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# An interdisciplinary approach to lifecycle management of university campus facilities

This article is a continuation of the series of publications devoted to the program creation of university campuses, which are one of the main drivers of scientific and technological development and training of highly qualified personnel today.
In the previous publications in this area, the author investigated the possibilities of using “Educational and technological conditions” as a new type of engineering parameters-measurers of the material and spatial environment, “Educational and technological task” as a new type of document that is part of the design task or part of the contract for the provision of services for the management or technical operation of capital construction of campuses, “Combinatorial matrix” as an institute for the development of university campuses within the framework of the program for the development of university campuses.
In this article, the author has identified and analyzed some features of defining the life cycle of capital construction objects of university campuses and their life cycle management. The author assessed the degree of influence of these features on different stages of the life cycle, depending simultaneously on the goals of national projects in the field of personnel training, and simultaneously on the material and technical base of educational organizations of higher education. The increasing emphasis of this direction is determined by the great challenges facing the Russian economy at the moment in the field of technological development. Science and technology get a new role as fundamental elements in solving many national and global problems. The article also reveals some approaches to the organization of educational environment, changing in the conditions of transition from post-industrial to information economy.
***Keywords:*** *Life cycle, life cycle management, university campuses, material-spatial environment, socio-economic effects, analytical indicators, interdisciplinary approach*

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## INTRODUCTION

In recent years, the world is actively developing the activity on life cycle management of capital construction objects of various functional purposes. Its basis is formed by the goals of the owner of objects, and these goals are not constant, but on the contrary, can change dramatically during the existence of the object. The goals may have different orientations, ways of achievement, required costs and degrees of influence of the object, its characteristics and properties. Managing the life cycle of real estate objects is an important and urgent task, because real estate plays a key role in the economy and society [1]. Buildings, structures, infrastructure with different parameters and characteristics, exist for a long time and go through different stages of the life cycle also differently. It is obvious that each stage of the life cycle of the object, especially if it is a multi or even multifunctional object, will correspond to characteristic goals and objectives. In general, all stages can be considered as a process of object development aimed at improving its efficiency and consumer appeal within the framework of change management.

## FEATURES OF THE LIFE CYCLE OF UNIVERSITY CAMPUS FACILITIES

A specialized, safe, efficient, and comfortable physical and spatial environment plays a major role in the life of university campuses. All these features aim to maximize the outcome of owning and managing campus facilities throughout their life cycle. For example, according to[1], the life cycle of a capital construction object is the period of the object's existence, during which engineering surveys, design, construction, technical re-equipment, reconstruction of linear objects, reconstruction of capital construction objects, major repairs of capital construction objects, major repairs of linear objects, and liquidation of the object are carried out. But this definition does not allow to reveal the variety of goals, objectives, development prospects facing the university at the pre-project stage, at the stage of preparation of design solutions, during construction and especially during the period of functioning. After all, here will necessarily be present the formation of plans for the development of the territory, ideas on the gradual increase in the number of graduates, vision of the development of research tasks to be solved, options for ways to manage the real estate complex and much more.

In systems engineering (GOST R 57193–2016[2]) there is a more precise definition of the life cycle as the development of an object system from the origin of an idea to its realization[2]. And within the framework of the system approach to technology, we can emphasize the principles that form the basis of the life cycle:

1. Within the life of the object, its development, change, including the change of investment priority is carried out.

2. At each stage of the life cycle of the construction object the corresponding engineering life support

1 GOST R 58179–2018. Engineering in construction. Terms and definitions. dated 16.07.2018.

2 GOST R 57193–2016. Systems and software engineering. System life cycle processes.

systems should be realized. Only with this approach it will be possible to realize the desired result.

3. Manufacturability, usability and maintainability, as well as waste utilization should be envisaged and practically implemented at specific stages of the life cycle.

4. Transition to the next stage of the life cycle of the construction object is necessary only when all the goals of the current stage are achieved [2].

The key concept in this case is the material-spatial environment of an educational organization. This is a set of material objects of the educational environment in a limited space, providing necessary and sufficient conditions for the realization of one or more functions provided by the educational technology in this space [3]. In the functional sense, the university campus is essentially a single material-spatial environment. It is united with the city, with industry, with local business.

In turn, the term "educational environment" is currently also undergoing changes. If initially the educational environment was supposed to be a favorable or well-appointed, providing external and internal conditions for achieving the goals of the educational process, now it is defined as a set of opportunities for personal development arising from its interaction with its social and spatial-subject environment[3]. In addition, there is a technologization of the concept due to the introduction of modern technologies of learning and development, due to the fact that all subjects of educational activity and external partners interact in the conditions of informatization, as well as other effective organizational and technological mechanisms and tools for this interaction. Thus, we see the educational environment of the university as a complexly organized system, depending on a variety of factors, a significant part of which is material and spatial in nature.

In the conditions of generation of new development goals, the value of educational space as a social system becomes more important [4]. The need for such changes logically follows from the processes that occur in society and economy. The fourth industrial revolution requires the acquisition by specialists of competencies corresponding to the demands of the digital economy [5].

According to the report "University campuses and the city: cooperation for the sake of competitiveness"[3], a campus is a set of objects that perform educational, research and innovation, as well as service functions, infrastructural issues of university development, models of interaction between universities and territories of presence. Therefore, let us note once again that the concept of "campus" correlates with the concept of "material-spatial environment".

The elements of the material-spatial environment, which includes the educational process, are the building itself, its premises, structures and design of premises, engineering systems and equipment providing internal microclimate, low-current networks, functional, educational and technological equipment. Accordingly, the material and spatial environment is formed on the basis of the campus as a "object" defined in time and space, and includes subjects (all participants of the educational and scientific process), partners (from the region, business), infrastructure, environment (social and material-spatial) and all the tools and mechanisms of interaction. At the same time, it is not an established system even for the time being, as its transformations are associated with the constant search and implementation in practice of new technologies and methods of organization of educational and research processes. Thus, speaking about the life cycle of university campus objects, we talk about the life cycle of a multifunctional, dynamic material-spatial environment.

## NEW INSTITUTIONAL ENVIRONMENT AS A LIFE CYCLE MANAGEMENT GOAL

Today, higher education organizations are moving towards Education 3.0 and include innovative activities in their agenda (University 3.0). The list of educational technologies that are used in the learning process is noticeably expanding. Many of them have already been described in previous publications. But it is necessary to note the technologies that require the device of special spaces. These are virtual educational laboratories, inverted learning, hybrid formats, collaborative centers, spaces for teamwork, demonstration areas for industrial development of the results of research, development and technological works, laboratories with the possibility of live broadcasting of experiments, AR, VR-labs, additive laboratories, robotized laboratories, etc.

Unfortunately, the existing outdated infrastructure and facilities of many universities do not meet modern requirements, and sometimes are not suitable at all. Meanwhile, in the conditions of implementation of the campus program, or simply reconstruction or overhaul of buildings of other educational organizations, there is an opportunity to provide in advance and justify the necessary parameters for the creation of a modern material and spatial environment.

For example, a specialized material-spatial environment with a practical orientation of educational and scientific processes provides the opportunity to: create and work in appropriate scientific laboratories to test technological hypotheses; expand the network of departments; create collaborative centers, collaborative spaces, digital departments, and advanced engineering schools in simulated, multifunctional spaces; make digital content and live streaming of experiments available to the public; and provide accessibility of digital content and live streaming of experiments to the public.

The effective functioning of the subjects of technological development described above requires a qualitatively new institutional environment, which will include:

- institutions to support their own lines of technology development, including collective use centers for research and development infrastructure, testing and trials;
- contractual forms of integration of research and development and production and technological activities, realization of public-private partnerships;
- digital platforms and information services to ensure networking of subjects of technological development.

If the Concept[4] defines key educational organizations of higher education and research centers as the driver of technological development of the Russian Federation, then, taking into account the demand for a new institutional environment, it is more accurate to call the concept of modern university campuses as the driver of technological development[5].

3 University campuses and the city: cooperation for the sake of competitiveness, August 2021. VEB RF University. Center for Strategic Research. URL: https://www.csr.ru/upload/iblock/3f0/kbpm276p3tau6knlzdla3d6ozz0fve0e.pdf (rus.).

4 Concept of Technological Development for the period until 2030. Approved by the Order of the Government of the Russian Federation dated May 20, 2023. No. 1315-r. URL: tatic.government.ru/media/files/KlJ6A00A1K5 t8Aw93NfRG6P8OlbBp18F.pdf (rus.).

5 Standard of Innovative Educational Environment (Campuses) (approved by the Ministry of Science and Higher Education of the Russian Federation on May 8, 2024). URL: https://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=EXP&n=854557#MN2KbeUroCluLXnY (rus).

Based on the definition of innovation projects[4], the campus can be conditionally equated to an innovation project in general, and in particular — to the environment for creating innovations necessary for scientific and technological development of the country. Since on the basis of the campus it is possible to create a kind of innovation and technology centers aimed at increasing the investment attractiveness of research and development, commercialization of their results, as well as expanding the access of citizens and legal entities to participate in promising scientific and scientific-technical projects.

The following tasks set before the participants of the campus program by the Ministry of Education and Science in the conditions of digitalization of the economy can be highlighted:

- using high technologies (listed in the White Paper) in the educational process: artificial intelligence, VR/AR, blockchain, etc.;
- training of personnel for high-tech industries;
- providing conditions for conducting research and development in priority areas of scientific and technological development of the Russian Federation, the list of critical technologies of the Russian Federation, and other areas of research and development;
- ensuring the implementation of activities within the framework of national and federal projects;
- ensuring conditions for the implementation of indicators of target models of educational organizations;
- ensuring conditions for personnel training in accordance with the goals of the regional socio-economic development strategy and the needs of strategic projects;
- ensuring the possibility of implementing educational programs using practical training together with industry leaders or industrial partners, network educational programs;
- providing opportunities to create RID and high-tech products;
- creating conditions and providing opportunities for testing new technologies and creating university startup projects;
- providing comfortable living and learning conditions;
- ensuring the creation of innovative products, technologies, patents on the basis of the research infrastructure of the campus;
- providing the possibility of creating (placing) on the territory of structural subdivisions of educational organizations together with external partners[5].

The stakeholders of the campus program are also: city, region, concessionaires, industries and business — all of them should eventually find themselves embedded in a new institutional environment that will contribute to solving the problems of technological development.

## SOCIO-ECONOMIC EFFECTS AND ANALYTICAL INDICATORS AS CRITERIA FOR ASSESSING THE EFFECTIVENESS OF LIFE CYCLE MANAGEMENT

According to Annex No. 1 of the Order of the Ministry of Education and Science of Russia No. 293-Z of 26.07.2023[6] the participants of the campus program should provide a number of socio-economic effects and analytical indicators of national, regional and institutional levels, which are used to assess the effectiveness of the material and spatial environment and management mechanisms of the created campuses. It is necessary to mention here the significant role of the created conditions for cooperation, additional jobs, etc., as well as the criteria of the top-performing campuses.

It is also worth mentioning the criteria of the top 500 global rankings of universities, correlated with the effects that are declared for analysis and control:

- reputation of the institution in the academic environment;
- reputation among employers;
- employment;
- sustainability. This indicator reflects how much attention universities pay attention to the problems of environment and diversity[7].

As part of the study, four categories were identified to systematize and evaluate the criteria:

1. Collaboration — the possibility to organize joint projects with partner organizations on campus. Important conditions for the implementation of this cooperation are the provision of material and spatial environment in terms of appropriate spaces and equipment, where it is possible to organize students' project activities, implement commissioned scientific research, etc. (including rent). (including rent).

2. Jobs — the ability to employ junior scientific and teaching staff in laboratories and other campus units, to conduct retraining programs on “order” from the city or region, and to provide new jobs in some way related to the functioning of the campus in the city or region. An important prerequisite is the reasonable enlargement or modification of spaces for research and development and retraining programs to expand the functions of the campus.

3. Practice-oriented — an opportunity to update some curricula taking into account current technologies and directions of scientific and technological research, to provide orders for research and development of scientific units of the campus under the condition of close cooperation with partner organizations. An important condition is a well-designed material and spatial environment with the necessary equipped spaces for the implementation of programs and research.

4. Prestige — the opportunity to attract students, graduate students and staff to study or work on campus. An important condition is again a comfortable, modern material-spatial environment that provides the necessary conditions for studying, living and working.

From the whole list of relevant socio-economic effects and analytical indicators of national, regional and institutional levels, the following were selected and systematized into four categories (Table). The table also summarizes some proposed ways to achieve the selected effects and indicators.

As it follows from the table, more significant effects and their greater number can be achieved through the creation and management of modern material-spatial environments. But we need to be clear that these are not just new premises, but elements of multifunctional and high-tech environments. This is even more difficult to achieve against the background of the fact that the share of the total area of the commissioned per year total area of teaching and laboratory buildings of educational organizations of higher education, increased more than fourfold over the past three years, and the effective teaching space per student is steadily decreasing [6]. And this trend is inherent in state, municipal and private organizations.

6 On approval of the list of socio-economic effects and analytical indicators of the national, regional and institutional levels and methods for calculating socio-economic effects (analytical indicators) for assessing campuses of the federal project “Creation of a network of modern campuses” : Order of the Ministry of Education and Science of Russia dated July 26, 2023. No. 293-r.

7 Top 500 World Universities By Nation, 2023. URL: tats/stats_unitopnbr_2023.htm (rus.).

*Systematization of socio-economic effects and analytical indicators of the Campus Program by category*

| Cooperation | Workplaces | Practice-orientedness | Prestige |
|---|---|---|---|
| Properly designed material and spatial environment provides conditions for the realization of joint projects with partners | Through new laboratories and projects with partners, there is an opportunity to increase the number of jobs | Partnership projects provide an increase in the number of practical tasks | Attractive MPS and improve campus reputation by ensuring the previous 3 criteria are met |
| No. 2. Change in the volume of expenditures of campus resident organizations on research and development | No. 3. Change in the number of full-time equivalent researchers | No. 9. Change in the number of employed in high-tech and knowledge-intensive industries | No. 6. Presence in the top 500 global university rankings |
| No. 3. Change in the number of full-time equivalent researchers | No. 10. Change in the number of outgoing population in the entity in which the campus is located | No. 28. Change in the number of structural units providing practical training for students established with partners | No. 10. Change in the number of outgoing population in the entity in which the campus is located |
| No. 5. Change in the number of patent and invention applications from campus residents | No. 25. Change in the number of postgraduate students and young scientists | No. 42. Change in the number of students systematically engaged in scientific and research activities | No. 27. Change in the number of students in the youth tourism program |
| No. 6. Presence in the top 500 global university rankings | No. 42. Change in the number of students systematically engaged in scientific and research activities | No. 44. Change in the number of students who completed final qualification work in the form of startup projects | No. 28. Change in the number of structural units providing practical training for students established with partners |
| No. 13. Change in the share of products of high-tech and knowledge-intensive industries | No. 43. Change in the share of scientific and pedagogical employees under 39 years of age | – | No. 43. Change in the share of scientific and pedagogical employees under 39 years of age |
| No. 28. Change in the number of structural units providing practical training for students established with partners | No. 9. Change in the number of employed in high-tech and knowledge-intensive industries | – | – |
| No. 20. Extrabudgetary funding | – | – | – |
| No. 25. Change in the number of postgraduate students and young scientists | – | – | – |

## AN INTERDISCIPLINARY APPROACH TO CAMPUS LIFECYCLE MANAGEMENT

Solutions to the problems described above are certainly found in a variety of areas, ranging from pedagogy to research funding.

Let us focus on analyzing the impact of the physical and spatial environment on campus program participants and suggest ways to competently and reasonably create and manage it in the context of higher education system development. This requires an interdisciplinary approach: we need to combine knowledge in economics, ergonomics, design, construction, pedagogy, psychology, and operations.

Modern universities are the driver of technological development, but on the way of their development there are various limitations and problems, which can be conditionally divided by the elements of the educational environment: “subjective”, “partnership”, “infrastructural”. Let us consider how the management of the material-spatial environment can contribute to overcoming these limitations.

Overcoming subjective limitations — a well-designed environment covers the needs of students in a comfortable university environment for study and life; it provides conditions for innovation and entrepreneurial activity, conducting relevant research and building a model of technological processes within the university, imitating real production; due to this, there is a probability of new jobs for yesterday's graduates, who will be interested in continuing their scientific activities and work on the campus.

Overcoming partnership limitations — a well-designed environment will allow launching joint projects on campus, which promotes the transition to the concept of University 3.0, in which the university is engaged in innovative activities in addition to education and science [7].

Overcoming infrastructural constraints - the environment is designed to solve all the infrastructural problems of the campus; the availability of convenient and relevant infrastructure, as well as inclusion in the urban and regional environment is a necessary condition for the sustainable development of the campus and the realization of the stated goals on its site[3].

In conclusion, we would like to offer the author's interpretation of the concept “Life cycle of university campus facilities” — it is “the period during which the interrelated development of campus facilities is carried out, integrating its various states, stable in time, for effective and safe functioning, starting from the moment of the need for them and ending with the full completion of work with them”.

## CONCLUSIONS

Modern higher education organizations must meet the current realities of the life style and the system in which modern specialists work, including those employed in high-tech industries and engaged in the development of critical and end-to-end technologies. And this happens only when holistic education includes training, projects, comfortable life and competence development.

How can the management of the material and spatial environment of campuses approach the solution of the tasks of scientific and technological development? A one-syllable answer to this question is as follows: thanks to it, adaptability and sustainability

are ensured, i.e. there is a clear understanding of which elements of the material-spatial environment are necessary for specific educational or research purposes today, which elements can be replaced, removed or appear later.

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## Междисциплинарный подход к управлению жизненным циклом объектов университетских кампусов

Данная статья является продолжением серии публикаций, посвященных программному созданию университетских кампусов, которые являются одним из основных драйверов научно-технологического развития и подготовки высококвалифицированных кадров на сегодняшний день.

В предыдущих публикациях по данному направлению автор исследовал возможности применения в рамках программы развития университетских кампусов «Образовательно-технологических условий» как нового типа инженерных параметров-измерителей материально-пространственной среды, «Образовательно-технологического задания» как нового типа документа, являющегося частью задания на проектирование или частью договора на оказание услуг по управлению или технической эксплуатации объектов капитального строительства кампусов, «Комбинаторной матрицы» как инструмента работы с различными видами требований, а также алгоритмы интеграции «Образовательно-технологического задания» с информационными моделями объектов кампусов.

В настоящей статье автор выявил и проанализировал некоторые особенности определения жизненного цикла объектов капитального строительства университетских кампусов и управления их жизненным циклом. Оценил степень влияния этих особенностей на разные этапы жизненного цикла, зависящих одновременно и от целей национальных проектов в области подготовки кадров, и одновременно от материально-технической базы образовательных организаций высшего образования. Возрастающий акцент данного направления определяется стоящими в настоящий момент перед российской экономикой большими вызовами в области технологического развития. Наука и технологии получают новую роль как основополагающие элементы решения многих национальных и глобальных проблем. В статье также раскрыты отдельные подходы к организации образовательной среды, меняющиеся в условиях перехода от постиндустриальной к информационной экономике.

***Ключевые слова:*** *жизненный цикл, управление жизненным циклом, университетские кампусы, материально-пространственная среда, социально-экономические эффекты, аналитические показатели, междисциплинарный подход*

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