ISSN 2729-7640

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ALFA ARCHITECTURE PAPERS
OF THE FACULTY OF ARCHITECTURE AND DESIGN STU
www.alfa.stuba.sk

3/2022 (Vol. 27)
DOI: 10.2478/alfa-2022-0015

On the Edge - future adaptation challenges: The role of futurology, scenario planning methodology and off grid design in architectural and urban teaching

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Article information
Sent: Jul 11, 2022
Accepted: Aug 30, 2022

Abstract: The article describes the role of thinking about the future and its importance in architectural and urban education. The first part deals with the scientific discipline of futurology and the possibilities of its use in architectural and urban practice. It covers topics that futurology makes available to architecture and their influence on the urbanized environment. It relates the creation of strategic visions for urban development with the UN 2030 Agenda for Sustainable Development and the UN Habitat III initiative. The second part is dedicated to introducing the futurological method of scenario planning, and its origin and use. It mentions so-called megatrends as the driving forces of future scenarios, effecting future challenges and threats that cities will have to deal with. Further, it provides insight into how this method can benefit architectural and urban work and represents the way it was used during architectural teaching. It reflects on the advantages of creating visions in the educational process. In the last part, it shows the off-grid design as a suitable simulator of structural and system thinking, leading to a better understanding of how complex architectural and urban systems function. It highlights the contribution of space architecture projects as a source of innovative thinking. It anticipates that working on space projects where self-sufficiency is a necessity can also benefit thinking about ecology, self-sufficiency, and the sustainability of settlements on Earth.

Keywords: adaptability, futurology, scenario planning, off grid, space architecture, moon base, architectural education

FUTUROLOGY

'Man has lost the capacity to foresee and forestall. He will end by destroying the Earth.'

Albert Schweitzer

All architects, in their work or design activities, from their very nature, think about the future and must include into their reflections or creative thoughts future events, and discover future problems and conflicts of all kinds, simply because the project when designed is not built and used at the same time, indeed often the process take years. Therefore, it could be said that futurology (the scientific discipline dealing with the direction of future development; such terms as prognostics and forecasting are also used for this discipline, which started to develop after World War II, fully developing its methodological foundations in the 1960s) is to some extent present in architecture as a permanent element, as architects, when designing projects, must confront their own ideas with future events in order to choose the best solution. They are setting the stage for future life, and the result can mean either easy or difficult work for builders, functional or problematic space for users, and a good or unpleasant environment for its inhabitants. So far this is happening mostly on an intuitive level based on accustomed solutions, which may no longer be suitable in the contemporary world's rapidly changing conditions.

What will our world, and our cities, look like in 15, 20, or 50 years? The built environment of cities is currently home to half of the world's population, which is likely to reach eight billion by the end of this year (2022). According to the UN (United Nations, 2018; Linden, 2013), the world's urban population is growing at a rate of 180,000 people per day, and by 2050 three-quarters of humanity will live in cities globally. In North America and Europe, 70-80% of the population already lives in cities; it is assumed that these regions are already stabilized, and a rapid increase of the population is not expected, but whether this will actually be the case depends on many circumstances. Developing countries, especially sub-Saharan Africa, are currently the most affected by urbanization. It is reported that the cities in these regions are now up to 40 times larger in area than they were in 1950. In Africa, 36% of the population now lives in cities, but 70% of them live in slums, and in some regions, this is even 90%. Altogether, in Africa, Asia, and Latin America, one

billion people live in slums. An estimated 3 billion people will require adequate and affordable housing by 2030. Cities are now home to 50% of the world's population. While they occupy only about 2% of the land surface overall, they are responsible for 60-80% of the world's energy consumption, 75% of resource consumption, 70-80% of the world's greenhouse gas emissions, and 70% of global waste. (United Nations, 2015, 2022)

Is it the easy availability of various services, resources, and the high concentration of products that puts urban dwellers at the top of the consumer chain, or a certain degree of self-sufficiency of the rural population that remains outside the statistics? And what will consumption, supply systems, and pollution look like when another 25% of the world's population moves to cities? Are cities as systems capable of absorbing such an increase? How will this affect the quality of life in cities? Climate change (IPCC, 2022) influences on our cities cannot be overlooked. Our cities suffer not only from extreme weather events as storms and floods, but especially from rising temperatures – the effect of Urban Heat Islands (UHIs) is more visible every year, due to lacking urban greenery. (Search for NBS nature-based solutions is currently on the rise.)

Acceleration of the global urbanization process, together with the growth of the world's population, climate change, environmental pollution, and new technologies, brings many challenges for cities to face. The Stress Nexus – energy/water/food supply – forms the very base for the functioning of our cities. Interrupting the supply of these elements is fatal. The dependence of cities or human settlement functionality on that entire system is critical. What is not often mentioned to cities' general inhabitants in connection with urbanization is the dependence of urban residents on the flawless functioning of a complex system of transport for energy, water, food, and waste and transport of people; everything must flow faultlessly from source to user. From time to time, a critical outage of some part of the system will reveal its vulnerability, though if it is repaired in time urban residents will not long remember it. But events that interrupt the faultless functioning of the system are becoming more frequent lately, caused either by already expected extreme weather events or by the previously unexpected pandemic.

For a person who has lived his whole life in the peace and in the comfort of a functioning urban system on planet Earth, it is difficult to perceive all the subsets of the system on which his own survival depends. Self-sufficiency seems a long-forgotten skill of past, related to a poor and simple lifestyle. But in light of unexpected events unfolding in our daily reality, it makes sense to be prepared for periods when the system will stop providing all necessary supplies. So it seems that the challenge for cities of the future could be to achieve the highest possible self-sufficiency in the energy/water/food system as well as in waste management (for an inspiration of good planning practice we can look to Singapore, the city incorporating the futurological method of scenario planning by Royal Dutch Shell into their urban planning process back in 1992). Architects and urban planners seem suitable candidates as experts capable of such a challenge, and architectural education should be the way to educate such professionals.

Designing self-sufficient, autonomous off grid systems or transforming the existing urban environment into a self-sufficient environment is a great challenge for architects and urban planners, but few have yet accepted it. So far, the percentage of architects who have embraced the challenge of 'sustainability' is quite small. Yet this is the mantra of our time, despite the fact that since the days of Agenda 21 (a non-binding United Nations action plan with regard to sustainable development, and a product of the Earth Summit, a UN Conference on Environment and Development, held in Rio de Janeiro, Brazil, in 1992 [UNCED, 1992]) the sustainability has become frequently used term in relation to architecture. Perhaps one reason for limited engagement could be the need to define better what exactly is to be 'sustained' and what needs to be abandoned under sustainability, because the current system of excessive consumption of non-renewable resources in which the civilized urban population finds itself is clearly not sustainable.

How should architects prepare for their profession, so their future work solves problems, rather than creating them? Do architects have to catch up to trends, or can they in fact set them? It is the role of architectural education to prepare future architects and urban planners for the challenges the future brings to cities. One proof of a university's quality is how well its graduates are prepared for the future. Architecture and urban planning, as well as other advanced disciplines, should also use forecasting or futurology to ensure their own safe development. Universities should first seek the best solutions for future events and facilitate their graduates' designing with responsibility toward future generations. From this perspective, it seems it could be beneficial for architects and urban planners to become familiar with forecasting methods or adopt some futurological methodology into their own design process.

In current architectural construction practice, it is not enough to be in touch with future needs just to respect the legislation, as this lags far behind real problems and changes. The biggest construction companies or major architectural offices can afford to pay consulting firms (like Arup.com [Arup, 2022]), and those active architects, who have time to study recent university research and publications or UN agendas, may have some insight. However, in general, production, architecture, and urban planning currently lack any friendly neighbour futurological guide and most often do not even realize the need for it. Universities and faculties of architecture should educate not only their students and graduates in this regard, but also practicing architects in their region. For there is a lack of a widely known or used platform that would provide easy orientation and guidance to an ordinary practicing architect as to developments, current events, and future directions, and help reveal the consequences of these developments on the lives of urban architecture users or city residents and provide a framework for critical evaluation of consequences and impacts. (Even the UN SDGs / 2030 Agenda for Sustainable Development – specifically Sustainable Development Goal 11, 'Make cities and human settlements inclusive, safe, resilient and sustainable' – provide little really practical and useful information for practicing architects. [United Nations, 2020] And in contrast the number of guide publications produced by UN Habitat III/The New Urban Agenda initiative is too large for easy access for practical information [Habitat III, 2016].)

The potential of cities to steer the direction of future development is not only through their economic power but also by example of innovative legislation, as we can see for instance in the activities of C40 Cities (A global network of mayors taking urgent action to confront the climate crisis; [C40, 2005]). And it is desirable for architects and urban planners to become active partners of politicians and economists in this respect, so strategic visions for transforming urban legislation are not just technocratic, but also take into account a wide range of factors that contribute to human life quality. Furthermore, it is at universities, especially faculties of architecture and urbanism, where such proactive attitudes should be formed, encouraged, and taught. Universities provide suitable facilities for the creation of multidisciplinary teams and interdisciplinary communication. So far, in some parts of the world, they continue to provide environments for freedom of expression and critical discussion,

and last but not least independence from lobbying pressures, to ensure objective professional quality.

SCENARIO PLANNING

'There is no guarantee that what works today will work tomorrow.'

Shell Scenario Team

Although there is no friendly neighbour futurological guide available to the architect or urban planner, every architect or urban planner can try to incorporate into their practice the futurological method of scenario planning (a method developed and first presented by Pierre Wack from Royal Dutch Shell in 1972, recently used mostly by economists and in strategic planning – see for example Shell scenarios [Shell, 2020] or scenarios by the Slovak Academy of Science's Institute for Forecasting [Filčák, 2017, 2020]) and to formulate future development ideas. Scenario planning is the practice of creating varying stories of possible future events based on a carefully selected list of driving forces, current tendencies (for example global megatrends – see below), and uncertainties in a set time frame. A scenario has to be rooted in the past as well as the present in order to extrapolate possible future events. Whereas current tendencies extrapolation and the worst possible scenarios reveal the challenges, threats, and opportunities, the optimistic vision scenario proposes how to solve them and creates a solid base for creating a design concept.

This method has the potential to clarify many controversial development issues by weaving a logical chain of causes and effects, putting data into context, and revealing the consequences of individual decisions. It works with variants of system development over time and can help optimize a design to respond to the various challenges the future will bring to cities. The scenarios can be adaptive or transformative depending on the purpose, and can warn us away from crises, bring out innovation possibilities, or just provide us with a 'to do list' and mark out steppingstones to the future we want. We know from experience that visions of the future can be achieved because they inspire and focus attention in a certain direction, even if the formal outlook can change according to a current style or fashion.

Futurological or forecasting studies reveal many important topics that might dominate in the future and influence how our reality is shaped. (For initial orientation in the topic see the activities of The Millennium Project, especially 'State of the Future reports' and 'The 15 Global Challenges' [Millennium Project, 2017; TVCHOSUN – TV, 2016, 2019], or works by the Slovak Institute for Forecasting [Lubyová, 2016; SAS, 2022]). Urban development will be further affected by more than just rural population migration into big cities or climate change; we must also take into account the impact of new technologies (see below). It is said that we are already at the breaking point of the exponential curve (processing speed curve over time) for increasing implementation of new technologies into practice. In their lectures, experts from various fields are coming up with assumptions that the degree of the human adaptability factor both in the labour process and in the adaptability of legislation will be insufficient due to the expected acceleration of innovations.

Let us imagine for example how self-driving cars, smart cities, the Internet of Things, and 5G networks as driving forces will transform the infrastructure, labour processes, and habits of residents in transport, shopping, and entertainment. Put this together with the growing trends of robotics and automation of work, artificial intelligence, and quantum computer advancements. Could this, for example, lead to such an unemployment rate that the subsequent social inequality would change the face even of Europe's seemingly stabilized cities? Will the concept of basic income be a suitable solution for this problem? What kinds of activities will then replace work no longer being done? (Bregman, 2018) And what about possible biological inequalities that could be caused by unequal access to new discoveries in prolonging healthy life expectancy or to genetic improvements. (Sinclair, 2019) Bearing in mind that the population's social, societal, and cultural status has influenced and continues to influence the face of the cities throughout the history, architects could help seek new solutions for these upcoming challenges. Even if it is not certain which influence will ultimately manifest the most, it is possible to prevent the worst scenarios through early response if we are ready and recognise the first signs.

Of course, there is a risk of incorrect judgment. Whether this be data in relation to climate change or to the increasing speed of new technologies implementation, not just the general population but also experts from unrelated fields who find it difficult to correctly evaluate their impact and consequences on our lives and the environment. Architects or urban planners must take into account a huge quantity of information inputs in their practice, and correct input data is crucial for proper understanding of the default state of the system with which they work. Trying to optimize the system without accurate input data is impossible and necessarily leads to erroneous conclusions. The ability to collect essential or key data for input analyses, and evaluate their importance and interrelationships, leading to obtaining decisive principles and information as a basis for creating a given project's concept, is then clearly reflected in the quality of the resulting work. So in order to achieve proper results, possible future events, challenges, and threats and opportunities revealed by scenarios should also be taken into account and integrated into the system.

'The future belongs to those who believe in the beauty of their dreams.'

Eleanor Roosevelt

ON THE EDGE

The author uses the development of visions and scenarios of possible future human settlements development not only in her own work, but also in her teaching in the architectural studio 'ON THE EDGE' at the Department of Urban Planning, Faculty of Arts and Architecture of the Technical University in Liberec, Czech Republic. In addition to standard current urban assignments, which themselves have an irreplaceable role in teaching, the 'ON THE EDGE' studio also offers a stable space for utopian, visionary, and futurological themes, for topics on the margins, for borderline themes, and for topics balancing on the edge that do not ride the wave of the mainstream architectural current but can still influence or enrich this work. The studio aims to provide the opportunity to freely develop one's own creativity, imagination, and innovative thinking rather than to train the acquisition of proven practices and approaches. This implies the possibility to question, examine, and check the validity of generally accepted opinions and fashionable or established attitudes in order to find and formulate one's distinctive view and ability to defend it.

This approach seems to be long valid in architectural education, as for example as Otto Wagner mentioned in his 'Inaugural address to the Academy of Fine Arts' – *'To third-year students I recommend solving a problem that you will probably never face in*

life, but whose design will help to fan the divine spark of imagination, the bright flame that should glow within you. At the Ecole des Beaux-Arts in Paris students annually try their hand at such exotic problems as a kind of training of the imagination for the budding art student. I can tell you from my own experience that I have on several occasions concerned myself with this type of problem and that the result has always been very useful.' (Wagner, 1894)

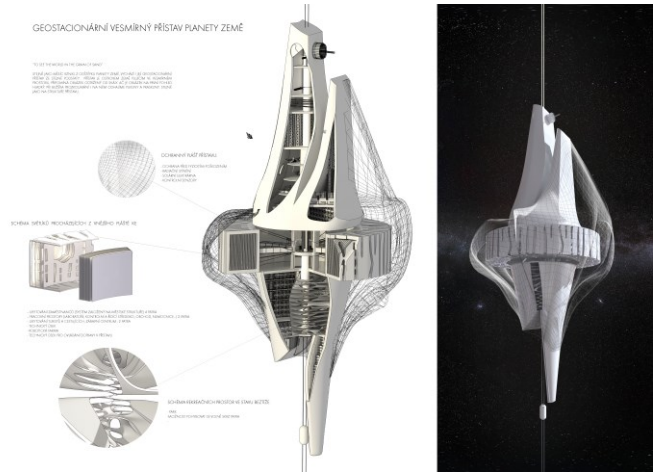


Fig. 1. Student work from Architectural studio 'ON THE EDGE'/Geostationary Space Port of Planet Earth (Author: Jana Šmejkalová, 2016; Source: Němcová Zedníčková)

Why undertake exploration expeditions to unexplored territories as part of the teaching process? Such assignments, freed from the binding stereotypes of everyday reality that incline to routine approaches, are an ideal simulator of conceptual, systemic, and structural thinking as a basic prerequisite for architectural and urban design, discouraging the automatic adoption of safe, proven procedures and attitudes, and thus encouraging the practice of independent critical thinking, helping form one's own attitude and distinctive view of architectural creation, and providing space for one's own 'architectural manifesto'. Further, working on an unrealistic project forces thinking outside the established framework, 'out of the box', and thus makes it possible to find new and unexpected solutions and approaches. This develops innovative thinking and imagination, which in turn can enrich one's own real architectural creation. Last but not least, the need to communicate new solutions and views of the world to others and to defend one's positions in the discussion tests communication and presentation abilities, skills an architect and urban planner cannot do without, as well as the ability to predict future development and the effects of time.

Visionary projects also provide the opportunity to become familiar with the Futurology and give a space to incorporate the futurological method of Scenario Planning into architectural planning process (Lüley, 2019). Scenario Planning is particularly beneficial in the analytical process, where it helps hierarchically structure input data and subsequently it is useful in the process of creation of the concept. At first it can help finding and detecting the problem, then it can be useful in search for the suitable solution. Knowledge of methods of anticipating future development possibilities and readiness to come up with solutions to problematic factors in time will enable a higher degree of adaptability. The ability to adapt and to think innovatively may then become, to some extent, a measure of survival. (Alvin Toffler developed thoughts about adaptability in his book Future shock back in the 1960s (Toffler, 1970) and more recently we encounter these ideas in the Yuval Noah Harari book 21 Lessons for the 21st Century (Harari, 2018).

With the future challenges mentioned above, strategic urban planning will need greater edification and truly practical approaches, with an understanding for how the urban metabolism functions (as where Abel Wolman developed and used this term in his work, The Metabolism of Cities [Wolman, 1965], and later other researchers have more clearly defined, as in The Changing Metabolism of Cities [Kennedy, 2007, 2011]), to be able to provide solutions for adaptation to approaching changes. Future visions, utopian projects of ideal cities and floating cities, and the settlement of the solar system, provide an opportunity for architects and urban planners to try to form their own versions of functioning systems, without the limits dictated by existing contexts or settlements. Such thought constructs of an ideal metabolism are not purposeless, because they teach sensitivities to perceiving patterns of system behaviour, which in turn fosters the ability to understand these patterns in the real world and understand the hierarchy of their functioning or reveal reasons for dysfunction.

OFF GRID

'If our long-term survival is at stake, we have a basic responsibility to our species to venture to other worlds.'

Carl Sagan

In particular, thinking about developing human settlements outside our home planet Earth is an excellent simulator and stimulator for systemic and structural thinking and critical thinking in general. Maintaining and developing life in the long term outside the protective arms of the Earth's atmosphere is a complex problem. Here architects – alongside classic subjects that they commonly deal with in their architectural projects such as the concept of spatial organization, its functions, character, morphology, materials, and construction – must consider topics that usually do not need to be addressed when building on Earth. Just to cite a few examples: construction in zero or low gravity; availability and transport of building materials; protection from radiation, extreme temperatures, vacuums, and micrometeorites; the influence of weightlessness on the human body and orientation in space; 'artificial' gravity; the influence of enclosed spaces and the proximity of a vacuum on the human psyche, and so on. These topics open up many unknowns, and filling gaps in the global knowledge is not a fruitless dream but rather an important initiator of the emergence of new technologies, processes, materials, and knowledge that enrich our daily lives. For architects or urban planners too, it can become a source of innovative attitudes and approaches that will positively influence how they perform in their own profession. It can also stimulate awareness of our industry's need for greater environmental friendliness.

The leading Japanese construction, architecture, and engineering companies Shimizu Corporation and Obayashi Corporation have incorporated this kind of thinking into their company profile. In 2014, Obayashi Corporation (Obayashi, 2014) presented The Space Elevator Construction Concept on their website. And Shimizu Corporation is taking on the challenge of innovative technologies, presenting on their web site proposals from a 'Shimizu Dream' division (Shimizu, 2022) focused on the future, with examples including OCEAN SPIRAL - Deep Sea Future City Concept, Mega-City Pyramid in Tokyo Bay, LUNA RING - Solar Power Generator on the Moon, Lunar Base and Space Hotel. Many other governmental and private initiatives are seriously considering building human settlements on the Moon. Moon base designs by ESA, NASA, and Bigelow Aerospace and Moon Village are just a few examples. In 2013 the renowned architects Foster + Partners joined with ESA to test the feasibility of 3D printing using lunar soil. This approach directly influ-

enced advancements in 3D printing use in architecture construction.

Fig. 2. Student work from Architectural studio 'ON THE EDGE'/HIVE 01 - Mining Station in Asteroid Belt (Author: Lukáš Dlabola, 2016; Source: Němcová Zedníčková)

Besides emergence of new technologies, these visionary approaches could also allow the Earth to be perceived as Spaceship Earth, as American architect and visionary Richard Buckminster Fuller popularized the term in his 1969 book Operating Manual for Spaceship Earth, and will lead to the revelation that our life support system is not unbreakable: *'This all brings us to a realization of the enormous educational task which must be successfully accomplished right now in a hurry in order to convert man's spin-dive toward oblivion into an intellectually mastered power pull out into safe and level flight of physical and metaphysical success, whereafter he may turn his Spaceship Earth's occupancy into a universe exploring advantage. If it comprehends and reacts effectively, humanity will open an entirely new chapter of the experiences and the thoughts and drives thereby stimulated.'* (Fuller, 1969) The Earth, our 'Hotel Mum' provides us with comfort that other planets of our solar system and open space cannot. There, creating a life support system will be entirely in our hands, and it will be necessary to control all its components, and their functioning and interactions. Reckless behaviour driven by short-term profit could be just as fatal as here on Earth.

When designing closed off grid systems on islands outside of the Earth's embrace, topics to incorporate into the design concept include much more than just energy production, sourcing materials for construction, water management, production and control of oxygen and nitrogen levels, air filtration and CO_2 extraction, food production and balanced varied diets, waste recycling, waste heat recovery, backup and repair ability of life support systems, sourcing and technology of producing spare parts and new daily use objects, replacement of fossil sources of raw materials, and selection of animal and plant species for coexistence. It also must address social status and social hierarchy, medical care and production of medicines, leisure and entertainment, relaxation, sport and necessary physical activity, reproduction, education, education and specialization, science, research and development, culture, politics, management, competence, communication, security, biological evolution, and more.

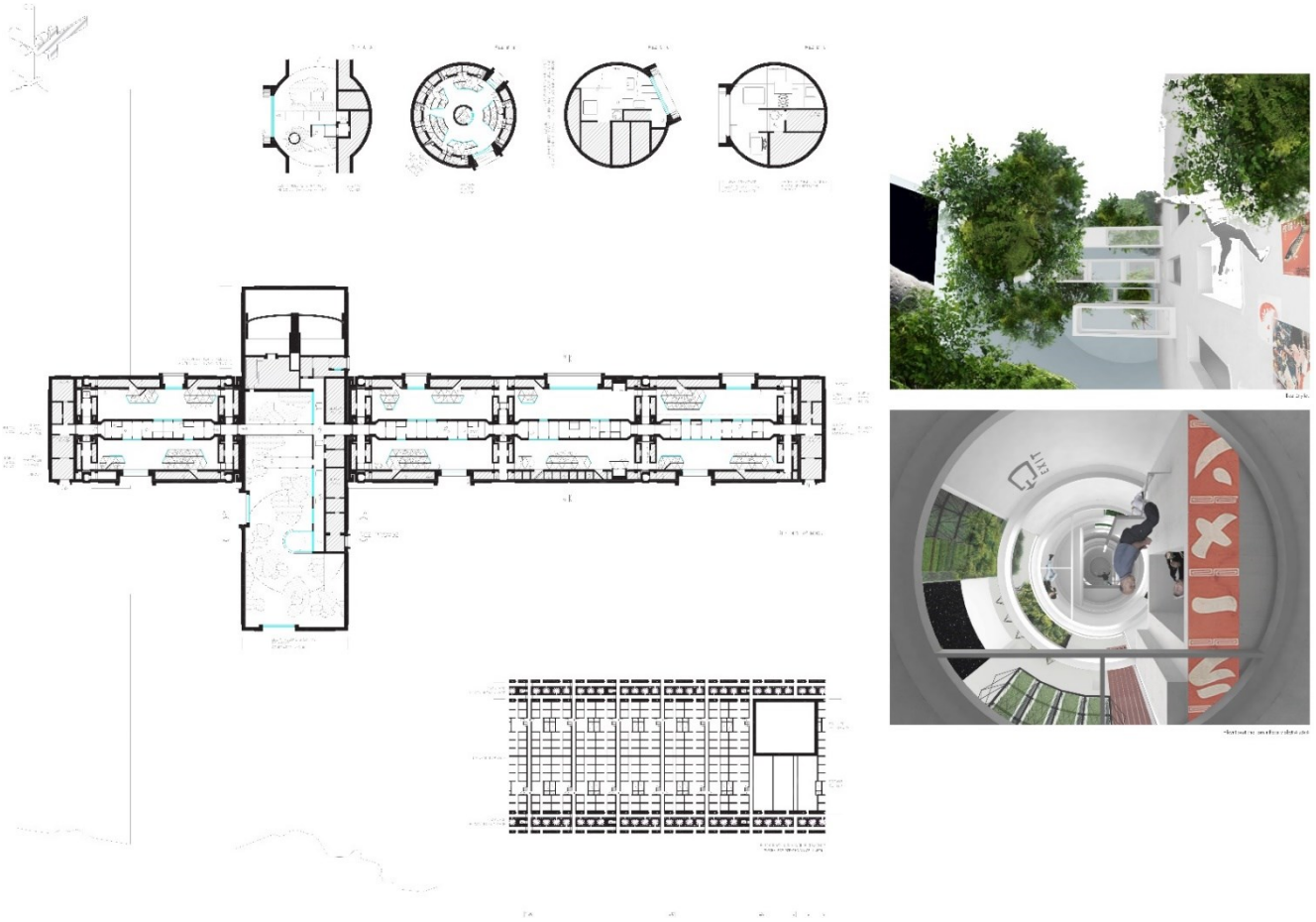


Fig. 3. Student work from Architectural studio 'ON THE EDGE' /MIKADO_04 - Mining Station in Asteroid Belt (Author: Samuel Nekola, 2016; Source: Němcová Zedníčková)

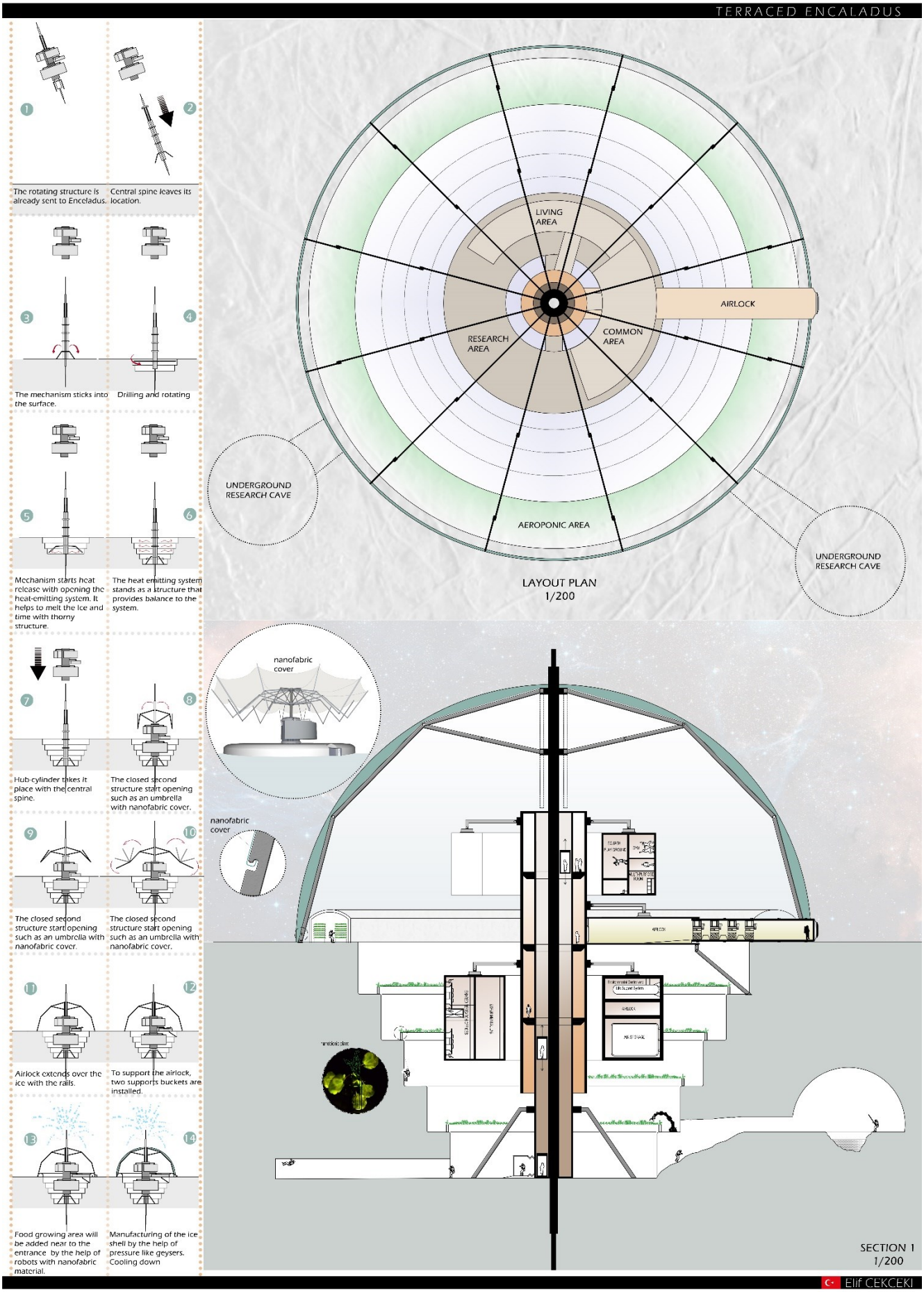


Fig. 4. Student work from Architectural studio 'ON THE EDGE'/Terraced Enceladus (Author: Elif Cekceki, 2018; Source: Němcová Zedníčková)

These and other themes or driving forces are puzzle pieces that, in various ratios, offer many different scenarios that humanity may embark on in the future. Resources and technologies are crucial to the human organism's survival in space, but quality of life, environment, and culture will define who a person becomes in this extreme environment. The extensive analyses required to process these topics reveals a wide range of information which an architect rarely encounters in common practice. They are serious enough to lead those who have gone through such a design process to be more sensitive to the environment in which we live, design, and build, and to respect for the environment in general. The intention is for the work on space architecture off grid projects to enrich not only the creation of visions of terrestrial ideal cities, but also real assignments. 'ON THE EDGE' studio work is focused on efforts to apply space innovations to terrestrial settlements, in the interest of their ecology or environmental friendliness, self-sufficiency, energy efficiency, social balance, etc.

Given the theme of settlement self-sufficiency, the benefit is the transfer of knowledge from space projects, where long-term self-sufficiency, sustainability, and total recycling are the foremost topic. This need not be just expensive high-tech sophisticated solutions that can be used by modern cities. On the contrary, simple DIY low-tech solutions accessible to all social classes can have a huge impact on, for example, improving the life quality of the one billion people who live in slum-like conditions. However, it also works in the opposite direction: designing the principles of self-sufficient communities in terrestrial conditions, independent of the external supply system, is in its way useful for space projects. The simplicity of the system limits the number of possibilities for critical failure. Visionary projects can be also beneficial on a purely theoretical level. With their visions, individual generations essentially create a list of attributes that the time and culture consider important for quality of life. In retrospect, we can separate the excesses of a time from the deeper qualities that pass through time and cultures. Today, it is clear that current visions must be not only ecological, and environmentally friendly, but should also actively contribute to repairing the damage that humanity has managed to do to the planet in pursuit of increasing profits. The above-mentioned considerations and assumptions led to the author's work on the creation of two moon bases.

'If we do not know to which port we are sailing, no wind will be favourable to us.'

Seneca

MOONFLOWER BASE // 2090

Experimental agricultural base with the hotel for scientific tourism (2015 - 2016)

2090: a time when Earth and Lunar space elevators have already been built; with a space station accommodating factory complexes in Earth orbit serving as a spaceport; with mining expeditions to asteroids; and the like. At this point Moon colonization will have entered the stage when it is possible to go beyond the simple and confined modules of the pioneering research, service, and mining bases. The reason is that these modules were not able to comply to long-term residence because of their minimized space, both in terms of the human psyche and as they provided only limited physical space, which could not sufficiently serve the increasing number of activities needed to ensure the Moon's independent sustainable development. The base was built for the purpose of developing self-contained life support systems. Its main activity is testing and innovating various ways to produce food within isolated systems, an artificial atmosphere, and low gravity to confirm the feasibility of ensuring a healthy and balanced diet in closed systems of perfect recycling, for multigenerational colonizing flights to distant solar systems. MOONFLOWER Base was for psychological reasons designed with special intention to the internal 'landscape'. This microcosm and its architectural elements provide symbolic pieces of terrestrial scenery. They represent such archetypes as a small village around a tribal tree, a valley surrounded by terraced mountain fields, a meadow encircled by a river, and a cave.

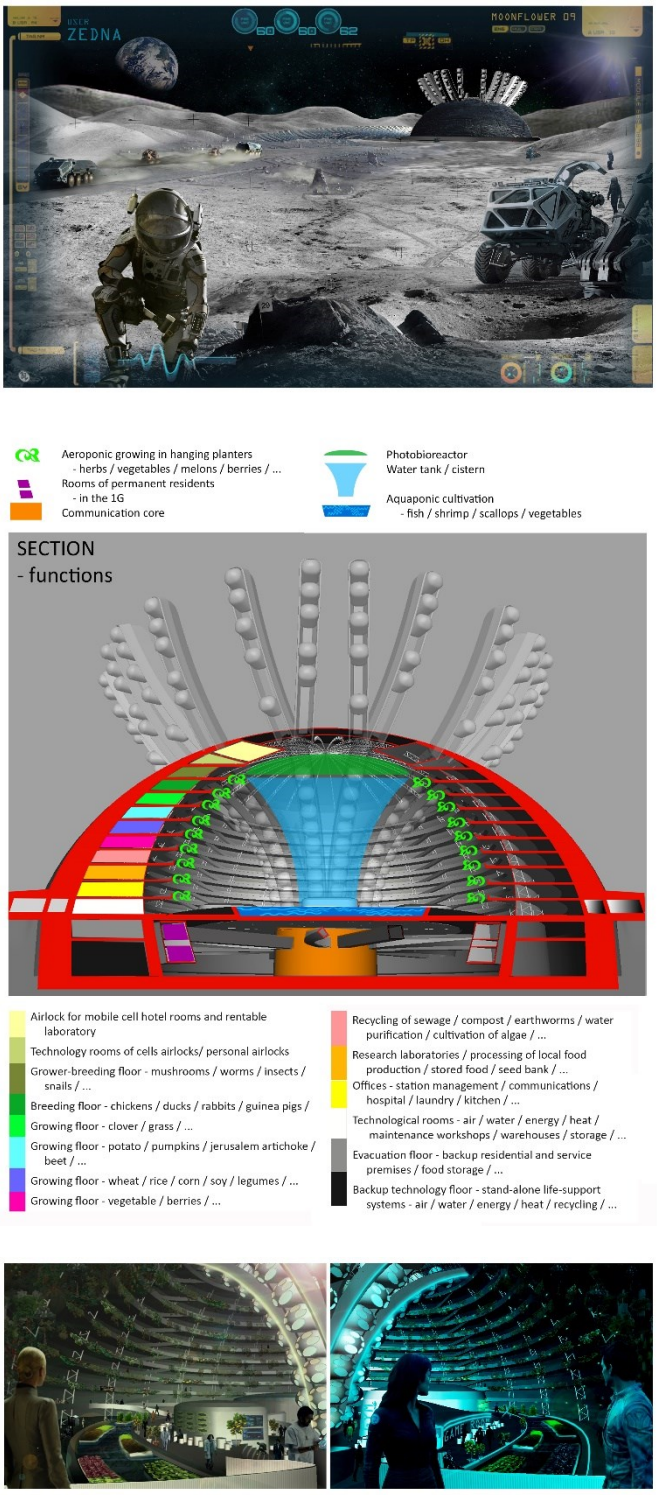


Fig. 5-7. Experimental Agricultural Base with Hotel for Scientific Tourism /MOONFLOWER BASE/2090 (Author: Zdeňka Němcová Zedníčková, 2016)

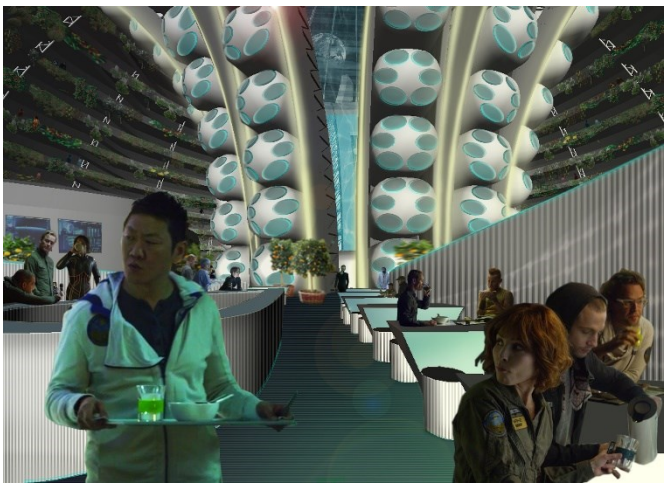


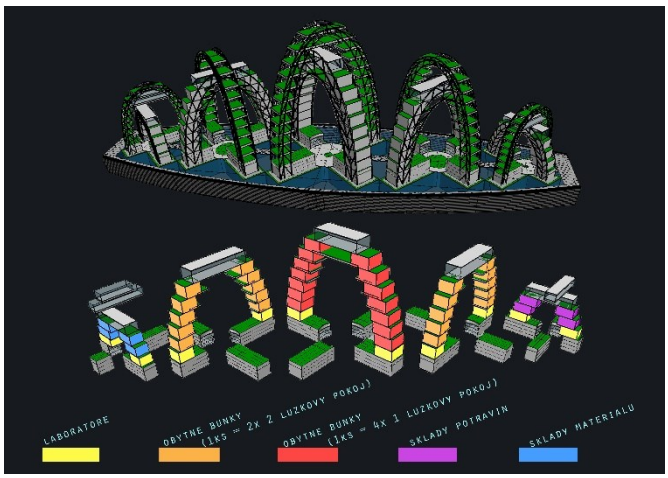
Fig. 8. Experimental Agricultural Base with Hotel for Scientific Tourism /MOONFLOWER BASE/2090 (Author: Zdeňka Němcová Zedníčková, 2016)

MOONWORM – NOMADIC MOON BASE

Self-sufficient exploratory scientific kinetic base traveling in Mare Imbrium (2017 - 2019)

Travelers who traversed the Earth's deserts headed from oasis to oasis, in order to replenish life-giving fluids and gain strength for journeying further. MOONWORM Base is an oasis in the wasteland of the lunar sea, but it travels together with travellers. MOONWORM is an exploratory science station that uses for its movement only the temperature difference during the moon's day and moon night, which makes it shrink at night and stretch during the day. The station forms a long-term self-sufficient micro ecosystem that simulates a cyclically dynamic nature-like environment. The base is like a living organism, with individual plants, animals, and humans in symbiosis. It is a large greenhouse, an oasis, a garden, and a landscape; it provides views from the tops of hills as well walks around the lake. The shrinking of the station, announcing the arrival of the lunar night, causes a 'change of the weather' in the interior: a dramatic moment accompanied by waves and wind. These natural or elemental manifestations are a sign of season's change: the end of 'summer' and the beginning of 'winter' or vice versa. The cyclical alternation of seasons gives life at the station the rhythm that normally accompanies our lives on Earth. There are symbolic references to the Earth's landscape.

Fig. 9. Self-Sufficient Exploratory Scientific Kinetic Base Travelling in Mare Imbrium /MOONWORM - Nomadic Moon Base (Author: Zdeňka Němcová Zedníčková, 2016)



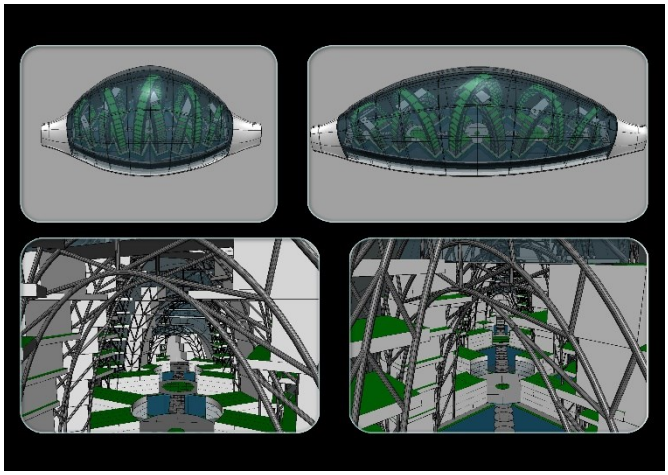


Fig. 10, 11. Self-Sufficient Exploratory Scientific Kinetic Base Travelling in Mare Imbrium /MOONWORM - Nomadic Moon Base (Author: Zdeňka Němcová Zedníčková, 2016)

Acknowledgements

The article was elaborated in the framework of an international mobility research and study stay at the Slovak University of Technology in Bratislava, Slovakia. It is based on the author's dissertation 'Architect in Media Network' (2012) and habilitation work 'Architecture and Futurology' (2020).

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