The Concept of BENIP – Built Environment Information Platform

Balázs Horváth, János Szép, and Attila Borsos

Abstract—**The built environment and its components require a continuous and uninterrupted flow of information between its various players. In this paper a conceptual framework is proposed describing the role of these players as well as the nature of the links between them. The authors introduce a new term, a conceptual framework which can be used as a platform called BENIP (Built ENvironment Information Platform).**

Index Terms—**BENIP; built environment; informaton platform**

I. Introduction

In the past half century there has been a great deal of discussion about the position of individual and teamwork and their role in science [1]; in relation to this it has been repeatedly argued that the era of lonely experts is over [2], [3], [4], [5], [6], [7], [8]. On the other hand, there is an increasing share of interdisciplinary topics spanning over several specialties accelerating the progress of research activities [9]. Furthermore, according to Barabási [10], based on the currently valid network models, our world is small enough for people to connect with each other employing a relatively limited number of steps. This concept was originally laid out by Karinthy saying that "any two people can be connected in a maximum of six steps" [11]. This was later scientifically phrased by Milgram [12] and proven by Guare [13] who also introduced the idea of six degrees of separation. Based on this thought, our world is indeed small and can be considered highly connected, not to mention how much data is gathered in the world every day [14].

Based on the above it seems logical that the information gathered in relation to the built environment should not be handled separately but could be shared for the benefit of all sectors. The built environment is a complex system surrounding us, human beings. There is always some sort of cooperation between its various fields and recently infocommunication has made these communication channels even more effective. A good example is Varga [26], who deals with traffic analysis using infocommunication techniques, or Nagy et.al. [27] who combine traffic-flow principles with a method from the field of infocommunication. These examples also made it clear, why it is important to handle problems in a holistic way.

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In this paper we introduce a new term called Built ENvironment Information Platform (BENIP). This concept aims to reveal the links in between the various domains of our built environment.

II. Definition of BENIP

Built Environment Information Platform (BENIP) is the concept of smart and system-oriented city planning and development spanning over the domains of architecture, civil, and transportation engineering integrated with the concept of Digital Realities such as virtual reality (including augmented reality, virtual and digital simulations and twins), artificial intelligence and 2D digital platforms thereby creating a highly contextual information platform.

BENIP shows the theoretical and practical aspects of the connected and chained world of engineering in the field of the built environment from the smaller entities of architecture (buildings) through the civil engineering domain (complex structures) to the expansive systems of transportation.

In the long term, BENIP would strive to be the main hub for scientists in fields of the built environment who interact with the interdisciplinary connections between architecture, civil engineering, and transportation. Specifically, as they relate to the generation, exchange and exploitation of data. Therefore, BENIP becomes an interdisciplinary meeting point for scientists and engineers of the built environment. Their general objective would be to foster the cooperation and information flow between the many engineering fields of the built environment.

III. Research fields of BENIP

The research fields of BENIP can be divided into two parts, the standard areas of built environment, and the Internet of Digital Reality (IoD). The concept of Digital Reality as a trademarked term refers to "technologies and capabilities that inhere in AR, VR, MR, 360° video, and the immersive experience, enabling simulation of reality in various ways" [20].

"Internet of Digital Reality (IoD) is a set of technologies that enables digital realities to be managed, transmitted and harmonized in networked environments (both public and private), focusing on a higher level of user accessibility, immersiveness and experience with the help of virtual reality and artificial intelligence. Connections among various cognitive entities also have to be handled not only at the end user level of virtual reality displays and software, but also at the levels of network protocols and network management, physical media (wired or wireless), hardware interfaces, and other equipment. AI is a key component of both digital reality and IoD, that enables a cohesion of context-driven content and intelligent network routing to emerge." [20]

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A simplistic definition by [15] says that the built environment is covered by the domains of outdoor spaces and buildings; transportation; and housing. According to [16] the built environment is more like a scale nature topic introduced at meso, micro, and macro scales. The built environment starts as a material or component form and grows into buildings, areas, cities, and finally a man-made environment of earth. [17] offers a broader view according to which the built environment 1) is everything humanly made, arranged, or maintained; 2) fulfills human purposes (needs, wants, and values); 3) mediates the overall environment; 4) produces results that affect the environmental context. [17] categorizes it into seven scales: products, interiors, structures, landscapes, cities, regions, and earth. In their study [18] the built environment scales are grouped into "Material", "Building", "Area", and "City". "Material" comprises all types of material and components while "Building" includes all types of structures, residential, non-residential, and infrastructure. "Area" represents the industrial parks and non-industrial areas that are smaller than cities but larger than facilities, and finally "City" includes both cities and large regions (see Fig. 1).

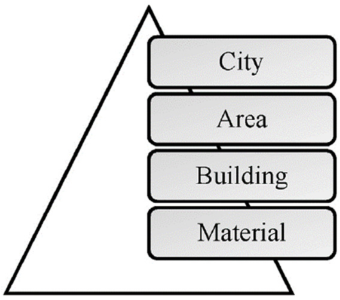

Fig. 1. Built environment scales [18]

[19] conceptualizes the built environment as a social-ecological system paying attention to two issues, the impact of spatial relationships and concepts of time. In their framework (see Fig. 2) where the natural and social overlap is in the built environment, which encompasses the fast changing, short-term processes – like design and management systems – within the constraints imposed by the features of long-lived buildings and infrastructure systems and the underlying land use patterns. Essentially the time rings for built environments provide a more systemic and graduated perspective on how time is valued (norms) and how elements of the built environment and ecosphere interact and influence each other. In Fig. 2. for built environments, the material and cultural realms are combined, with the fast pace of the social processes (design, assessment, contracting, management) balanced by the longer-term influences of buildings and landscapes.

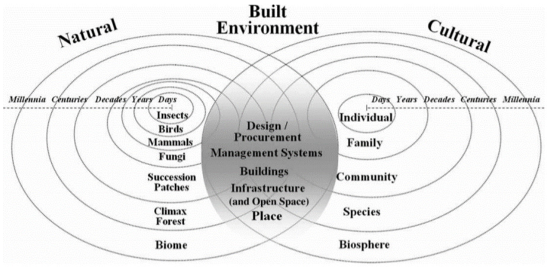

Fig. 2. Built environment as a social-ecological system [19]

Research fields of BENIP are also related to the Internet of digital reality (IoD) [20, 21]. Based on the definition of Baranyi et al. [20] IoD is a set of technologies allowing Digital Realities (DR) to be connected in networked environments, allowing a higher degree of user accessibility and experience. Here, the Digital Reality is an integration of virtual reality (including augmented reality, virtual and digital simulations, and twins), 2D digital environment (including all software and web applications, collaborative and cloud-based solutions) and artificial intelligence. This means, that a DR can combine physical, virtual and digital entities into a highly contextual reality. We can transform this idea into the world of BENIP as follows.

The different disciplines can be treated as separate Digital Realities, where each party is working on their own Virtual Twin (VT). This means a planned object has a 3D visualization in a different, usually computer-generated reality. This representation has different characteristics according to the disciplines: the focus, the scale and the level of detail vary along the architecture, civil engineering, and transport sciences. This Virtual Twin can be used for simulations to analyze various effects and compare alternative solutions. Here, the Virtual Simulation (VS) presents the 3D motion and changes in the geometrical 3D representation of the object, while the Digital Simulation (DS) demonstrates a temporal process, where the 3D representation is not in primary focus, according to [20]. For instance, in architecture and civil engineering the BIM method allows examining the deformations of the structure (VS), while also a life-cycle analysis can be made using the information content of the model (DS). The introduction of Digital Simulation into Virtual Twins means an extension of the existing model with the user interaction, which turns it into a Digital Twin (DT). This was a logical outgrowth of complex, but static simulations performing interference checks in industrial environments. These virtual and digital simulations and twins are components that can be integrated into a virtual or augmented reality. In architecture, the planned building (Virtual Twin) can be visualized in its real environment using augmented reality, just as the planned infrastructural object in transport sciences. With the help of different simulations, the interaction between the planned object and its environment may also be examined.

The Digital Reality of the disciplines serves as a medium (environment) of communication between the involved parties and uses various digital tools in an organized and specific, topic-oriented way. In relation to the BIM method, the concept of

Common Data Environment and its digital, internet-based solutions serve as the key element of the communication and collaboration along numerous participants.

It becomes Internet of Digital Reality, when these Digital Realities are connected via public or private networks in order to create a higher-level functional integration [20]. IoD bridges the gap between the disciplines and allows interoperability in a broader range. Here, the planned objects can be inserted into other Digital Realities, which enables more complex understanding of the interaction between the different disciplines. The combination of the architectural, civil and transport engineering realities connects the different scales: products, interiors, structures, landscapes, cities, regions, and earth. With the help of digital solutions (virtual and augmented reality), the smaller elements (products, buildings) can be visualized in a larger scale (city, region), as in the case of integrating BIM and GIS models and data. Furthermore, the virtual and digital simulations enable various analysis between these elements resulting in a dynamic relationship. At a city scale, the effect of a newly designed infrastructural or architectural element can be examined on the transport network and vice versa. When collaboration on 3D objects between several realities will become common in VR environments, it will also require the integration of big data and artificial intelligence [20]. As a result, it will be possible to filter and organize the entire information content to increase the efficiency of processes.

IV. Flow Of Information Between Research Areas

Based on what is drafted in the introduction, the continuously increasing amount of information as well as the connection between the specific disciplines it can be stated that Every coordinated and sustainable design for the built environment requires a timely and comprehensive transfer of data between multiple sources. This is nicely illustrated by Wanga et.al [22] in Fig. 3, where the flow of information links between various domains and strengths of connections are visible, where by the flow of information we mean knowledge transfer.

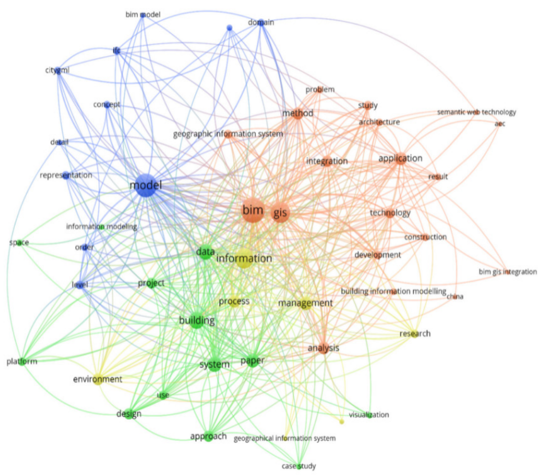

Fig. 3. Word co-occurrence network [22]

This figure clearly summarizes what we experience every day in our connected world. However, it masks the reasons and benefits hiding behind these numerous links. BENIP gives a meaning to these links.

If we focus closely on the built environment and its three associated disciplines, we can conclude that it describes the cooperation between architecture, civil engineering, and transport sciences. These three disciplines can be figured out as three set of knowledges, where all three are having specialized but also joint parts, like shown in Figure 4.

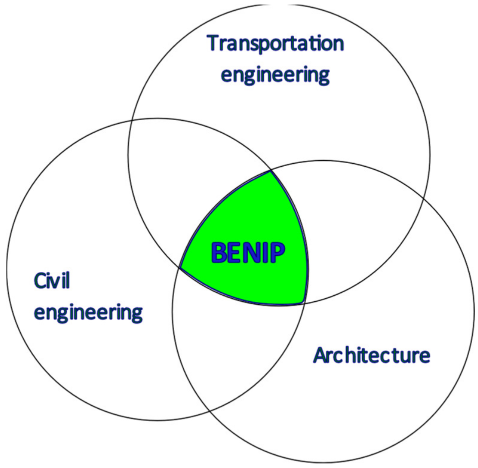

Fig. 4. Three major disciplines of the built environment

Based on our experiences this draft approach could be detailed with players and connections (relationships) as it is illustrated by Figure 5.

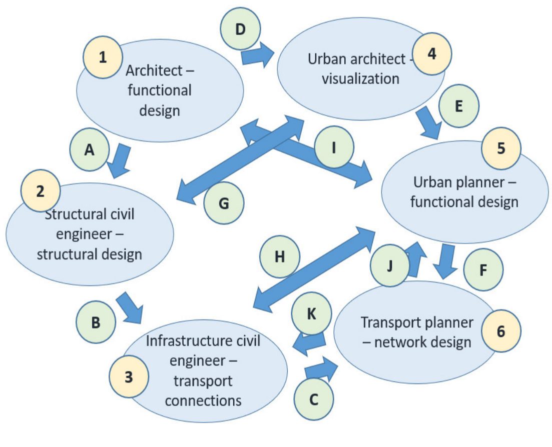

Fig. 5. Core of the BENIP logic

The various players and their relationship are described in detail in the following two sections.

V. BENIP Players

As figure 5 shows in the BENIP circle there are at least six groups of players. While the players may be ordered differently in different applications, all players are equally important. There is order from the viewpoint of the explanation, e.g. do we understand the story bottom up or top down? This discussion will show it bottom up, so we start from the small details and finish with the full picture, therefore the architect is the first player to be described.

1) Architect

The architect is the master in the creation of the building; the designer who provides building spaces with function. As a result of their work the function and the form of the building are created. Furthermore, he defines the position and orientation of the building according to the natural and built environmental factors as well as the aspects of the sustainable operation

2) Structural Civil Engineer

The structural civil engineer provides the building envisioned by the architect with a frame. As a result the structure of the building is created, which eventually influences its look and its general impression.

3) Infrastructure Civil Engineer

The infrastructure civil engineer provides the individual buildings with transport connections, they are responsible for designing the network around the buildings, thus extending individual buildings into the general built environment.

4) Urban Architect

This player formulates the atmosphere and the harmony of buildings, or as we might also call it, the city visualization. Furthermore, he does not only create a visualization but a living space as well.

5) Urban Planner

This player launches the functional relations in the city, defines the location and importance of individual social, economic, and practical functions. This is the player who induces life in between spots in the urban fabric. As a result, the functional areal units of cities are born.

6) Transport Planner

They are responsible for planning, regulation and operation of movement in the urban network by envisage of the provision for more or less space for transport. As a result of their work the network connecting the functions of individual buildings can become sustainable and environmentally friendly, if the regulatory frames enables sustainable transport solutions like walking, biking or using public transport as real competitors of private car usage.

VI. BENIP Relationships

Under this section the relationship between the above players is explained. These links can be either one- or two-directional, however, even opposing-competing links can exist.

A. The architect delivers the building features based on a **functional design** to the structural civil engineer. The form and function created by the architect has a great effect on the applicable structural types and materials.
B. The **physical location** of the buildings envisioned by the structural engineer will be the information based on which the infrastructure civil engineers work.
C. **Characteristics of the infrastructure** will provide the framework for the infrastructure civil engineer.
D. The **building design plan** based on the functional design provides a basis for the urban architect and vice versa. Since the building should be adapted into its surroundings, the city architecture may cause limitations or requirements to the architect in designing the form and façades, especially in case when cultural heritage has a presence in the area.
E. The **city visualization and atmosphere** made by the urban architect influences the urban planner's functional design to a great extent. The natural and built environment, and the entire landscape has a significant impact on the usage of urban spaces, which should be considered in the functional design process as well.
F. The **functional layout** created by the urban planner serves as a basis for the transport planner's work. It defines several requirements for the type of the applicable transportation systems and for their capacity.
G. The **city visualization and atmosphere** made by the urban architect will react to the structural design of buildings and vice versa: the applied structural type and material has a great effect on the visualization of the building, and therefore it influences the atmosphere of the entire landscape,, thus a mutual understanding is needed here.
H. The **functional layout** created by the urban planner as well as the **characteristics of infrastructure** mutually influence each other requiring a close cooperation. The urban planner defines the demands and needs of the infrastructure civil engineer, while the existing systems and environmental conditions have a significant effect on the range of applicable technical solutions.
I. **Characteristics and location of the functional areal units** stem from the **individual functions** created by the architect. The starting point for the architect is the functional areal unit. It affects the use of the urban spaces, therefore it influences the building orientation,

the position of the entrances and the connections between the different functions.

J. The transport planner connects the functional areal units by their use, thus **transport connections** react on the operation of functional clusters.

K. The transport planner is responsible for flow regulation and decide if the **requirements against transport connections** exceed their capabilities making them unable to ensure an appropriate connection, therefore the existing network system determines the possible solutions for the newly designed transport connections. If the existing capacities are not sufficient, the BENIP logic allows to go back to connection E or F to redesign the structure which will generate the transport demand.

Overall, the six players and the eleven links between them provide the basis for the appropriate flow of information in relation to the built environment. This, however, demands a common language that requires a uniform and standard description of information. This is not always self-evident or simple as described by Horváth et al. through a transport related example. This case revealed how complex and difficult it is to harmonize the methods of various disciplines. A well-known example is also BIM (Building Information Model), which is nowadays an accepted communication platform in the fields of architecture and structural design.

What the authors propose with BENIP is not a further expansion of BIM with the description of settlements and transport systems, but a new and complex language which can include the content of BIM, GIS as well as other data.

VII. Conclusions

In our connected world the cooperation of different disciplines and specialties is essential. The data driven society needs more and more information. These phenomena lead to the situation that even specialists need a more and better-connected environment. The answer for this challenge is the newly formed term: BENIP - Built ENvironment Information Platform. It provides a conceptual framework that handles all the relevant information of the built environment from BIM to GIS in one single system. CogInfoCom unifying both engineering and human-oriented perspectives can give more room to reach progress in developing this platform further. [23, 24]

On the other hand, we have to remark, that this conceptual framework is viable and sustainable if 1. the regulatory framework editors and decisionmakers are feeling the responsibility and necessity of conceptual and system-based approaches like BENIP and 2. the specialist using the benefits of system-based and data-driven planning and operation of built environmental systems, especially in urban environment.

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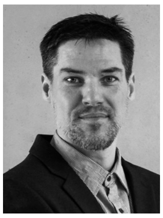

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