacewalks) surfaces in a separate hangar, which means that the participant is not in contact with the sun's rays throughout the mission. This offers great opportunities for the development of useful research for future space missions.

LunAres has great scientific and research potential and has a significant contribution to the development of research on future human space missions. Analog Astronauts on missions in this facility come from all over the world and represent respected and well-known space agencies and institutions. Despite the few years of operation (since 2017), LunAres has ambitious development plans that will further increase the rank and prestige of the project in the international arena.

It is worth highlighting that these were pioneering studies of qualitative assessment of the space habitat by architects. The research was conducted in parallel with the space mission. The research results constitute an interesting resource for the design of a space habitat.

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THE PANDA SPACE PROGRAM IN THE LUNARES HABITAT - RESEARCH ON NEEDS AND BEHAVIOR DURING ISOLATION

INTRODUCTION. SPACE TECHNOLOGIES

Rapid technological development allowed for new possibilities of the conquest of space on a so-far unknown scale. Despite the tools and solutions at the disposal of the largest companies and space agencies, the need for continuous testing and improvement is colossal to ensure the most important aspect of space missions – safety and reliability. "The risk of the incompatible vehicle or habitat design"[3] has been officially recognized by NASA as a threat to human health and life. This demonstrates the significant need for research, testing, and experimentation that is possible thanks to analog space habitats. However, research in habitats not only contributes to the development of solutions in the field of space technologies but also affects the quality and standard of life on Earth.

Extreme environments in space, such as other planets, determine a design strategy (and not only) based on an economic, sustainable approach, including an economy with the closed circulation of materials and resources(at best, ensuring 100% independence of the facility's operation). The science of what solutions can and should be used is closely related to what most research in analog space habitats – simulation research facilities - concerns. The fact that space projects contribute to the emergence of solutions that positively affect welfare and standard of living can be observed by citing several known solutions. The NRC thermal blanket, widely used in rescue and saving lives, was created by NASA research in 1964 - the technology that protects the space station from extreme temperatures, protects human life. Rubber soles, Velcro, and a carbon filter have also been deployed in space research. The

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[2] Space is More, Wrocław (POLAND), OrzechLeszek@gmail.com, Mintus Agata agata.mintus@gmail.com
[3] NASA, *Evidence Report: Risk of Incompatible Vehicle/Habitat Design,* p. 3.

solutions to which space technologies contribute can solve the current problems of mankind. These are, for example, urban problems related to megacities, a growing population, urban sprawl, and thus drastically increasing the need for space and resources[4].

Fig. 1. Transfer of knowledge and technology in space and terrestrial. Source: I. Schlacht, B. H. Foing, O. Bannova, F Blok
Rys. 1. Transfer wiedzy i technologii kosmicznej i ziemskiej. Źródło: I. Schlacht, B. H. Foing, O. Bannova, F Blok

PANDEMIC AND SPACE

The problem faced by humanity in early 2020 was the outbreak of the Covid-19 virus pandemic. Many countries closed their borders, suspended air connections, and traffic was significantly limited, if not impossible. On a daily basis, the possibilities of movement were limited, schools, as well as cultural and entertainment facilities were closed, ending a barrier-free life. Work and life took place at home without unnecessary contact with the environment. What will be the actual impact and consequences of the pandemic remains to be seen, but there are more and more publications and studies on the impact of the pandemic on mental health. Quoted by "The preliminary report from the research conducted by Dr. Hab. Małgorzata Dragan – Mental health during the Covid-19 pandemic."[5] at the Faculty of Psychology at the University of Warsaw, a significant impact of the epidemic on people's health and well-being can be noticed. The research was carried out on a group of 1,390 people aged 18 to 78, while 66.3% of people declared fully remote work. As emphasized in the preliminary report, up to 75% of respondents indicate that the epidemic is the sensor that causes their stress. It was also indicated that "*more than half of the respondents (51%) report symptoms indicating a breakdown in functioning and performing daily duties*", which is associated with symptoms such as post-

[4] I. Schlacht, B.H. Foing, O. Bannova, F. Blok, *Existing and new proposals of Space analog, off-grid and sustainable habitats with Space applications.*

[5] psych.uw.edu.pl/2020/05/04/zdrowie-psychiczne-w-czasie-pandemii-covid-19-raport-wstepny-z-badania-naukowego-kierowanego-przez-dr-hab-malgorzate-dragan/

traumatic stress symptoms, sleep disturbances, problems with concentration, overthinking and worrying. This stressful situation also significantly affects children, making it difficult for them to function and develop social relationships, harms the psyche, causing anxiety, loneliness or cognitive impairment.[6] Participants of space missions face similar challenges as life in a pandemic. On the other hand, the factors that cause stress for astronauts are *"limited available space, constant confinement, irregular or unnatural light cycles, extreme temperatures, unusual environmental hazards (meteorites, radiation, snowstorms, etc.), noise and vibrations, sterile and monotonous environment, restricted diet, restriction of privacy, necessity of forced interaction with a small group of people, disconnection from the natural world, no separation of work from social life, no family life."* [7]

In response to this and the challenges humanity has faced (and is facing) in the context of pandemic isolation, scientists from LunAres Research Station, a simulation research facility in collaboration with institutions and universities, have initiated a program of space missions aimed at research in conditions of "total isolation". The cosmic conditions in the habitat in some respects turned out to be analogous to those during 'pandemic isolation'. The similarities are:

- Staying in constant isolation from the outside world - both in the habitat and during the so-called forced isolation (e.g. as part of quarantine), there is no possibility of contact with the outside: in the habitat on an even larger scale than in an average flat without a balcony, the scale: in LunAres, there is no windows/contact with the outside world.
- Communication options - the ability to communicate with loved ones only and exclusively through telecommunications devices - video calls, chat.
- Isolation/quarantine period - mission duration is 14 days, while home isolation is around 10 days, with cases up to 2-3 weeks in the case of continuous new infections of family members.
- Staying with the same people, the crew during the mission consists of 5-6 people who have to cooperate and co-exist in a very small space. Assuming six crew members and the usable area of the rooms in LunAres, i.e. the atrium 40 sq m, a hygiene module, half of which is a space for storing water resources: 25 sq m (12.5 sq m), 15 sq m biolab, 15 sq m kitchens with a dining room, 15 sq m

[6] Shweta Singh, Deblina Roy, Krittika Sinha, Sheeba Parveen, Ginni Sharma, and Gunjan Joshi "Impact of C OVID-19 and lockdown on mental health of children and adolescents: A narrative review with recommendations", 2020.

[7] S. Häuplik-Meusburger, "Habitability Studies and Full Scale Simulation Research: Preliminary themes following HISEAS mission IV", 2000.

dormitories, gym 15 sq m, studio 15 sq m, workshop 15 sq m, i.e. a total of 155 sq m (The area does not include the lock (20 sq m), because it was not used everyday space, only during EVA – spacewalks). For a standard six people, the crew is 25.83 sq m per person, which can be compared to a small studio apartment.

- Delivery of products only from the outside, in the absence of something needed, e.g. warmer clothes, some items, only delivery by third parties as possible, which took place only after a few days and without personal contact, leaving shipments in a special lock.
- Remote work – both related to the mission and personal duties and obligations.

It is worth adding that people on missions are positive and prepared, unlike those forced to isolate themselves.

Additional elements that cause stressful situations during the simulated mission are:

- limited clean water and food supplies,
- monotonous meals in the form of freeze-dried food,
- lack of access to sunlight, which affects the production of vitamin D and the daily cycle,
- being in an unfamiliar environment, with strangers (possible social conflicts),
- the astronaut's busy schedule and duties,
- common "black-outs" related to power supply problems,
- continuous observation and numerous psychological tests.

PANDEMIC ANALOG MISSION_ PANDA MISSION – M01_Q1.21

The first mission in the "Pandemic Isolation Campaign" series took place in January 2021. The mission was under the honorary patronage of the Ministry of Health and was carried out in cooperation with the Silesian University of Technology and the Pomeranian Medical University. The organizers of the mission were Space Garden Sp. z o.o., Space is More Sp. z o.o. The team consisted of astronauts on a mission and a remote team that supported and monitored the entire process.

The analog Astronauts included in the PANDA mission are:

- Lef Karagiannis (Greece) – as Commander/Engineering Support
- Wiktoria Dziaduła – (Poland) – as Data Officer/Media Officer

- Barbara Gronwald – (Poland) – as Medical Officer/Data Support
- Piotr Skonieczka – (Poland) – as Software Engineer
- Leszek Orzechowski – (Poland) – as Habitat Specialist

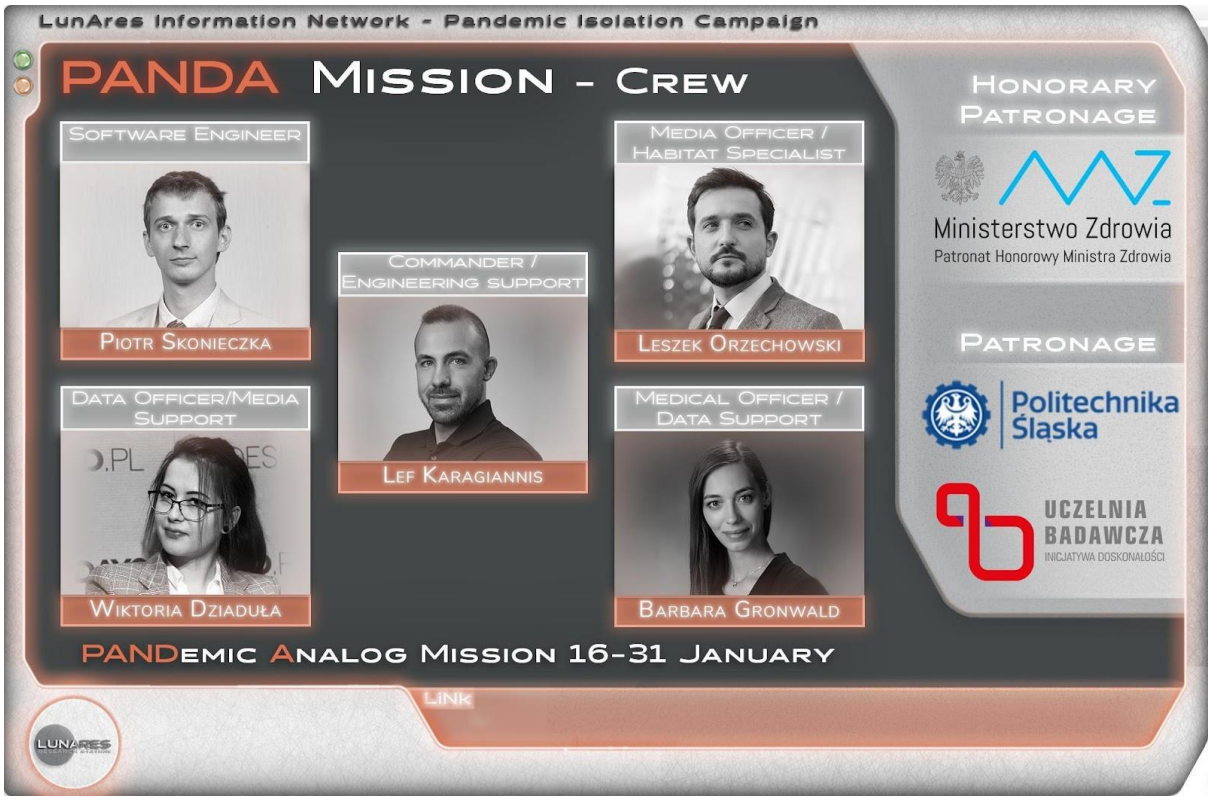

Fig. 2. Team PANDA 01/2021. Source: LunAres
Rys. 2. Zespół - Misja PANDA 01/2021. Źródło: LunAres

The remote control team was:

- Jas Purewal – (UK) – as Remote Crew Data Officer.
- Dobrochna Fryc (Poland) – as Remote Crew
- Jakub Zemek (Poland) – as Remote Engineer
- Anna Miller - (Poland) – as Remote Crew

Organization and Mission Control Center:

- Agata Mintus – (Space is More)
- Natalia Ćwilichowska – (Space is More)
- Aleksander Gorgolewski – (Space is More)

In addition to the insulation aspects, during the mission, tests of a new sanitary module were carried out, including the possibility of using and storing gray water, including for cultivation of hydroponic crops, the possibility of prototyping using 3D

printers. The possibilities of remote control of the lunar rover during spacewalks were recognized and individual expert qualitative research was carried out.

PURPOSE OF THE MISSION - GENERAL ISSUES

The main goal of this two-week simulation was to investigate the effects of isolation on mental and physical health. Health data was collected by IT systems, sensors, and monitoring. Analog astronauts were subjected to detailed psychological examinations and questionnaires twice a day and before and after the mission. There were also studies on creativity in isolation - through creative thinking tasks. The specific aim of these studies is to *"determine the volume of the hippocampus (the part of the brain involved in spatial orientation) and the levels of selected brain neurotransmitters and metabolites (which gives information about brain activity) in order to investigate possible changes due to short-term - timely isolation in a small space."*[8]

The analysis of the dynamics, behavior, and stress of the group was observed by a group of psychologists thanks to a monitoring system. In addition, in the context of physical health, studies were carried out on the mission factors of the human movement system - possible deviations from the norm caused by staying in a small space and potential changes in muscle mass and strength. At the moment, comprehensive data related to the above-mentioned issues are collected during the entire campaign, then the data will be analyzed and the conclusions published by their authors.

LUNARES AND DEALING WITH SPACE AND ISOLATION

Staying on a mission during long-term isolation highlighted important aspects that make the participant "feel good". The subjective list of aspects is presented below, and the author's assessment with justification is summarized in the conclusion.

- **functionality, i.e. a set of necessary functions:**

Basic division - in terms of rooms and functions they fulfill. These are atrium, hygiene module with toilet, shower and water supply, biolab with crops, kitchen with dining

[8] https://lunares.space/pandemic-isolation-campaign/ (access: 2.11.2021).

room, dormitory, remote workroom with computers, gym with storage, workshop and lock.

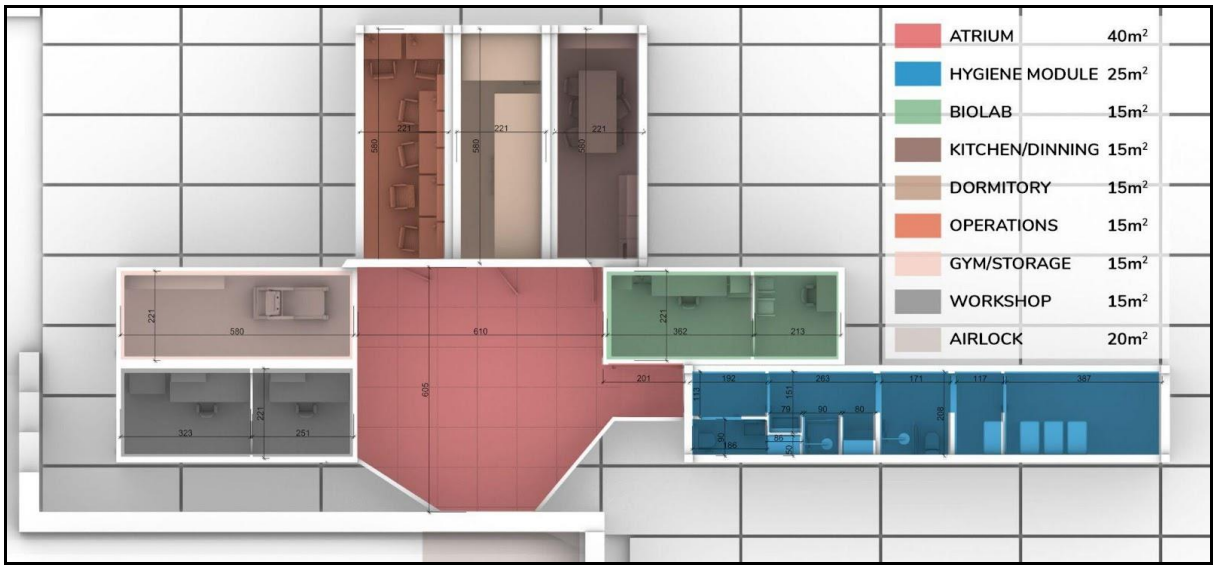

Fig. 3. Basic typology - types of rooms. Source: LunAres
Rys. 3. Podział podstawowy - typy pomieszczeń. Źródło: LunAres

- **Spaces enabling the performance of specific types of activities related to work-life balance:**

The division in terms of 'activities' includes the division of space in terms of the needs of everyday life and standard functioning, these are the functions of work/everyday activities/entertainment. The comparison shows that this division is the most balanced; there is a similar number of places for work, entertainment, and daily activities. According to observations, after about a week these spaces began to interpenetrate, for example, while the lunch eaten by astronauts was in front of the computers in the studio, when working from the dormitory, or when people spent time watching movies in the kitchen.

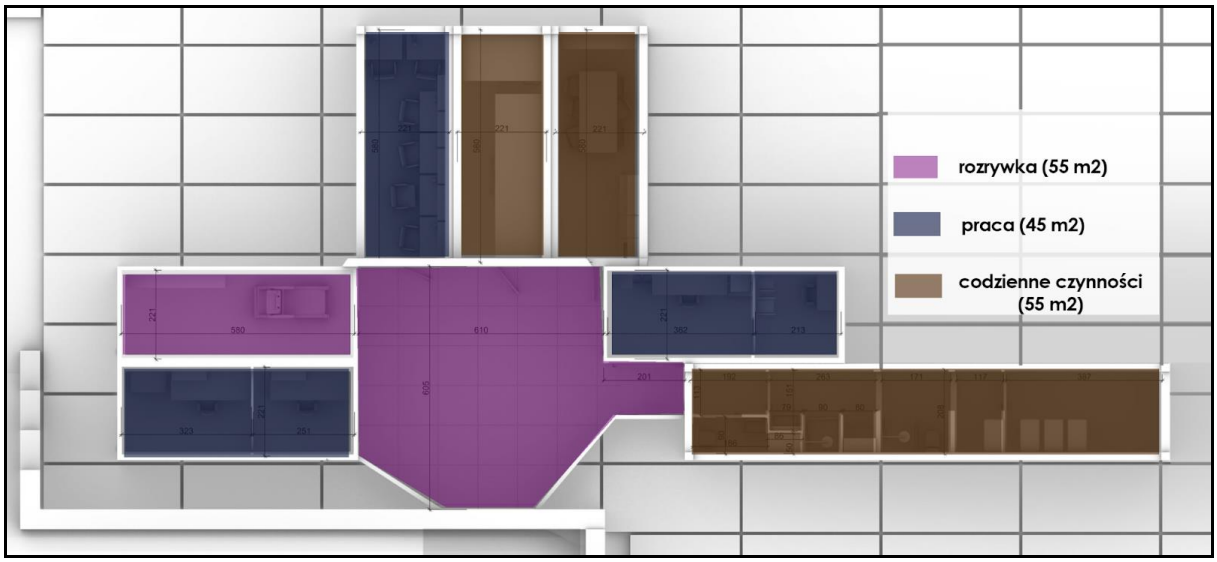

Fig. 4. Division to "activity". Source: own study based on LunAres graphics
Rys. 4. Podział “aktywności”. Źródło: opracowanie własne na podstawie grafice LunAres

- **Privacy and space sharing:**

The division of "ownership" has been processed on an analysis of accessibility and the need for privacy. Almost all spaces are shared, except the toilet space, part of the dormitory, and your desk. The notion that space is temporarily private is intended to accept that it is not a space that falls under the direct responsibility of an individual – it can be privatized for a certain time, e.g. in a bathroom – for the duration of a bath. The space that the astronauts had exclusive was only the area of their sleeping capsule – this space they could use in any way.

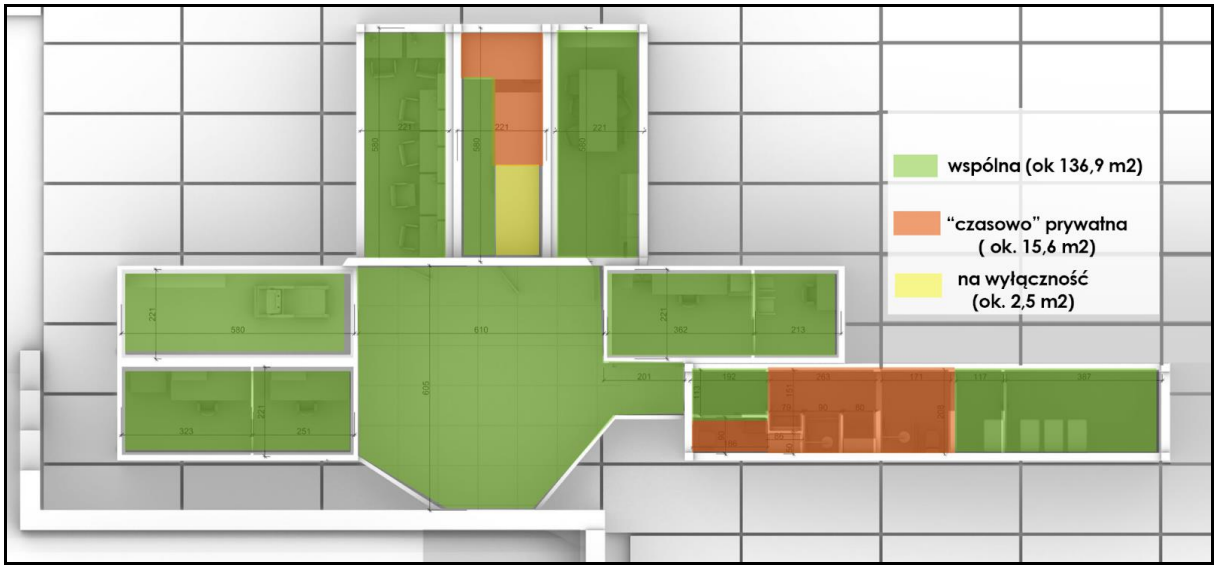

Fig. 5. The division of "ownership". Source: own study based on LunAres graphics
Rys. 5. Podział “własności”. Źródło: opracowanie własne na podstawie grafice LunAres

- **Coziness:**

The concept of how to design good and comfortable interiors is the hygge philosophy. Hygge was born in Denmark in the 19th-century [9] and is understood as an expression of coziness, bliss, the balance of being both with oneself and with others. This is also reflected in the design - special attention should be paid to supporting family and social life by creating the right spaces and atmosphere. The hygge ideas can also be supported by the materials used - choosing natural materials, such as wood, which brings you closer to nature not only visually, but also through other senses, such as smell or touch. Equally important are small elements that make you "feel good" in a given space - it is primarily green - when you are out of contact with the outside world, the empty and austere interior had an even more negative effect on your well-being.

LunAres is built of containers, which is also reflected in the interior - internal walls are made of sheet metal, most of the interior is white or black/gray. The interiors are small and compact, which means that there is no room for additional decorations – the main goal is functionality and versatility of the space. However, you can see soft elements in the common area.

Fig. 6 and 7. 'Raw' interior inside one of the containers – The interior of the dining room in the LunAres habitat and colorful elements in the atrium. Source: LunAres

Rys. 6 i 7. Surowe wnętrze wewnątrz jednego z kontenerów - Wnętrze jadalni w habitacie LunAres. Źródło: LunAres

[9] https://pl.wikipedia.org/wiki/Hygge (access: 2.11.2021).

- **Contact with nature:**

As research shows, vegetation not only has a good effect on human health and psyche, but also cleans and filters the air. Even greenery outside the window has a positive effect on well-being - research in one of the hospitals has shown that it had a positive effect on recovery of patients after surgery, even vegetation in films or pictures can lower muscle tension, pulse, and electrical conductivity of the skin. The only place where there was vegetation was the biolab. The hydroponic cultivation there was a contact with nature. The participants of the mission have repeatedly pointed out that caring for and dealing with the plants gives them satisfaction and release.

Fig. 8 and 9. Hydroponic plants in biolab, during PANDA mission. Source: LunAres
Rys. 8 i 9. Rośliny hydroponiczne w biolabie podczas misji PANDA. Źródło: LunAres

CONCLUSIONS

Being locked in the space base is full-fledged isolation, which has allowed the author to experience and observe some dependencies related to space during isolation. Some important elements were distinguished in the context of space and isolation, such as functionality, privacy, work-life balance, coziness, and contact with nature. According to observations and analyzes, the habitat meets all the elements necessary for its functioning – it has both basic living spaces as well as places for work and entertainment. A good solution is a formal separation of work and living space, it allows you to organize time well. Daily exercise was an important element – they were allowed to maintain physical fitness, while the space to move was very limited -

the number of steps during the day was very small. The big problem during the mission was the lack of privacy and the sharing of almost all spaces. From a psychological point of view, there was no place to calm down and escape at worse times. In extreme conditions, the key issue is to ensure safety; therefore, the functional program of the facility should provide for an extensive and advanced technical infrastructure, matched to the needs of the environment. Security is an important component of the so-called comfort. There was no presence of plants, greenery and interior design elements that make the space personalized, related to someone, showing its character and not just an anonymous, universal space that may and works well but lacks individual, tailored features. In addition to these elements, the microclimate aspects of the interior should be considered: appropriate humidity and temperature, thermal comfort, which is a well-known issue in architecture, that is even more important in extreme, isolated spaces.

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Beata KOMAR[1]

IMPLEMENTATION OF THE FUNCTION OF WORK AND HOUSING DURING PANDEMIC OF COVID-19

1. INTRODUCTION

The function of the apartment has been of interest to builders, architects, urban planners and ordinary users for centuries. The conditions in which we live have a direct impact on how we work, how we learn, and what our relationships with our loved ones and the environment. It also affects our mental condition. The Covid-19 pandemic has shown even more strongly how important the place where we live, its size, distribution, location, access to greenery and infrastructure is. It has clearly verified the quality of our headquarters.

A similar, earlier verification factor can be considered the political transformation, which also showed the adaptation of apartments to the new reality, self-employment, which also forced the development of space for running a business. However, this process took place much slower and did not concern all citizens. The current requirement to carry out the functions of work/study and living under one roof appeared suddenly, you can even use the phrase from day to day .

In June 2021, the author of the article conducted a survey on combining the functions of work and housing during the Covid-19 pandemic. In total, 43 questionnaire responses were obtained, the respondents were students of the Faculty of Architecture of the Silesian University of Technology in Gliwice. The main purpose of the article is to present the results of this study.

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2. CHANGING REQUIREMENTS FOR THE FUNCTIONS OF THE APARTMENT BEFORE 1990 AND AFTER 1990

This issue was described, among others, by Władysław Korzeniewski in his article [2], who pointed to the existence of 3 essential functions of housing, these are the following:

I. Biological and psychological functions

II. Cultural and social functions

III. Economic and utilitarian functions, where in the "life processes of residents" he mentioned the performance of professional work and in the requirements for the function of housing, he noted the need to provide a place and conditions for performing professional and amateur activities. He also carried out a very interesting characterization of changes in the processes of family life in an apartment in cities after 1990. For the purposes of this article, you can quote the relevant passages – Table 1.

Table 1

Characteristics of changes in the processes of family life in an apartment in cities after 1990

Characteristic processes (activities)	Changes in the meaning or intensity of processes	
	Before 1990	After 1990
Contacts between family members and other people	Limited contacts with other people due to: – the universality of full-day employment in plants and participation in socio-organizational activities. Extended commuting time to and from work, including mass transport, – universal, all-day stay of children in nurseries and kindergartens and extended stays in school common rooms, – use by children, youth, pensioners and pensioners from community centers and municipal clubs	The increasing need for contact between family members (except young people) in the apartment with other people due to a decrease in the rate of permanent employment in workplaces, an increasing scope of professional work in the apartment, the disappearance of other forms of spending time outside the home, both of a socio-organizational and ludic nature.

Learning family members in the apartment	The system of general and vocational education, including institutional forms of general and company education, satisfied real qualification requirements and limited learning in an apartment to performing homework and preparing for examinations or qualifications.	The system of general education at the primary and secondary level did not causa a significant change in the learning conditions in the apartment, except for the possibility of using a computer. In the field of higher education and continuing vocational training, there have been significant changes in the conditions for obtaining or frequently changing qualifications. Due to the high costs of education and the limitation of the share of the trowel plants in covering the costs of further training, this requires a greater range of these tasks to be performed through self-education, in large part in an apartment equipped with a computer and internet connection.
Professional work in an apartment	Professional work in the apartment was limited almost exclusively to casual work performed after hours of permanent work, but rarely to permanent entitlement to a liberal profession (e.g. a doctor or a lawyer) and cottage industry, i.e. performing permanent paid work outside the system of paid employment. Professional work in the apartment can also include permanent individual home exercises of artists: musicians, singers, stage actors. On the other hand, the work of visual artists(e.g. painters or	Forms of work in an apartment performed before 1990 are still used, but the area of permanent employment in workplaces is gradually decreasing in favor of the so-called "self-employment" consisting to a significant and sometimes decisive extent in performing one's work at home. The number of people practicing liberal professions is also constantly increasing, a significant part of whom perform such work in an apartment occupied by a family. Without change, you can list other forms of work in the artists' apartment, such as before 1990

	sculptors) who had the right to obtain for this purpose a studio that is an independent premises or related to an apartment should be treated differently.	
Using computers and electronic informatics	Minimal use of computers in apartments.	The widespread use of computers in apartments and the increasing use of the Internet and other information technology.

Source: Adapted from [2]

Summing up the characteristics presented in the table, it can be concluded that it shows the housing situation in which the Covid-19 virus appeared in Poland in 2020.

3. SURVEY RESULTS

The questionnaire developed by the author of the article consisted of 10 questions, of which 5 were closed questions and 5 were open questions. The survey was answered by 43 respondents, who were students of the Faculty of Architecture of the Silesian University of Technology.

1. Place of residence:

According to the results obtained, the majority of respondents live in houses – 65%, and only 35% in apartments.

2. How many people are in the household where you live?

The following results were obtained:

Table 2

Answer to question 2

Number of people in the household	Number of indications	Procent
6	4	9,3%
5	6	13,95%
4	8	18,7%
3	14	32,55%

2	8	18,7%
1	3	6,8%

Source: Author's own.

3. Do you have your own room? If the answer is in the affirmative, please answer the following questions.

96% of respondents indicated that they have their own room, only one negative indication was obtained 2,5%, and also one indication other 2,5%. In the case of other answers, the respondent explained that he lives independently in the apartment.

4. What is the square area (m²) of the room you live in?

The most indications were given to a room with an area of up to 20 m². Up to 10 m² – 23% and above 20m² – 21%.

5. Is the room area sufficient for you?

It also turned out that for 72% of respondents, the indicated size of the room they live is sufficient for them. But also 28% of respondents answered that the area is not sufficient.

6. Does the room fulfill the functions of work, rest, hobby realization?

For 86% of respondents, the room fulfills the function of work, rest and hobby. For 9.35% of respondents, they did not meet, and 4.65% of other answers were obtained.

7. What did you have to change in your room to suit your work/study during the pandemic?

This question received 41.87% – 18 indications – affirmative answers and they were as follows:

- add a second desk and change the arrangement of furniture
- I had to use more space for learning, doing projects
- improve the workplace: change the chair (daily back pain after months of the pandemic), laptop setting, monitor height (thus bad posture in front of the computer), adding a cooling pad for the laptop (because it works on average 17 hours a day – remote classes plus doing projects later)
- I had to change the chair to an ergonomic one due to back pain due to the time spent in front of the computer, add better lighting
- I had to cover my desktop computer with material to feel that it was not there and I was not at work/university; aromatherapy.

- changing the desk setting – adjusting the background to classes conducted using the camera
- put on the appropriate lighting (no ceiling lamp), change the desk to a larger one, have a designated place needed for the easel and work on it (painting, drawing)
- better adapt the workplace, change the Internet to a stronger one
- adapting to other household members working remotely during the pandemic;
- Due to the fact that I live in a large house, I had the opportunity to develop another room that was adapted to work / study.
- buy a larger desk and footrest so that you can sit ergonomically at your desk.

Among the answers obtained, the most common were those related to enlarging the workplace by buying a larger desk and buying a more ergonomic chair that would not cause back pain. In addition, it was noted that it is necessary to clearly divide the functions in the room, so that on the one hand, one can work productively, on the other hand, rest well.

In addition, 58,13 % (25) of the answers were 'nothing'.

8. Do you want to return to university classes?

This question received 39.54% (17 indications) of affirmative responses and in their explanation respondents gave, among others, the following responses.

- to be able to attend universities and meet other people
- because I can no longer sit in one room, which performs two functions at the same time: work and rest. It exhausts mentally, because even resting you can not fully do it, because you think about work, and while working you have the desire to rest and often there are too many distractions around (family, as well as even the objects around, e.g. serving hobbies)
- the lack of direct contact with the instructors makes it difficult to understand some of the content; better organization of own work in stationary classes
- classes at the university involve the student more, easier contact with the lecturers, contact with other people for the year
- contact with peers and lecturers.
- a clear division into homework, rest, and university activities;
- remote learning negatively affects my physical fitness and the level of real knowledge gained while studying at home

- The person was more motivated to do the work, was better informed, he had a daily dose of physical activity.
- because I miss meeting friends from the university, I miss the view of people and all this envelope of social life; consultations and learning at the university satisfy me more than remote classes, because what at the university, stays at the university, what stays at home, and in private life stays at home, this time everything has merged into a whole and I feel overwhelmed with all this.
- because I miss student life.

There were also 44.2% negative responses and the following explanations:

- Since the risk of infection will be quite high in stationary classes, I believe that classes in this mode will be uncomfortable for students and instructors, given that we will wear masks inside the rooms that are uncomfortable to wear.
- due to living 100 km from the university, this system suited me, the time to travel and spend long hours waiting for consultations could be sensibly used.
- I don't waste time commuting
- I feel that I am not wasting time on commuting and sitting at the university waiting for my turn for consultation. I can make better use of this time, distribute my work in such a way that I have the opportunity to rest, which makes me feel more psychological comfort on a daily basis and I have the feeling that it better affects my creative and creative work. I have the impression that this mode is more effective for me and for others from what I talked about, because we also learn ourselves and feel how to manage our work so that it is still pleasant for us, not 'by force'; in addition, contact with the lecturers is very good
- current conditions (pandemic) meant that I could take up work on working days. I have time for classes, study and work – I am able to reconcile everything; in addition, I am able to save on travel costs; although one small downside is that I personally would be better off consulting projects in the "real world"
- through a long commute to the university
- Remote classes are less stressful, which has a positive effect on my mental state
- because at this stage of education, classes in a remote form are sufficient in transferring knowledge and allow you to take up professional work, while participating in them – time optimization. The implementation of the subjects is at a high level and does not differ in a visible way from the classes conducted in

the traditional mode. In addition to the above reasons, remote learning allows you to study at a university in your hometown

- because I am afraid of the fourth wave of the pandemic.
- saving fuel (I live far from the university) and saving time on commuting and returning from university
- significant time savings, better ability to organize one's own time, comfort at work in calm conditions, greater opportunity to take part in additional, external and internal: classes, lecture courses to expand knowledge. The problem with parking lots near the university. Unnecessary difficulties that would be associated with this in the context of the pandemic.
- better organization and saving of own time, greater development opportunities thanks to remote classes – learning new technologies, programs, spending time in a different place than where you live, the city of the university
- convenient participation in classes from anywhere;
- It is simply convenient for me because before the pandemic I usually commuted to the university by train and I also use time at home, which often takes longer breaks between classes (e.g. 1 hour).

And also 16.28% (7 indications) other and the following explanations:

- and yes and no, because returning to classes is a good idea, but only for those where we have to consult or work with a lecturer on a project, but lectures should be conducted in a further online way
- remote learning does not bother me in anything, a big advantage is saving money, because I do not have to rent an apartment, but isolation from people can be depressing. I think there is no definite answer
- hybrid form of teaching
- remote learning was not a problem and I did not feel much difference between the form of conducting classes, the organization of the university is a plus and I think that no student has a reason to feel that he is losing something, that the form of learning is worse, etc. I believe that both the stationary and remote forms are equal and I have no objections to any of the forms.
- I have no opinion, there are for and against, certainly remote lectures are a very big facilitation, e.g. during interesting lectures you can deepen your knowledge of external information. Visit the object, e.g. on google maps.

- personally, I think that all classes should take place stationary except lectures, which could take place remotely on a designated day of the week – so that there is no situation that during the day there are stationary and remote classes in the schedule. It turned out (comparing my experience) that I was able to focus more on lectures conducted online than on those that took place stationary.

9. How long did it take you to travel to the university per day?
   Very different answers were obtained to this question, which selected a group of people living in a dormitory or in another place but near the university – 9 respondents 20.9% – hence their trip to the university took an average of 15 minutes, and the second group of people who lived in their home towns, hence the trip to the university took them much more time like 1-2 hours one way – 34 respondents 79,1%.
10. Own observations

In their own observations, respondents drew attention to the positive and negative aspects of the pandemic situation, which forced combining the function of work with the function of housing including considered positive aspects that:

- during remote learning, they wasted much less time on commuting
- remote forms of learning developed during the pandemic can be transferred to stationary learning, which will make it more flexible
- it was possible to consult and work on a computer at the same time
- very good organization of remote work by the Silesian University of Technology ... ..."Our university is doing very well in remote learning and I am very impressed that it works so well"... [1]

On the other hand, they considered the following negative aspects:

- lack of at least a minimal dose of movement
- lack of social contacts, which adversely affected their psyche
- laziness and nervousness
- no possibility to change the environment for different functions: learning and resting in the same room.

4. CONCLUSION

Summing up the survey, on the basis of the housing realities described in the first part of the study, it can be concluded that the respondents – students of the Faculty of Architecture of the Silesian University of Technology generally coped very well with the pandemic situation, which forced them to combine the functions of work / study, rest and hobby in one room. Most of them live in single-family houses and have rooms up to 20 m², which gives them the opportunity to organize the space well. Nevertheless, the long-term implementation of the functions of work and rest in one room forced them, for example, to enlarge workplaces, purchase more ergonomic furniture and try to decisively divide the room into different functions.

It can be said that they themselves felt on their own experience what it means to have a non-ergonomic place to work.

In turn, the negative effect should be considered primarily as the deterioration of the psychological situation of the respondents, caused by long isolation and lack of contact with peers and lecturers, and even in a broader sense, simply people.

On the other hand, it turned out that the remote work patterns developed during the pandemic can be combined with stationary work, which can be very helpful in many cases.

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BIM – THE CONCEPT OF ONE MODEL AND THE IMPLEMENTATION MODEL

1. INTRODUCTION

The Building Information Modelling method is generating a lot of hope the world over as a way of improving the efficiency in the civil engineering sector. According to many an expert, the role of architects in the implementation of the aforementioned method ought to be vital. The BIM method defines future changes and is referred to as the third information revolution in civil engineering. This method sees the use of three-dimensional computer models of architectural structures, which include information about the building, used not only at the design stage by all the members of that process, but also during the building's occupancy. The article provides a commentary of the idea of a one three-dimensional digital model, presented as a strong advantage of the BIM. Moreover, the notion of a multi-dimensional (nD) design space was presented. Thanks to it, it became possible to implement non-geometric information into the three-dimensional model. In addition, the implementation model for the BIM method was also elaborated on, defining the levels and methods of integrating information generated during the design stage. The study uses an analysis of the state-of-the-art connected with the BIM method.

2. ONE MODEL?

BIM constitutes a design method which utilizes "intelligent" three-dimensional computer models of architectural structures. These enable the creation, modification,

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exchange and coordination of information concerning the building throughout the time of its design and between all the members of the process [1], [2]. The BIM methodology is also defined as the construction of a building in the virtual world before its execution [3], [4]. Professor Glema states that the BIM model "is a digital representation of an actual building. Each element of the actual building is represented by a corresponding element of the digital model" [5]. According to Autodesk, the BIM model, which is introduced during the design process, can prove useful in the design of structural solutions, in the optimization process of the performance by means of computer simulations of the latter, as well as in the visualization of the architectural concept visualization, and finally in the presentation of the esthetic side of the work through renderings and animations [1]. As far as the models are concerned, one should remember that they constitute a greatly imperfect attempt at imitating the reality. Autodesk, in their training materials devoted to analyses of buildings' functional efficiency, quotes the words uttered by George E.P. Box (dubbed "one of the master minds behind 20th century statistics"): "All models are wrong, but some are useful" [1]. Therefore, when preparing a model intended for specific tasks, one must be aware of its limitations in a given field.

Author's experience gives witness to the fact that with contemporary computer possibilities, the use of a one BIM model for all the aforementioned tasks is impossible as a totally different level of detail, in a given model, is required by various components of the BIM software. For example, an incorrectly prepared model, for the purpose of visualization (too detailed) will cause that the expectations of the final result in the form of a rendering or animation will be unacceptably long. An incorrect preparation of the model for the purpose of performance analyses will cause that the results of the simulation will have nothing in common with the functioning of a given building in the real world or, in extreme cases, the software will not be able to perform such a simulation. It could be stated that one of the characteristics is that it shows a high level of complexity, as the goal is to record as much information about the building as possible, including all the engineering fields that contribute to the design process.

However, should one go through the contents of the Building Performance Analyses course, it is possible to find information stating that at various stages of the design process different models are required, there is a widespread opinion that one of the main assets of using the BIM methodology is the work with "one three-dimensional digital model" [6], [7], [8]. The following citation might serve as an example: "thanks to the work done on the basis of only one model, businesses

involved in the design, construction and management of the building could significantly increase the productivity and reduce the number of errors which occur throughout the entire documentation preparation process" [7].

3. THE ND MODEL – THE IDEA OF A MULTI-DIMENSIONAL DESIGN SPACE

It is a fact that the BIM model could easily be recognized thanks to the "nD" mark, for example: 4D, 5D or even 6D. Together with the BIM method, the idea of a multi-dimensional space is introduced, exceeding the standard three-dimensional geometric information [9], [10]. Prior to the presentation of the extra dimensions, the weight of the three-dimensional model will be highlighted as the overriding framework for recording information about the building and the course of the investment. The 3D model forces the designer to reconsider each and every detail. It makes it impossible to avoid "difficult spots", which often happened when choosing the right section or details of the two-dimensional documentation [3]. The 3D model also lowers the margin of error in interpreting, which often occurs in the case of a failure to understand the 2D documentation, as a result of not being familiar with the defined norms, signs, or lack of spatial imagination. If one should add to this the possibility of placing models of specific products, prefabricates, and constructional technologies in the design, made available and updated by manufacturers, the virtual design becomes something that really reflects the reality. The BIM method takes a step outside of the three-dimensionality, incorporating the following non-geometric information [2], [6], [9], [10], [11], [12]:

- 4D (time) BIM – investment execution time: this piece of information, especially valuable during the execution of large, complex structures or when building structures in difficult locations, is necessary for the contractor. It enables the most optimal planning of the erection as early as the design stage. If the information is updated as the construction works go by, the BIM model becomes an useful tool for controlling the progress in the works, and in analyzing the possible repair works.
- 5D (cost) BIM – the cost of the investment execution: advantages resulting from the knowledge of actual investment costs at all stages of the investment process are indisputable and were described at length in the later part of the article;
- 6D (FM) BIM – Facilities Management – managing of the built environment during the occupancy: RIBA accentuates the fact that, for individuals managing structures that have been put to use, this might be the most novel and useful aspect of

implementing the BIM method. Data within the BIM model, recorded at the stage of design and execution, render it a highly powerful management tool.

The presented description of non-geometric information, saved in subsequent dimensions of the BIM model, is the most used, however, one might find opinions that data type assigned to dimensions that go beyond the geometry might be treated with more flexibility [13].

When trying to describe the BIM, one should definitely mention the attempt to solve the problem of incompatibility of software coming from various producers, or even a single producer, owing to the fact that companies that use the BIM methodology use a plethora of computer programs (more on that in later parts of this article), between which models containing data about the building are exchanged. An international organization called BuildingSMART (earlier it was called International Alliance for Interoperability (IAI)), whose goal was to create and introduce open, open-access, international BIM standards (openBIM), designed a format for exchanging virtual models - Industry Foundation Class (IFC), based on the ISO standard - 16739 [6], [10], [11], [12], [14]. BuildingSMART calls it 'the basic operation system for data exchange'.

4. BIM MATURITY DIAGRAM

BIM Maturity Diagram was devised in 2008 by Mervyn Richards and Mark Bew. It defines 4 levels [2], [6], [12], [15], [16], [17]:

- The level 0 BIM: a generally applied method of work using 2D CAD programs to prepare design documentation;
- The level 1 BIM: next to the 2D information, there is also a 3D model in the design. It is the most frequently used level by architects who are at the stage of conceptual design, and for the purposes of preparing a visualization for the investor. The 3D model is not used by the remaining industries;
- The level 2 BIM: advanced work methodology for all designers operating in the 3D space. All key industries that make up the Integrated Team require 3D models, however, these models do not have to create one, common model for all the industries. Accent is placed on the manner of work alone, a place where the members of the Integrated Team have unlimited access to all information created within the 3D space;

- The level 3 BIM: the highest level where a single BIM model is the source of all information about the investment process and is created by the parties committed. This is an actual BIM method, with the advantages described below.

5. ADVANTAGES OF USING BIM

Among the main advantages of using the BIM, the most often discussed are [2], [4], [6], [7], [10], [18], [19], [20]:

1) the possibility of executing complex analyses of performance of a building, from the earliest stages of the process; thanks to which "knowledge-based design" concerning the influence of design decisions on the future performance of the building is executed in practice and includes energy-saving, natural environment friendliness, and above all, the comfort in usage;
2) improvement in the communication between the participants of all the stages of the investment process, their actual integration, also through an unlimited access to information about solutions applied in the project;
3) automatic detection of colliding elements of a building, construction, and installation, reducing the number of design errors.
4) a quick and precise investment cost calculation at the design stage, giving the possibility of choosing cheaper solutions and technologies, together with the calculation of exploitation costs. Cost estimation is also more precise, e.g. during the design process at the Faculty of Sculpture at the ASP Warsaw the use of the BIM model shortened the time of preparing the bill of quantities 8-fold, while the number of errors was reduced to zero. For the sake of comparison, the traditional methods are encumbered with an inaccuracy of 10-30% [21].

   RIBA emphasizes the importance of designers' access to credible information concerning the costs at the earliest stage of design. Thanks to that, the probability of matching up the design concept with the planned investment budget will become much bigger. It would seem that fulfilling that requirement is the basic condition for the execution of each and every investment. Prominent executions such as the Elbphilharmonie in Hamburg, performed by Herzog and de Meuron, or the Paris Philharmonic designed by Jean Nouvel, both being public investments, stand in opposition to that. The costs generated by Elbphilharmonie, at the time of taking the decision on the beginning of the investment, were estimated at EUR 50 million. In reality, the philharmonic cost almost 18 times more (EUR 866 million) and was put to use 7 years after the planned deadline [22]. The Paris

Philharmonic was “merely” 3 times more expensive in relation to the planned expenses (EUR 173 million were planned, EUR 535 million were spent), while its opening was postponed by “merely” 3 years [23], [24];

5) completion of the construction on time or ahead of it, without errors detected during the execution;
6) the use of the BIM model to store the experiences from the stage of execution and usage stage. An analysis of that information enables the building of knowledge, which will be used during the construction of future structures.

6. THE ROLE OF COMPUTER SOFTWARE IN THE PRACTICAL APPLICATION OF THE BIM METHOD

The most important fact is that the BIM methodology is closely tied with tools such as programs, or computer platforms which make its usage possible. Tomana emphasizes that ‘contrary to the advertising slogan, the BIM is nothing like specific software’, while firms that take advantage of the BIM method use programs developed by various producers [11]. The author agrees with the aforementioned opinion only in part. Of course, the BIM method is not a computer program, however, each user is trying, and will be trying to maximally simplify his or her work tools. In this process, dominant BIM software designers, or the creators of the BIM program platform take the lead. The G2 Crowd Report, issued in 2021, states that among programs which constitute work tools for architects, the global and undisputed leader among BIM software producers is Autodesk along with their programs - the Revit and AutoCAD. The only competitor to the aforementioned company, which is definitely worthy of a mention, is the Nemetschek. It offers software called ArchiCAD [25] (here it should be stressed that the author of the article is aware of the presence of other BIM type computer programs on the market, examples of their use in the investment process are described in later part of the paper).

From that perspective, the question of “what is BIM?” could be transformed into “what functions does prominent BIM software offer, and are these functions as efficient in projects of any level of complexity?” (The author’s experience shows that as far as using parametric computer programs in architectural design is concerned, a typical phenomenon that has been observed is that reliability and efficiency are reduced as the level of complexity of architectural design goes up). Answers to the first part of the question raised (about the functionality of the BIM software) are openly accessible in the informative materials for products of specific firms. The

second part (concerning efficiency and reliability related to the level of complexity of the project) will be very difficult to answer in the current stage of BIM implementation in Poland. In order to outline a highly general and merely illustrative image of the current situation, one might make use of the comments made by architects who have used the BIM software. It is obvious that one should expect natural reluctance towards changes, which are paramount to the necessity to master a new tool and to create work methods from scratch. In critical comments one may find the following remarks [2], [26]:

1) high implementation costs of BIM, hardware requirements often go beyond the reach of many a design studio;
2) poor understanding of the design tool and cooperation principles, lack of the preparation on the part of specialist from the industry;
3) lack of actual help from software providers under Polish conditions;
4) the additional time necessary to prepare new cooperation standards;
4) the amount of work necessary to implement BIM is enormous, software is not adjusted to conditions present in Poland;
5) the BIM software proves useful at large design studios with “all the industry sectors, and the department of information exchange control”;
6) The client is usually not interested in the design being prepared on the basis of the BIM standard.

Despite these remarks, reading the comments might get a sense of the impossibility that the BIM methodology could be rejected, together with the whole computer software that goes with it. Explicit benefits coming from the usage of the BIM are also visible. Developed countries are very advanced in the process of implementing those methods, techniques, and tools, and at present it seems that there is no alternative road of development. Polish experts confirm that opinion [6], [15], [26].

ArchiCAD, a competitor to Revit software, though with significantly lower market share, is a worthy challenger. It was impossible for the author to get hold of credible information concerning the market share of the BIM worldwide expressed in percentages, however, on the basis of available data (without the source or focused on a single country [27]) one could assume that the number of users who have chosen Revit is 1.5 - 2.5 times higher than those who opted for the ArchiCAD. At this point, it should be emphasized that the situation in Poland differs from global. In Poland, ArchiCAD has been known for about 20 years, and thanks to its efficient price policy, it has been a recognized architectural design program able to compete with

products developed by Autodesk (mainly AutoCAD). The ArchiCAD program was launched in 1987 and from the very beginning it has stood out thanks to its three-dimensional work environment. There are some who believe that the BIM method was first implemented using ArchiCAD itself [28]. In 2003, Laiserin called that program 'one of the most mature BIM solutions on the market' [29]. It is known for a fact that at certain stages of ArchiCAD development, available BIM functions started to be accentuated and perfected. Just because the software might feature BIM tools, one should not draw conclusions that architectural design studios that design by means of ArchiCAD actually take advantage of these functions in the scope of prepared BIM methodology. In contrast, Revit is a relatively new product which, due to its price, cannot compete with the most popular Polish program used for architectural design, the AutoCad (also developed by Autodesk). However, the author presumes that if an architectural design studio should decide to purchase Revit, they would do so due to the need to implement the BIM methodology.

When describing the BIM software, the market situation, according to the author, is not beneficial to the client. Some companies introduced a new sales policy. Instead of a purchase of perpetual license for the software, with a possibility of special offer for updates, the user is forced to lease the license for a specified period. Moreover, every year another version of the program is introduced, and the participants of the investment process, conducted by way of the BIM method, are forced to install an update on a regular basis. Using programs from many different producers and many versions of the software carries the risk of losing part of the data during the conversion process, or even the impossibility of opening a project in older versions of the program [4]. The new, more demanding software forces people to make more frequent purchases of stronger computers. It seems that the highest, level 3 BIM – a simultaneous work of all members of the Integrated Team using one model – is connected with serious costs arising from the ensuring and maintaining of adequate software and hardware conditions.

7. POLISH EXAMPLES OF USING THE BIM METHOD

Below, two Polish examples of a practical use of the BIM methodology were presented in the scope of the tools applied. Drzazga describes the design process of an office building in Wrocław, in which the following programs were used [3]:

1) Autodesk Revit (a 3D model which constitutes the basis of the whole design process; a conceptual architectural design; coordination of all projects:

architecture, construction, installations, technology; architectural design; constructional design; defining of the building's execution stages);
2) Autodesk Robot Structural Analysis Professional (construction design - geometric and analytic models, statistical calculations);
3) MS-Project (schedule of construction works);
4) Autodesk Navisworks (visualization of the execution of the building: the 3D model was connected to the schedule);
5) Zuzia BIM (cost estimate).

The description is too laconic to assess the BIM level (2 or 3) and multi-dimensionality of the design space (4D or 5D).

Dejer presents the design of the Sculpture Faculty at the Warsaw ASP as the first one to have been executed by means of the BIM method [21]. In the design process programs of different producers were used, with data being exchanged between them by means of the IFC format. Below is the list of programs used:
1) ArchiCAD (architectural design);
2) Tekla Structures (constructional design);
3) Autodesk Robot Structural Analysis (a calculation model for the construction: Dejer makes a remark that the limitations of the software - lack of compatibility between the Robot and ArchiCAD caused that the model in Robot had to be created from scratch);
4) Autodesk Revit MEP (installation design);
5) Tekla BIMsight (coordination of industries using the 3D model);
6) Zuzia BIM (cost estimate and bill of quantities).

Despite the assurances of Dejer that we are currently dealing with 'a complete design executed on the basis of BIM technology", the description of the the course of design works raises many doubts. The lack of regular cooperation between industries is quite visible. Architects designed a building and saved it as a IFC model. This exact model was then uploaded by other engineers and 'each of the firms worked on their own model'. The three-dimensional model itself generated many facilities, the Tekla Structures program tracked down and marked modifications entered into the architectural design in another version of the IFC model, while the Tekla BIMsight enabled swift identification of collision points following the uploading of all industry related models of IFC. In such a case, surely we are dealing with level 2 BIM. Despite the remarks made above, it should be highlighted that the examples present a high level of BIM application in Poland, a country where most firms that acknowledge the

introduction of this method in fact are using level 1 BIM, creating a spatial model of the building within the architectural design [3], [15].

8. SUMMARY

The BIM method might be presented as a building built into virtual reality. This constitutes the construction of a three-dimensional computer model of an architectural structure, each element of which contains information created by all engineering branches that participate in the design process. Data of that sort is then used during the execution and occupancy. All participants in the investment process have access to these data. The work done with “a single tree-dimensional digital model” is presented as the main asset of the BIM method. The notion of a multi-dimensional design space is an inseparable element of the BIM method. So, in the three-dimensional model, nongeometric information is saved: investment execution time (4D BIM), investment execution costs (5D BIM) along with Facilities Management - the managing of the built environment during occupancy (6D BIM). 4 levels of BIM maturity were defined: 0 BIM,, 1 BIM, 2 BIM and 3 BIM. While the first two are connected with traditional design processes, 2 BIM grants all members of the integrated design team access to information stored in the virtual space, the 3 BIM, on the other hand, is an actual, targeted BIM method, where a single model is created by all members of the team and plays the role of a source of all information.

The main advantages of implementing the BIM method include: “knowledge based design”, that is the use of the Building Performance Analyses; better communication between the members of the investment process; automatic collision point detection system for constructions and systems inside a building; swift and accurate preparation of the cost estimate; meeting investment deadlines; collection of data coming from all stages of the technological life of a building in the BIM model and its analysis done for the sake of acquiring and developing knowledge useful during the execution of future investments.

For architects’ sake, Autodesk with their Revit, and Nemetschek with their ArchiCAD are the undisputed leaders on the BIM tools market. Although Polish architects can observe some difficulties in implementing the BIM methodology, its benefits are obvious to them. A great difficulty might be caused by the fact that creating and maintaining the conditions for simultaneous work of all the members of the design team on a single model, that is, the highest, level 3 BIM, seem to generate regular and high expenses.

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Dariusz MASŁY[1]

BIM AS A DRIVER OF CHANGES IN ARCHITECTURAL DESIGN

1. INTRODUCTION

The issue of deploying the BIM method in Poland is, on the one hand, very important. On the other hand, it was recognized only a couple of years ago. It carries a lot of weight as the BIM method is perceived as a key method of improving efficiency in the construction sector worldwide. Angela Brady, the president of the Royal Institute of British Architects (RIBA) has stated [1]: "The three inter-related issues of sustainable design, Building Information Modelling (BIM) and procurement will have a great deal of influence on the future shape of both the architects' profession and the broader construction industry". Polish experts also confirm that the BIM is a platform for changes in the construction sector [2], [3]. Moreover, RIBA is of the opinion that it should be the architects themselves that should be playing the key role in the implementation of BIM method, and in utilizing the benefits coming from its application [1]. It should be highlighted, at this point, that in the global perspective, the efficiency of the industry is improving, while the performance of the construction sector in richest countries is constantly going down [4]. The construction sector, which for decades has been struggling with the problem economic fluctuations, has not invested in any new tools nor techniques, and is currently highly fragmentated. On a global scale stretching from 1995, the efficiency of the construction sector rose 4 times slower in comparison to the machine industry. In developed countries, the situation looks much worse. In France and Italy productivity dropped by 1/6, in Japan and Germany, on the other hand, no increase has been observed, while in the USA the efficiency halved in relation to the results produced in the 60's (of the 20th century) [5]. As mentioned before, this study utilizes the analysis of the current state of the knowledge related to the BIM method.

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2. BIM IN THE CONSTRUCTION SECTOR IN POLAND AND WORLDWIDE

In Poland, the deployment of BIM started quite recently. However, the then President of SARP - Mariusz Ścisło noticed, as early as 2015, that the "BIMdolino train had been in motion for a good couple of years in Poland. This is a very important signal for all those who believe that the BIM technology should be deterred because Polish architects cannot afford it" [2]. The first meeting "concerning the commencement of a pilot project aimed at verifying the possibility of deploying the BIM methodology in Poland", the crown of a series of expert meetings organized since September 2016, took place at the Ministry of Infrastructure and Civil Engineering in October 2017 [6], [7]. That project was supposed to recognize the benefits and difficulties arising from the use of BIM, so as a result, various projects were selected - architectural and engineering structures, together with critical infrastructure. From November 2019 to October 2020, a project called "Digitization of the construction process in Poland" was carried out [8]. Its purpose was to make the elements of BIM more accessible on the Polish construction market. Keeping in mind the works completed as part of the project, one should remember that at the beginning of 2014, the European Parliament and the Council adopted the 2014/24/UE Directive on public procurements [9]. It included art. 22 s. 4, which stated that member countries could require the use of tools intended for electronic modelling of building information (the Directive does not use the acronym BIM but it used "building information electronic modelling tools") in relation to public procurements for construction works and invitations to tenders [10]. Public procurements constitute 20-30% of civil engineering in Europe and the US [5]. State and self-governmental authorities, simultaneously acting as notable client and entity supervising the introduction of new standards and regulations, have measures that improve the performance of the construction sector. Countries such as Great Britain, France, Singapore, Denmark, and Spain already require companies that compete for public procurements to use the BIM methodology [1], [5]. These countries might soon be joined by Germany and Czechia. Tomana observed that the BIM method is often described as 'technology for investors" [11]. The benefits arising from the use of the BIM have caused the investors to become its most prominent promotors among countries which have the most experience of using it. As part of the project called "Digitization of the construction process in Poland", "a roadmap for the implementation of the BIM in public procurements" was prepared [8]. This document draws up an action plan which is going to "lead to the implementation of the BIM methodology in public procurement processes connected with civil engineering" [8].

For the moment, ‘the question of BIM being obligatory has its proponents and opponents’ [12], while the experiences of countries in which the requirement was introduced, do not, in many cases, do justice to the generally anticipated benefits from the use of BIM (see [12]). There have also been spectacular failures, such as one of the biggest BIM investments in Great Britain - the construction of the High Speed 2 railway (more in [13] (see [12])). Scandinavia is thought to be one of the most developed regions as far as practical use of BIM is concerned, without the obligation to use it.

3. WHAT IS BIM IN THIS DAY AND AGE?

The idea of BIM has been in existence since the 1970s of the twentieth century [14]. The phrase ‘Building Information Model” was first used in an article written in 1992 [15], but it was the white book titled “Building Information Modeling’, published in 2002, that put to use the general term of “Building Information Model”, “Building Information Model’ and acronym “BIM” [16]. In 2003, Jerry Laiserin, ‘the godfather of BIM’, when organizing and moderating a debate devoted to BIM, featuring the largest suppliers of construction design software in the USA (Autodesk, Bentley Systems, Graphisoft) contributed to the popularization of the notion of BIM in the form of a digital representation of the investment process [17]. The first conference devoted to BIM, a result of the cooperation between industry and science, took place in 2005 at the Georgia Institute of Technology (Laiserin was its co-organizer) [14]. In the literature, upon the introduction of the question ‘What BIM is”, one might often come across ‘What BIM is not”. The author believes that this only proves that there are many a view on that subject, and that many of them are erroneous as far as the construction sector is concerned. In the following, based on literature-based research, the author undertakes to answer the question of ‘What is BIM in this day and age?’ The Ministry of Competence for issues related to civil engineering and housing policies uses the concept of “Building Information Modelling (BIM) methodology” [7]. In scientific publications and reports, the author has come across the following notions: ‘parametric building information modelling technology’ [18], ‘information modelling in buildings’ [10], [19].

The definition of BIM proposed by the National BIM Standard - United States Project Committee (a project carried out under the auspices of the National Institute of Building Sciences) is generally used worldwide [20]:

“Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition”.

In the publications devoted to BIM, this method is described as innovative, revolutionary, advanced, and even “one of the largest technological innovations of the past decade” [11], [21]. The introduction of the BIM methodology, though frequently compared to the historic moment of transition from tracing paper to CAD, reflects a more breakthrough nature. At the end of the day, design documentation prepared by means of a computer did not differ from traced documentation. Comparing the current situation to the one from over 40 years ago, RIBA is convinced that just as in the case of CAD software, in the immediate future the critical point will be reached when the BIM methodology is accepted by all architects and the whole engineering sector as a new work philosophy, and a world-changing technology [1]. Andrzej Tomana, the author of the first Polish monograph on the subject of BIM, titled one of the chapters of his book ‘BIM – the third information revolution in civil engineering’ [22].

4. INTEGRATED PROJECT DELIVERY (IPD) IN THE CONTEXT OF CONSTRUCTION SECTOR EFFICIENCY

When discussing BIM, one should also mention the Integrated Project Delivery - IPD, the essence of which is the pursuit of maximal use of knowledge and experience of all the members/ participants of the investment process (the investor, architects, designers, contractors) and treating the stages of design and building as a single process [19], [23], [24], [25], [26], [27], [28]. IPD was designed under the auspices of the American institute of Architects (AIA) by an interdisciplinary group that was made up of architects, engineers of various disciplines, contractors, investors, and lawyers [24]. The most important goal of IPD is to optimize the construction process. However, it should be emphasized that its essence lies in cooperation; therefore, the success of the whole process is conditional on the participants sharing the same values and goals [25].

In Poland, one can observe the traditional method of project delivery, Design-Bid-Build. This method draws a visible line between the preparation of the conceptual architectural design, then the construction design, and the procurement and execution of the construction works. For the sake of comparison, developed

countries of the West have been utilizing the Design and Build method in which the firm undertaking the delivery of the investment is responsible for both the preparation of the design documentation, and the execution of construction works [28]. Specialists agree that the most important decisions as far as the performance of the building is concerned, are made at early stages of the investment process, in this case this takes place at the stage of conceptual design. At that stage, also alternative solutions should be analyzed in detail, as it is very easy and cheap to make necessary changes then. In Poland, it is usually the architect who takes such decisions, while necessary analyses are not carried out. Specialists of the discipline (the design engineers, designers responsible for the electrical and sanitary systems, as well as heating, ventilation, and air conditioning) proceed to design at the stage of preparing the construction design, and then the working design, if such is being delivered. Inter-disciplinary coordination is often limited to an absolute minimum, therefore preparing variants for possible solutions and searching from optimal solutions hardly ever occurs. It should be emphasized that these actions, at that stage, would already have been too costly, not to mention time-consuming, which in practice would make them impossible to carry out. As presented above, traditional construction processes exclude the searches for optimal solutions which are key for future high performance of an architectural structure. Additionally, as part of the tender process, working documentation is used, in which, as a standard, there is a lack of „significant information from the perspective of procurement proceedings and logistics as well as quality assurance" [29]. It is only then, or even at the stage of delivery, or execution, that the final choice of construction technology is made, and that the actual cost planning and scheduling is done. The lack of such information translates into an increase in expenses as well as an extension of the execution stage.

As the efficiency of the construction sector is steadily declining compared to the efficiency of the machine industry, it would be a good idea to look at the methods and techniques applied. It was stated above that in Poland there is a traditional, linear model of the construction process, where specific actions take place in a strictly specified sequence of events. The main deficiency of that process is that there is a lack of feedback, mechanisms of passing information from later stages of the process to the earliest ones, or between simultaneously undertaken actions, but through various engineering disciplines. The most often quoted example of utilizing feedback in the context of BIM, from the moment the work on the design commences, is the access to detailed information on materials, systems, and construction technologies, updated by producers. One of the most popular means of

making such information available, the largest and also the most swiftly developing, is through the online portal called BIMobject [30], which uses the slogan: “100 of the world's largest 100 architect firms use bimobject.com”. This type of undertaking stirs up some anxiety and doubt for the author. For one, there is a serious risk that, in practice, designers who choose a model of a specific producer and by implementing it in the BIM environment, confirm its usage. This thesis is validated by a remark made on the portal, addressed to producers: Producers utilize BIMobject for the purposes of promotion and introduction of their products directly into BIM processes, thanks to which they create conditions conducive to their application [within a structure built], thus raising the results of the sales. Secondly, this type of initiative strengthens the market position of the largest producers who are able to devote significant means to the making and managing of the BIM structure library, and, finally, to taking an advantage of portals that have a profile similar to the BIMobject. It would be self-evident to find that the position of a monopolist is not conducive to improving the quality of the products. One might, however, wonder if the BIM, executed in such a way (utilizing ready-made, standard solutions dominating on the producer markets) can bring about an improvement in the quality of the built environment, even if the lowering of investment costs, energy-saving and the lowering of the negative influence on the natural environment are evident.

Another example of using feedback is the instantaneous exchange of information between various engineering disciplines that participate in the design process (introduction of an element into the BIM model is visible by all the users of the system). The BIM environment can instantly recognize potential collision points in installation and construction systems, allowing their elimination. Another example involves the use of a model intended for recognizing the requirements and the needs of potential users, in the scope of functional and aesthetic solutions. The model, a three-dimensional representation of spaces designed (which constitutes a natural element of the BIM method), is an easy and proven method of presenting architectural design solutions to the client. The information is passed onto the future user in a clear way, giving feedback in the form of reactions, opinions, and doubts. The method of the three-dimensional presentation of an architectural idea is nothing new, however, working in the BIM environment does not require the application of additional computer programs for the visualization and animation of architectural concepts. Speaking of feedback, one should not, of course, omit to mention building performance analyses.

Coming back to the comparison of methods and techniques applied in the construction sector and the machine industry, one should emphasize the basic difference. Design of architectural structures constitutes the creation of prototypes (repeatable models of hotels, restaurants, chain shops, distribution centers constitute an exception), while the natural characteristic of industrial production is its repeatability. The said repeatability makes advanced simulations on three-dimensional models profitable (commonly used since the 1990s [28], [29]), as eliminating the design error results in an increase in quality in hundreds of thousands, or even in millions of copies of the product. The literature might also provide comments on the subject of differences in the manner of preparing design documentation. The civil engineering sector is, supposedly, based on two-dimensional techniques and paper documentation, the industry, on the other hand, takes advantage of solid modeling [29]. The author begs to differ as far as that opinion is concerned, as ArchiCAD, developed in the 80's, serves as a living proof of that in architectural design. When writing on the subject of differences between the engineering sector and the widely understood industry, it should be noted that there is a "complex layer of information regarding the components of the building" [29].

Considering the low and ever-decreasing efficiency of the civil engineering sector, compared to the machine industry, one should definitely think about what ought to be done to reverse that trend. Kalisz suggests that techniques and methods applied in the industry should be copied, and above all, a computer model able to include the nuances of the whole investment process should be created and then followed up by including the problems of usage and demolition [29]. It is the author's opinion that the low efficiency of the civil engineering sector is not the result of negligence in the development of techniques or computer-assisted tools. The main reasons have been listed below:

1) each investment is actually a prototype;
2) a large number of people participating in the investment process and a lack of a correct information flow between them;
3) an enormous number and variety of component parts of the building with low standardization and prefabrication of construction materials, as well as components of the construction.

There is a realistic chance that the modelling of the investment process in the BIM environment will improve the exchange of information, but there is also the risk that buildings which are erected will be steering more and more in the direction of a mass, repeatable product, composed of ready-made elements. The time of the investment

process will be radically shortened (in China a 57-story skyscraper was erected in 19 days [31]); moreover, the costs will be cut, while tens and hundreds of proven solutions will become more energy efficient, not to mention more environmentally friendly. The issue of uniqueness and beauty of architecture will slowly fade away because of all the actions that are aimed at optimization.

5. THE RESULTS OF THE RESEARCHES OF THE BIM USAGE IN POLAND

In 2015, Autodesk ordered a BIM study – "BIM – the Polish perspective", as part of which the situation of 350 firms from the architectural and structural industry was analyzed [2]. One of the honorable patrons of the study was SARP. Results show that:

1) BIM was mainly used at bigger firms (at least 10 people on a payroll);
2) the future of BIM at those firms is thought to look optimistic;
3) junior staff are the main users of that method.

The benefits coming from using BIM also include a higher quality of projects and a lower number of design errors, not to mention delivery errors. It was emphasized that the main obstacles in the wider introduction of BIM include not only too low project prices, but also a lack of properly trained staff, or the preparation of cohesive standards in the construction sector. At a relatively low level of BIM awareness (below 50% among respondents), it is interesting that architects are in fact in the first place among specialist familiar with the subject.

Generally speaking, the results of the report look optimistic; however, upon deeper reflection, some doubts arise. Most of the respondents who acknowledged the use of the BIM method at their firms, assessed at the same time that in practice 2D and 3D models are used, while the information is not integrated - not available to all branches and only partly electronic. It is the first level of BIM, but in fact a stage that precedes its introduction. The respondents (there were up to 89 people) who prepared the projects and used BIM were asked the following question: 'Are there any savings from the BIM at different stages of the construction investment?' At first glance, we can observe that most respondents are convinced of the influence of BIM on cost reduction at specific stages of the investment. However, if we consider the piece of information stating 'BIM reduces the costs of a given stage by 1-15 %' as a poor way of convincing respondents that such savings could be made, it turns out that the only stages where one could see any significant indications of savings are 'Bill of quantities and cost estimates" and 'The whole process of a building being erected, and its life cycle' (about 30-40% of respondents believe so, while the author of the

article doubts if the data concerning the life cycle stage, the second of the ones presented, are possible to collect, not to mention possible to compare with anything, or draw conclusions from. It seems that such are the beliefs of the respondents). Among the stages where the percentage of respondents declaring that savings have been made exceeds 20%, the following should be listed: “Completion of construction”, “Industry-specific design”, “Structural commercialization - sales and marketing”. The results connected with the stage of ‘Architectural design’ are quite interesting. In this group, there is a large proportion of respondents who are convinced that savings exist (about 35%), and at the same time, it has the highest proportion of respondents (considering all the stages analyzed) convinced that “BIM increases the costs” (about 30%).

When bringing up the issue of costs arising from the introduction of the BIM method, one should emphasize the aspect of its implementation which may be unnoticeable to the majority. Most people accept the fact that BIM lowers costs connected with investment execution. This does not mean that it lowers the costs of all the stages of the investment completion. It should be emphasized that after the deployment of the BIM method, the design stages become more expensive [22]. For example, the committee overseeing the BIM in Singapore recommends moving 5% of the whole investment cost from the delivery stage to the design stage [28]. There are also expert opinions stating that the price of a project delivered by means of BIM is bound to increase [2]. The traditional system of carrying out investments in Poland (see: “4. Integrated Project Delivery (IPD) in the context of construction sector efficiency”) leads to even more difficult conditions for architects.

“BIM - the Polish perspective” is not the only study on the condition of the BIM implementation in Poland. In 2016, at the request of the Ministry of Infrastructure and Civil Engineering, KPMG Advisory prepared an expert assessment called “BIM Methodology”. The current state of implementation in Polish public procurements” [32]. One of the questions that respondent-designers had to answer: “Would you be able to deliver a public procurement using BIM method today?”. 58% responded “No”, 13% definitely responded “Yes”, while 24% said “Yes, but only if correct cooperation between all the parties to the process is ensured”. Also in 2016, Antal, a company, conducted a study in which 100 specialists and managers working in the construction industry, were surveyed [33]. The results show, in fact, that every fifth firm that has been surveyed applies the BIM, but it is seen as work with a three-dimensional model during the design process (4D and 5D BIM are practically non-existent). It should be emphasized that 78% of the respondents are planning on

implementing the BIM. Interestingly, the requirements of the clients constitute the main reasons behind the BIM implementation by design studios.

In 2021, results of the survey called “BIM in Poland through the eyes of the industry - 2021” were published [34]. The survey was a part of a project called “Digitization of construction process in Poland” [8]. As many as 170 surveys were filled out. Designers constituted the largest group of respondents (48%). Results of the study showed that “in whole of last year the number of organizations in which BIM had been planned rose, while the number of firms in which the implementation took place in recent years went down”. The number of firms which do not plan on implementing the BIM is also on the rise. Firms which did implement BIM are currently assessing the results of its use in a positive way. At 40% of the surveyed firms, the BIM serves as a method of exchanging data between branches/ industries in the design process. 30% of respondents use it in the scope of their discipline, 9%, on the other hand, use it merely for the purposes of working out architectural concept visualization purposes. 39% of respondents did not carry out the BIM project while 22% delivered more than 10 projects. The level of knowledge in the scope of BIM methodology has been consistently on the rise. While the respondents have confirmed the benefits coming from BIM , the number of people who do not expect any benefits from BIM deployment in Poland rose sharply (up to 10%). Software cost was deemed the biggest obstacle in the deployment of BIM, with too low remuneration for the projects delivered, a low level of knowledge on the subject of BIM on the part of professionals, as well as lack of any standards.

Comparing the results of studies conducted 5 years ago and today, one might distinguish specific trends and invariable conditions: participants are aware of the benefits from using BIM; their knowledge on its deployment is growing; similar obstacles appear in the form of high prices for tools, low prices for projects and lack of sufficient knowledge among all participant of the investment process; the level of BIM use is on the increase - it is used to exchange data and information in a broader group of professionals, while the BIM model alone provides more and more information.

6. SUMMARY

Globally, the Building Information Modelling (BIM) is deemed as the main way of improving the efficiency in the construction sector which has been on the decline in the richest countries. By contrast, the performance of the whole industry is on the

rise. There is a general belief that the BIM method sets the trend for changes and constitutes the third information revolution in the construction sector. RIBA proposes an opinion that in the nearest future all architects will accept BIM as a new work philosophy, and a technology that can change the world. Although the BIM method has been spoken of for a relatively short time in Poland, the European Union has taken measures to improve its popularization. To prove this statement, there is a provision in the 2014/24/UE Directive on public procurements which enables member countries to introduce a requirement to use electronic modelling tools for building information. It should be emphasized that both in the EU and the USA public procurements constitute 20-30% of construction investments, while the authorities that have the necessary means are able to effectively give shape to changes in the construction sector, as well as architectural design.

The Design-Bid-Build method, used to deliver construction projects, is not conducive to the introduction of the BIM method in Poland. This method is a traditional, linear model in which not only the design process is visibly separated from the procurement, and the execution of construction works, but also the stage of conceptual design lacks a close cooperation between specific disciplines. The main obstacle in the BIM implementation is the cost increase resulting from the isolated stage of design. The Design-Bid-Build method seriously limits, if not excludes, the possibility of multi-disciplinary search for the best design solution by means of Building Performance Analyses. For sake of comparison, in developed countries, it is the Design and Build method that is popular. In such circumstances, upon the deployment of the BIM method, it is possible to transfer a part of significant savings, arising at the stage of construction, to the stage of design which is bound to ger more expensive. The future of delivering building projects is connected with IPD, the Integrated Project Delivery.

In Poland, a majority of architects are planning on deploying BIM as a result of the requirements set by the investors. Currently, the conditions for implementing the BIM are difficult. In 2017, at an expert meeting devoted to the BIM methodology, the European Certification Center for BIM, as well as the BIM Association presented their assessment of the condition of education and BIM standardization. They also assessed the state of education of tools, data, and process standardization, as well as standardization of processes and data. One of the experts described it in this way: “BIM deployment requires a significant number of new people who are ready to work. This poses a challenge for schools and universities” [2]. In 2021, there have been few changes in that respect [34].

At the close of the summary, it should be explicitly emphasized that the BIM method might be a serious threat to uniqueness and beauty of architecture, if, as on an assembly line, buildings will be mass built from ready-made component parts, “pasted” into the virtual reality of BIM.

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ENERGY CONSUMPTION IN BUILDINGS: THE EXPERIENCE OF THE GREAT BRITAIN, THE LONDON CITY HALL - A CASE STUDY.

1. INTRODUCTION

“How much energy will be consumed when a specific building is used?" Such question should be raised by every architect involved in the design process as of 2021. Of course, only if the said energy efficiency, within finished buildings, is subject to an effective review. This issue is definitely not straightforward. “Luckily enough”, Poland will erect buildings described as “low energy buildings”, not Net Zero Energy Building - NZEB, nor nearly Zero Energy Buildings - nnZEB). In the case of office buildings which could potentially take advantage of the energy generated within the borders of a single building lot, the biggest challenge, perhaps even impossible to overcome, would be to produce an NZEB. The phase of conceptual design could not be completed until simulation results show that the adopted design concept could make it possible that the building’s infrastructure would produce an amount of renewable energy adequate to compensate for the amount of non-renewable energy consumed on an annual basis. Let us raise a question that might, at first glance, come across as easy to answer: “how much energy is consumed during the usage of an existing building?” The author has raised a speculation that in the case of most structures in Poland, the answer to the question above, seemingly straightforward as far as current structures are concerned (due to the fact that all individual pay bills), might never be found. On the other hand, another question comes to mind, namely, “why”. The author is again formulating assumptions. The most probable answers might be:

1) the building has not been equipped with appropriate measurement devices;

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2) the building has been equipped with many a measurement device for various utilities, but no one is interested in making a summary breakdown;
3) it has not been clearly stated which components should be taken into consideration while reporting the annual energy consumption by a single building;
4) such information is accessible, however, the owner, or the facility manger has no interest in this information being made available to third parties. Such information might even pose a threat should the conditions prove to be poorer in comparison to the buildings, or structures that belong to competitors;
5) disclosure of building's too high an energy consumption, should they constitute public property, especially in case of new structures, might lead to accusations against political authorities of improper supervision of the investment and consequently of squandering public money.

Should the information concerning energy consumption of buildings, as well as inspections performed by independent institutions fail to become enforceable through appropriate regulations and implemented by correctly financed organizations, then probably the information on the actual energy consumption will never come to light.

2. EXPERIENCES FROM GREAT BRITAIN

The experience since 2008 in Great Britain could serve as an example of how dangerous information on energy consumption in buildings could be. All of a sudden, (as is the fashion of the British press) a wave of critical articles deluged the media, bearing the following headlines: "Public building CO_2 footprints revealed" [1], "Halls of shame: biggest CO_2 offenders unveiled" [2], "Government buildings emit more CO_2 than all of Kenya" [3], "Parliament's carbon emissions 'among worst in UK'" [4]. Words such as: 'ignorance among officials, inefficient equipment, and poor energy management" [3], 'those operating them had little idea how to improve their energy efficiency' [5], "The Department of Health, which really needs to save money, achieved only F and two G in its London buildings." [6] (in: [5]) were only some of the words and phrases used. For the government of Great Britain, for years involved in the policy of sustainable development and reduction of CO_2 emissions, this appeared to be a cause of great embarrassment. The choice of the word 'seemingly' is explained below.

Why did energy efficient buildings occupied by governmental and self-governmental authorities stir up so much interest on that very day, the 2nd of

October 2008? One day prior to that date, regulations came into force requiring that owners of buildings, public buildings, in both Wales and England, exceeding 1,000 square meters of floor space, present the Display Energy Certificate in places clearly visible to civilians. An institution responsible for that program was the Department of Communities and Local Government, the DCLG [7]. As a consequence, in a single day, everyone was able to see the energetic performance of 18,000 buildings, and the results were appalling. The structures were classified according to a scale on which A stood for the highest, while G stood for the lowest grade as far as energy performance is concerned. Most prominent institutions, such as the Palace of Westminster or the Bank of England received lowest grades, both received Gs. The Guardian compares the joint CO_2 emission in both these buildings (21.356 tons) to the emission generated by flights of 14,000 passengers from London to New York [2]. The headquarters of the Department of Environment, Food & Rural Affairs received an E category. Until the 2nd of October, every fourth building out of 3,200 buildings assessed received either F or G category, with the average grade being D, while only 22 buildings, which is less than 1%, received A category [4]. In 2011, 40,147 buildings had the certificate, 142 received grade A, 6,112 received G [6] (in: [5]). “Leaky and draughty”, such phrase was used by the president of the UK Green Buildings Council, an organization promoting sustainable buildings in Great Britain. In the case of most public buildings, the assessment of energy performance had not been executed within the deadline specified by law, despite the risk of a fine of 1,500 pounds. Among the structures that came in late was a masterpiece of a prominent architect, Richard Rogers- the building of the National Assembly for Wales.

The author presents the situation of Great Britain in such detail because he is of the mind that in Poland, at the moment of introducing a comparable system of assessing the energy performance, the results would be similar (the author is aware of the Polish energetic certification requirement, binding since 1st of January 2009. By ‘a comparable system” the author means the working system). The whole situation occurred during the time when the government of Great Britain was obliged to transform every public building into a zero energy building, not later than 2018. The director of public affairs at the Commission for Architecture and the Built Environment (CABE), a governmental organization supervising the designs of new structures, stated: "We review 350 significant new build projects a year at the design stage and we hear a lot of greenwash. (...) The knowledge that from now on this performance will be objectively measured should mark the end of that" [2]. The

housing minister, responsible for the certification programme, summed up by saying: "Display energy certificates are a valuable tool in the fight against climate change."

The voice of reason uttered by Healy in the whole affair should be mentioned [5]. He is of the opinion that the criticism received was undeserved, and then goes on to provide the following arguments:

1) A typical building in Great Britain was expected to rank somewhere between D and E. From that perspective, a low number of A's is understandable;
2) Historic buildings, built using outdated techniques (from the contemporary point of view), uninsulated, drafty had to do badly in the assessment;
3) Criticism of the results of the first assessment is unfair because the purpose of the whole program was to constantly improve the energy performance of buildings. Categories which were assigned to buildings in later years, showing lack of improvement, definitely deserve the criticism;
4) The building's technology life cycle is very long compared to, e.g., household appliances. The forecasts prepared by BRE indicate that in 2050, 60% of the building stock will comprise buildings built before the year 2010. In such a situation, one should not expect any immediate improvement;
5) The category alone does not tell us everything. One should be able to recognize whether a given building, either a building over 100 years old, or one that is technologically advanced and ultramodern, is properly managed and occupied.

Here, the author wishes to add that criticism might be deserved if designers working on a new or an upgraded building, during the entire design process, had assured the investor that the erected building would be high performing, and then it would transpire that the reality was utterly different. From that perspective, an example worth mentioning might be the 10-year-old headquarters of the DCLG (it was 10-year-old in 2008), the Eland House, an office building, and The Treasury's headquarters on Horse Guards Parade. It received an E and despite undergoing a thorough upgrade 6 years earlier, it was supposed to ”set new environmental standards in Whitehall' [2].

3. THE LONDON CITY HALL – THE CASE OF A HIGH PERFORMANCE OFFICE BUILDING

On the list made in 2008, one can find a building whose designer, none other than Sir Norman Foster, was able to account for his work's appallingly low performance. The building the author is referring to is the City Hall in London (Foster and Partners,

2002, Londyn) [8], [9], [10], [11], as it happened, it received an E. The inauguration ceremony of that ultramodern and sustainable building was supported by a declaration (still visible on the website of Foster and Partners Design Firm). This declaration stated that the said building was ‘a virtually non-polluting public building’ [10]. As far as the building is concerned, apart from issues connected with high performance, natural environment friendliness, the designers accentuate the idea of transparency on the part of authorities. It is said that, initially, the City Hall was supposed to be shaped like a glass sphere suspended over the River Thames. At the end of the day, the structure resembles an egg leaning south. Located on the southern bank of the Rover Thames, it is as strange and as alien as a meteorite [8].

The most optimal solid figure in terms of the the proportion of external area to cubature is the sphere. Foster designed such a deformed sphere, leaning south, to create a natural sunshade through cumulatively extended floors. On the northern side, there is the atrium to avoid overheating of the interior in the summer through direct insolation. There is a double facade, thanks to which there is an increased thermal insulation, automatically operated sunshades were installed in between the two layers of the facade, while the windows on the office-side had been installed at desk-level, therefore no one could claim that the overly glassy facade had been designed unnecessarily [12]. With all architectural decisions taken correctly, where did such high-energy consumption come from, and how big is it actually?

With the obligation of displaying the Energetic Certificate in a place visible to all citizens, the building makes us wonder as why it is so difficult to find information about how much energy Foster’s building actually consumes. Wikipedia provides us with information about the yearly consumption of 375 kWh/m^2 in 2012 [as per Wikipedia]. And that is that. The whole situation is curious therefore the author devoted some time trying to find some data on the Internet. On the whole, it can be said that we are dealing with a public building, while explicitly defined regulations have been introduced. On Carbon Culture, an internet portal which also serves as a social platform and whose goal is to help people grasp the idea of an efficient use of natural resources, one can find that the Display Energy Certificate had been published, showing the results the Town Hall received in 2010-2012 [13]. At that time, it was possible to raise the energetic efficiency of the building by one category, up to D. The certificate itself is colorful, resembling the energetic efficiency certificates intended for household devices, with the category of the building visible at first glance. However, in order to learn how many kWh/m^2 per annum is hidden behind each category, one must him/herself perform a very tedious calculation, as

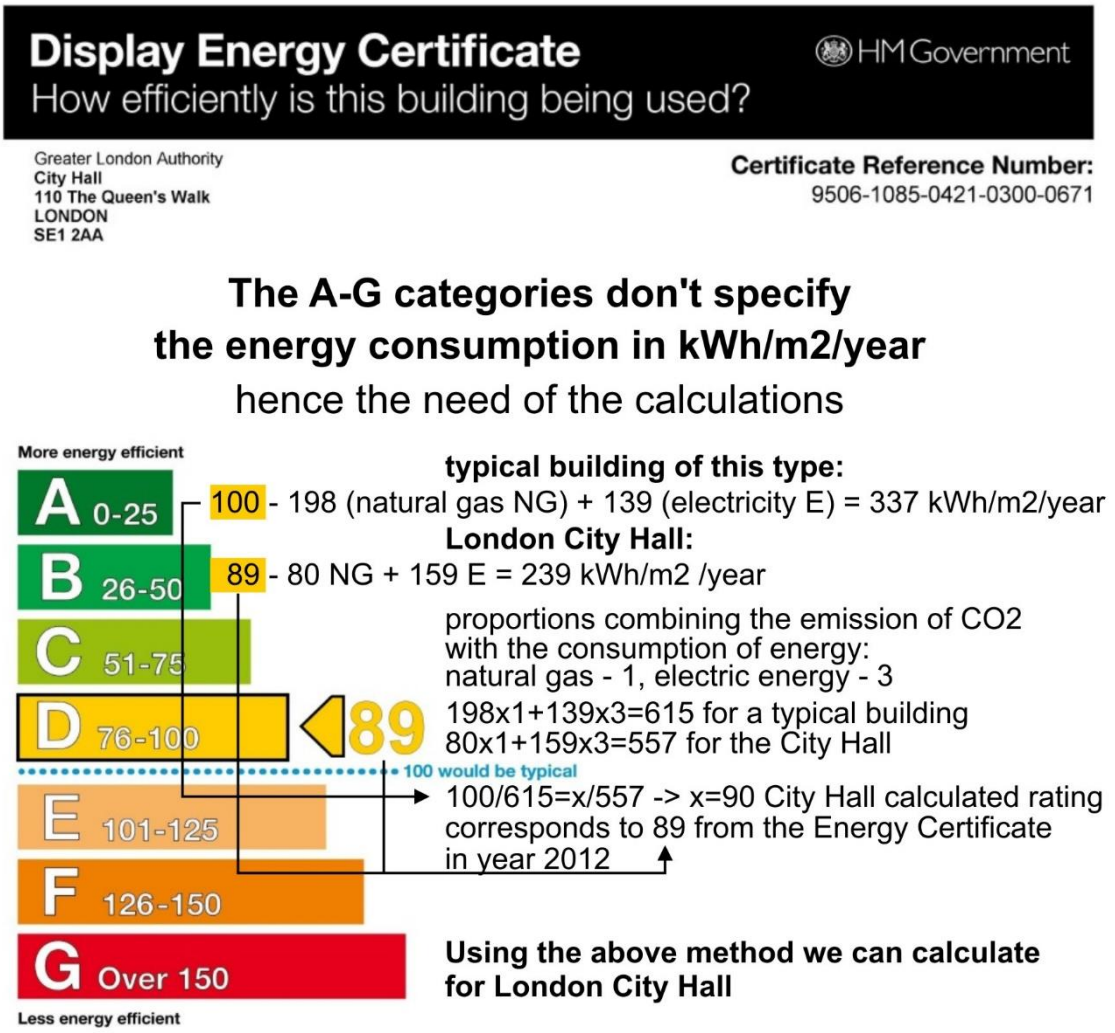
presented below. So, even though the D category has been assigned digits 76-100, they do not specify the energy consumption expressed by kWh/m^2. The author finds this quite bizarre.

At the bottom of the certificate, written in small print, reference data is presented. A typical building of 'this type' consumes up to 198 kWh/m^2 (natural gas) for heating purposes and 139 kWh/m^2 as far as electric energy is concerned. So, the number "100" corresponds to 337 kWh/m^2. The City Hall consumes 80 and 159 kWh/m2, respectively, a total of 239 kWh/m^2 (information obtained from the certificate). When it comes to determining the category, the energy produced by the building is also taken into consideration, the values for the A category range from 0 to 25 apply. Foster's building produces hardly any energy, with only 1.3% accounting for the electric energy produced, the author of this article will ignore it in future calculations. Unfortunately, a common proportion may not be applied because, to make matters worse, the energetic category represents CO_2 emission, not the energy consumption [7]. In the DCLG document, it is stated that the methodology used to calculate the category had been approved by the Secretary of State, along with the Internet address of the website it might be downloaded from (in 2019 that website was unavailable). At this point, the author shall utilize the proportions known to him, combining the emission of CO_2 with the consumption of energy: natural gas – 1, electric energy – 3. So, 198x1+139x3 amounts to 615 for a typical building, while 80x1+159x3 = 557 for the City Hall. The use of the 100/615=x/557 proportion gives us a number 90, which might be accepted as it corresponds to number 89, provided on the certificate. In 2010, the City Hall received number 97, while in 2011 it received 94. Assuming that the proposed calculation method might yield results approximate to the actual ones, below the author provides a calculation showing the energy the building could have used in 2008 when it received the E category. The E category is defined by values ranging from 101 to 125. For the upper values, 100/615=125/y yields a result approximate to 769. For the purposes of the calculation, proportions showing the gas and electricity consumption in 2012 were used: 80/557 = 0.14 and 159x3/557=0.86 were used. By the same token, 0.14x769 and 0.86x769/3 amount to 107 kWh/m^2 of heating and 220 kWh/m^2 of electric energy, respectively, a total of 327 kWh/m^2 for the number 125 on the Certificate. The author is unable to determine whether these speculations are accurate. There is a possibility that these speculations might be erroneous. If we compare the theoretical maximum value of 327 kWh/m^2 in the City Hall with the E category and the 337 kWh/m^2 value in the reference building with the D category, some doubts may arise. This is the specificity

of the difference between the negative impact of energy (the CO_2 emission), generated as a result of natural gas combustion, on the natural environment and the electric energy.

By means of this calculation method, the author shall attempt to determine the upper limit of the A category (0-25), taking into consideration the more advantageous proportions of the gas and electricity from the reference building. The proportion of 100/615=25/z yields the number 154. The proportions of gas and current in the total energy consumption are as follows: 198/615=0.32 and 139x3/615=0.68. The reference building used up 49 kWh/m^2 for gas heating (0.32x154) and 35 kWh/m^2 for electric energy (0.68x154/3), which in total amounts to 84 kWh/m^2. If the building used up a higher percentage of electric energy (just like the City Hall), the maximum energy consumption necessary to reach the A category would have to be lower. When designing Heelis, an office building in Swindon, Feilden Clegg Bradley Studios set sights on 75 kWh/m^2 annual energy consumption. When reading this article, one might spring to mind as to whether the issue of energy consumption during building occupancy might get even more complicated. In the said certificate, there is a phrase: 'Consumption data based on actual meter readings'. So, the Energy Use Intensity (EUI) is presented.

The question of 'what level of energy consumption was planned during the design stage of the City Hall?' was answered by Osaji et al. [14]. Even though some speculation was performed, the data on which it had been based are definitely worth a detailed presentation. To start with, two citations shall be provided presenting the intended purposes of energy consumption. Ken Shuttleworth, also known as Ken the Pen thanks to his outstanding skill in drawing going back to the time of his studies, Norman Foster's right and left hand for as long as 30 years [15], once said: 'the starting point of the project (of the City Hall) was to reduce the building's energy load by 75 percent. " [16] (in: [14]). In 2005, on Greater London Authority's website (the then main user of the City Hall) the following piece of information was posted: "energy consumptions for [the Greater London Authority Building's]



In 2008, the City Hall received **E rating** (101-125), for **125**:
100/615=125/y -> y=769
Let's calculate proportions from 2012 year's data:
80NG/557=0,14; 159E x3/557=0.86
eventually: **NG** - 0,14x769=**107** kWh/m2/year; **E** - 0,86x769/3=**220** kWh/m2/year
total - **327** kWh/m2/year

Let's calculate **energy consumed by the reference building with A rating for 25**:
100/615=25/z -> z=154

Let's calculate proportions from 2012 year's data for a typical building:
198NG/615=0,32; 139E x3/615=0.68
eventually: **NG** - 0,32x154=**49** kWh/m2/year; **E** - 0,68x154/3=**35** kWh/m2/year
total - **84** kWh/m2/year

Fig. 1. Calculations of energy consumed annually
Rys. 1. Obliczenia rocznego zużycia energii

Environmental systems are less than half levels in the DETR good practice office guide. The radical shape of the building minimises the surface area (approximately 25 percent less than equivalent rectangular building)" [17] (in: [14]) (in 2019 merely the information concerning the area, smaller by 25%, could be found [11]). Special attention should be drawn to the aforementioned report, prepared by the Department of the Environment, Transport and the Regions, also known as DETR, especially the table that presents the annual energy consumption in 4 types of office buildings (tab. 1).

Based on the data contained in that table, Osaji et al. present the following speculation [14]:

1) the average energy consumption in the "good practice" buildings is equal to the arithmetic mean of the 4 types listed in the DETR table (tab. 1) – (112+133+225+348)/4=818/4=204.5 kWh/m^2 per annum;
2) The GLA declared that around the year 2005 "energy consumptions for [the Greater London Authority Building's] environmental systems are less than half levels in DETR good practice office guide." [17], which is <102.25 kWh/m^2 per year.

In 2008, "the truth came out" and the City Hall received the E category. However, as early as 14th September 2005, a representative of Liberal Democrats, Mike Tuffrey, raised a question to the Mayor of London, Ken Livingston: why have recent inspections revealed that the City Hall had been consuming 50% more energy than intended at the stage of design [12], [14].

One might wonder what the review of energetic efficiency might look like if Polish flagship office buildings were taken into account. In later parts of the article, Osaji et al. raised some doubts about the credibility of the buildings' assessment of the BREEAM method (Foster's building received the highest category with a score of 76%) [14]. Credible sources provide information about the CO_2 emission of the City Hall (the building measures 19,814 m^2 [10]): year 2008 - 2.255 tons [1], [4]; 2014/2015 - 1.985 tons [11].

4. THE SUMMARY

The author was unable to get hold of any information on why the level of energy consumed by the City Hall - a "model, sustainable" building - is so high. The projected energy consumption in the City Hall was based on computer simulations.

Table 1.

Annual delivered energy consumption (EUI) of Typical (T) and Good Practice (GP) offices in the UK for the four office types (in: [18])

	annual energy consumption (EUI) (kWh/m^2)							
	cellular, naturally ventilated		open-plan, naturally ventilated		A/C, standard		A/C, prestige	
	GP	T	GP	T	GP	T	GP	T
heating, hot water	79	151	79	151	97	178	107	201
cooling	0	0	1	2	14	31	21	41
fans, pumps, controls	2	6	4	8	30	60	36	67
humidification	0	0	0	0	8	18	12	23
lighting	14	23	22	38	27	54	29	60
office equipment	12	18	20	27	23	31	23	32
catering, gas	0	0	0	0	0	0	7	9
catering, electricity	2	3	3	5	5	6	13	15
other electricity	3	4	4	5	7	8	13	15
computer room	0	0	0	0	14	18	87	105
total gas or oil	79	151	79	151	97	178	114	210
total electricity	33	54	54	85	128	226	234	358
total	112	205	133	236	225	404	348	568

Source: Reprinted from [18].

According to many scientists, the reason for so many discrepancies might be the fact that the computer model is not 100% a 100% copy of a real building [12]. The author does not agree with such hypothesis so the reason why validation studies are performed is for the correctly created simulation models as well as adopted assumptions to yield actual results. Probably the computer model will never be able to do justice to the actual projection. Another hypothesis says that it might be the

change in the buildings usage that is responsible. It might be difficult to refute that argument. It is obvious that a building used 5 days a week, from 9 AM to 6 PM, will use less energy than the same building operating 24/7. In response to questions raised by Tuffrey in 2005, the Mayor of London stated that the building was in use for more than 50% longer than anticipated at the stage of design [12]. Obviously, the behavior of users largely affects the energy consumption in high-performance buildings. In fact, authorities of London are doing their best to lower the energy consumption in the City Hall. It is the author's opinion that one should take a better look at what might be done in such situations as the Foster's building, between 2008 and 2012, managed to climb up to a higher category, from E to D (which is the average for all the buildings of the category). The following solutions were introduced [11]:

1) in 2007 photovoltaic panels were installed (their contribution to the total energy balance is barely visible, as mentioned before);
2) "voltage optimization" technology has been installed;
3) electric lighting (LED);
4) employee detecting movement sensors switching off artificial lighting;
5) optimized heating system;
6) smart meters measuring energy use on each floor (collected data shall be used during the preparation of future strategies for reducing energy consumption).

In summary, one can recapitulate that despite the measures taken the results fail to impress.

In architectural design, the issue of designing buildings with the lowest possible energy consumption level, during its usage, became really important, if not the most important of all. Since 2021, architects have had to do their best to design "low energy buildings". These are not net zero energy buildings (NZEB) nor nearly net zero energy buildings (nnZEB), however, such targets will surely soon be set up, too. At present, an effective enforcement of whether energetic certificates are displayed might prove a useful tool. Spreading the idea of energy-saving to people not only engaged in the building of structures, but also to normal users, could stir up some interest as well as a sense of agitation similar to that of Great Britain, as described in this article. From that state to changing the reality, the road seems shorter.

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COMMON SPACE IN CONTEMPORARY BUILDINGS OF PRIMARY SCHOOLS IN POLAND. CASE STUDIES IN QUALITATIVE RESEARCH

1. INTRODUCTION

The article is concerned with issues related to the design of contemporary primary school buildings in Poland taking into account architectural and spatial aspects. To enable proper performance of the tasks the institution of school is entrusted with, it is necessary to optimally shape the space of the school building to support the educational and upbringing processes in the best possible way. The most important organizational unit of the educational space of school is a classroom. The so-called classrooms make up the functional-spatial system of the building and are linked to common spaces which are available to all users. Such places, first of all, play a role of internal circulation spaces which connect the educational zone of classrooms with other spaces of the school building. In addition, they are spaces frequented by pupils during breaks and after-school activities.

The main objective of the undertaken research was the analysis of the zones available to all users. Such spaces defined as common spaces serve the purpose of educational tasks, after-school activities, as well as social interaction and integration. The analysis encompassed the methods of shaping common spaces, functional and spatial solutions as well as architectural and arrangement aspects. In order to draw attention to the currently changing approach to the designing of the architecture of school buildings, three primary schools were selected. They were built between 2010-2020 in Poland. In situ investigations were carried out and then supplemented with the analysis of the current state of research on the basis of selected literature and scientific publications, as well as design documentation of the investigated school objects. The analysis and evaluation focused on the building's entrance zone

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of the flagship part of the school building, as well as the corridor/hall zone, connecting all zones of the school.

2. STATE OF RESEARCH

School building in Poland is often associated with a typical building, such as millennium memorial schools[3] built in the 1960s within the framework of an action to construct one thousand schools to commemorate the millennium of the Polish state. The period of building schools of exactly the same type lasted almost twenty years and resulted in many still functioning school buildings (Kuc M., 2017). In the late 20th century and early 21st century, architects started to search for an ideal form of the school building and its functional solutions. Such solutions should satisfy the users' needs which became known thanks to the development of the science of pedagogy and environmental psychology. The classroom, which used to be the only necessary condition for school operation, appeared to be insufficient. New designs began to be implemented as the architects started to take into consideration the assumptions of a friendly and modern school institution which aimed at the holistic development of the child.

In the subject literature published abroad, a well-known expert on kindergarten and school space, Mark Dudek, issued many publications devoted to the issues of the design and formation of educational space. The publication *Children's Space* (Dudek M., 2005), edited by him, contains a collection of experts' opinions and research in the scope of architecture, pedagogy and sociology with reference to the creation of the environment for children in the context of the significant role the environment plays to provide educational and social support. The above-mentioned author cites several key examples of a good school design, emphasizing that architecture may and should go beyond the functionality of the building, thus encouraging learning, education and social interaction. The publication *Architecture of Schools: The New Learning Environments* (Dudek M., 2000) contributes greatly to the debate on the role and impact of architecture on the educational process and combines the theme

[3] 'Millennium Memorial Schools' – a colloquial name of schools commemorating one thousand years of the existence of the Polish state. The schools were constructed in the 20th century within the framework of an educational programme launched during the celebration of the one-thousand-year anniversary of the Polish State (1966). The millennium memorial schools were sponsored by the state budget and social donations. Within the framework of this action, more than 1400 objects were built. Most of them were constructed in accordance with one of the several obligatory typical designs.

of pedagogy and architecture. The above-mentioned author attempts to explain the value of architecture in the school building, which he understands, among other things, as aesthetic and environmental values of the surroundings. An important publication in the scope of architectural solutions for schools is *21st Century Schools. Learning Environments of the Future* (a joint initiative between the CABE and RIBA, 2004), made in the form of an investigation report focusing on social needs connected with architecture. The school of the future should be oriented at the integration of pedagogy, management and technology with design. Dealing with interaction and safety through design will constitute the key aspect. The design of solutions should integrate basic elements of the school structure, providing, at the same time, flexibility. This will enable the application of various systems and their adaptation to different styles of teaching. Another publication worth paying attention is *Designing the Sustainable School* (Ford A., 2007) by Alan Ford, whose output includes many school designs. The publication presents selected implementations of school buildings located in different parts of the world, which were designed and constructed in accordance with the rules of sustainable development.

In Poland, the literature about the design of school buildings developed in the second half of the 20th century. An important publication from this period is *Architecture of Schools (Architektura Szkół)* (Łukasiewicz S., 1954). Other significant publications contributing to this topic were published in the 1960s, such as *Building of Schools and Nursery Schools (Budownictwo szkół i przedszkoli* (Jankowska J. et al., 1962) and *Primary School Buildings (Budynki szkół podstawowych)* (Mieszkowska D., Wachowiak R., 1968). These publications introduce the readers to the issues of designing school buildings and their facilities by presenting, among other things, ready-made typical solutions, characteristic of the-then trend. *The Architecture of School (Architektura Szkoły)* (Włodarczyk J., 1992), by Janusz Włodarczyk, an active architect, includes functional and technical solutions used in the Polish and European school architecture of the second half of the 20th century. A significant publication of the recent years is a doctoral dissertation by Małgorzata Balcer-Zgraja entitled *The Architecture of a Modern School Building in View of Modern Technologies and Social Requirements (Architektura budynku szkolnego lat najnowszych w aspekcie wpływów techniki i wymagań społecznych)* including examples of both concepts and implementations of school buildings (Balcer-Zgraja M., 2008). Equally interesting is an unpublished doctoral dissertation by Maria Kuc, 2017, entitled *Architecture and Spatial Solutions of the School Buildings Constructed in Poland after 1999 Presented against the Background of the Educational System Reform, Historical Conditions and*

Multi-aspect Guidelines for the Design of School Spaces (Architektura i rozwiązania przestrzenne budynków szkolnych wybudowanych w Polsce po 1999 roku na tle uwarunkowań reformy systemu oświaty, uwarunkowań historycznych i wieloaspektowych wytycznych projektowania przestrzeni szkolnych), which refers to the-then concepts and assumptions of the previous reform of the educational system (Kuc M., 2017). In 2018, a new publication appeared, namely *Thousand Schools for the Millennium (Tysiąc szkół na Tysiąclecie)* (Wałaszewski K., 2018). The publication was concerned with the issue of a complex enterprise of building millennium memorial schools. The book raises both architectural and political issues of the 1960s period. It also includes an invaluable list of all schools that were built under the banner of 'the millennium memorial school'.

3. MATERIALS AND RESEARCH METHODS

The subject of this article concerning the formation and architecture of common spaces in primary school buildings was based on the investigations carried out in three contemporary school facilities. A detailed analysis covered common zones and spaces in school buildings, taking into thorough consideration the entrance zone and corridor/hall zone. Selection criteria of the objects to the research were: date of the object implementation (in the last 10 years), location in different provinces, innovative architectural solutions.

Objects selected for the investigations:

- The Fryderyk Chopin Primary School in Książenice (mazowieckie voivodeship)
- The Stefan Krasiński Primary School in Chotomów (mazowieckie voivodeship)
- The Astrid Lindgren Public Primary School in Milicz (dolnośląskie voivodeship)

The school buildings presented in the article are part of broader research on the quality of school buildings in Poland, taking into account architecture and functional spatial solutions. An on-site visit to the above-mentioned school buildings took place in June and July 2021. The investigations aimed to assess the quality of school space and architecture, in particular, common spaces in contemporary educational facilities.

To conduct qualitative research, a method of the Post-Occupancy Evaluation (POE) was adopted (Niezabitowska E. D., 2014). It began by walking through and becoming familiar with the building. In order to doing research, a list of criteria was prepared as a research tool for expert opinion and a survey for a free interview with

the building's users. In each school building, an interview was held with the building principal / manager. The questions included aspects related to the use of the building and the impressions and general perception of the building. The investigations took place at several levels, beginning from walking through the building within the framework of stage 1 of the POE; through the analysis of the building in the urban planning context (location, site) and architectural context (cubature, shape, spatial concept, functional and utility system); photographic and graphic documentation, including selected spatial measurements, drafts and diagrams of spatial-functional solutions; and finally, ending at free interviews with the buildings management.

4. BUILDINGS OF PRIMARY SCHOOLS SELECTED FOR RESEARCH – CASE STUDIES

4.1. Primary School in Książenice

The entrance to the building is an open, multi-functional space which provides users with formal and informal places for rest, creating thus common spaces for social interactions. The entrance zone includes also a locker zone, which, in typical school buildings, is usually associated with a dark, closed space. The locker zone, where almost all pupils gather every day, was shaped in the form of open space with lockers for older users and cubicles for younger users. In addition, the locker zone is interwoven with other functions of the entrance zone. In the centre of the building, at the axis of the main entrance doors, there is a high two-storey hall including the zone of the school canteen. The multifunctionality of the canteen is worth emphasizing because, apart from its main function, it serves as a multimedia room and a multi-functional space which can be used for school events. Moreover, this space features a grand piano which is used during all sorts of celebrations. This place overlooks the school garden/yard through glazed walls. The studied space can be characterized as open, spacious and full of sunlight due to numerous glass walls, which smoothly 'connect' the school interior with its outdoor facilities.

The hall of the building was made in the form of a broad circulation route running along both wings of the architectural object and connecting all school rooms. Spacious horizontal circulation zone enables an interesting arrangement for the activities not included in the curriculum, such as playing chess. The space under the stairs is used for sitting places and spending time during school breaks. The hall was widened in many places. In doing so, a leisure and meeting space was created.

Different colours depending on the purpose of rooms are used on the doors from the corridor side, creating thus a system of visual information.

4.2. Primary School in Chotomów

The entrance zone was designed in a much more traditional way than in the school in Książenice. While entering the building, the user comes directly to an open information point / secretary's office, which facilitates the orientation in the building. On the left-hand side of the entrance zone there is a cloakroom / locker room taking the form of a niche in the main hall. The locker room for older pupils is separated from the one for younger pupils. The entrance zone features an open staircase in green, characteristic of the whole school building. There is also a lift for pupils with disabilities. Inside there is a lot of greenery, which creates friendly atmosphere in the school building. Atria and numerous glass walls let a lot of natural light into the interior.

The school building has an extended multi-unit layout. The spatial system of the school consists of smaller functional blocks linked by means of a common space of the circulation zone. Horizontal circulation consists of wide corridors, which feature niches with wooden sitting places. The chief asset of the corridors is atria which provide access of the natural light to the interior. In the vicinity of the staircase, the corridor was widened into an open space hall, which may be used for didactic classes in smaller groups. The majority of the corridor walls are painted with a special chalkboard paint, which gives opportunity to pupils to use them during their free time. There are also educational and teaching aids on the corridor walls.

4.3. Public Primary School in Milicz

The entrance zone in the school building is directly combined with the main corridor that runs through the whole building. Different parts of the whole concept are linked by means of visual identification and selected colours. All this creates an aesthetic and friendly space. The chief motif of the visual identification is a circle, which appears again and again throughout the whole building starting from the entrance zone. The entrance zone features the exposition of selected works made by pupils, as well as a rest zone in the form of a waiting room. Staircases in the buildings are marked with yellow, which facilitates orientation.

The corridor was designed as a wide circulation route linking school rooms, as well as the locker room and the canteen. The open space of the cafeteria was designed as a 'city alley', which provides space to eat meals, doing homework, meeting friends and do things together. The corridors and classrooms are linked by a yellow steel pipe joint motif that brings associations with industrial space, as the school occupies the site of a former industrial plant. Yellow pipes were designed at different heights and serve as an exhibition space for the work of the pupils. The pipes are harmonised with staircases, which are also made of yellow. Legible visual identification present in the building and the choice of colors facilitate orientation in this architectural object. The corridor walls are equipped with installations and decorative elements, including educational aspects (e.g., the map of the world). The designers created many common spaces in the corridors, which fact contributes to the interaction and integration of the users. There are theme corners or niches in the form of freely arranged sitting places.

Fig. 1. Entrance zone with an open staircase in the Primary School in Książenice. Photo W. Skowronek

Rys.1. Strefa wejściowa z otwartą klatką schodową w Szkole Podstawowej w Książenicach. Fot. W. Skowronek

Fig. 2. Entrance zone with an open staircase in the Primary School in Chotomów. Photo W. Skowronek

Rys. 2. Strefa wejściowa z otwartą klatką schodową w Szkole Podstawowej w Chotomowie. Fot. W. Skowronek

Fig. 3. Entrance zone in the Public Primary School in Milicz. Photo W. Skowronek

Rys. 3. Strefa wejściowa w Publicznej Szkole Podstawowej w Miliczu. Fot. W. Skowronek

Fig. 4. Open space of the corridor in the Primary School in Książenice. Photo W. Skowronek
Rys. 4. Otwarta przestrzeń korytarza w Szkole Podstawowej w Książenicach. Fot. W. Skowronek
Fig. 5. Open space of the corridor in the Primary School in Chotomów. Photo W. Skowronek
Rys. 5. Otwarta przestrzeń korytarza w Szkole Podstawowej w Chotomowie. Fot. W. Skowronek
Fig. 6. Part of the corridor in the Public Primary School in Milicz. Photo W. Skowronek
Rys. 6. Fragment korytarza w Publicznej Szkole Podstawowej w Miliczu. Fot. W. Skowronek

5. RESEARCH RESULTS AND DISCUSSION

The research carried out on the architectural objects resulted in the analysis and assessment of the the quality of common spaces, which constitute an integral part of the school building. The analysis of the selected buildings aimed to systemize development trends and, finally, to define the contemporary features of the newly designed school buildings, as well as the shaping of their functional and utility systems. On the basis of the conducted investigations, the analysis of the collected research material was performed with special attention paid to common spaces in school buildings. The results were collated and compared with a typical school building in Poland, i.e. the ‘millennium memorial school’.

The spatial solutions presented in this article refer to the contemporary aspects of the design of common spaces in educational facilities in Poland. The overriding objective of school is to educate and pass on knowledge. To fulfil this goal, it is necessary to have an optimally shaped space. The so-far image of the school as a building with classrooms is changing due to growing expectations of the users and technological progress. Taking into account the above, the school building where

students spend most of their daily time should represent the highest standards and offer a functional-spatial programme adapted to users' expectations. Thanks to new implementations, a classic image of the school building is beginning to change in Poland. What is crucial from the perspective of school architecture is new spatial solutions which make use of good features of educational environment, create safe and friendly social space as well as the comfort of use.

In the analyzed buildings, the entrance zone guides users into the open space of the building which combines multifunctional spaces such as the canteen, multimedia and information space. In addition, school cloakrooms / locker spaces were freely combined with the common space and interact with each other. The hall / corridor zone in each school building was designed in a different way, however, they have the following in common: wide circulation routes, including arranged formal and informal places for resting. The hall / corridor plays an educational function by means of different games marked on the floor surface, as well as educational and recreational elements on the walls. Moreover, visual identification plays an essential role, including the cohesion of colours, guiding marks, and leading motifs, which enable the users to freely move around the school facilities.

Table 1

Evaluation table of selected common spaces acc. to the adopted design criteria

ANALYSIS OF SELECTED PRIMARY SCHOOL BUILDINGS IN THE CONTEXT OF DESIGN AND ARCHITECTURE OF COMMON SPACE						
Selected design criteria of common space in the school building **Entrance zone and hall/corridor zone**	PRIMARY SCHOOL BUILDING – EXAMPLES OF CONTEMPORARY SCHOOL BUILDINGS (21st CENTURY)	**SCHOOL No 1** The Fryderyk Chopin Primary School in Książenice	**SCHOOL No 2** The Stefan Krasiński Primary School in Chotomów	**SCHOOL No 3** The Astrid Lindgren Public Primary School in Milicz	PRIMARY SCHOOL BUILDING – EXAMPLE OF A TYPICAL SCHOOL BUILDING (20th CENTURY)	**TYPICAL 'MILLENNIUM MEMORIAL SCHOOL'** Primary School no 23 in Sosnowiec
functional and spatial system		Hall/corridor and classrooms system, extended multi-building (or multi-unit) body, open high spaces, overlapping and fusion of functions	Hall/corridor and classrooms system, extended multi-building (or multi-unit) body, overlapping and fusion of functions, open space, atrium	Hall/corridor and classrooms system, T-shaped building body, overlapping and fusion of functions		Hall/corridor and classrooms system, T-shaped multi-unit body.
multi-functionality of space		**YES** Entrance zone and hall space are combined with the canteen space which also has multi-media functions; possibility of organizing games and school events; locker space located in corridor niches.	**YES** Possibility of organizing school games in the corridors. Widening of the corridor in some places makes it possible to run classes in small groups outside classrooms.	**YES** Hall space partly combines functions of the canteen and locker room. Possibility of combining selected classrooms.		**YES/NO** Hall space in the form of a wide corridor serving the purpose of circulation. Rooms have their specific functions; the structure of the school gives no possibility of changes or flexibility.
space adaptation to the students with disabilities		**YES** Building is equipped with the lift for the disabled; slight differences in height in the corridors are levelled by ramps.	**YES** Building is equipped with the lift for the disabled, which is located in the entrance zone.	**YES** Building is equipped with the lift for the disabled, which is located at the staircase in the entrance zone.		**YES/NO** There is a ramp in front of the building. No facilities for the disabled inside the building (no lift or toilet for the disabled).
legibility of space and visual identification		**YES** Corridors are highlighted by floor games and colourful circles. The colours of the doors to various rooms differ depending on the purpose of the rooms. Easy orientation and circulation in the building. Particular zones are marked.	**YES/NO** There is no explicit visual identification, however, circulation routes are clearly highlighted and maintained in dominant green colour. Vertical circulation – staircases are emphasized. Particular zones are marked.	**YES** All corridors are highlighted by the use of installation in the form of yellow pipes running through the whole building between staircases. All rooms are clearly and cohesively marked. Easy orientation and circulation in the building. Particular zones are marked.		**NO** No visual identification in the building, no dominant motifs.
arrangement - finishing methods and materials		**YES** Colourful common spaces. Corridor floor surface covered by colourful floor games.	**YES** Dominance of green colour, soft seats located in the niches of corridor walls. Corridor walls partly covered with chalkboard.	**YES** Elements of industrial installation in the form of yellow pipes; soft seats for students located in corridor niches and open spaces.		**YES/NO** Standard finishing materials, terrazzo flooring, walls painted in one colour.

Source: W. Skowronek

Compared to school buildings of the 20th century, which are often associated with Poland's Millennium Memorial Schools built in the 1960s within the program to construct one thousand schools to commemorate the millennium of the Polish state, there is a visible updating and modification of traditional solutions in the approach to designing common spaces in contemporary buildings.

The above-mentioned buildings were characterized by the symmetry of their systems, projections, and elevations. The introduction of flat rooftops and recreational spaces was a novelty in comparison with the previous perception of school architecture, however the common space was often limited to corridors which were the only places to spend free time in the building. The positive aspect is the fact that corridors were wide circulation routes which could accommodate their pupils. However, it is in vain to look for the multifunctionality of these spaces, connecting and permeating zones, separating places of rest with many features and possibilities. The functional layout, including the classrooms, administration, and the canteen, was clearly separated in the building, which gave less possibilities for various arrangements and use of the potential of the space.

The newly-designed school buildings show the tendency of the formation of open and spacious common spaces. According to the rule of equal and just use, these spaces are accessible to each user of the building, also to students with disabilities, as there are no architectural barriers. The chief concept of the contemporary common spaces is their multi-functionality and changeability of spatial systems. It also focuses on space accessibility, creative organization of time and social integration. The interview conducted with the school principal / manager indicates the significant role common spaces play in architectural objects, as well as their positive perception by pupils, parents, and other users.

Table 2

Selected aspects and results of the free interview conducted in the presented school buildings

ANALYSIS OF SELECTED ISSUES FROM THE FREE INTERVIEW WITH SCHOOL BUILDING USERS IN THE CONTEXT OF DESIGN AND ARCHITECTURE OF COMMON SPACE				
Users were asked selected questions and issues concerning the use of the school building	SELECTED ASPECTS OF THE FREE INTERVIEW WITH THE PRINCIPAL / MANAGER OF THE SCHOOL OBJECT	SCHOOL No 1 The Fryderyk Chopin Primary School in Książenice	SCHOOL No 2 The Stefan Krasiński Primary School in Chotomów	SCHOOL No 3 The Astrid Lindgren Public Primary School in Milicz
Which space is the greatest asset in the school building?		Open space of the entrance zone, the hall is linked to the canteen zone with the possibility of arranging the multi-media zone; development of the school grounds outside.	Open staircase with atrium, common space of the hall/corridor, well-equipped classrooms.	Multi-functional school hall/corridor, combined with the canteen and locker zones; day-care room, modern gymnasium.
Does the school building cause positive associations as an educational establishment among pupils, parents, teaching staff and other employees?		Yes, both pupils and parents' perception of the school building is positive. Children are happy to spend time in this building.	Yes, both pupils and parents' perception of the school building is positive.	Yes, both pupils and parents' perception of the school building is very positive. The pupils and teachers participated in the arrangement of school space.
Are there formal and informal spaces and rest areas in the school building which are popular with pupils ?		Yes, there are. Open space of the canteen, stairs and places under the stairs, wide school corridors.	Yes, there are. Open space of the hall/corridor including atrium and staircase, school corridors with places for playing games.	Yes, there are. School hall/corridors along with staircase, niches located in corridors serving the purpose of resting and sitting areas, day-care room as a multi-functional room.
Has the school building been adapted to the needs of the people with disabilities?		Yes, it has. School building is equipped with a lift for the disabled; slight differences in height in the corridors are levelled by the use of ramps. There are bathroom facilities adapted to the needs of the students with disabilities.	Yes, it has. School building is equipped with a lift for the disabled. Width of the room doors is adapted to the needs of the students with disabilities. There are bathroom facilities adapted to the needs of the students with disabilities.	Yes, it has. School building is equipped with a lift for the disabled near the staircase. Width of the room doors is adapted to the needs of the students with disabilities. There are bathroom facilities adapted to the needs of the students with disabilities.
Does the school building have the system of visual identification?		Yes, it does. The corridors are highlighted by means of floor games and colourful circles. Room doors depending on the purpose of the rooms have different colours.	No, it does not have explicit visual identification, however, the circulation routes are clearly highlighted and maintained in dominant green colour.	Yes, it does. Corridors are highlighted by the use of industrial installation in the form of yellow pipes which run through the whole building between staircases. All rooms are clearly and cohesively marked.

Source: W. Skowronek.

There are many interesting architectural and functional solutions to school buildings in Europe. They are characterized by an innovative approach to designing, often rejecting a classic 'corridor and classroom' model. An example of a 'deskless school' was described and discussed in an article concerned with the modern designing of educational space based on the contemporary school in Helsinki (Reinius, H., Korhonen T., Hakkarainen K., 2021).

As far as common space is concerned, the implementations of school buildings in Sweden should also be mentioned. Special attention should be paid to the Kollaskolan School, which was built in Sweden in 2014. This school is a good example of a passive primary school building. Apart from well-balanced pastel shades of the interior, the key point of the object is the entrance zone, which is open on three planes. All spaces accessible for all pupils are located around the atrium. Classrooms are situated at the farthest distance from common spaces, that is, in the wings of the building. This layout constitutes a legible division between classrooms and common space. The common space combines many interwoven functions and solutions, which

encourage the users to make use of it and spend time there[4]. The building of Vittra School Sodermalm, also in Sweden, is another example of contemporary school space designed in 2012. The design and functional-spatial layout is treated in a free way, making it possible for teachers and students to work in different arrangements. The spaces overlap and permeate, drawing users' attention by means of interesting colour solutions and rich furnishings. The school premises have become the focal point of both education and social activities. According to the author of the design, the supreme importance was given to the creation of the environment in which students feel good and happy spending their time at school and crossing the border between work and leisure[5].

6. CONCLUSIONS

The article focuses on the architecture and the designing approach to common space in the primary school buildings. In the authors' opinion, common space is a basic and integral part of contemporary school building. The spaces and zones presented in this article show an innovative approach to the creation and fusion of the space of common integration in a conscious and creative way in order to provide diversity and multi-functionality of the use. The following factors contribute to the positive feedback from the users of such common spaces: modification of typical corridor-classrooms systems and adaptation to modern requirements, more flexible formation of the functional-spatial system of the building, provision of place and space for interaction between users, existence of formal and informal places for resting and recreation beyond school lessons, multifunctionality, flexibility, changeability and diversification of common spaces; their accessibility and adaptability to the needs of students with motor system disabilities, legible visual identification in common spaces, an interesting choice of materials and interior design. All of the above-mentioned aspects contribute to the sustainable and conscious approach to the design of contemporary school architecture in Poland.

[4] www.archdaily.com/572189/kollaskolan-school-kjellgren-kaminsky-architecture
[5] www.pol.architecturaldesignschool.com/vittra-school-s-dermalm-99646

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Rafał SZRAJBER[6]

DESIGNING THE NON-EXISTENT – FROM THE CREDIBILITY OF VIRTUAL SPACE TO THE MATERIALIZATION OF ELEMENTS IN VIDEO GAME WORLDS

1. PRESENCE IN A VIRTUAL WORLD

Architecture is a mirror in which the world is reflected. The space surrounding man is a silent witness to the aspirations, knowledge, and abilities of past and present generations. The places created by man are thus composed of stories. The purpose for creating virtual worlds is, above all, to tell them. The virtual environment, like "every form of space, needs to be told in order to be understood". To read it fully, sometimes knowledge and familiarity with the language of architecture is needed, but part of the story can be read by anyone participating in the space. Architectural Intelligence, i.e., the ability to deduce from space, is the ability to actively process information, analyse and interpret changes recorded in space, their consequences, and, as a result, the story accompanying the place. In this case, we analyse space as a collection of stories, bearing in mind that an appropriately defined set of challenges for the user, or lack thereof, may highlight some and strengthen other transmitted stories and the way they are read. The phenomenon that initiates the reading of stories recorded in virtual spaces is the sense of presence in the created world.

Presence is linked to engaging with and being part of a virtual world. Sanchez-Vives and Slater [1] defines presence as the phenomenon of experiencing a place as a realistic space, and therefore believable, which elicits responses in their broadest sense, from physiological arousal to emotional and behavioural reactions. Slater, in his analysis of presence through the prism of space, defines it by two components: the place illusion, i.e., the feeling of being in and being able to explore the place represented in the virtual environment, and the plausibility illusion, i.e., the feeling of

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reality of the situation presented in the explored world for a given user of his knowledge and experience [2]. The presence in some way satisfies and at the same time attempts to verify the credibility of the space, combining the player's capabilities and the available actions so that their consequences are possible in similar circumstances or taken from the conventions of other virtual worlds, thus making use of the viewer's experience.

In virtual space, presence is mainly influenced by the quality of the content of the experience presented, from the refinement of the world to the possibilities to interact with it, including the NPCs and thus the entities inhabiting it. Some researchers differentiate the sense of presence into a spatial aspect, referring to the possibility of self-location and self-orientation in the environment, and a social aspect related to the perceived presence of other space participants and the possibility of interaction with them. [3] From previous research and my own research experience, it is worth emphasising that presence depends on the user's motivation and involvement in the exploration of virtual worlds. [4,5,6,7]

Presence as one of the components that define the experience of virtual reality (beyond immersion and interactivity), is most related to the way the world is presented in its sensory and meaningful form, supported by interactivity as a way of communicating with the viewer. Such a place, in design terms, thus consists of form, function and credibility.

Undertaking the task of defining the credibility of worlds created for the purposes of video games precisely in terms of the broadly understood design of space, bringing together architecture, urban planning, landscape design, and each of these fields in a multisensory communication (depending on the device providing access to the virtual world, the main channels of communication considered and implemented so far have involved mainly sight, hearing, and, to a lesser extent, touch), combined the author's previous work and research on the virtual representation of heritage in digital environments [8], taking into account the postulates of the London Charter [9] with contemporary narratology [10].

This combination made it possible to define the virtual space of video game worlds as a place whose purpose is to tell multiple stories. It thus becomes a space construct, which can be referred to a quote taken from Hamsun's novel Hunger and which defines the space of the museum that is dedicated to it [11], "space [building] as a body, a battlefield of invisible forces". The backbone, in this case, becomes the main means of communication in the story, a metaphorical lift allowing movement between successive chapters of the story, the individual bones of its stages within

chapters, and the connections and spurs accompanying the environment of side stories, depending on their location influencing the whole. This approach to space design directs and sets the design goal of storytelling. Daniel Libeskind takes a similar approach, saying "If there were no history, the building would only be an abstract exercise, as if it were talking to itself", however, refers to the process of creating space as an attempt to find a narrative in the project, which begins its story, initiated by a history and an attempt to tell it through the prism of the creator [12]. And the story, the real one, very rarely ends with the sentence: "they lived happily ever after", although so many architects think so, but the passing of time puts the space to new tests, enters a dialogue with its creators by means of users, changing ideas, or aspirations. The passing of time makes its mark on a place, and just as movement gives a third dimension to a space, revealing its spatial character with the help of the changing position of the observer, so in the case of the passage of time, stories are created.

The process itself, which the author has proposed and presented at scientific conferences and articles [13,14], will not be discussed here, but only a reference to the very credibility of the space shaped by such a design challenge.

The relevance of the very topic of designing virtual worlds, which appears not only in architecture or design, but above all in literature, game studies, and cultural studies, where there are "all the changes in artistic practices at the turn of the 20th and 21st century, marking a shift from understanding the fictional world as a background for fictional events to valuing its role in the creation of narrative heterocosms and vast trans-fictional and transmedial reference systems, called universes because of their vastness" [15]. Such an approach to the problem defines the created world rather as a space of free exploration and countless stories contained in the environment, the highlighting or deepening of which is only up to the designer and the means of communicating the content. The world created in this way, and therefore designed, with the current technological possibilities does not remain just an architectural vision, an idealised model, but becomes an inhabited space. Here, as nowhere else, speculative design or all forecasting methods focused on prototyping the future find their justification, yet the stories contained in the environment come to the fore, as they make it easier to design this world, and thus understand it. The issue under analysis thus has a very wide spectrum of influence, from the creation of alternative worlds based on heritage to futuristic visions of the future, for which it is the story that carries the information about what happened in space.

2. CREDIBILITY OF THE SPACE

Credibility, which is verified by presence in virtual worlds, is defined by three areas that influence its formation and reception. They make up the design process accompanying the shaping of the story. The definition of credibility, as the third component of the virtual world project, can be referred to the deliberations of Umberto Eco, who, defining allotopia, assumed that its basic property is the determination of such patterns of reality that will ensure the truthfulness, and therefore credibility, of a given representation of the virtual world [16].

How can defining and describing architecture through reliability help to understand the accompanying changes and, in the very process of creating a digital representation of it, better design the components of the virtual universe?

Credibility is most often perceived in everyday life through authenticity and truthfulness, but these are not the only characteristics that make up the scope of this concept, because they are only part of the connotation of meaning most often referring to the spatial form itself and its nature, and yet virtual worlds by their very nature may seem untrue. In a broader sense, it is the usefulness for participants, including the readability of the history of a place, that builds credibility, which concerns not only the representation of a space and its digital materialisation, but also its relationship with the audience, its inhabitation and therefore participation in the story. In fulfilling the needs of history, the space becomes, apart from its defining function, a tool for communication with the user. Thus, credibility encompasses the spatial form and usability of the environment and their changing relationship over time.

Thus, in terms of space design, credibility as a function of utility has technological, cultural, and social dimensions.

The technological dimension refers to those methods that provide the possibility to traverse the world and define the way of exploration. It is about ensuring that the interface and the mechanics that correspond with the space are adjusted in such a way as to allow the reading of the design patterns written in it, related to the exploration decisions made and the possibilities for the player to act or insight into the presented world itself. It is one of the components of space that does not include its appearance in its scope, because it concerns, in relation to the game, the area of game design and level design without considering the final visual representation of the environment (level art), and thus focuses on shaping the world so that it allows the player to explore it by making appropriate use of the available mechanics. The

technological dimension of the important elements consists, therefore, not so much of the choice of the platform itself providing access to the world and the associated devices giving control to the user over his presence in the world, but primarily refers to design decisions such as the choice of graphic perspective from which the world is presented, the mechanics associated with exploration and actions taken, and their reflection in space (each game creates its own language, which communicates with the user by defining the elements of active and passive space [17]). Thus, the technological dimension refers to the way the story is told through the mechanics used. It is worth highlighting here the important role of empowering the user by providing traces of their presence in the environment, as an essential element in shaping the presence that the technological dimension verifies.

The second important aspect of the technological dimension is the possibility to introduce changes and analyse successive iterations of the project based on tests carried out as part of the creation of the environment. The real world does not provide such a scale and possibility to test the users' behaviour and collect feedback before finally making the space available to its target users. Striving for the best possible fit between the world and the user, on a test basis, for a given environment, allows the designer's experience to increase very quickly and thus subsequent stories in that environment are more efficiently constructed and become more believable.

The cultural dimension is the use of the code of meaning, which allows the information contained in space to be read, because environment, including architecture, is a space of stories through meaningful elements, which is a code that transforms space into a place, usually with a coherent character [18] or interconnected spaces to create a coherent story. An important element of virtual worlds, which defines their cultural dimension, is the possibility of reaching and using a wide range of design and artistic activities, which, through their context, i.e., information content, shape the story. And this dimension should not be defined only in terms of the reflection of the story in the environment, because it can be mainly attributed to worldbuilding in video games, which creates the narratological field. This does not refer to the mode of storytelling through the possibilities made available to the player, but in relation to the design of the narrative identity of the player accommodating to the representation of the world in virtual space (topography, architecture, culture, art, language, etc.) [19]. This dimension, to function, requires designing the world, considering all available channels of communication with the player. Design conceived in such a way, i.e., multisensory,

allowing to define not only the lighting conditions for a given stage of the story, the influence of atmospheric conditions, the appearance of the location and the entire soundscape that accompanies presence in the created world, must be juxtaposed with the story, presenting a vision of a new society built based on the presented concept of organizing the space of the place. Thus, the cultural dimension includes the area of filling the world and all the expressive elements that shape the stories that accompany it [20].

The social dimension refers to the relations within and outside the environment, as the co-creation of the community inhabiting the created world. Here it is important to understand that virtual worlds have their depopulation and desolation written into their existence. By completing the objectives set by the games or simply by exploring the space, users tame it and turn it into a place. These places become empty after some time and their users move on. However, there are also those who stay and celebrate their presence in the environment which has become their virtual home. They remain mainly due to the possibility of modifying the world or elements of its environment and thus reinventing it (games with a predominance of emergent narration and space as a creator), and when their status in the virtual world or skills allow them to achieve high scores or decide on the fate of the game or have a significant impact on the environment and its inhabitants (games with a predominance of embedded and role-playing narration and space as a guide/ ally and informant/narrator) [21]. However, this dimension also goes beyond the world and concerns the relationship with it through communication systems (e.g., Discord), the exchange of experiences and support for gameplay (forums, solutions, dedicated portals, or groups), and as one of the important, having a huge impact on shaping the social dimension ensuring the sharing of one's experiences of being in the world whether directly (e.g., lets plays) or through artistic activities (e.g., photo mode). Creation based on the virtual world, by means of presence in it, is close to the author, because it constitutes one of his areas of creative use of games in art and thus of maintaining their social dimension.

The narrativity of space including architecture and all its components, including industrial design, as forms that frame space and the whole expressive power of changes in space based on human activities related to presence in the designed place, define the view of space very broadly. Because designing virtual worlds as a narrative form goes beyond the design process dedicated to architecture,

basing it on a "back and forth" action to fully understand the whole accompanying story of the space. First, it is necessary to understand the idea of the creation of the work, everything that accompanied it up to its birth, and then to show what has happened with the passage of time, showing, to the best of our ability and knowledge, each of the stories written in space. The return is understood here in such a way that the viewer, after the crumbs of information left to him, defined by the environment, can reach that original form, function, and relationship with the users. The result of such a design process is a place that contains, with the passage of time, a record of successive days or years and the events accompanying them, human fates and everything that can be accumulated and described by the creator of space. It is a process that goes beyond the architectural design pattern because it considers and allows its users to inhabit their place during the design process, so that it can then be narrated through their actions. Such design is based on anticipating change, the consequences of human actions and the reflection of events in space. The author implements such a process in design practices and design classes, beginning with the design of objects, through interiors to fragments of urban landscapes or more open locations incorporating a plausible story.

3. MATERIALISATION OF ELEMENTS OF VIRTUAL WORLDS

To sum up and refer to some of the topics discussed in the article, there is the materialisation of virtual worlds to make them credible, which goes beyond the world of the game itself and therefore is not related to presence. Seeing an object, being able to touch it, makes the world credible by involuntarily experiencing its existence in physical form. Such an attempt at authentication was made in the author's project on the Steam Rift universe and the process of authentication itself was the subject of ongoing research into the effect of the prop accompanying a work of art, as a video game should be treated as such, on its reception and credibility.

Fig. 1. View of the repulsor port. Main Gap. The world of the Steam Rift. The first expedition. Designed by Rafał Szrajber. Source: Author's own study
Rys. 1. Widok na port repulsorowy. Szczelina Główna. Świat parowych Szczelin. Pierwsza ekspedycja. Projekt Rafał Szrajber. Źródło: Opracowanie własne autora

The research conducted in virtual space additionally included the influence of information scope, interaction complexity, and information balance in the presentation of exhibits in the virtual museum space. The interest in such a way of making virtual worlds credible stems from two reasons: the first is the direct transfer of elements of the created reality and presenting them in the form of a design object, as an exhibit, thus giving it value and placing it in the exhibition space (virtual and real); the second is the use of such activities in the marketing process, making the essential elements of the created universe available in collector's editions of video games. The first and the second reasons have their basis in giving the user the tangibility of possessing objects relevant to the universe, important for the presented story and thus having a value indicated in it. Such a targeted way of making space credible may be referred to the actions of cosplayers who create costumes and impersonate fictional characters, thus become a part of the universe, representing it in the physical dimension of reality.

Thus, the author has developed several elements that define the universe of the Steam Rift he designed. The Steam Coin, as it will be used here as an example, is an essential element not only for survival (a steam reservoir enabling the operation of objects from the world, the contents of which also constitute currency in the

underground city complex) but also an object that is a symbol of belonging and functioning in the Steam Rift society.

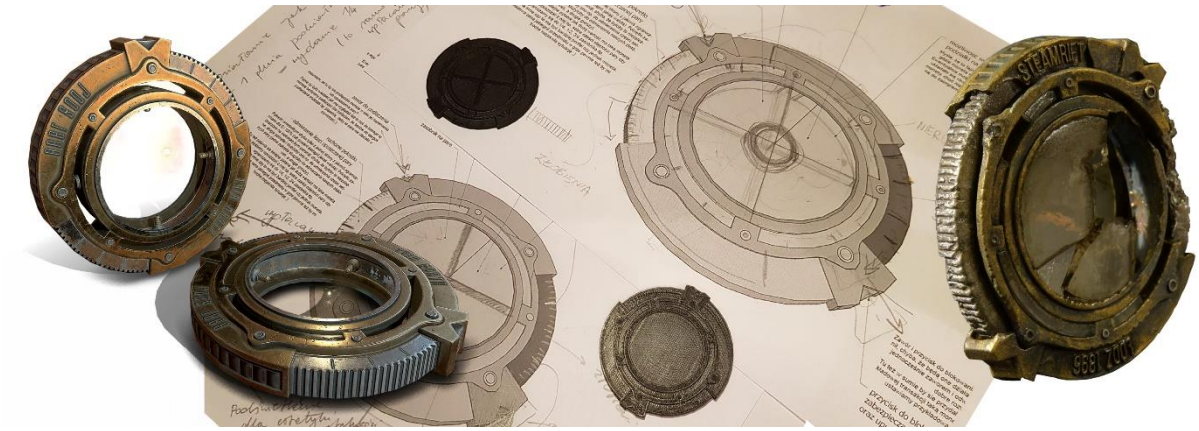

Fig. 2. Models and record of the design process for a steam coin. Design by Rafał Szrajber. Source: Author's own study
Rys. 2. Modele i zapis procesu projektowego dla monety parowej. Projekt Rafał Szrajber. Źródło: Opracowanie własne autora

The materialisation in the form of a three-dimensional representation in two forms (destroyed and functional) and the attribution to it of the story associated with its finding, was considered true and credible by many listeners. The association of the steam coin with the industrial heritage of city Łódź and the stories surrounding the development of the city, as well as the current construction works related to the implementation of the cross-town tunnel, made it possible to lend credibility to the find, to reach the remains of the steam geysers and to enable the first expeditions to the underground complex of the Steam Gap under Łódź. A complex whose design phases the author defines as expeditions, each of which uncovers new facts, new places, new stories written in space, becoming a field for research and analysis of virtual worlds. Due to the course of events in the underground complex, such as the steam disaster, the 1905 revolution and several other events, the place has been completely abandoned and only space resounds in this story and the accompanying remnants of information.

4. CONCLUSION

Designing credible video game worlds, i.e., those for which the phenomenon of presence occurs, is a marginalised phenomenon in architecture, as it has different creative processes and concerns virtual spaces. However, looking at the number of

architects in the gamedev industry and the use of knowledge from the fields of urban planning, architecture, or landscape architecture design in the design process, a new area emerges, so far not so strongly associated with space design in its broadest sense. This link, although broad in practical terms, is closest to interior architecture, which for the author defines the design field of video games due to the scope of world development, which even in an open space requires the design of walls, floors, and ceilings, i.e., a complete environment that tells stories inside. Comparing such a scope of design process to current video game research in other fields of science, this relates to one of the components of term ludotopia - topos, describing the time-shifting space of fictional reality, shaped by the stories and events that comprise it [22]. Therefore, achieving the topos becomes a design goal. Framed in this way, it provides a basis for understanding the design of plausible game worlds and is also an experience that enriches the architect's knowledge of architecture and the architect's design workshop.

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ABSTRACTS

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QUALITATIVE RESEARCH IN THE LUNARES SPACE HABITAT

Abstract

The article concerns the qualitative research carried out at January 2021 in the LunAres Research Station. The qualitative research in the LunAres habitat during the PANDA mission has been developed by the architect, analog astronaut Wiktoria Dziaduła, as part of the work of BK (Faculty of Architecture of the Silesian University of Technology, in the Rar5 Department) under the supervision of Prof. of SUT, Klaudiusz Fross. Qualitative research was an expert assessment of the facility in qualitative categories: technical, functional, organizational, economic, and behavioral. It is worth emphasizing that these were pioneering studies of the qualitative assessment of the space habitat by architects. The research was conducted in parallel with the space mission. The research results constitute an interesting resource for the design of a space habitat.

BADANIA JAKOŚCIOWE W HABITACIE KOSMICZNYM LUNARES

Streszczenie

Artykuł dotyczy wykonanych w styczniu 2021 roku badań jakościowych w habitacie kosmicznym LunAres. Badania jakościowe w habitacie LunAres podczas misji PANDA wykonała architekt analogowa astronautka Wiktoria Dziaduła w ramach pracy BK (Wydziału Architektury Politechniki Śląskiej, w Katedrze Rar5) pod kierunkiem prof. PŚ Klaudiusza Frossa. Badania jakościowe stanowiły ocenę ekspercką obiektu w kategoriach jakościowych: technicznej, funkcjonalnej, organizacyjnej, ekonomicznej i behawioralnej. Warto podkreślić, że były to pionierskie badania oceny jakościowej habitatu kosmicznego przez architektów. Badania prowadzono

równolegle z misją kosmiczną. Wyniki badań stanowią ciekawy zasób wiedzy do projektowania habitatu kosmicznego.

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THE PANDA SPACE PROGRAM IN THE LUNARES HABITAT – RESEARCH ON NEEDS AND BEHAVIOR DURING ISOLATION

Abstract

Isolation in the confined space of a research station and isolation during forced quarantine have a lot in common. The article concerns the research that was carried out in the analog space habitat LunAres in Piła, January 2021. The main purpose of this simulated mission was to study the effects of isolation on mental and physical health. The article presents the details of the analog mission, the scope of research and preliminary conclusions, good practices resulting from own observations, and analyzes the needs and behaviors during isolation.

PROGRAM KOSMICZNY PANDA W HABITACIE LUNARES - BADANIA POTRZEB I ZACHOWAŃ W CZASIE IZOLACJI

Streszczenie

Izolacja w ograniczonej przestrzeni stacji kosmicznej oraz izolacja podczas przymusowaj kwarantanny mają wiele wspólnego. Artykuł dotyczy badań, które zostały przeprowadzone w analogowym habitacie kosmicznym LunAres w Pile w styczniu 2021 roku. Głównym celem tych symulacji było zbadanie wpływu izolacji na zdrowie psychiczne i fizyczne. W artykule zostały przedstawione szczegóły analogowej misji, zakres badań oraz wstępne wnioski, dobre praktyki wynikające z obserwacji własnych i analiz dotyczące potrzeb i zachowań w trakcie izolacji.

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IMPLEMENTATION OF THE FUNCTION OF WORK AND HOUSING DURING PANDEMIC OF COVID-19

Abstract

The article is based on a survey conducted among students of the Faculty of Architecture of the Silesian University of Technology in Gliwice. The survey discussed factors such as preparing a place for work and rest at home, as well as moving and organizing remote work at the university. The results of the research may be helpful for the organization of home office and university learning during the pandemic or in the future for e-learning. They also provoke reflection on social relations.

REALIZACJA FUNKCJI PRACY I MIESZKANIA PODCZAS PANDEMII COVID-19

Streszczenie

Artykuł opiera się na badaniu sondażowym, ankietowym, przeprowadzonym wśród studentów Wydziału Architektury Politechniki Śląskiej w Gliwicach. W ankiecie poruszone zostały takie czynniki jak przygotowanie miejsca do pracy i odpoczynku w domu oraz przemieszczanie się i organizacja pracy zdalnej na uczelni. Uzyskane wyniki badań mogą być pomocne dla organizacji biura domowego oraz nauki na uczelni podczas pandemii lub w przyszłości dla e-learningu. Skłaniają także do refleksji dotyczącej stosunków społecznych.

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BIM – THE CONCEPT OF ONE MODEL AND THE IMPLEMENTATION MODEL

Abstract

This article describes the concept of a three-dimensional computer model of an architectural structure erected by means of the Building Information Modelling, the BIM method. Moreover, the notion of a multi-dimensional design environment, the BIM, which allows the possibility of recording within a three-dimensional model non-geometric information was presented. Furthermore, it also provides a description of

the various levels of the BIM implementation. The study has used the analysis of the state of knowledge related to the BIM method.

BIM – IDEA JEDNEGO MODELU A MODEL WDROŻENIA

Streszczenie

W artykule opisano ideę trójwymiarowego modelu komputerowego obiektu architektonicznego powstającego w metodzie Building Infromation Modeling (BIM). Przedstawiono pojęcie wielowymiarowej przestrzeni projektowania BIM, która daje możliwość zapisania w modelu trójwymiarowym informacji pozageometrycznych. Przybliżono również poziomy wdrożenia BIM. W pracy wykorzystano analizę stanu wiedzy związanej z metodą BIM.

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BIM AS A DRIVER OF CHANGES IN ARCHITECTURAL DESIGN

Abstract

The article describes Building Information Modelling as a key method in improving the efficiency in the building sector, thus becoming an important driver of changes in architectural design. It also presents the position at the time of BIM introduction, both in Poland and throughout the world, and it also provides answers to the question of what BIM is in this day and age. Moreover, this study utilizes the analysis of the current state of the knowledge related to the BIM method.

BIM MOTOREM ZMIAN W PROJEKTOWANIU ARCHITEKTONICZNYM

Streszczenie

W artykule opisano metodę Building Information Modeling (BIM) jako kluczowy sposób poprawienia wydajności sektora budownictwa, a co za tym idzie – ważny czynnik zmian w projektowaniu architektonicznym. Przedstawiono sytuację wprowadzania BIM w Polsce i na świecie, a także odpowiedziano na pytanie, czym w obecnych realiach jest BIM. W pracy wykorzystano analizę stanu wiedzy związanej z metodą BIM.

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ENERGY CONSUMPTION IN BUILDINGS: THE EXPERIENCE OF THE GREAT BRITAIN, THE LONDON CITY HALL – A CASE STUDY

Abstract

This article elaborates on the issue of energy consumption within buildings, as well as examines problematic attempts made to reduce it. Experiences from Great Britain were described, focused on the period of when specific regulations came into life, requiring that users of public buildings make a public display of Energy Certificates of the buildings. Moreover, the article examines the case of the City Hall in London, designed by Foster and Partners, the architectural design studio. At the time of its designing and putting to use, the structure was advertised as 'a virtually non-polluting public building'. In truth, it hardly fits into the average category of all the buildings analyzed. This study utilizes the analysis of current state of the knowledge related to buildings characterized as low energy buildings.

ZUŻYCIE ENERGII PRZEZ BUDYNKI: DOŚWIADCZENIA WIELKIEJ BRYTANII, RATUSZ W LONDYNIE – STUDIUM PRZYPADKU

Streszczenie

W artykule poruszono zagadnienie zużywania energii przez budynki i problemy z obniżaniem tej konsumpcji. Opisano doświadczenia Wielkiej Brytanii z okresu, gdy w kraju tym weszły w życie przepisy nakazujące użytkownikom budynków, będących własnością publiczną, ogólnodostępną prezentację Certyfikatu Energetycznego tych budynków. Ponadto został przedstawiony ratusz w Londynie, zaprojektowany przez biuro architektoniczne Foster and Partners. Obiekt ten w momencie projektowania i oddania do użytkowania był reklamowany jako „budynek użyteczności publicznej prawie niezanieczyszczający środowiska naturalnego". W rzeczywistości z trudem mieści się w średniej kategorii dla wszystkich analizowanych budynków. W pracy wykorzystano analizę stanu wiedzy opisującej budynki o niskim zużyciu energii.

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COMMON SPACE IN CONTEMPORARY BUILDINGS OF PRIMARY SCHOOLS IN POLAND. CASE STUDIES IN QUALITATIVE RESEARCH

Abstract

The article is concerned with the design as well as architectural and spatial issues of contemporary buildings of primary schools in Poland. It refers to the design and architecture of common spaces in school buildings, which is illustrated by examples of entrance zones and hall/corridor zones. The main objective of the undertaken research was the analysis of the areas available to everyone, defined as common spaces, which serve the purpose of educational tasks, after-school activities as well as social interaction and integration. The analysis encompasses the ways of formation of common spaces, functional and spatial solutions as well as arrangement and architectural issues.

To enable proper performance of the tasks the institution of school is entrusted with, it is necessary to optimally shape the space of the school building to support the educational and upbringing processes in the best possible way. The most important organizational unit of the educational space of school is a classroom. The classrooms form a part of the functional-spatial system of the building and are combined with common spaces which are available to all users. First, common spaces play a role of internal circulation routes, which link the educational zone of classrooms with other spaces of the school building. In addition, they are spaces frequented by pupils during breaks and after-school activities.

In order to draw attention to the currently changing approach to the creation of the architecture of school buildings, the authors chose three primary schools built in the 21st century in Poland. In situ investigations were carried out and then supplemented with the analysis of the current state of studies on the basis of selected literature and scientific publications, as well as design documentation of the studied school objects. The research aimed to analyze and assess architectural solutions applied to contemporary school buildings taking into account functional and spatial systems with a special focus on common spaces.

PRZESTRZENIE OGÓLNODOSTĘPNE WE WSPÓŁCZESNYCH BUDYNKACH SZKÓŁ PODSTAWOWYCH W POLSCE. STUDIUM PRZYPADKÓW W BADANIACH JAKOŚCIOWYCH

Streszczenie

Artykuł dotyczy projektowania współczesnych budynków szkół podstawowych w Polsce w odniesieniu do kształtowania przestrzeni ogólnodostępnych – strefy wejściowej oraz rozwiązań korytarzy. Głównym celem podjętych badań była analiza stref ogólnodostępnych, zdefiniowanych jako przestrzenie wspólne, które służą do realizacji zadań edukacyjnych, zajęć pozalekcyjnych, jak również interakcji i integracji społecznej. Analizie poddano rozwiązania funkcjonalno-przestrzenne oraz aranżacyjne.

Do realizacji zadań organizacyjnych w szkole niezbędna jest optymalnie zaprojektowana przestrzeń budynku, która właściwie wspiera procesy edukacyjno-pedagogiczne. Najważniejszymi pomieszczeniami w szkole są sale lekcyjne, które łączą się poprzez korytarze, hole, strefy wejścia. Przestrzenie te pełnią przede wszystkim funkcję komunikacji wewnętrznej, łącząc strefę edukacyjną sal lekcyjnych z pozostałymi strefami szkolnymi, dodatkowo będąc miejscem częstego przebywania uczniów podczas przerw śródlekcyjnych i czasu pozalekcyjnego.

Chcąc zwrócić uwagę na obecnie zmieniające się podejście do kształtowania architektury budynków szkół, do badań wybrano trzy szkoły podstawowe, zrealizowane w XXI wieku, zlokalizowane w Polsce. W tym celu przeprowadzono badania in situ. Miały one na celu analizę i ocenę rozwiązań architektonicznych stref ogólnodostępnych.

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DESIGNING THE NON-EXISTENT – FROM THE CREDIBILITY OF VIRTUAL SPACE TO THE MATERIALIZATION OF ELEMENTS IN VIDEO GAME WORLDS

Abstract

The creators and designers of virtual worlds, those being interactive spaces inhabited by users, are referred as architects, like the main creator of the iconic Matrix. The architecture of virtual worlds itself, like the real world, combines beauty, function, replacing permanence, if we refer to the perception of architecture through

the Vitruvian triad, with credibility. This perception of one of the place-shaping elements also changes the design approach, the main one in terms of storytelling, because credibility has precisely this connotation of meaning in this case. The paper will attempt to outline not so much the design process of virtual worlds but the issue of the narrativity of space because of its credibility. The author will define the concept of credibility of virtual worlds as a utility function in the technological, cultural, and social dimensions. Theoretical considerations will be supported by the implementation of the proposed methodology into the design process and an exemplary materialization of the elements of the virtual world of Steam Rifts, going beyond the digital environment in order to authenticate it.

ZAPROJEKTOWAĆ NIEISTNIEJĄCE – OD WIARYGODNOŚCI WIRTUALNEJ PRZESTRZENI DO MATERIALIZACJI ELEMENTÓW ŚWIATÓW GIER WIDEO

Streszczenie

Twórcy i projektanci wirtualnych światów, tych będących interaktywnymi przestrzeniami zamieszkiwanymi przez użytkowników, określani są, niczym główny twórca kultowego Matrixa, architektami. Sama architektura wirtualnych światów, podobnie jak rzeczywista, łączy w sobie piękno, funkcję, zastępując trwałość, jeżeli odnosić się do postrzegania architektury przez witruwiańską triadę, wiarygodnością. Takie postrzeganie jednego z elementów kształtujących miejsce zmienia też podejście projektowe, główne w ujęciu kształtowania opowieści, bo wiarygodność ma właśnie taką konotację znaczeniową w tym przypadku. Artykuł podejmie się próby zarysowania nie tyle procesu projektowego wirtualnych światów, ile problematyki narracyjności przestrzeni jako wypadkowej jego wiarygodności.

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