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## BIM STANDARD AND THE NEW SPECIALISATIONS THAT HAVE EMERGED BECAUSE OF IT AROUND THE ARCHITECTURAL PROFESSION

### STANDARD BIM I POWSTAŁE DZIĘKI NIEMU NOWE SPECJALIZACJE W OTOCZENIU ZAWODU ARCHITEKTA

#### **Abstract**

Civilisational development brings new challenges in the discipline of architecture. In order to meet them in architectural and construction design, it is becoming inevitable to introduce the broadly understood BIM standard as widely as possible. New, previously unknown professional specialisations have emerged around the architectural profession.

- ▶ More and more often, the redevelopment and modernisation of existing buildings is performed in the BIM standard, which is why it is necessary to convert existing 2D documentation into a virtual 3D model of a building
- ▶ Laser rangefinders coupled with appropriate computer software allow the performing of intelligent measurement, which is based on the simultaneous measuring and modelling of a virtual building's elements.
- ▶ The technologically latest, most accurate, quickest and non-invasive method of gathering data on a building is performed using measurements that employ a laser scanner, which creates a point cloud within a 3D space.
- ▶ The creation of object libraries which represent specific commercial products for the most popular computer aided design programs has become one of the most dynamically developing specialisations surrounding the architectural profession.
- ▶ The possibility of presenting a design using an interactive multimedia presentation broadens the capabilities of using it in ways that are different from the traditional manner.

The new specialisations that are emerging in association with technological progress around the architectural profession broaden the traditionally understood market for architectural services. The subject of design in the BIM standard and the new specialisations should be introduced into the curriculum of architecture students as quickly and as broadly as possible.

**Keywords:** architect's professional toolkit, 3D design documentation conversion, laser scanning, object libraries, Building Information Model eXplorer

#### **Streszczenie**

Rozwój cywilizacyjny przynosi w dziedzinie architektury nowe wyzwania. Aby im sprościć, w projektowaniu architektoniczno-budowlanym nieuchronnie staje się powszechne wprowadzenie szeroko rozumianego standardu BIM. Wokół zawodu architekta powstają nieznane wcześniej nowe specjalizacje zawodowe.

- ▶ Coraz częściej projekty przebudowy i modernizacji budynków istniejących wykonywane są w standardzie BIM i z tego względu konieczne jest na wstępie przekształcenie istniejącej dokumentacji 2D w wirtualny model budynku 3D.
- ▶ Dalmierze laserowe, sprzężone z odpowiednim oprogramowaniem komputerowym, pozwalają na inteligentne inwentaryzacje, polegające na jednoczesnym pomiarze i modelowaniu elementów wirtualnego budynku.
- ▶ Najnowsza technologicznie, najdokładniejsza, najszybsza i bezinwazyjna metoda zbierania danych na temat budynku to inwentaryzacja za pomocą skanera laserowego, który tworzy chmurę punktów w przestrzeni 3D.
- ▶ Tworzenie obiektów bibliotecznych do najpopularniejszych programów wspomagających projektowanie, które dotyczą konkretnych produktów handlowych, stało się jedną z najbardziej dynamicznie rozwijających się specjalizacji na obszarach zawodu architekta.
- ▶ Możliwość przedstawiania projektu w interaktywnej i multimedialnej formie poszerza możliwości wykorzystania go poza tradycyjne zastosowania.

Nowe specjalizacje które powstają w związku z postępem technologicznym wokół zawodu architekta, poszerzają tradycyjnie rozumiany rynek usług architektonicznych. Problematyka projektowania w standardzie BIM i nowe specjalizacje powinny być jak najszybciej i w możliwie najszerszym zakresie wprowadzone do programu nauczania studentów architektury.

**Słowa kluczowe:** warsztat architekta, konwersja dokumentacji projektowej do 3D, skanowanie laserowe, obiekty biblioteczne, Building Information Model eXplorer

## 1. Introduction

Civilisational development brings new challenges in numerous disciplines. In order to face these challenges, each profession changes and evolves, with new, previously unknown professional specialisations emerging around them.

The situation is similar in the discipline of architecture and construction. Over the course of recent years, a series of new, previously unknown specialisations have emerged around the architectural profession. The cause of these ongoing changes is, chiefly, an extraordinary development in the field of information technology, which has revolutionised the professional toolkit that supports architectural and construction design. These changes, to be as brief as possible, are based on replacing traditional 2D CAD systems with BIM standard software that allows the creation of virtual models of buildings linked with an enormous database, which precisely parameterises all the elements of a design.

New programming tools dedicated for architects are being supported by more and more modern peripheral devices, such as laser scanners and drones. All of this – when put together – stimulates the emergence of new professional specialisations. Among the new specialisations that have emerged around the architectural profession, we should mention, for instance, spatial building measurement techniques, both on the urban scale, as well as on that of an individual structure, the development of object libraries for specific commercial products, as well as the use of virtual design presentation techniques in association with databases, used for various new applications.

The new information technologies are implemented most quickly and easily by the youngest generation of architects. This is the basis of the immensely important role of universities that are responsible for the quality of the education that the graduates who are entering the employment market receive. Engineer-level studies (level I) and Master's-level ones (II level) in architecture and urban design, which culminate in the awarding of the title of *magister inżynier architekt* (equiv. to MS Eng. Arch. – transl. note), should provide graduates with full professional knowledge, which is not only adapted to the reality of today, understood as a state-of-the-art professional toolkit, but is also one that takes into account the direction of changes that are going to take place in the following decade at the minimum. Proper education can provide current students of architecture with immense professional opportunities and a generational competitive advantage. On the other hand, an improper configuration of courses during studies and the omission of state-of-the-art practical, professional knowledge regarding the profession's tools can waste these opportunities.

## 2. Configuration of tools that aid in design

Along with the currently ongoing changes, it is becoming necessary to configure professional tools in the form of computer-aided architectural and construction design software in a manner that can meet current needs.

The vast majority of professionally active architects are very reluctant to change the computer-aided design software that they work on. Furthermore, they often use them in the wrong configuration.

An example of such a wrong configuration of computer-aided design software can be as follows:

- ▶ The spatial conceptual design is developed in the freely available Sketchup program by Google. It is a program that enables relatively easy and quick three-dimensional modelling; however, it does not give the ability to provide a detailed parameterisation of each of the elements and the material from which they are made.
- ▶ All the more detailed architectural and construction solutions are developed as 2D drawings – independent floor plans and cross-sections – in programs following the 2D AutoCAD standard.
- ▶ Sketchup is once again used to develop photo-realistic visualisations; however, the virtual model is built completely separately and independently from the 2D architectural and construction documentation, developed in AutoCAD.
- ▶ 3DMax Studio, expanded in order to obtain better effects with such programs like V-ray, etc., is used to create photorealistic visualisations.
- ▶ The final production of sheets is performed in a bitmap and digital photography editing software, e.g. Photoshop.

The verification of the appropriateness of the configuration of the tools that are being used and that support design occurs during attempts to introduce modifications and designs changes. In the configuration of an architect's digital professional toolkit described above – let's call it the "typical" configuration – actions like moving, changing the size and shape of windows and/or slight modifications to a building's massing entail a very large number of independent and tedious activities and, furthermore, increase the risk of making numerous mistakes in the form of the mutual inconsistency between each of the elements that comprise the design documentation (floor plans/cross-sections/facades/3D model).

The alternative, which eliminates the problems and inconveniences listed above, is the use of a cohesive, BIM-standard digital platform that supports architectural and construction design. In Poland, this is most often a choice between Autodesk's Revit and Graphisoft's Archicad. The performance of analogous modifications and changes in a design is simple and quick. Furthermore, the modifications are performed on a virtual building model, ruling out mistakes in the form of inconsistencies between drawings – when a 3D model is the basis for the generation of 2D floor plans, cross-sections and facades, then mistakes simply cannot be made!

### 3. Design using the bim standard

BIM (abbreviation of *Building Information Modelling*)<sup>1</sup> is based on the creation, with the use of appropriate software, of an immense database, precisely defining each part of a building (its structure, materials and their properties, fittings, etc.) and ordered in a three-dimensional space in the form of a virtual 3D model. A BIM-standard design is developed using three-

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<sup>1</sup> *BIM Curriculum*, Graphisoft, 2013, <http://www.graphisoft.com/learning/training-materials/bim-curriculum/> (access: 21.03.2016).

dimensional objects, such as walls, floor slabs, roofs, ceiling surfaces, windows, doors, etc., which, apart from their geometric dimensions, are being assigned with appropriate parameters (physical properties, technical properties, etc.). Integrating information within a single database makes it possible to automatically identify modifications and detect possible collisions. A building's model can be appended and verified using various types of schedules, timetables, cost estimates, etc.

The distinctive element of designing in BIM-standard computer-aided design programs is the shift of the main workload on the early phases of the design process (the conceptual design stage), which provides the greatest capability of influencing effectiveness, at the lowest cost and at the lowest difficulties that are associated with it<sup>2</sup>.

Designing a building as a virtual spatial model, in which all the parameters of a real structure have been introduced, such as the layers of partitions with defined sets of parameters and their physical properties, technical parameters, prices, etc. allows us to carry out various types of analyses<sup>3</sup> and simulations already during the early stages of design, something which is completely unavailable in the case of traditional designs, developed in 2D CAD software (*Computer Aided Design*)<sup>4</sup>, in the form of 2D floor plans, cross-sections and facades. One example of such an analysis is the daylighting and shade analysis of a building. In a design developed using BIM-standard software, the virtual model has a precisely defined geographical location, along with its height above sea level and orientation in regard to the cardinal directions. Thanks to this, we have a defined angle of incidence of solar rays which is characteristic of the design, and which can be determined for any given hour and day within a year. Daylighting analysis is particularly crucial and key in the design of residential buildings, which have a legally regulated amount of hours of direct access to sunlight. At the same time, the prescribed time of access to sunlight is often difficult to achieve, particularly in the case of apartments in a quarter-based, intense urban built environment.

The revolutionary change that has occurred in the professional toolkit of architects is best illustrated in the form of the typical parameters that are contained in a BIM-standard design<sup>5</sup>:

- ▶ a precisely parameterised structure of the external elements of a building (layer structures for all partitions):
  - ▷ specific thicknesses for each layer of a partition,
  - ▷ a selection of construction materials with their associated physical parameters (heat transfer coefficient for the purposes of calculations, density per cubic metre, etc.),
- ▶ openings with specified parameters regarding windows and doors:
  - ▷ translucent elements are introduced along with their U coefficient and thermal gains from sunlight,

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<sup>2</sup> Nordby A., *Przewodnik MaTrID – Zintegrowane projektowanie*, European Commission Executive Agency for Competitiveness and Innovation, 2013, p. 3.

<sup>3</sup> *BIM Curriculum*, Graphisoft, 2013, *op. cit.*

<sup>4</sup> Sydor M., *Wprowadzenie do CAD. Podstawy komputerowo wspomaganego projektowania*, Wydawnictwo Naukowe PWN, Warszawa 2009, p. 47.

<sup>5</sup> *BIM Curriculum*, Graphisoft, 2013, <http://www.graphisoft.com/learning/training-materials/bim-curriculum/> (access: 21.03.2016).

- ▷ opaque elements are presented along with their U coefficient, Psi values (linear thermal energy transfer coefficient [W/mK], which is used to calculate the effect of thermal bridges that occur at the connection between the window frame and the wall around the opening) as well as linear infiltration characteristics,
- ▶ the more important external elements, which form a mass that accumulates heat, divided into:
  - ▷ heavy (concrete structures), > 400 [kg/1 m<sup>2</sup>] of useable area,
  - ▷ medium (masonry structures), 250-400 [kg/1 m<sup>2</sup>] of useable area,
  - ▷ light (post and beam structures), < 250 [kg/1 m<sup>2</sup>] of useable area,
- ▶ the level of air infiltration through a partition over an hourly energy balance, as well as the total air change rate per hour (ACH), with the following division:
  - ▷ 0.6 [1/s,m<sup>2</sup>] is a low value (for a passive building),
  - ▷ 1.0 [1/s,m<sup>2</sup>] is a medium value (recommended building),
  - ▷ 1.5 [1/s,m<sup>2</sup>] is a high infiltration value (similar to a building fitted with mechanical ventilation),
- ▶ the properties of the designed material on the external surface of a layered structure, which affect the absorption characteristics of a given structure – the capacity to absorb solar energy by a given partition [%].

#### 4. New specialisations within the architectural profession

New programming tools, which support BIM-standard design and the peripheral devices that cooperative with it, have caused immense progress in recent years, along with the emergence of numerous specialisations that surround the architectural profession. The demand for architects educated in the new specialisations grows each year not only in Poland, but also, and perhaps the most, in the most developed countries of the world, which are the quickest to adopt new technologies.

The most distinct of these new specialisations in the architectural profession have been described below.

##### 4.1. Converting 2D documentation to 3D

All manners of building redevelopment and modernisation projects require the development of design documentation. Insofar as in the case of historical buildings, the basis for the development of such a documentation is a record of its extant state, in the case of buildings that have been built in recent decades, the basis for the development of design documentation is usually such a building's existing documentation, developed using digital support in accordance with AutoCAD's 2D standards. Due to the fact that building redevelopment and modernisation designs are being developed in accordance with BIM standards, it is necessary to perform an initial conversion of the existing 2D documentation into a virtual 3D model of the building. This poses numerous problems. Practical experience

shows that 2D documentation typically contains enough mistakes that it requires thorough and precise verification over the course of the development of a virtual model, as well as in confrontation with the verification measurements of the existing structure.

Upgrading existing documentation to 3D, as the building of an existing building's virtual model is colloquially called, is tedious, time-consuming and requires a lot of work. The lack of designers in this specialisation is widely felt. However, the capabilities of designing the redevelopment and modernisation of a building on the basis of a BIM spatial model are absolutely incomparable and will become a widely established standard in the future.

A virtual BIM-standard model of a building is, at the same time, a database that allows the precise parameterisation of, among other things, the following elements:

- ▶ The numerical model of the terrain
- ▶ The construction materials that form the layered partitions of a building along with their physical characteristics
- ▶ The parameters of windows and doors
- ▶ The technical infrastructure and systems of a building
- ▶ The operating temperatures of each room as well as operation schedules and timetables
- ▶ The climate parameters associated with the geographical location and immediate surroundings of a building
- ▶ etc.

## 4.2. 3D extant state documentation development

3D extant state documentations of buildings can be divided depending on the scale of the documentation, such as extant state documentation on the urban scale, in which the virtual spatial model includes a large area with numerous structures that are presented with limited precision in accordance with the scale, as well as extant state documentation of individual buildings, which is developed in a fairly detailed manner, taking into account technical infrastructure, etc.

### 4.2.1. 3D extant state documentation on the urban scale

Modern extant state documentation development on the urban scale should be performed in the following order:

- ▶ **Aerial photography** – The Central Surveying and Cartographic Facility possesses an archive of aerial photographs from various years, which cover most of Poland's surface area. The photogrammetric measurement precision of such photographs ( $x$ ,  $y$  and  $h$ ) is estimated at around 0.5 m (RMS<sup>6</sup>). Areas for which documentation is being developed and for which archival materials can be obtained, can also have a proper photogrammetric air run plotted and performed.

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<sup>6</sup> RMS – (root-mean square) – interpreted as an area of the root mean – for instance, RMS = 0.25 means that 65% of the observations are within a root-mean square with a 25 mm radius.

- ▶ **Aerial triangulation** – in order to perform precise measurements based on aerial photography, it is necessary to perform their georeferencing<sup>7</sup> with points measured at ground level. A surveyor is usually commissioned to perform this.
- ▶ **Measurement of buildings** – the measurement of buildings can be performed with various degrees of precision. There are three basic levels, which have been presented in Figure 1.



Fig. 1. The three degrees of precision of 3D extant state documentation on the urban scale

- ▶ The most appropriate one seems to be the intermediate variant (for the performance of analyses as well). The measurement of chimneys or of the detailed elements of roofs yields poor results with a photograph that has a pixel size equivalent of 0.24 m. Should it be necessary to reduce the outlines of the buildings to their ground floors as seen in the Building and Land Registry (BaLR – EGİB in Polish – transl. note) – the complicated and work-intensive nature of such documentation can only be exacerbated. It should also be pointed out that aerial photographs cannot be used to ascertain whether a visible roof has walls, or is it purely a freestanding cover – just as it cannot be determined whether it is a registered building or not. It can, however, be determined (by comparing with the BaLR) whether a building visible on the BaLR exists, or whether the outline of the ground floor does not extend beyond the outline of the roof (an error in the BaLR or an outdated outline of the ground floor), locate buildings, structures or freestanding roofs.
- ▶ **NTM measurements (Numerical Terrain Model)** can be performed in the form of documentation on a stereo model (the highest degree of precision) or can be generated on the basis of aerial photography either automatically or semi-automatically – depending on the expected precision. Each of the methods has its advantages and disadvantages. For instance, preparing data for the performance of a shade analysis in the case when a model of a group of buildings is being built – the NTM data that we are able to obtain should ideally be capable of being simplified into a network of points spaced 2-5 metres apart.
- ▶ **Orthophotomap**<sup>8</sup> – provided that we have photographs and an NTM, the preparation of an orthophotomap from photographs with a pixel size equivalent of 0,24 m is not as work-demanding. An orthophotomap constitutes excellent reference material.
- ▶ **Streets** – in the case of having an orthophotomap, the street grid can be presented using it as a background, in the form of vectors of street axes. To this end, we can consider

<sup>7</sup> Georeferencing is based on providing a raster or vector file with a predetermined coordinate system.

<sup>8</sup> The map whose content is being presented is an aerial photographic image (ordinary aerial or satellite images of the Earth's surface).

importing data from Open-Street-Map that can be easily downloaded in vector format. Any blank spots or inconsistencies can be identified and re-measured from aerial photographs or from stereo measurements. The streets should then be superimposed on the NTM so that they can be assigned their respective height values.



Fig. 2. The superimposition of a vector road grid on an orthophotomap – the Market in Slomniki

- **Spatial urban model** – a virtual model – mock-up – of the entire area of a commune can be developed in various graphical styles (depending on particular needs). Vector street axes, along with the names of streets, can then be superimposed on the virtual mock-up.



Fig. 3. Various graphical styles of an urban scale virtual mock-up

#### 4.2.2. Developing extant state documentation using measurements performed by a Flexijet laser rangefinder

Modern equipment used to develop extant state documentation has revolutionised traditional methods of measuring and recording the extant state of buildings. One example of such a device is Flexijet<sup>9</sup>. The system is composed of a laser ranging device which cooperates with ArchiCAD software installed on a laptop computer that is connected to said device<sup>10</sup>. This enables us to perform an intelligent measurement, which is based on the simultaneous measurement and modeling of the elements of a virtual building. It is the first solution that allows the creation of intelligent BIM models directly during field measurements performed using a laser rangefinder.

<sup>9</sup> <http://bimm-gmbh.de/en/> (access: 7.04.2017).

<sup>10</sup> <http://www.archicad.pl/sprzet/flexijet/76-1/286-inteligentne-inwentaryzacje> (access: 7.04.2017).

The Flexijet device performs laser-based measurements. During measuring, the Flexijet device plays the part of a computer mouse – each measurement is a “click”, which defines the location of a point within a three-dimensional space. The measurements have a precision range of 2 mm. They can be used to construct the elements of a BIM model, such as walls, beams, pillars, etc. with the help of ArchiCAD tools. The model that we obtain is complete. It can also contain complex, parametric and intelligent BIM objects, such as windows, doors, stairs, railings, etc. This makes the data that is obtained easy to modify later on, serving as a basis for further design work.

Over half of the construction projects that are being carried out in urban areas are redevelopment projects. These often encompass the modernisation of complicated structures, including historical buildings. Flexijet guarantees the high precision of an extant state documentation regardless of the complexity of the measured building. Measurement precision is particularly important in the case of detailed construction documentation.



Fig. 4. Extant state documentation of the frontal facade of the Palace in Łobzów, which houses the Faculty of Architecture of the Cracow University of Technology, developed using the Flexijet device in 2014 at the Descriptive Geometry, Technical Drawing and Engineering Graphics Laboratory (A-43). Source: <http://arch.pk.edu.pl/blog/2014/10/13/kurs-obslugi-systemu-pomiarowego-flexijet/> (access: 7.04.2017)

Flexijet also allows the performance of terrain surveying. This makes determining the shape and the location of key elements of a site quick and easy. Considerable benefits offered by the use of innovative BIM measurement technologies are also gained in the form of measuring complicated structural systems. The BIM model that is thus obtained can be used to easily extract a range of additional information, for instance, a schedule of the elements of a timber roof structure.

#### 4.2.3. Laser scanning

The latest in terms of technology, the most precise, quickest and non-invasive method of gathering data about a building is measurement using a laser scanner. The effect of scanning various places (which takes only a couple of minutes) is measurement data in the form of millions of measurement points, which create a so-called point cloud within a three-



dimensional space. After initial refining, which takes the form of “superimposing” the results of measurements from mutually supplementing measurement stations, we can very quickly obtain a visualisation of the scanned structure. Scanning using this method can be used in the case of many types of structures, from telegraph lines and circulation routes, through industrial and engineering structures and their infrastructure, to historical and modern buildings of various types and sizes. The end product of the scanning process can be both the point cloud itself as the final product, as well as, after further refining – plans, maps, drawings, terrain models, visualisations and many other things.

In the case of laser scans, measurement is performed with a laser beam (which usually operates in the near infrared spectrum), which pulses at a very high frequency, thanks to a prism that rotates in the vertical plane. The maximum speed of scanning is dependent on the model of the scanner, usually amounting to a couple of thousands of points per second. The distance to the measured point is determined on the basis of measuring the time it takes for the beam to travel to the object and back. The measuring toolkit includes a laptop computer with specialist software. The data obtained using laser scanning is stored on a data storage device, which is most commonly a hard drive. This is caused by the sheer size of this information. However, along with the progress regarding flash cards, more and more scanners provide this option in terms of data storage. Afterwards, we are given the ability to export the data in the form of a point cloud to various formats, along with characteristic qualities. The products of laser scanning can be: a point cloud within a three-dimensional space, three-dimensional models, drawings and plans, orthoscans and virtual models.

Laser scanning is a relatively new method of obtaining a large amount of data using laser beams. It can be divided into:

- ▶ **Terrestrial Laser Scanning (TLS)**, which is performed using ground-based 3D laser scanners,
- ▶ **Mobile Laser Scanning (MLS)**, which is performed using an integrated scanner that travels on such platforms like boats, trains or cars,
- ▶ **Airborne Laser Scanning (ALS)**, which is a method obtaining 3D data for very large areas in terms of surface,
- ▶ **Satellite Laser Scanning (SLS)**<sup>11</sup>, which is performed from Earth’s orbit<sup>12</sup>.

Laser scanning technology is continuously improving, while equipment is becoming more accessible and the software provides more and more capabilities.

One example of BIM-standard design support software that makes it possible to import a point cloud is ArchiCAD by Graphisoft. This program makes it possible to quickly create a BIM model on the basis of an imported point cloud. Especially concerning large and complicated buildings, this method of developing an extant state documentation greatly shortens the time that is necessary to perform work and eliminates mistakes made during the traditional measurement process.

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<sup>11</sup> Kurczyński Z., *Lotnicze i satelitarne obrazowanie Ziemi*, Oficyna Wydawnictwa Politechniki Warszawskiej, Warszawa 2006.

<sup>12</sup> So far the only instrument using this technique was the Geoscience Laser Altimeter System (GLAS) which is fitted onto the ICESat satellite. The beam footprint of the laser sent from a 600 km high orbit on the surface of the earth is around 70 m, and their centres are placed around 172 m apart from each other.



Fig. 5. Example of a scan of a building in the form of a point cloud. Source: <https://blog.graphisoft.com/graphisoft/archicad-19-new-features-point-cloud-introduction-to-point-clouds> (access: 7.04.2017)



Fig. 6. Extant state measurement of the Dominican Monastery in Dubrovnik, with a surface area of 5500 m<sup>2</sup>, performed by BimPoint from Krakow, which required carrying out around 1100 laser scans. Source: <http://bimpoint.pl/> (access: 7.04.2017)

The most common applications of 3D scanning using point clouds are:

- ▶ the modelling of existing buildings before renovating or redeveloping them,
- ▶ site modelling before designing new structures,
- ▶ the modelling of existing structures of buildings in order to identify inconsistencies in existing documentation.

We can obtain the following information from a BIM model developed on the basis of a point cloud:

- ▶ a database of information on a structure required for further renovation, conservation or design work,
- ▶ a cohesive and precise technical documentation,
- ▶ all types of technical drawings (floor plans of any level, cross-sections through any location, external and internal facades),
- ▶ quantitative schedules: of rooms, doors and windows, as well as other elements of a building,



- ▶ analyses: daylighting, energy balance, structural, etc.,
- ▶ a bill of quantities and a cost estimate of construction work,
- ▶ all types of perspective or axonometric views, virtual walkthroughs, visualisations and animations,
- ▶ etc.

A typical scope of a building's extant state documentation includes:

- ▶ a BIM model, which is a virtual building (.ifc, .pla, formats, etc.),
- ▶ technical documentation in a scale of 1:50 or 1:100 (.dwg, .pdf, .jpg format) – floor plans of characteristic levels, facades, cross-sections through any location, etc.,
- ▶ schedules: of rooms, volume, windows and doors,
- ▶ perspective and axonometric views of a structure and additional 3D cross-sections,
- ▶ a 3D model of a structure useable on mobile devices, enabling virtual walkthroughs,
- ▶ additional data packages depending on specific needs.

The market's demand for designers who can effectively work within the scope described above is becoming higher each year.

#### 4.2.4. Creating library objects

The creation of object libraries which are meant to represent specific commercial products for the most popular computer-aided design software has become one of the most dynamically developing specialisations around the architectural and interior design professions.

- ▶ From the manufacturers' point of view, professional libraries with systematised objects that represent specific commercial products that can be placed in a design developed by an architect have become one of the most effective means of reaching clients and increasing the sales of offered products.
- ▶ From the point of view of the architect, the capability of inserting specific commercial products that retain their true dimensions and technical descriptions into a design greatly eases and quickens design work. This applies to both elements like all sorts of construction systems, windows, doors and gates, as well as all types of infrastructural and fitting elements of a building, etc.

The basic idea behind online services that offer object libraries that represent specific commercial products can be described in the following manner<sup>13</sup>:

- ▶ Manufacturers supply a service with their products in digital form – CAD drawings, technical data, descriptions, photographs, calculations. The online service provides special tools that enable this information to be entered.
- ▶ Manufacturers reach out to designers with their offering – they send emails to the inboxes of designers who are registered with a service, order their own CD-ROMs through the services, “opening their windows” to the designers with their offerings on their own websites, etc.

<sup>13</sup> [https://www.archispace.pl/node/31231\\_Oferta](https://www.archispace.pl/node/31231_Oferta) (access: 7.04.2017).



- ▶ Designers search for and select specific products through an online service's search engine, the manufacturers' websites, or by reading messages sent by manufacturers.
- ▶ Designers download products from the online services of manufacturers – in the form of CAD drawings, drawings showing the details of construction solutions, layout patterns, etc.
- ▶ Designers include the manufacturers' products in their design documentation in the form of premade product drawings – 3D models, floor plans, cross-sections, views, drawings of construction details and their descriptions.
- ▶ Manufacturers deliver their products to a construction site.

A complete offering of online services that supply object libraries should include file formats for all the most popular CAD programs, starting with 2D CAD files, we should expect to find among search results files for AutoCAD, BIM-standard software should include files for Revit and ArchiCAD, while in the case of programs which are used to make photorealistic visualisations, files for 3ds MAX and other CAD systems.

Object libraries, depending on the product that they represent, should be developed in different ways:

- ▶ **2D object libraries** – for designs developed in AutoCAD, as flat drawings of top-bottom and side views, as well as cross-sections.
- ▶ **3D object libraries** – for designs developed in BIM programs (for instance ArchiCAD and Revit), as well as for Sketchup and 3ds MAX.
- ▶ **Parametric object libraries** – for designs developed in BIM programs (for instance ArchiCAD and Revit). Parametric objects make it possible to change certain parameters within the objects, such as width and height of doorframes or the type of door. They require adapting the objects to the library module of the program for which they are designed.

An example of the use of object libraries in the design of a toilet for disabled persons has been presented in Figure 7.

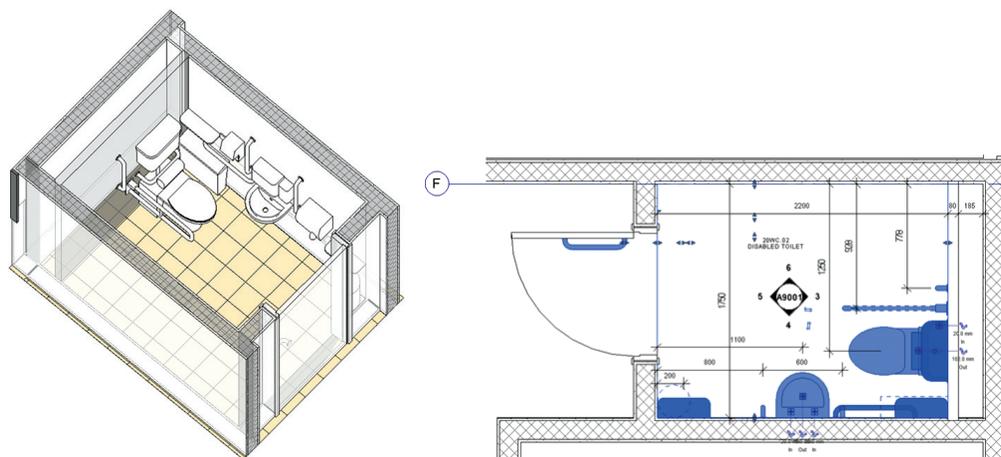


Fig. 7. Working with a BIM Library – highlighted in blue is the BIM Library plumbing fixture accessible toilet family with shared nested plumbing fixtures; the accessories are available as individual families. Source: <https://www.thenbs.com/knowledge/working-with-nbs-national-bim-library-content> (access: 21.04.2017)

Using libraries featuring premade elements is becoming widespread among architects, even already at the stage of their architecture studies. We can download all sorts of elements from the numerous object library sharing forums, so that we can use them in the designs that we work on. However, despite a very large and constantly increasing offering of online services with object libraries, a very large amount of products are still not available. Thus, the ability to create our own object libraries is greatly needed and should be introduced into the educational curriculum. Furthermore, due to the large market demand for designers who can create such objects, it is an interesting possibility of the commercial application of one's skills and cooperation with professional services.

#### 4.2.5. New presentation methods – BIMx

According to architecture students, the printing of course design theses is associated with a heavy financial cost. The cost of preparing a complete set of full-colour sheets glued to a stiff sheet of foam that presents a typical design work along with visualisations amounts to around 200 PLN. Over the course of a semester, students typically produce around 5 of such designs. When the costs are multiplied by the amount of students, this produces truly sizeable amounts of money...

As it turns out, it is not necessary to pay these costs, as new technologies in the presentation and archiving of design work allow us to make multimedia presentations of a design in a manner which is qualitatively incomparable to traditional paper prints.

The ability to present a design in the form of an interactive multimedia presentation broadens the possibilities of using it so that they exceed traditional applications.

One example of such a technology is BIMx software (Building Information Model eXplorer)<sup>14</sup> – it cooperates with ArchiCAD and allows the creation of a virtual presentation of a designed building. The program converts the model of a building into an .exe file, which can be sent to a client. After opening the file we can take a walk around the building like in a computer game, moving between rooms, using doors. By using appropriate virtual reality goggles like Oculus, we can obtain an illusion of depth. Such a virtual visit to a building which does not exist yet is an extraordinary experience for a client, while enabling architects to more effectively sell their designs. The GRAPHISOFT BIMx application has led to a situation in which BIM has also reached parties which are interested in, but that are not directly participating in the process of a building's design, for instance to contractors, manufacturers, clients and owners of buildings or real estate agencies.

The program is available in Polish.

BIMx models can be viewed on mobile devices such as iPads/iPhones. Thanks to a dedicated free application, BIMx files can be opened on any device using iOS or Android, as well as on Mac or Windows computers. The application is linked with the Facebook user community which shares these types of files.

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<sup>14</sup> GRAPHISOFT BIMx Desktop Viewer User's Manual, GRAPHISOFT, 2016.



Fig. 8. BIMx Application, used to present a BIM-standard design on mobile devices like iPads/iPhones.  
Source: <https://itunes.apple.com/us/app/bimx-building-information-model-explorer> (access: 7.04.2017)

New uses of programs of this type, like the aforementioned BIMx, are still growing. Thanks to the ability to “plug in” any database and additional information to the presentation of a virtual design saved in a BIMx program, we can use such a presentation in numerous, entirely new ways:

- ▶ **The presentation of real estate developer designs** – a virtual design of a building can be visited using Oculus-type goggles, selecting furniture and fittings.
- ▶ **Designs of exhibitions** – exhibits that we can “approach” in a virtual model of an exhibition can have any and all descriptive information, multimedia presentations and videos “plugged in”.
- ▶ **Interactive urban mock-ups** – the ability to “attach” various types of interactive information into any selected points of a virtual urban mock-up can help both in the creation of designs used to tour an urban space across various education routes, as well as commercial projects – that promote certain structures or services.
- ▶ **Instruction manuals regarding the equipment and infrastructure of a building** – a virtual design of a building can be used during the operation phase, for instance by “attaching” various types of instruction manuals to the technical elements of a building, as well as infrastructure drivers.
- ▶ etc.

Architects who can create these types of innovative virtual presentations for iPad-type mobile devices have a wide field from which to obtain new commissions and broaden the market for their services.

## 5. Summary and conclusions

Even a cursory review of new technologies that support architectural and construction design as well as the new specialisations that have emerged around the architectural profession indicate that currently ongoing changes are revolutionary in character – to a much wider



degree than the changes that occurred a couple of decades ago when manual drafting had been replaced by computers with the first 2D CAD systems.

The ongoing changes are invariably leading to alterations in the current design standards, based on 2D CAD systems, in the direction towards the widely understood BIM standard.

The new specialisations which emerge in association with the technological progress around the architectural profession broaden the traditionally understood market for architectural services.

The subject of designing using the BIM standard and the new specialisations should be, in the author's opinion, introduced into the curriculum of architecture students as fast and as broadly as possible.

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