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Preface of the publisher

22. Journal for Facility Management: Science meets Practice

At our congress in November last year Andrej Grieb told us that the COVID-19 pandemic will not go away but become common to us. This spring the next challenge arose: The Ukrainian War, not far from us, changing our perspectives on the future of Europe, economic development and relations, energy supply and resilience totally. All these developments change the demand of the users and the requirements of the company to be successful also in the future. The traditional office is old fashioned, working from home and hybrid offices seem to be the future. Activity-based offices are booming to engage the employees, to increase the binding to the company and win the war for talents. This asks FM to concentrate on the “final” product “the workplace” to perfectly support the human being to be productive and engaged. That a workplace is clean, safe and has the optimal climate conditions are deficiency needs according to Maslow’s motivation model. But FM must leave the boiler room and go for the growth needs that are covered by the proper workplace design.

Of course, also basic problems have to be focused on. Energy was cheap the last years. Facility Managers in some cases just had to sit and wait and their costs dropped because energy cost was decreasing. Now prices are skyrocketing and ESG asks for actions. FM is looking for investment in technology e.g. for monitoring and optimisation, but beside the increased prices for the devices the delivery time is now several months. If FM now orders ESG monitoring devices, they might get the products as a Christmas present. But they need the data from the 1st of January to fulfil the reporting demand. So, we see a lot of challenges but also possibilities showing up and a lot of new management tasks that FM has to undertake.

This issue of Journal für Facility Management provides you with solutions to optimise district planning to boost up your work environment and insight how to get the basic data by optimised use of BIM:

- A Collaborative Research on Hybrid Work and 15-Minute Cities
- On the Applicability of Open Standard Exchange Formats for Demand-Oriented Facility Management (FM) Service Delivery
- Barriers for Efficient Facility Management: Perspectives of BIM-users and non-BIM-users

The goal of the first paper is to identify healthier lifestyles and sustainable facilities that support residents from the economic, social, and environmental impact. The initiative focuses both on promoting hybrid work developed as a relationship between organizational workspaces, living spaces, and neighborhood co-working spaces, and the sustainable mobility solutions from the concept of '15-minute city'.

Data is a decisive success criterion for efficient provision of services in Facility Management (FM). The second paper presents a possibility for integrating dynamic data into BIM-based, open data exchange formats. For this purpose, the data and IT systems relevant to FM are analyzed and the open data exchange format IFC is evaluated concerning the integration of dynamic FM data. Based on this, approaches for the integration and use of dynamic data in IFC are developed.

The third paper amplifies the previous findings on the current BIM awareness and utilization within the FM industry in Turkey. This study analyses the problem areas of the FM profession from the perspectives of BIM-user and non-BIM-user facility managers and identifies the usage areas of BIM in FM. Even though BIM enables the involvement of FM teams for introducing operational requirements in the early phases, the absence of up-to-date facility information seems to be the major problem area for BIM-enabled FM practices.

At this point, I want to thank all international researchers who sent us numerous abstracts and papers for the double-blind review. The decline rate was kept high with more than 50%. This high-quality research enabled us to increase the quality of the IFM journal over the last years. I also want to thank the members of the editorial and the scientific board for their terrific work. They supported me in reviewing first the abstracts and then the full papers and gave a lot of input to the authors.

The high decline rate, the high reputed members of the editorial and the scientific board and the supporting universities ensure that the articles are not only having a high scientifically quality, but also that practitioners can put them into practice easily.

I also want to thank my team, especially Barbara Gurdet, Antonia Heil, Christian Lau and Lisa Thrainer. Without their personal engagement, the journal would not be available in this high quality.

I wish you all the best from Vienna, an enjoyable read, a lot of input for your research and/or for your daily work. I look forward to new striking research in the next IFM Journal and a refreshing exchange at the15th IFM Congress from 17^{th} to 18^{th} of November 2022.

Yours,

Alexander Redlein

Head of Editorial Board

To my family Barbara, Caroline Sidonie und Alexander David

Scientific Committee

Herausgeber / Editorial Board

Organisation

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Vielen Dank an alle KollegInnen des IFM für die Mithilfe bei der Organisation!

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Science meets Practice I:

Workplace Management and District Planning

UrbanLink15’
A Collaborative Research on Hybrid Work and 15-Minute Cities

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Abstract

The goal of UrbanLink15’s research was to identify healthier lifestyles and sustainable facilities that support residents from the economic, social, and environmental impact. The initiative focuses both on promoting hybrid work developed as a relationship between organizational workspaces, living spaces, and neighbourhood co-working spaces, and the (re)connection with the sustainable mobility solutions of the concept of ‘15-minute city’. The article presents the research results (a survey, two focus groups and solutions of the application projects) achieved with the support of researchers, practitioners, and students from different specialties such as architecture, engineering, management, applied science organized in two main topics: (1) workplace relationships, living spaces within the framework of “15-minute city”; (2) alternative mobility through green-blue corridors and gardens. The research refers to the metropolitan area of Timisoara, Romania. In the last part of the article, good practices are included, as the Seestadt aspern projects; this will serve as an example based on the data analysis from a local mobility behavior study (Mobilitätspanel Seestadt aspern, realized within the framework of the aspern.mobil LAB) and will underline the existing relations between the workplaces and the living spaces, looking at changes imposed by the home-office sanitary regulations due to the pandemic situation.

Keywords: Hybrid Work, 15-Minute City, Green Wetlands, Alternative Mobility, Community Project, COVID-19 pandemic

1. Introduction

The SARS-CoV-2 pandemic has accelerated the megatrends manifesting in the labour market and, especially, the increase of shared workspaces (or working from anywhere) and the digitization solutions to support remote work. Hybrid work, both at home or in other places, including the spaces of employer organizations or collaborative ones, will remain an important working way, due to the positive implications, from economic and ecological perspectives, but also due to the better balance created between personal life and professional life. Working and learning remotely has become more widely accepted during the pandemic and it probably will be accepted in the post-pandemic era (defining the new normal way of living) (Nieuwenhuijsen, 2020). Therefore, the high cost of living in many cities around the world (e.g., related to housing, utilities, facilities) has pushed people to move in the suburbs, exurbs, or in other metropolitan areas altogether (Florida et al., 2020). During this period, flexible working conditions and the availability of more affordable housing outside the city were shown to be preferred for balancing the working and social conditions of life; population to living areas placed approximately '15 minutes' from the city center becomes more and more obvious; the concept has become of great interest not only for the residents of urban areas' habitants but for other stakeholders as public communities, transport companies, real estate companies, architecture companies, designers, etc.

On the other hand, climate change and ecological imbalances are still the main challenge of the 21st century, and here modern approaches of social, urban organization have a and will have major responsibility. In the nearest past, practical approaches based on planning paradigms (e.g., "car-friendly city" (Crawford, 2000) have created the field for new urban models, most frequently used are the "city of short distances" (Feldtkeller, 2008), the "compact city", the "walkable city" or the "Cities for People" initiatives and solutions (Crawford, 2000). The models are based on the intensive use of green mobility and the growth of green areas, wetlands that has recently been recently accelerated due to the pandemic context of work and living; an emergent implemented is "15 minutes cities" (as supported by the research of Selzer and Lanzendorf, 2019). It has been recognized that 'in a number of cities, novel planning concepts are being introduced that go some way to address urban planning issues: compact city, superblocks, 15-minute city, the car-free city, or a combination of these' (Sietsma et al., 2021). Thus, accordingly, optimizing and improving car traffic had been the core idea of urban transport planning for decades, but today environmental aspects have increasingly been considered and concepts for 'traffic calming' (Newman and Kenworthy, 2014), 'pedestrian zones' (Selzer and Lanzendorf, 2019) or "car-free inner cities' (eg Oslo (Rydningen et al., 2017)), as well as car-free or car-reduced neighborhood design have completed approaches to more sustainable metropolitan area. Furthermore, the actual context of the digital transformation era has imposed the extended use of smart technologies and intelligent devices, all of which are associated with the "smart mobility" (Selzer and Lanzendorf, 2019).

In this context, the article presents the UrbanLink15' research which aims to define healthier lifestyles and sustainable facilities that support them, considering economic, social, and environmental impact of human activities. The focus of UrbanLink15' research (developed in the context of a public-private initiative in Timisoara city, Romania) is on the relationship between organizational workspaces, living spaces and local coworking spaces that meet the need for professional relationships, outdoor activities, natural ways of green wetlands ways, and the need for community improvement. The structure of the article consists of the following chapters: (1) the presentation of the UrbanLink15 approach, the research methodology and the achieved results; (2) a debate on some good practices in the field that could inspire future measures to be implemented in the city of Timisoara, Romania.

2. Methodology

2.1. Description of the UrbanLink15' initiative and project contest

UrbanLink15' initiative (as presented on the ErgoWork Society website, https://urbanlink15.wordpress.com/2021/02/08/competitia-urban-link-timisoara-15/) has been designed to discover innovative ways, ideas for post-pandemic hybrid work and to implement the '15-minute cities' concept in the metropolitan area of Timisoara, Romania. The target group envisaged by the project consist of students from different specializations and years of study, from universities located in Timisoara (they are familiar with the city life and living and could express pertinent, feasible solutions to the actual problems). The UrbanLink15' initiative consists of several stages for knowledge capitalization, tutoring, documentation, etc. before the participants submit their final projects, as briefly described in Figure 1.

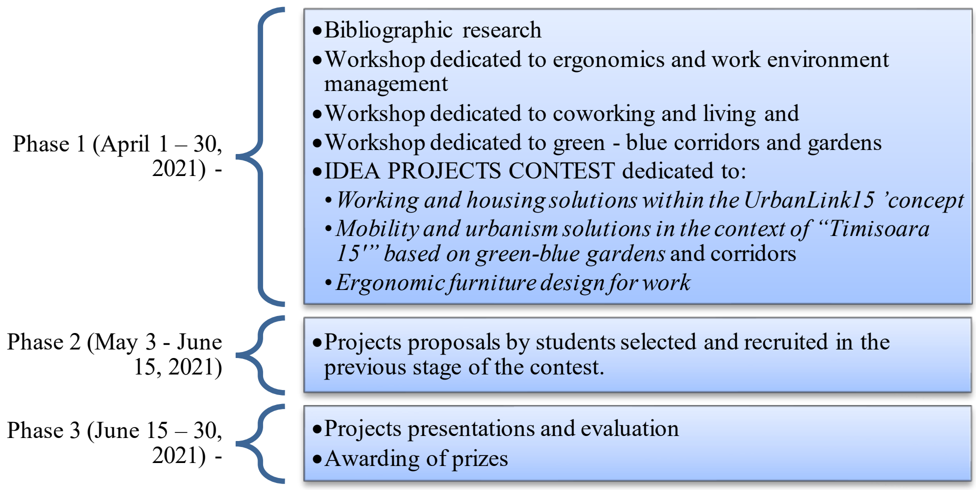

Fig. 1: Schematic description of the UrbanLink15' initiative

2.2. Methods and tools used in the UrbanLink15' research

The first stage of UrbanLink15's research has been developed using two methods: (1) an online survey based on a designed questionnaire and (2) application of the focus group technique (2 sessions of 1-hour duration and participants were asked to act and react under the time pressure). The questionnaire was used to capitalize on opinions on factors that influence individual well-being of respondents in general and how the pandemic changed this perception, particularly. There were anonymous respondents participating in the research, the respondents consisting mainly of students from different universities of Timisoara, Romania. The survey has been developed online (https://forms.gle/V8V1Vey9eHeAMq4AA) asking students to distribute the questionnaire to other colleagues and friends (snowball techniques for collecting responses from a randomly created sample). The focus group technique was applied for two groups of eight participants each. Each session has two topics of debate:

(1) Appling '5 Whys' analysis for two debate items: 'Why we should work?' and 'Why we should not work?';
(2) Participants were asked to express their opinions on the best way they work, how they live and spend extraprofessional activities (social tasks to be accomplished, how leisure and relaxation time are consumed) with maximum satisfaction.

The purpose of applying both methods of research was to create a correlation between the perception of well-being of the personnel and the need for new sustainable ways to work and live according to the emergent adaptation to climate changes and urbanization (facing the growing population of the urban area of Timisoara, Romania). Thus, the proposed approach defines qualitative research; the results are not available at the level of the entire city population, but it is a first pilot study exploring the proposed correlation. Furthermore, it is necessary to consider two aspects of the presented research: (a) the sample consists of participants with a predominant behaviour in work performance behaviour, which are students belonging to the Z Generation; (b) "The social desirability bias" is mostly associated with the answer about task orientation and personal development/way of life than were provided by the answer regarding individuals 'orientated towards relaxation behaviour'.

3. UrbanLink15' research results and debates

1. Results of the online survey

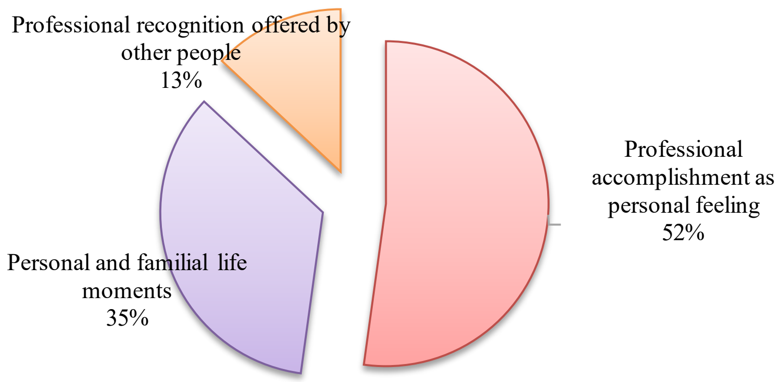

Fig. 2: UrbanLink15' research results showing the 'happiest moment from personal life'.

The present research is considered a pilot one (due to the small sample of 23 respondents) and will be extended in the nearest future, because the methodology is considered well defined and pretested. The first question is open and descriptive one about 'one of the happiest moments of my life was when '... (Figure 2). Most of the answers were about professional situations and a few about personal lives. The second question asks respondents about their perception on "the situations that make them feel well' (Table 1).

#	**Situation that makes it well (survey research results)**	**Hierarchy**
1.	To be with my friends and with people who make me feel comfortable	1
2.	To be appreciated by the people that are around me	2
3.	To have good results in what I am doing and to be very well compensated this	3
4.	To work in a good quality environment, well equipped from a technical and technological point of view	4

5.	To work alongside other people who share the same values and principles	5
6.	To be able to travel and meet new people and see new places, without any limitations	6
7.	To have adequate living conditions and be able to perform my hobbies with my friends, without worries about tomorrow	7
8.	To be able to afford long walks and various activities outdoors, in nature	8
9.	Other situations	9
10.	To be able to contribute to the improvement of living conditions for the people who are suffering and, in general, to have a positive impact on the humanity	10
11.	To have the necessary living conditions and to do only do as I wish, without having too much interaction with other people	11
12.	To be able to meditate and practice a spiritual life, without any material concerns and with a minimal invasive impact on other people and the Earth in general	12
13.	To be able to contribute to the preservation of biodiversity and to the sustainable management of the Earth's resources	13

Tab. 1: The hierarchy of the situations that make the respondents feel well.

As seen in Table 1, the first two situations are related to social needs (belonging and recognition) followed by three statements related to professional accomplishment. Situations related with wellbeing, not related with others, or connected with the need to have positive contribution on the community and the planet generally, are in lower positions of the presented hierarchy.

A question to test the interest of the respondents in ‘meaning of life’ and ‘meaning of work’, as components of personal perception, feeling was referring to the Japanese Ikigai concept (□ □ □ □, ‘a reason for being’) (Lassiter, 2017); Ikigai is represented as a Venn diagram (as a conceptual model) with four overlapping qualities (Lassiter, 2017): ‘What do you love?”; “What are you good at?”; “What does the world need from you?”; “What can you get paid for?’ In this case, the survey results underlined that only 26% of the respondents knew about the Ikigai concept and they were able to develop definitions, in their own words, that correctly reflect the concept. Furthermore, a question in the designed questionnaire was ‘What do you miss the most during the pandemic?’ Most of the responses (15 of 23) were about social life – direct interaction. Other important responses were about lack of physical activities, such as university and cultural interactions, participation in restaurants and club events and other physical spaces (most related to the lifestyle of students).

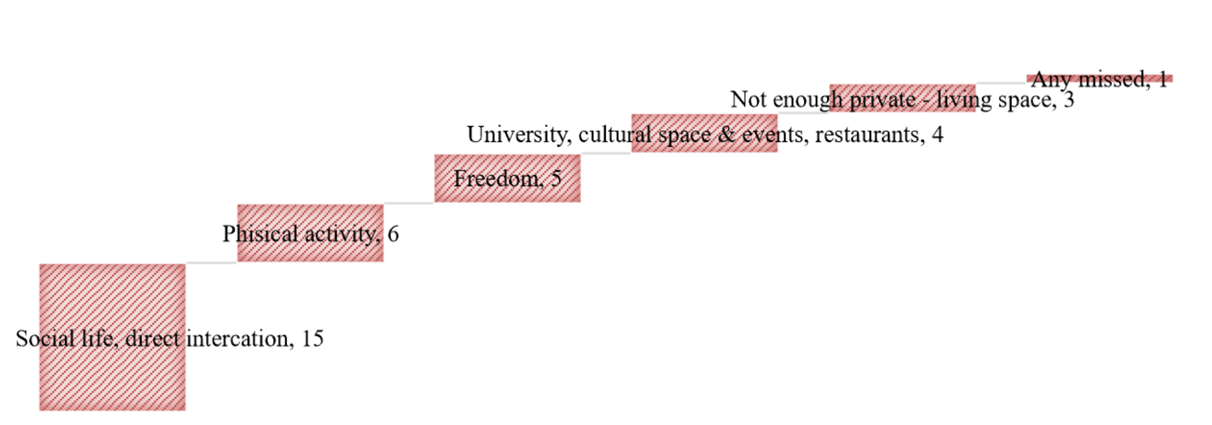

Fig. 3: UrbanLink15' research showing the distribution of responses about the missing aspects of life during the pandemic crisis.

The last question of the survey was about 'pandemic lessons learned" and most of the answers were associated with the idea of enjoying, re-evaluating and appreciate every moment of real-life interaction, friendship limits, and human kindness and patience.

2. Results of the Focus Group

The first answers related to the reasons to 'do the work' were dominant in money or financial support for living and all respondents declared that they want to have (achieve) a certain standard of living. Following the topics of debate on 'Artificial Intelligence (AI) and robotics development and application in the future', the participants in the focus group have discovered that the workforce demand will be reduced and probably guaranteed minimum income (GMI) will be a common solution applied by governance. Therefore, the maximum interests are how motivation to "do the work' goes beyond the first level of reasons.

Motivation factors for "doing the work" (answers)	Levels of why (motivation)
For money	1
To have a life standard	2
To follow your passion	3
For human and environment contribution	3
For a useful feeling	4

A way to express yourself to the others	4
Personal growth and self-esteem	5

Tab. 2: Focus group results – The hierarchy of reasons why to "do the work".

As seen in Table 2, the results of the survey show that there are all categories expressed by the respondents, including issues that are not related to money and cover basic needs mentioned. Furthermore, in Table 3 is presented the hierarchy of the reasons associated with the attitude of 'not working' that are not related to money and cover basic needs, mentioned during the UrbanLink15' focus group.

Motivation factors for "not working" (answers)	Levels of why
Not get out from the own comfort zone	1
Not deviate from following the own passion	2
Not affect the own freedom of choice	3

Tab. 3: Focus group results – The hierarchy of reasons for "not working".

Although the basic idea of the initiative was '15-minute cities', the bibliographic research and the content of the ideas of the youth projects revealed many cases in which personal choice was assimilated with a 'dream of the way of life and work', but designed according to classic patterns based on the house in the city, movement and free time spent in nature, a job in the city and ensuring mobility between different areas of activity by car. On the other hand, the winning projects and research results showed that young people believe in the choice (dream) of living in a model of life, work, and mobility based on the '15-minute concept', adopting a hybrid work style, encouraging, and supporting the development of urban communities, alternative mobility through green-blue corridors.

4. Good practice

1. Aspern Seestadt show case and living LAB

A good example of a sustainable pilot project that can be developed in the spirit of a '15-minute city' is Aspern Seestadt from Vienna (https://www.aspern-seestadt.at/en), one of Europe's largest urban development projects. In Vienna's fast-growing 22nd district in the north-east part of the city, a new urban centre is taking shape: a smart city with a heart, designed to accommodate the whole spectrum of life. Through a multiphase project development (til 2028), high quality housing will be built 'for more than 20,000 people and, eventually, an equal number of workplaces'. Built on a foundation of innovative concepts and forward-looking ideas, this city-in-a-city combines high quality of life with economic drive. Diverse, open, and planned for the future, with excellent transport links, aspern Seestadt is a business hub of international dimension and a living environment with a high feel-good factor, a perfect combination of urban flair and laid-back pace.

Aspern Seestadt is both a showcase project and a 'living laboratory' for cutting-edge technologies, considered an ideal environment in which to study the future of urban energy supply. ASCR Aspern Smart City Research is entirely dedicated to this field of study. The consortium of Siemens, Vienna's infrastructure and utilities operators Wien Energie and Wiener Netze, Vienna Business Agency, and Wien 3420 AG co-founded the venture in 2013 with the aim of demonstrating how the cities of the future can function in a climate-friendly manner.

Building on international experience, ASCR Aspern Smart City Research is not limited to individual aspects but looks at the system as a whole: data on buildings, the electricity grid, information and communications technology, and user behaviour all feed into one overarching energy research programme. A key element of the living concept is the Seestadt aspern neighbourhood management team, which helps new residents settle in and find their feet, facilitate the development of a lively community, provide information on the latest developments in and around Seestadt, and support initiatives for active involvement in the neighbourhood.

2. Alternative mobility through green wetlands

Urbanization involves increasing amounts of impervious surfaces, which conflicts with the need for green areas (Johansson et al., 2020). Built areas and green spaces are integrated within cities, but the need for blue and green infrastructure is increasing. Such infrastructure might be used to improve water infiltration or reduce the heat island effect and air pollution. Green corridors in the urban environment have recreational opportunities for citizens and significantly contribute to the conservation of biodiversity conservation and improve the quality of groundwater. They can also help mobility. Citizens, especially the active population, can benefit from the advantages offered by such infrastructure during their daily commute, when exercising or walking.

A) Aspern Seestadt Mobility Concept

Since planning began in the early 2000s, the Seestadt mobility concept has been based on a city-friendly mix of mobility that conserves resources and contributes to a high quality of life.

Six central building blocks are intended to enable residents and workers to move in a sustainable manner in and around Seestadt; high-level public transport right from the start, a city of short distances, the restriction of individual motorized transport, alternative mobility offers, the involvement of residents inside as well as pilot and research projects.

The innovative mobility concept is based on the principles and values of sustainable development. The aim is to create a mobility mix that conserves resources and contributes to a superlative quality of life. The target is that 40% of trips to Seestadt will be made by public transport, 40% by bike or on foot, and only 20% by car, moped, or motorbike. These are possible because Seestadt is a city of short distances. Furthermore, the local shopping concept Aspern shopping is designed to ensure just that; residents and visitors can easily do all your shopping on foot or by bike, and for those occasions when your purchases are heavier than usual, the Seestadt Flotte bike fleet has electric cargo bikes for hire. The principles behind aspern mobil are reflected by the following ideas: get from A to B as quickly and energy-efficiently as possible while providing ample space to linger and enjoy life. That is why we attach such great importance to the design of our public spaces. Seestadt is full of attractive pedestrian zones with plenty of space for strolling and wide cycle paths. All this is possible because most of the parking is off-street, in communal underground garages, which leaves lots of room above ground for cyclists and pedestrians.

B) Mobility data from Mobilitätspanel Seestadt Aspern

The Pern mobility survey has been carried out in the built quarters of Seestadt since 2019. Residents use smartphones to record their routes and provide insight into everyday life. The paths of the randomly selected participants are recorded by an application: the ‘path collector’. In addition, participants fill out questionnaires about themselves and their household. The mobility data of 142 people were collected and 114 personal questionnaires plus 67 household questionnaires were filled out. Respondents were able to record their journeys for 7 days (on average, they recorded their journeys for 4 days). The mobility survey and the post-processing of outliers has not finally completed; future results may differ from those shown. The partial results are represented in a mobility simulation made as a video show (https://vimeo.com/457721212). The Seestadt ern are out and about throughout the city and beyond over the course of a day. Above all, the interrelationships within the district are also easy to read, including, for example, routes to destinations such as the Stadlau business park or the Danube Center as work and shopping locations. This network that spans the city and especially the district can also be seen well in the video simulation.

5. Conclusions and final remarks

As discussed in the present article, UrbanLink15' is a feasible approach to capitalize on innovative solutions for the city of Timisoara. Applying a coherent research scenario (one survey, two focus groups and the proposed projects review and selection by experts), there have been capitalized opinions from the young habitants (belonging to Z Generation) about how they would like to work and live in the city and neighbourhood areas. Finally, we conclude that the research objective was achieved on a small scale and few innovative ideas were identified for healthier lifestyles and sustainable facilities that support residents from the economic, social, and environmental impact; All participants in the UrbanLink15' initiative have profited from the interactive discussions on hybrid work developed as a relationship between organizational workspaces, living spaces, and neighbourhood coworking spaces, and the (re)connection with the sustainable mobility solutions of the concept of '15 minute city'.

From the perspective of the UrbanLink15 research results cumulated with formal discussions with different groups of participants, the following conclusions and recommendations have been provided:

- Hybrid work will be preferred even by students of the Z Generation students because they need to balance the professional life with the social life dimension (like the findings of Errante (2021)). The ideas of the projects of working and housing solutions within the UrbanLink15 concept and the ergonomic furniture design for the ideas of the work projects ideas (capitalized at the moment of writing this article) have provided interesting solutions, easily adapted to the lifestyle and working style in Timisoara;
- In the field of mobility and urbanism solutions in the context of 'Timisoara 15' based on corridors and green-blue gardens, the strong need for sports facilities in the suburb of Timisoara city, pedestrian and bicycle riding roads to allow proper social distancing and to improve active transportation; maintaining public green spaces and corridors near residences will allow residents to exercise and maintain a healthy lifestyle (as presented and supported also by Selzer and Lanzendorf (2019)). Furthermore, the students have been more 'aggressive' in proposing concrete solutions for green-blue gardens (more extended near the Bega River and the sanitation channels of the swampy area in the local area), water gardens in the campus area and which they can continue, in the long-term support of LAB living. The findings of the presented research are similar to those presented by (Cortes, 2021; Banerjee and Rai, 2020; Alraouf, 2021; Chan, 2021);

- In the same context, another solution that emerged from the UrbanLink15' research was the expansion of outdoor sidewalks / walkways and parklands near businesses, restaurants, and shopping areas on the boulevards to allow businesses (especially restaurants) to use these spaces for dedensified business activities, simultaneously with the increase in outdoor air quality;
- Private developers (companies in the area) should also be encouraged to implement design elements that prioritize indoor air quality and outdoor private space to make multi-unit housing both safer and more competitive with detached, single-family housing. This may be particularly crucial in the immediate post-pandemic period when anxieties about contracting the virus, coupled with greater workplace flexibility, may drive a new era of de-densification; a potential anti-new urbanism. The consequences of this demographic shift could be severe and long-lasting; future research should investigate the magnitude and consequences of such changes.
- Additional design recommendations and guidance from researchers and academic specialists should be provided to local stakeholders, including those from the metropolitan area of the city, for planning, promoting, funding, constructing, and maintaining public green spaces and corridors to allow people to perform sport activities and maintain a healthy and happy lifestyle. In general, designing municipal strategic plans for resilience will need to be based on strong stakeholders' management accompanying by mitigation strategies, resource allocation, information provision, and coherent intergovernmental cooperation not only at the city level but also in the West Region of Romania (a good practice has been provided by Maes et al. (2019)).

Finally, the good-practice solution demonstrated by the aspern Seestadt from Vienna (Austria) should be analysed in deep to find which solutions could be adapt and implemented in the local conditions of Timisoara (Romania). Collaboration of the universities in Timisoara, with colleagues from the Technical University of Vienna, could provide the context for the development of new projects development with the purpose of awareness of sustainable development awareness in the case of the new Z Generation (future inhabitants of the cities); These can be supported with the participation of the institutions of the mayors of both cities' mayors' institutions (possible solutions were provided by Herman and Rodgers (2020) and Berg (2020)). In addition, as Bereitschaft and Scheller (2020) suggested, there should be analyse other similar projects and initiatives from other cities in Europe that manage to better manage urban design, planning and development with respect to sustainable development values and principles should be analysed.

Acknowledgments

Finally, the authors would like to thank all the colleagues, collaborators, partners and participants involved in the UrbanLink15 projects for their anonymous responses to the questionnaire, for all valuable inputs, comments and contributions.

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Science meets Practice II:

Use of BIM

On the Applicability of Open Standard Exchange Formats for Demand-Oriented Facility Management (FM) Service Delivery in the Context of the Cross-Lifecycle Building Information Modeling (BIM) Method

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Abstract

Data is a decisive success criterion for efficient provision of services in Facility Management (FM). Therefore, various IT systems are used to process static and dynamic data. The Building Information Modeling (BIM) method offers a possibility to optimize the cross-lifecycle data exchange between these IT systems through open data formats, such as the IFC format. Currently, BIM is mainly used to map static data, while dynamic data for FM is rarely mapped. In particular, the integration of dynamic data, such as runtime and monitoring data generated by sensor technologies, for results-oriented FM service provision is still insufficient within the framework of the BIM and the associated data formats.

This paper will present a possibility for integrating dynamic data into BIM-based, open data exchange formats. For this purpose, the data and IT systems relevant to FM are analyzed and the open data exchange format IFC is evaluated concerning the integration of dynamic FM data. Based on this, approaches for the integration and use of dynamic data in IFC are developed.

Keywords: Building Information Modeling (BIM), Facility Management (FM), neutral data exchange formats, cross-lifecycle process consideration

1. Introduction

Data represents a key success criterion for Facility Management (FM) provision of service (Otto & Bartels 2018). FM uses various data to perform and maintain multidisciplinary activities of all building life cycle phases as part of its integrated processes. A distinction must be made between dynamic and static data processed in different software systems and tools (May 2018). Especially in the maintenance phase, dynamic data are crucial to fulfilling building performance contractually defined by Service Level Agreements (SLA) between service providers and clients (Hirschner et al. 2018). In recent years, there has been a trend towards outcome-based and activity-based contracts. By this, data-based Key Performance Indicators (KPIs) and monitoring of building performance gain in importance.

Dynamic data can be generated by sensor technologies, IoT technologies, or IT systems. Hereafter, the sources of dynamic data are referred to as sensor technologies. The integration of sensor technologies in FM offers new opportunities for assembling, exchanging, and using data required to provide FM services, such as predictive maintenance and repairs (Lu et al. 2020, Edirisinghe & Woo 2021). Using dynamic data generated by sensor technologies for building maintenance represents the most commonly used approach applying sensor technologies for FM, but focuses on building systems and energy management (Atta and Talamo 2020, Edirisinghe & Woo 2021). Due to date, fewer synergies exist between sensor-based and FM-based IT systems, but sensor data is processed in proprietary systems. That means that hardware components (e.g. sensors or building automation systems) could only be maintained using the vendor's software. Due to many software systems and tools, missing interoperability leads to a loss of static and dynamic data (Teicholz 2013, Behaneck 2018). To counteract data loss, using Building Information Modeling (BIM) enables a possibility to exchange data interoperable, open, and lifecycle-spanning (Teicholz 2013, May 2018, Bartels 2020).

An essential factor in applying the BIM method is the use of open data exchange formats. However, BIM-based data exchange formats mainly focus on transferring static data to FM (Atkin & Brooks 2015). While recent research endeavors have identified the advantages of using BIM in FM, there is a clear need to examine scopes of exchanging dynamic data through different life cycle phase. Therefore, it is the purpose of this article to investigate if an extension of the international and neutral data exchange format IFC is suitable for mapping dynamic data. A solution approach for the integration of sensor data in IFC will be presented and analyzed.

2. State of research

The main task of FM is the support of primary processes while providing services around facilities, e.g., real estate for the production of specific goods (Kaiser et al. 2018, GEFMA 2004). The primary basis for FM processes is contracting, which classically distinguishes between performance-based and results-based commissioning and service provision (Kummert et al. 2013, Schawel & Billing 2012, Kaiser et al. 2018). Using sensor technologies in FM offers potential for building performance optimization, particularly in the case of results-oriented service provision (Nävy 2018, Gerrits & Pilling 2021). In addition, IT systems in FM are crucial for efficient and successful service provision. By this, dynamic data and IT systems in FM will first be examined.

2.1 Dynamic data in FM

Dynamic data, also known as runtime or transactional data, is periodically updated and show a change of condition. Sensor technologies and IoT devices measure dynamic data. Dynamic data already form an essential basis for the Building Management System (BMS). Data aggregated in the building (e.g. from sensors and hardware) provide information on mechanical and electrical equipment, such as ventilation, pumping, or lighting, and controlled and managed using the BMS software (Wilde 2018). Typical sensor-technology measures for FM are temperature and humidity monitoring in ventilation and heating systems, presence detectors in buildings, or filling levels for controlling technical building equipment (Hossenfelder et al. 2019). Sensor technologies in buildings are used for assembling data on climate, energy and resource consumption, building condition, and space demand (Jaspers et al. 2018). Thus, the collection and processing of dynamic data enable FM strategies that support outcome-based service delivery based on predictions and controls, such as condition-based and predictive maintenance (Atta & Talamo 2020).

2.2 Software in FM

All dynamic data generated for providing facility services must be aggregated, stored, and analyzed in IT systems. Computer Aided Facility Management systems (CAFM systems) are the primary IT system to store and process data for FM. A consistent definition of CAFM systems is missing, but it can be stated, that a CAFM system is an administrative tool for automatizing processes of FM. Therefore, CAFM systems focus on people, assets, and financial aspects (Reddy 2013, Teicholz 2012, Nävy 2000). Storing all data relevant for FM is a crucial factor for efficient CAFM systems. A CAFM system consists of three components. The first component, the CAFM functionality, constitutes all CAFM systems and contains the software, programming, and applications. Customizing, the second component of CAFM systems, enables customizing of the specific use cases in the property. The third and most crucial component of a CAFM system constitutes the CAFM data. In this component, all property-relevant data is stored and displayed in the CAFM system by using both other components (May 2018, Otto & Bartels 2018).

Besides the CAFM system, various other FM software for fulfilling facility services exist, e.g.

- Integrated Workplace Management Systems (IWMS) for organizing and optimizing workplace resources and assets located in a facility (van Sprang 2021),
- Computerized Maintenance Management Systems (CMMS) for scheduling, managing, and documenting the maintenance of assets in a facility (Keady 2013) and
- Enterprise Resource Planning Systems (ERP) for supporting commercial aspects are worth mentioning. (Nävy 2018).

The systems are mainly used to provide facility services. Furthermore, Document Management Systems (DMS) for storing documents, and Geographic Information Systems (GIS) for further geographical data might be helpful. The IWMS, CMMS, or ERP are connectable to CAFM systems or other systems for exchanging data. Depending on the consideration, a commercial (ERP) or a technical system (e.g. CAFM) is the leading system (Nävy 2007). Fig. 1 displays a CAFM-centered FM software system.

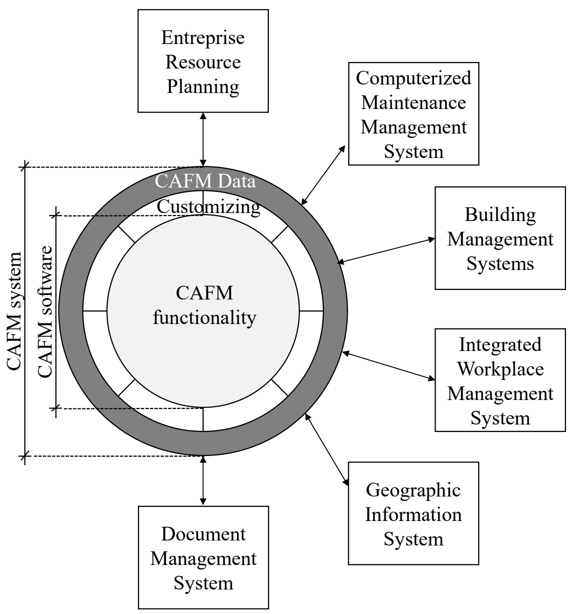

Fig. 1: CAFM-system and connected systems

As shown, many software tools for gathering and storing building-relevant static and dynamic data are necessary to conduct facility services. To avoid a loss of data, using open data exchange formats is required. By using the BIM method, all static and dynamic data can be stored in a structured way and exchanged in open data exchange formats. In addition to that, a BIM-based structure for storing data is crucial because

1. due to the increasing use of sensors, the object orientation in facilities will become more critical to handle all the data,
2. object orientation enables better analysis, visualization, and assignment of errors during monitoring, which in turn enables optimization of KPIs and
3. due to object orientation, the model forms the basis for a digital twin (Boje et al. 2020, Talamo & Atta 2019).

Therefore, integrating all static and all dynamic data into an object-oriented digital building model based on IFC and BIM is required for supporting the result-oriented provision of services by affording all relevant data.

2.3 Ongoing projects and scientific related work

Although the number of scientific projects and publications related to BIM and FM is increasing, a trend of the scientific BIM projects in dealing with as-built models instead of dealing with the planning and construction phase of buildings is recognizable (Fassl 2020). Ongoing scientific projects, that aim to integrate BIM, IoT and FM focus on energy monitoring, the visualization of values like temperature or humidity in 3D (e.g. Kazado et al. 2019) and sustainability (e.g. Desogus et al. 2021). By analyzing various papers, it becomes obvious, that proprietary exchange formats (e.g. Autodesk Revit) are regularly used.

For this reason, an analysis of projects that work with data exchange formats was carried out in a second step. The project BIM4BEMS, for example, investigates the use of BIM for reporting purposes of energy and comfort-related parameters in the maintenance phase. Combining building data with building management system data creates a dynamic system. Such a model may significantly improve the analysis and visualization of changes in the current state of a facility. The BIM is derived semi-automatically from available design, operational and maintenance data with semantic and geometric reasoning. In the final report, the authors state that various challenges existed during the data processing. Especially incomplete documentation, limited data interoperability, and a clear definition of data was mentioned (Gaida et al. 2020). Furthermore, the focus of the project was not on using open data exchange standards as IFC. Besides these scientific projects, various ontologies, such as ifcOWL, Colibri, Building Topology Ontology (BOT), and schemes have been developed to store, visualize and exchange sensor data and data of the building automation. In particular, the Brickschema, the ProjectHaystack, or the Smart Applications REFerence (SAREF) offer possibilities to integrate sensors and hardware of building automation (Sanz et al. 2018, Anjomshoaa & Curry 2020). Approaches for linking the BIM-methodology IFC classes with the conventions of the ProjectHaystack or with the Brickschema and the integration of SAREF models into the Brickschema already exist (Brick 2021, ProjectHaystack 2017). By analyzing these schemes, it can be stated that they focus on technical specifications so that various services of FM cannot be conducted by using only one of these schemes (e.g. cleaning due to the missing of various relevant geometric and equipment details). Furthermore, these schemes do not depict the whole lifecycle of a building, so that the integration of FM during the planning and construction stage is missing. As mentioned before, first scientific and practical approaches to integrating databases and additional ontologies with open standards have been investigated. However, due to frequent changes in service providers, software systems, or building owners, FM must store all data processed throughout the lifecycle using an open and lifecycle-orientated standard.

Moreover, an open standard should allow to store all data in one file format so that only one file needs to be exchanged between service providers and owners. That means that data loss and expenses for proprietary data formats can be avoided. Lastly, it is necessary that all FM tasks could be conducted by using the data, which are made available via an open data exchange format. Therefore, it is crucial to integrate the data into an object-oriented digital building model with an associated data exchange format by using BIM.

3 Course of Investigation

The use of BIM over the entire life cycle, and especially in FM, is steadily increasing (Falcão et al. 2021). BIM represents a method that operates over the entire life cycle and links different building models to exchange data between the technical participants in real-time and based on defined data standards (Borrmann et al. 2015, van Treeck et al. 2016, Bartels 2020). To enable data exchange, it is necessary to investigate open data exchange formats for integrating sensor data. The positive effects of using BIM become visible only by using open exchange formats, e.g., standardized, and open interface data exchange formats. This concept is called Open-BIM and avoids data loss while exchanging data between different software systems (Schiller & Faschingbauer 2016, Rajabifard et al. 2019, Jiang et al. 2019). The IFC standard currently forms an essential basis for Open BIM (Ha-Minh et al. 2020).

4 Approach for Integration of Sensor Technology in IFC

For investigating open data exchange formats on the applicability for FM, data required for the demand-driven provision of services in FM is analyzed. A categorization of the required data into static data and dynamic data is conducted. Then, the IFC standard is analyzed for the mapping of static and dynamic data. For data that is not linkable with the current IFC standard, new data sets, so-called PropertySets (PSets) are defined based on the data requirements of FM. Finally, solution approaches are shown and examined for possible restrictions.

4.1 Analysis of FM tasks

The main challenges faced by FM participants are demand-driven data collection, acquisition, and delivery (Matarneh et al. 2019). Therefore, standards and guidelines of the German Facility Management Association (GEFMA) or the German Institute for Standardization (Deutsches Institut für Normung, DIN) considering data relevant to FM exist, e.g. standards of GEFMA 100-2 or GEFMA 540. Based solely on the range of FM processes defined by GEFMA, an amount of 335 requirements for the operative provision of services exists. The data basis for these processes are static data and dynamic data with respective subcategories (GEFMA 2013). Fig. 2 visualizes the relevant and categorized data for service provision.

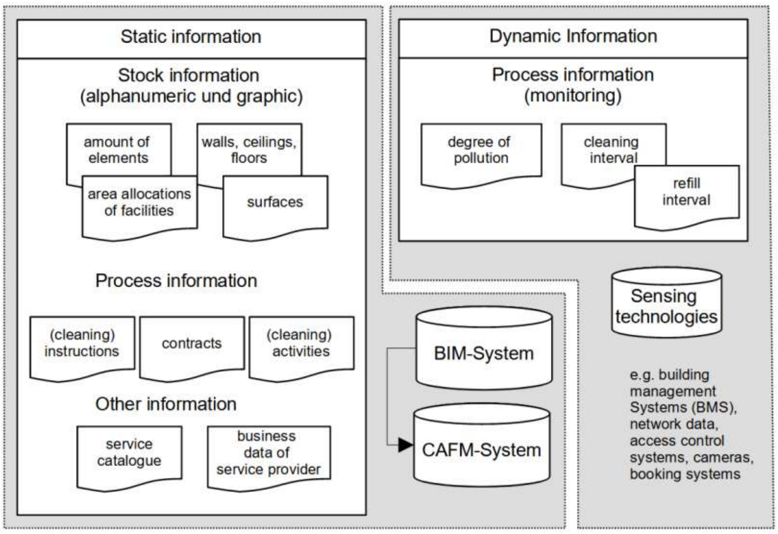

Fig. 2: Static and dynamic data for provision of services in FM

An examination of the relevant DIN standards and GEFMA guidelines shows the minimum of required data for the provision of services in FM:

- Facilities affected by the service provision (stock data)
- Area allocations of the facilities (e. g., floor-wing-room) (stock data)
- Service provider of the service provision (order data)

- Activity descriptions of the facility service to be provided (order data)
- Interval or time of service provision (condition data)
- Documents for supplementing the performance of services, e.g., execution certificates, acceptance protocols, or defect documentation (order data).

A BIM-based mode of operation enables an open transfer of the data mentioned above over the complete life cycle of a building. For example, the technical-geometric data from the BIM-based IT systems of planning and construction can be transferred automatically and linked with the organizational-commercial data from the FM systems (e.g. CAFM, ERP, or IWMS).

4.2 Analysis of the mapping possibility in open data exchange format IFC

This paper investigates the open exchange of sensor data by using the BIM method. In this context, the respective sensor types generate dynamic data for demand-oriented service provision in FM that consist of condition and consumption data. The measured variables are transferred to the IT systems of the FM for analysis and monitoring purposes. By defining rules (algorithms) for service provision, conditions in buildings can be analyzed based on current sensor readings and used to initiate service provision. The required algorithms put the generated sensor data into the relation of defined limit values. By reaching limit values, the demand of service provision is proofed.

Data generated by sensors is processed and stored in the IT systems of the FM. To avoid data loss, e.g., due to a change of the service providers, by a change of software systems, or by unstructured data storage, it is necessary to use open data exchange formats. The Industry Foundation Classes (IFC), standardized in ISO 16739, have become the established standard for data exchange within the BIM method (Baldwin 2019, Nawari 2018, Ha-Minh *et al.* 2020). The goal of IFC is to enable open data exchange between technical stakeholders throughout the whole lifecycle of a building (Wu 2017).

Other data formats for FM based on IFC, such as the Construction Operations Building Information Exchange (COBie) data format, transfer static data from the planning and construction phase to FM (East & Jackson 2016). COBie is an IFC-based specification developed by buildingSMART that explicitly defines building and equipment data transfer to the operator. Although all disciplines involved in a building life cycle can use and edit these spreadsheets, the COBie standard does not integrate dynamic data. COBie provides planning and execution data of buildings and technical equipment but does not include FM service delivery data (Bartels 2020). Therefore, it is necessary to take a closer look at IFC itself.

Section 4.1 identified the relevant static and dynamic data for FM. The static and dynamic data for FM, identified in section 4.1, are examined for representability in the open standard data exchange format IFC4. In May 2021, IFC4 includes 776 different entities (buildingSMART 2020). In IFC, an entity describes a concept for typifying and describing the structure and behavior of similar objects. (Borrmann *et al.* 2015) In addition, there are 418 PSets in IFC4, which combine attributes for a specific purpose (Borrmann *et al.* 2015, buildingSMART 2020). Many entities and PSets exist in IFC, focusing on the description of architecture and technology and forming the basis of the definition of as-built data of the building usage phase (Bartels 2020). An investigation on FM-interoperability in IFC4 shows that the current IFC standard does not support the representation of dynamic data for demand-oriented service provision. To represent dynamic FM data in IFC4, various attributes of individual IFC4 entities must first be connected.Implementation of FM processes in IFC.

Since IFC4 currently does not offer mapping sensor-based FM processes, extending the schema to ensure a lifecycle-oriented data exchange is necessary. For this purpose, a proposal for the class IfcSensor is presented below, intended to capture sensor-based process data. This IFC class enables a clear and understandable assignment of the data. The first step is to examine which general attributes of IfcSensor are directly related to service provision. The attributes GlobalId, author, name, description, and object type, are general attributes for the description of the (sensor) component. An immediate context to FM processes provision of services in FM does not exist. The general attributes represent the sensor identification and its physical description in a digital building model. Nevertheless, the location of the sensors, which IfcObject Placement represents, directly relates to the service provision. The physical location of a sensor implements a measurement environment.

An example are sensors for detecting the number of people frequenting an area. The identified amount of people constitutes the basis for decision-making on cleaning floor areas. If the sensor under consideration detects the limited number of people defined in the rule, cleaning the floor surface is required. This shows that the sensor location affects FM service provision. A formal representation of the sensor placement and its measuring area has to be fixed in IFC4. Furthermore, it is necessary to consider the type of sensors represented by IfcPredefinedType, to determine the demand of a service provision already in the planning phase of a building. Fig. 3 illustrates the dependency of the sensor placement and the used sensor type in dependency of the FM service provision. On the left side, the IFC class of sensors is shown, in which FM requirements are to be implemented. Influencing FM factors for the ground inclination are e.g. the weather and the number of people passing. While the IFC hierarchy can cover the building area to be cleaned, the influencing FM requirements have to be covered by suitable sensors. Service provision activities, e.g., cleaning and maintenance services, are categorized as events (IfcEvent). The sensors required to determine the measured values of a rule for identifying the demand of a service provision are attached to IfcEvent. PSets via IfcHasProperties assign the rules and rule types to the sensors. In turn, the sensors under consideration have properties through which the limits and rule types are determined for capturing the demand.

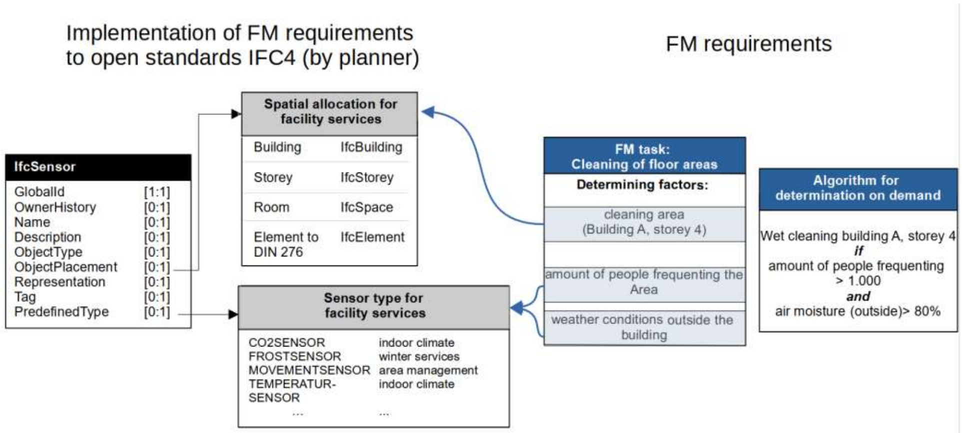

Fig. 3: Dependence of general attributes IfcSensor to provision of services in FM

In practice, the defined rules with their limit values and the control types are interdependent.

4.3 Application of IfcSensor

Fig. 4 shows an example of the IFC link for determining the need for cleaning floor surfaces using the IfcSensor entity. The boxes symbolize IFC classes and relationships between each other. Multiple links between different classes are required to display the event "floor cleaning" in IFC, though only the minimum linking entity of required IFC4 entities for acquiring service demand is shown. Only two sensor types (sensor for determining the number of people passing an area and sensor for determining the relative humidity) are considered, as shown on the right side of Fig. 4. However, the number of sensors used for detecting demands of FM service delivery is much higher. IFC allows the mapping of thresholds and control types as PSets, but does not offer the possibility to set the thresholds and control types to each other. Determining the demand for service delivery assigns a consideration of all physical sensors that determine the demand of service provision to the elements and facilities affected by the service provision.

Consequently, a multidimensional and complex relationship between building elements, sensors, and sensor data arises that does not include any runtime data. Proprietary systems must then first access the IFC construct again.

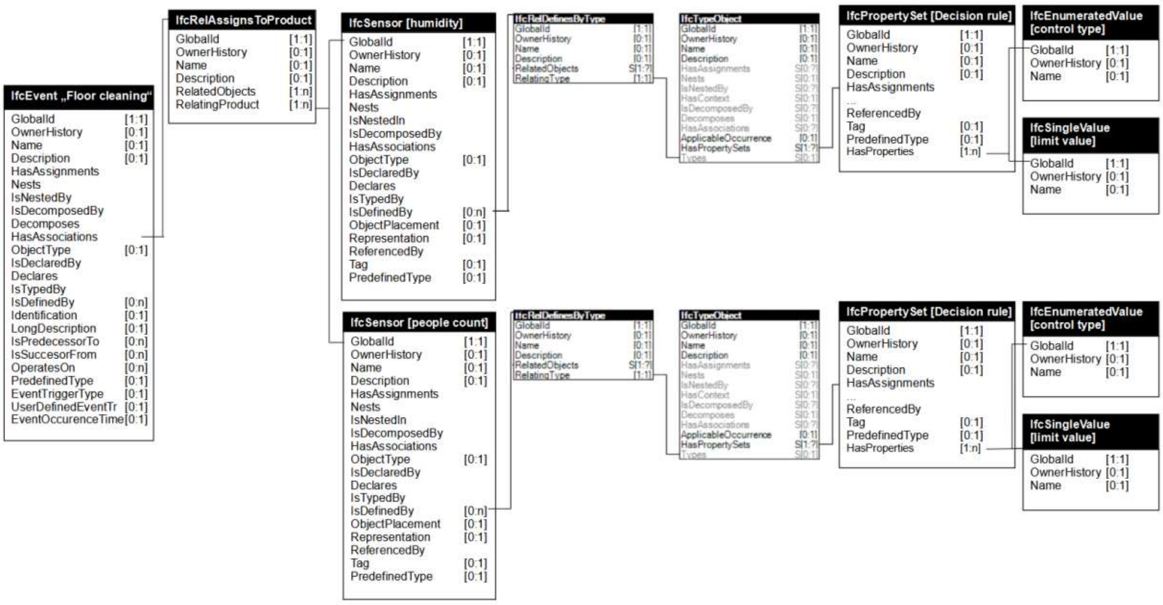

Fig. 4: Exemplary application of IfcSensor for determining the cleaning requirement

As can be seen, IFC focuses primarily on the geometric, supply-related, and process-related mapping of a building. In particular demand-oriented service provision, the mapping of dynamic service provision is only possible in IFC via many links. Therefore, IFC is not yet capable of capturing dynamic parameters of BMS and sensors. Linking geometric classes with process-oriented classes is a significant challenge.

5 Recommendation for further development

The integration of dynamic data in open data exchange formats is crucial for FM, because proprietary systems create a dependency on vendors and data platform providers, what leads to data loss, inefficiency and high effort with every change. Therefore, a further development of IFC is necessary, e.g. by mapping parameters relevant for demand-oriented FM service provision (e.g. limit values and control types) in IFC as static data in PSets. However, to enable demand determination and service assignment, the two parameters must be dynamically related to each other. Such a direct and dynamic relationship is not possible in IFC by now. The presented mapping only represents an intermediate result for the applicability of IFC in the context of demand-oriented service provision in FM.

Another requirement of FM is that a demand definition, e.g. the definition of limit values, should be flexible, so that the FM can react dynamically to external influences. In the case of large numbers of people or construction work and the resulting pollution inside a building, a change of limit values is possible. The limit values in the PSets can only be adjusted in the IFC for the respective sensor to which they are connected. Accordingly, the demand is only determined for one activity and not for several activities that belong to one decision and access the same sensors. This is not a fully comprehensive solution for the needs of FM, since it can be stated that the dynamics achieved by using the PSets are not sufficient for mapping IoT-based FM processes and should therefore not be the goal of open data formats.

Two solution approaches arise for the further development of IFC concerning integrating dynamic data, particularly sensor data. The first solution approach for further developing IFC for integrating sensor technology bases on a native extension of IFC. For this, the development of specified classes for FM is required, which enable the linking of sensor technology with FM processes. Thus, IFC must undergo an evolution from a static data format to a dynamic data format. Furthermore, it will be necessary to extend the domain layer about FM to map the FM processes in a new FM domain. This will enable an optimal combination of all classes and PSets necessary to provide services in FM. Therefore, further development of the IFC from a static to a dynamic data format is necessary for a demand-oriented service provision. This is realizable by a native further development of the IFC concerning the integration of sensor measurement data. The development of specified classes for FM, which enable a linking of sensor technology with FM processes, a dynamization of the data, and the integration of sensor measurement data in IFC classes, is necessary. The PSets developed for demand assessment would then be directly linkable to the classes for sensor technology. Furthermore, the domain layer must be extended to map the FM processes in a new FacilityManagementDomain. This enables an optimal combination of all classes and PSets that are necessary for FM service provision.

A second recommendation for further development aims to integrate sensor data into FM processes by linking IFC with other schemas, e.g., BRICK or ProjectHaystack. For FM, further developments of IFC are essential, as it allows project participants to access and using current sensor data for respective disciplines. In addition, it is necessary for FM to continuously record both static and dynamic data in a digital building model to ensure cross-lifecycle building operation. This enables the FM to ensure that all data is available in a uniform and standardized data exchange format so that data loss between the individual lifecycle phases in the event of a software change or a change of service provider is avoided. If only static and no dynamic data can be exchanged via IFC, the use of another third-party system is required, which would have to access standardized IFC data and proprietary measurement data. A dynamic IFC class, in which measured value data can be stored and exchanged, could allow evaluations and thus FM requirements assessments to be carried out wholly based on an open data exchange format.

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Barriers for Efficient Facility Management: Perspectives of BIM-users and non-BIM-users

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Abstract

After replacing the conventional design and construction practices of the architecture, engineering and construction (AEC) industry, building information modelling (BIM) is now influencing the way facility managers operate buildings. Although the use of BIM in FM has been disseminating across the globe, the industry is still in need of explicit evidence of its practical implications and potentials for efficient and effective FM practices. The present study amplifies the previous findings on the current BIM awareness and utilization within the FM industry in Turkey. This study analyses the problem areas of the FM profession from the perspectives of BIM-user and non-BIM-user facility managers and identifies the usage areas of BIM in FM. The results indicate that BIM has great help for visualizing the exact locations of building components, creating and updating digital assets, accessing the real-time facility data, tracking maintenance and repair works and monitoring energy consumption, specifically for large projects. Even though BIM enables the involvement of FM teams for introducing operational requirements in the early phases, the absence of up-to-date facility information seems to be the major problem area for BIM-enabled FM practices.

Keywords: Facility management (FM), Building information modelling (BIM), Barriers, Usage areas

1. Introduction

The initial scope of facility management (FM) practice was cleaning the buildings and maintaining the building equipment (Atkin and Brooks 2021, FMA 2012). In the late 1980s, FM has been accepted as a profession (Nor et al. 2014) that embraces multiple disciplines to ensure the functionality, comfort, safety and efficiency of the built environment by integrating people, place, process and technology (IFMA n.d.). Today, FM encompasses various activities such as maintenance operations and repair works, workspace management, energy planning and management, renovation, refurbishment and retrofitting, administrative and office services, emergency planning and management, financial management and FM personnel training for the efficient and effective operations of physical assets (Atkin and Brooks 2021, Chotipanich 2004, Springer 2001). To smoothly operate all those diverse disciplines and complex processes, the FM industry needs to embrace digitalisation and benefit from different information and communication technologies (Bröchner et al. 2019, Redlein and Grasl 2018).

FM professionals have been using numerous computer integrated FM environments, namely building automation systems (BAS), computerized maintenance system (CMMS), computer-aided facility management (CAFM), and integrated workplace management systems (IWMS). Although the conventional building handover process has evolved from paper-based drawings and documents to digital copies, FM teams need to transfer an excessive amount of data into their systems (Patacas et al. 2015). This transfer process is one of the major problem areas of FM because it takes a significant amount of time of the FM staff and is open to errors and data losses (Kasprak and Dubler 2012, Patacas et al. 2015). As a solution, the last decade has introduced the building information modelling (BIM) to the FM practice. BIM is an IT-enabled approach that involves applying and maintaining the integral digital representation of all building information for different phases of the project life cycle in the form of a data repository (Gu and London 2010). In the early phases of the building life cycle, BIM enables enhanced communication and coordination between project stakeholders, reduced errors and omissions, decreased project cost and project duration for architecture, engineering and construction (AEC) professionals (Azhar 2011, Bryde et al. 2013, Ghaffarianhoseini et al. 2017, Love et al. 2012, Suermann and Issa 2009). In the operational phase, BIM can help facility managers to create digital assets, visualize the exact locations of all kinds of building elements in a 3D environment, plan and track maintenance tasks, manage workspace, monitor the indoor environmental conditions and building performance, and train FM personnel for emergency situations (Becerik-Gerber et al. 2012, Pärn et al. 2017).

As a natural result of its benefits, the AEC firms are gradually adopting BIM into their practices. However, its implementation within the FM industry is remarkably low. Lack of owner demand, economical concerns, fragmented FM data, data exchange standards and interoperability issues, incomplete BIM models, model maintenance ambiguities, and lack of BIM experienced FM personnel are the major reasons for limited BIM implementation within the industry (Becerik-Gerber et al. 2012, Korpela et al. 2015, Pärn et al. 2017, Patacas et al. 2015). Besides, a recent study uncovers the short-term FM contracts as another hindrance for low use of BIM (Tezel et al. 2021). On the other hand, both researchers and practitioners are intensely focusing on the ways to implement BIM into FM since 2015 (Wong et al. 2015). Current FM practices are not fully benefiting from BIM but the professionals are expecting BIM to play an important role in the industry's near future. To carry out a smooth implementation process, facility managers first need to know with which purposes FM experts can use BIM and which barriers can BIM overcome to achieve an efficient and effective FM service. Therefore, the objectives of this study include understanding the BIM's contributions to the on-going problems of FM practices and identifying the BIM applications areas in FM.

2. Research Method

2.1. Background and research questions

Previous research by Tezel et al. (2021) demonstrates that FM professionals in Turkey have high BIM awareness but low BIM utilization. Although lack of owner demand, short-term contracts, limited budget, old building stock and incompetent FM workforce constitute the underlying reasons for the low BIM utilization, BIM is expected to be a trending phenomenon within the upcoming five years. The current study expands on previous findings by analysing existing barriers to efficient and effective FM practices and identifying BIM application areas in FM. The self-administrated questionnaire aims to find answers to the following questions:

RQ 1: Do the barriers to efficient and effective FM practices differ in conventional and BIM-based methods?
RQ 2: For which operational functions do the FM personnel utilize BIM?

2.2. Sampling method and sample characteristics

This study targets professionals from the three largest FM associations, namely, Turkish Facility Management Association (TRFMA), Professional Facility Managers Association (PTYD), and Urban Facility Management Association (TRKTYD), and a couple of well-known international FM companies in Turkey. There are more than ninety FM companies constituting these three associations, -among them are six international and two state-owned firms-, providing various hard and soft FM services. The online survey link has been shared with these organizations via email and responses were collected between February and March 2021. Overall, thirty-eight experts have responded to the survey. However, one response is excluded during the data screening process because the missing information related to the respondent's professional background prevents the credibility of the answers. In the end, the study population consists of thirty-seven experts.

Tab. 1: respondent characteristics

	Experience in years (b)						BIM user (c)		
Position (a)	**<5**	**6-10**	**11-15**	**16-20**	**21-25**	**26+**	**Yes**	**No**	**Total**
General Manager	1	6	3	4	1	1	2	14	16
Vice GM	-	1	2	-	2	1	-	6	6
Director	-	3	5	-	1	-	3	6	9
Consultant	1	-	-	-	-	1	1	1	2
Specialist	1	1	-	-	-	-	2	-	2
Other	1	-	-	1	-	-	-	2	2
Total	**4**	**11**	**10**	**5**	**4**	**3**	**8**	**29**	**37**

Table 1 represents the current positions of the respondents (column a), their years of experience in the FM profession (column b), and whether they have BIM experience or not (column c). Overall, the largest portion of the respondents (16 out of 37) are general managers of FM companies, followed by directors (9 out of 37), and vice general managers (6 out of 37). Also, the majority of the respondents (22 out of 37) have more than 10 years of experience in the FM industry, which indicates a highly representative and experienced study population. The survey includes the question of "have you ever worked with BIM" to determine BIM experiences of the respondents. Around twenty per cent of the respondents (8 out of 37) have used or are still using BIM in one or more of their projects. The latest research of BIMgenius (2020) also reports the use of BIM for FM purposes in Turkey as ten per cent. Both results refer to shifting interest of FM professionals to the BIM subject.

3. Different Perspectives Towards the FM Barriers

A detailed review of both scientific literature and industry reports reveals a number of hindering factors for FM. Although most of these barriers have generic characteristics, they have different impacts on FM operations depending on the facility type and size, required services, applied technologies, and so on. Given the emerging BIM implementation within the FM industry, it is important to distinguish the problem areas for conventional and BIM-based approaches. Respondents were asked to indicate their agreement or disagreement with the given barriers in order to identify the main issues influencing the efficient and effective operations of FM teams. The responses are divided into categories based on the respondents' BIM experiences, as shown in Figure 1.

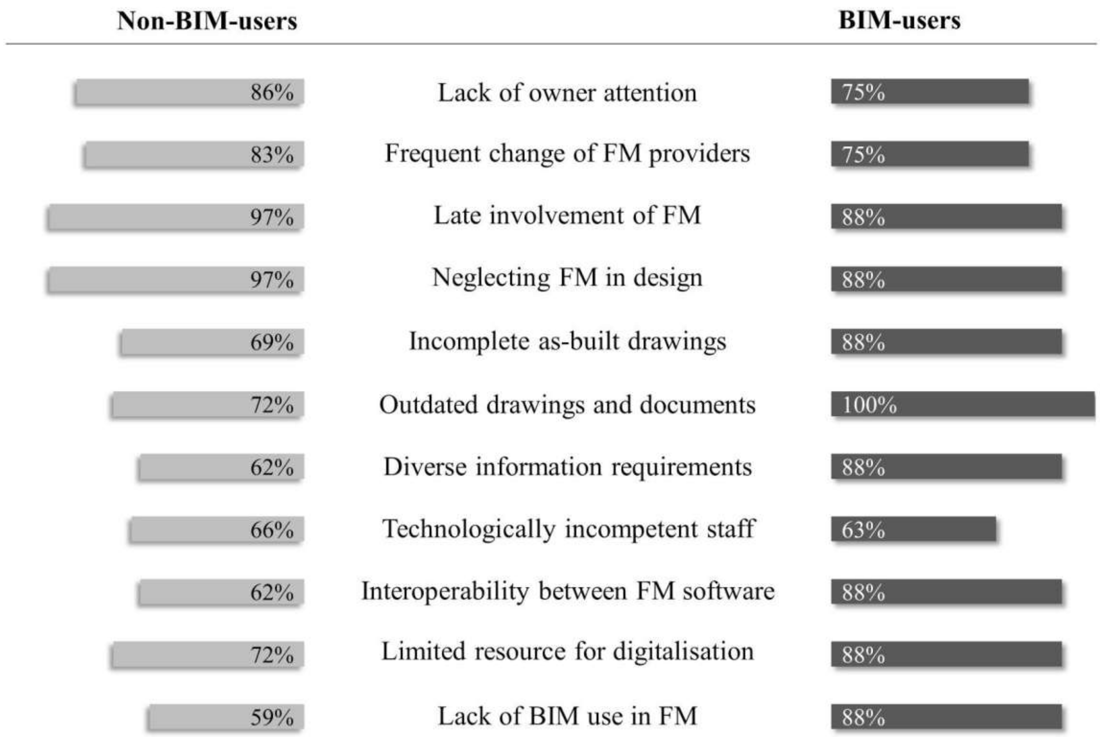

Fig. 1: barriers for efficient FM practices

Figure 1 reveals that all the listed barriers are influencing FM operations to some extent regardless of the use of BIM. In other words, neither conventional nor BIM-based methods are a solution to the given problem areas. However, the most and the least frequent problems of both approaches are different. Among the non-BIM-users, late involvement of FM professionals in the projects and neglecting the FM requirements in the design phase are the most frequent problems with the highest rate of 97%. On the other hand, BIM-users fully agree on the outdated drawings and documents of facilities as their most frequent problem. The most frequent problems of non-BIM-users settle among the second most frequent problems of BIM-users (88%) together with the delivery of incomplete as-built drawings, diverse information requirements of operational tasks, interoperability between FM software, allocating limited resources for digitalisation and insufficient use of BIM in FM.

The two groups also differ in terms of the least frequent problems as well. To the non-BIM-users, lack of BIM use in FM is the least frequent problem (59%) whereas to the BIM-users it is the technologically incompetent FM workforce (63%). Even though the scores seem close, the tiny difference between the two items embodies certain insights for FM professionals. First of all, although it is the least frequent problem for the BIM-users, technology-related incompatibilities of FM staff are still an important problem with the 63% frequency. To fully benefit from BIM and other related technologies, it is important for FM personnel to use them actively and properly. On the other hand, increasing use of machines and robots cause some people the fear of losing their job. At this point, managers need to remind the importance of the personnel for building operations, emphasize the vitality of technology for fast and accurate decisions, and provide necessary training and support for the staff. Another point is the thoughts of the non-BIM-users towards the current usage of BIM in FM. A non-negligible amount of them (59%) think that the lack of BIM use causes inefficiencies in operational tasks. Hence, the firms using BIM in FM are going to be the competitively advantageous ones.

4. Usage Areas of BIM in FM

The preceding analysis clearly demonstrates that BIM is not the ideal solution to the existing efficiency issues in FM practices. Nonetheless, the industry is recognizing and implementing BIM with increasing enthusiasm due to its promising potential. Becerik-Gerber et al. (2012), Sabol (2013), Matarneh et al. (2019), and Gao and Pishdad-Bozorgi (2019) identify and explain the application areas of BIM in FM. However, because each facility has its own needs and requirements, there is no one-size-fits-all solution in the operational. Respondents were asked to specify their reasons for employing BIM in facility operations, and the results are shown in Figure 2.

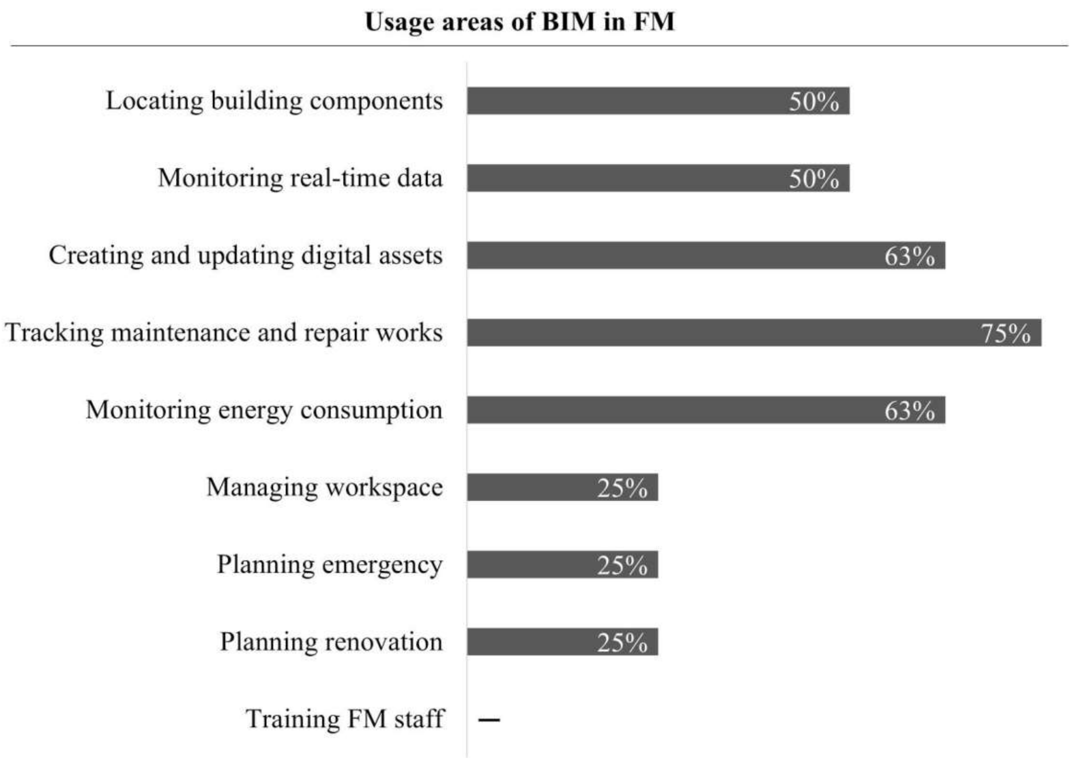

Fig. 2: usage areas of BIM in FM

As seen in Figure 2, the most frequent BIM application area in FM is tracking maintenance and repair works. 75% of the BIM-users issue maintenance and repair work orders of equipment or building components and track their progress using BIM. In connection with this, creating and updating digital assets and monitoring energy consumption are the second most frequent application areas of BIM in FM. In the conventional handover process, it is highly probable to observe discrepancies between the hard copy documents and the actual building. Moreover, during their life cycle buildings face numerous changes in the furniture, MEP system components, fire and other safety systems, façade elements and so on. Therefore, it is crucial not only to keep the data on an easy access digital platform but also keep them up-to-date (Korpela et al. 2015). At this point BIM emerges as a promising platform because it can capture the data in a 3D environment, perform further analysis and simulations, and enable data transfer between different software systems. Although data updating requires extra time or use of advanced technologies such as point cloud and laser scanning, a single and transferable data source contributes to the decision-making process of facility managers and FM personnel.

FM professionals spend half of their time in building operations tasks including conducting equipment checks and daily rounds, maintaining facility and systems, and conducting facility repair activities (NIBS 2015). To efficiently perform these activities FM personnel need to detect the exact location of building components and related information as soon and accurately as possible. Although BIM models are able to capture and visualize the necessary data and related documents (i.e., location, manufacturer information, attributes, manuals and warranties, etc.) of each component, only half of the users benefit from BIM for locating building components and monitoring real-time data of facilities. Furthermore, having the aforementioned data and real-time monitoring of the facility are critical to take immediate actions during emergency situations (Becerik-Gerber et al. 2012). However, only 25% of the users are utilizing BIM to manage emergencies, plan renovation and manage workspace. Nevertheless, the most interesting finding of this study relies on the missing use of BIM as a personnel training platform. BIM models are capable of realistically visualizing buildings and other assets so that FM personnel can get familiar with the facility in a virtual environment. Yet, none of the BIM-users benefits from BIM as a training platform. The last-minute involvement of FM teams might be the reason for the limited time for training, however fast personnel adaptation to the facility plays a crucial role especially in emergencies.

5. Conclusions

The population of BIM users in the FM industry is remarkably low compared to the AEC. Yet integration of BIM and FM fields is attracting the world's attention. Increasing number of studies in this field are trying to identify how BIM can improve the FM practices and develop various strategies to its implementation barriers. However, lack of real-life examples in BIM-based FM applications causes building owners to approach it with suspicions. Following the previous study revealing the BIM awareness and use in the Turkish FM market, the present study aimed to analyse the problem areas of the FM practice from two different perspectives and identify the current BIM applications in FM. Results show that both conventional and BIM-based methods struggle with similar problems. However, it seems that BIM handles the two major problems, namely, late FM involvement and neglecting FM requirements in early phases better than conventional methods. This study also reveals that BIM is actively used for tracking the maintenance, creating and updating digital assets and monitoring energy use within the facilities, but it can help the other functions of FM as well.

The small number of survey participants and even fewer BIM-users may have a negative impact on the study's representativeness. However, BIM is still a relatively new topic in FM practice around the world, and not all operational functions are suitable for management with BIM. As a result, this study is expected to provide a broad overview of the ongoing BIM-based FM practices in Turkey. FM professionals anticipate that BIM will be a trending phenomenon in the FM market in five years from now. Considering this expectation of the industry, more research should be conducted to develop BIM implementation strategies for FM companies to facilitate a smooth transition process.

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