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INFORMATION TECHNOLOGY OF MAKING CONTROLLED CRITICALLY SAFE DECISIONS ABOUT MODEL PARAMETERS CONVERSION AT TRANSFER BETWEEN VISUALIZATION SYSTEMS

In modern production, computer-aided design systems have become widespread, which provide the opportunity to create technological processes with less time and engineering. Automated design system is a system capable of automated level to implement information technology to perform design functions, is an organizational and technical set of software tools designed to automate the design process, consisting of staff and a group of technical, software and other means of automating its activities.

Computer-aided design systems are an important link in industrial design, widely used in many industries, including the automotive, shipbuilding and aerospace industries, industrial and architectural design, prosthetics and many others. CAD is also widely used in computer animation for special effects in movies, commercials, and technical materials, often referred to as digital content. Due to its economic importance, the computer-aided design system has become the main driving force of research in the field of computational geometry, computer graphics (both hardware and software) and discrete differential geometry.

In today's automated manufacturing market, most constructors use additional engineering software. As a rule, such add-ins are used in the functional infrastructure of a specialized set of solutions that implement the principle of building information modeling (BIM). The most common system of this type is Autodesk Revit, a platform that provides three-dimensional modeling of building elements and flat drawing of design elements, designed for architects, designers and design engineers.

This research presents the results of information technology for Autodesk Revit computer-aided design system based on 2019-2021 packages, which will allow users of the architectural visualization platform to use the functions of viewing, processing, mathematical transformation and serialization on elements of 3D building models.

Keywords: coordinate systems, visualization systems, Autodesk, Autodesk Revit, Building Information Modeling.

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ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ ПРИЙНЯТТЯ КОНТРОЛЬОВАНИХ КРИТИЧНО-БЕЗПЕКОВИХ РІШЕНЬ ПЕРЕТВОРЕННЯ ПАРАМЕТРІВ МОДЕЛЕЙ ПРИ ТРАНСФЕРІ МІЖ СИСТЕМАМИ ВІЗУАЛІЗАЦІЇ

На сучасному ринку автоматизованого виробництва більшість інженерів-конструкторів мають потребу в застосуванні додаткового програмного забезпечення. Як правило, такі надбудови використовуються у функціональній інфраструктурі спеціалізованого комплексу рішень, що реалізують принцип інформаційного моделювання будівель. Найпоширенішою системою такого типу є Autodesk Revit, тобто платформа, яка надає можливості тривимірного моделювання елементів будівлі і плоского креслення елементів оформлення, призначеного для архітекторів, конструкторів і інженерів-проектувальників.

Ключові слова: системи координат, системи візуалізації, Autodesk, Autodesk Revit, Building Information Modeling.

FORMULATION OF THE PROBLEM

Computer-aided design system has a set of functional tasks that allow engineer to basically proceed the information modeling of architectural and construction 3D models. However, like any system of geometric visualization, these platforms are limited in the implementation of specialized processes, for example, in the calculations of local coordinates related to the view elements on the engineering sheets. Therefore, by the infrastructure of Autodesk platform and its application programming interface developers obtain the ability to

organize an unlimited number of engineering add-ins which will be used to solve a specified collection of tasks.

ANALYSIS OF RECENT RESEARCH

Autodesk Inc. is the world's largest provider of software for industrial and civil construction, mechanical engineering, media and entertainment markets. The company has developed a wide range of replicated software products for architects, engineers and designers. There are currently more than 9 million Autodesk users worldwide [1].

In total, Autodesk currently produces about a hundred software products. Four systematized divisions are engaged in development:

1. Solutions for industrial production and mechanical engineering is a comprehensive set for design and engineering, which is used in various industries, including mechanical engineering, electromechanical, automotive production of industrial equipment and consumer goods. Many products are based on digital prototype technology. The solutions of this segment include: Autodesk Inventor, AutoCAD Mechanical and AutoCAD Electrical, Autodesk Simulation.

2. Solutions for the architectural and construction industry [2]. The programs of this group are used mainly by various architectural and design workshops, as well as other construction companies for the design of various buildings and structures, modeling and analysis of their structures and subsystems. These solutions include parametric design systems based on building information modeling technology Autodesk Revit Architecture and Autodesk Revit Structure, applications for the design of building subsystems AutoCAD Architecture, AutoCAD Civil 3D and AutoCAD MEP, as well as analytical systems for solving problems of environmentally friendly design. The solutions of this segment include: Autodesk Revit, AutoCAD Civil 3D, AutoCAD Map 3D.

3. Solutions for working with animation, graphics and creating virtual reality. Tools for creating multimedia materials in all areas of the entertainment industry, from visual effects in film and television, and color correction to animation, rendering, and computer game development. Major developments include 3D graphics editors Autodesk Maya, Autodesk 3ds Max and Autodesk Softimage, Motionbuilder animation solutions, Mudbox digital image sculpting, Burn, Inferno, Flame, Flint, Luster and Smoke special video effects processors.

Information technology about parametric transformation based on the system of building information modeling belongs to the category of solutions for the architectural and construction industry, so at the stage of analysis of existing software in the subject area were selected the following computer-aided design systems: Autodesk Revit and AutoCAD Civil 3D.

Autodesk Revit or simply Revit is a software package for computer-aided design, which implements the principle of information modeling of buildings (figure 1).

The computer-aided design system is designed for architects, designers and design engineers [3]. The platform provides the opportunities for three-dimensional modeling of building elements and flat drawings of design elements, creation of custom objects, organization of joint work on the project, starting from the concept and ending with the release of working drawings and specifications.



Figure 1. Autodesk Revit

AutoCAD Civil 3D is a software product for professionals in the field of land management, surveying, master plan design and infrastructure [4]. It is based on the use of BIM-technologies and three-dimensional mathematical model of objects. AutoCAD Civil 3D allows you to fully automate the design of infrastructure objects, the creation and release of working documentation, ranging from the collection and processing of field data, geodetic surveys and ending with 3D-visualization of the design concept and the construction of the objects themselves.

In the market of automated products for solutions of the architectural and construction industry, there are a large number of software products for the development of BIM-model and subsequent design of working documentation. If you consider modeling tools, the Revit package has everything you need to quickly and accurately build a 3D model.

With proper preparation of the template, all the information part will already be embedded in the BIM-model. As part of the template preparation, BIM coordinators configure all the necessary specifications. As the BIM model is built, these specifications are automatically populated and, in the event of any changes, are automatically updated. These settings can also be made with dynamic blocks in Autocad, but in some technical scenarios they may not look very stable.

In the Revit computer-aided design system, the model and the specifications are interrelated [5]. That is, you can select any element in the specification and show it in any form where this element/elements are present. This allows you to: eliminate unnecessary elements, quickly fill in the specifications and coordinate the project.

When Revit lacks standard tools, there is a large database of plug-ins that allow you to perform various actions. From the simplest, such as alignment of elements according to the given law or the expanded choice of elements of model on parameters, to more difficult - for example, automatic construction of finishing of rooms.

Therefore, after analyzing the existing software of the subject area and determining all the necessary conditions for creating information technology for model parameters conversion, we can conclude that the software add-in will be implemented for the automated design system Autodesk Revit.

The purpose of the research: thus, having analyzed the characteristics of the subject area, a set of definitions for working with the position of mathematical objects and architectural and construction visualization system, for information technology about conversion of BIM 3D model parameters there is an implementation of the following functional stages:

1. Development and organization of technical means for creating a tool add-in in the computer-aided design system Autodesk Revit.
2. Definition of the basic parameters for work with components of building 3D models. Systematization of data on the elements of the room, obtaining standard information through the Revit API.
3. Formation of a mathematical model in order to convert the coordinates between the elements of the architectural and construction model and engineering sheets.
4. Organization of the results related to mathematical processing in the text format of data exchange. Generation of built-in elements of architectural and construction visualization.
5. Development of an auxiliary module for working with software resources of the Azure cloud service. Create and configure a storage account with a 5GB quota. Sending the resulting data with subsequent synchronization within the cloud service. Transfer of engineering specification between architectural visualization systems.

PRESENTATION OF THE MAIN MATERIAL

Coordinate transformation is the replacement of a coordinate system on a plane, in space, or, in the most general case, on a given n -dimensional variety [6].

All rectangular coordinate systems in the study space are equal, ie the choice of one of them is not worse or better than the choice of another. These or those preferences are given based on the specifics of a particular task. The use of different coordinate systems poses the problem of converting the coordinates of a point, ie the problem of calculating its coordinates in one coordinate system by its coordinates in another system.

The Revit computer-aided design system, designed to work with architectural solutions, uses two coordinate systems: the survey coordinate system and the project coordinate system [7].

The survey coordinate system is the real context for the building model. It is designed to describe the location on the earth's surface. The survey coordinate system is used to identify a specific location on the ground where the Revit model is located. This coordinate system is created outside the context of the project.

A large number of shooting coordinate systems are standardized. Some systems use latitude and longitude, while others use the coordinates of points on the X, Y, and Z axes. Surveying coordinate systems use much larger scales than project coordinate systems, and take into account details such as land and terrain curvature that are insignificant for coordinate systems of project systems.

The coordinate system of the project describes the location relative to the building model. It uses the selected point within the plot as a reference point to measure the distances and locations of objects relative to the model.

The project coordinate system is used to determine the location of objects relative to a given point next to the model. This coordinate system is unique to the current project. The beginning of the internal coordinate system is the basis for the survey coordinate system and the project coordinate system.

Information technology for converting the parameters of geometric objects involves the generation of a single digital model in the context of architectural components. To implement this idea there is a need in systematization of mathematical algorithms to convert the coordinates between the elements of the BIM model and engineering sheets.

The essence of the View is the basic view for all types of View in Autodesk Revit. The view can display an image created with the Revit model. Displays can be graphical, such as plans, heights, or 3D views, or textual, such as graphics (figure 2).

Autodesk Revit's suite of application programming interface allows you to operate architectural objects at

the Active View level. As a rule, the array of geometric primitives is organized under the coordinate system of the project, that is, the center of mathematical calculations is a point set by the author of the document.



Figure 2. Floor Plan in Autodesk Revit

Engineering sheet or Sheet/ViewSheet entity is a type of architectural mapping consisting of a model view and a header. Each sheet has a unique sheet number in a complete set of drawings. The number is displayed before the sheet name in the project browser (figure 3).

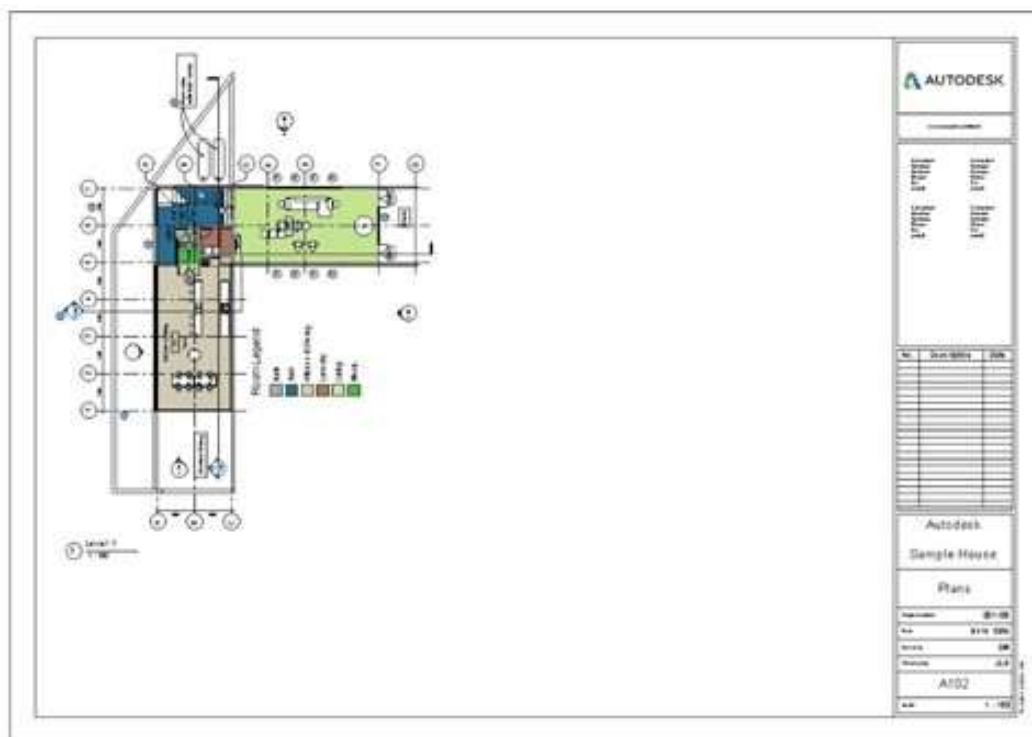


Figure 3. ViewSheet in Autodesk Revit

The main structural element for the ViewSheet entity is an object called Viewport, which acts as an information intermediary between the specific mapping of the floors and the engineering sheets on which these mappings are placed. The ViewSheet coordinate system is a two-dimensional paper space, where the center of coordinates by default is the lower left corner of the active sheet. In case the user of the platform for architectural solutions tries to remove the header from the ViewSheet view, Autodesk Revit will automatically set the center of

the paper coordinate system depending on the location of the Viewport components.

For design of structure and systematization of information technology regarding the parameters transformation of architectural and construction 3D models there is a need in the analysis and automation of information flows processing. The functionality of the engineering add-in must match all the necessary conditions for data processing from the Revit API. The business processes in Autodesk Revit can be divided into the following groups:

1. Business process for working with views of the active document (figure 4):
 - display a list of document views;
 - view data of the active view;
 - interactions through Revit: connection and scaling functions for the relatively active view;
 - search for objects from the list of available views.

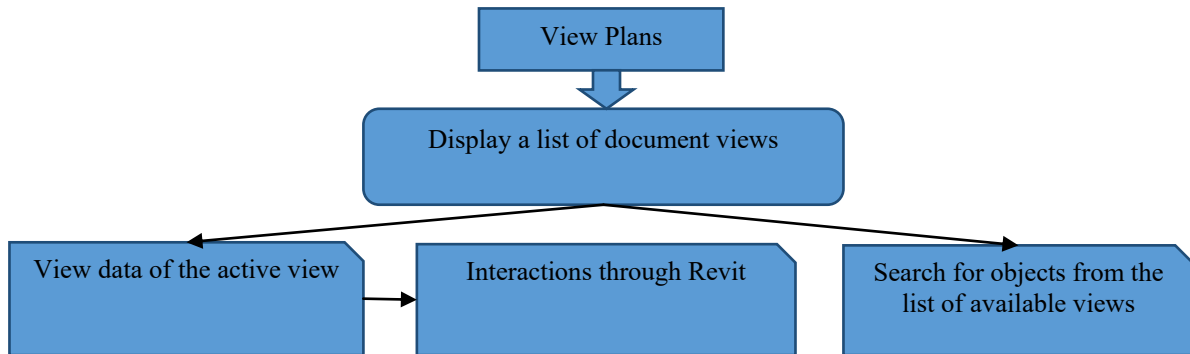


Figure 4. Business process for working with views of the active document

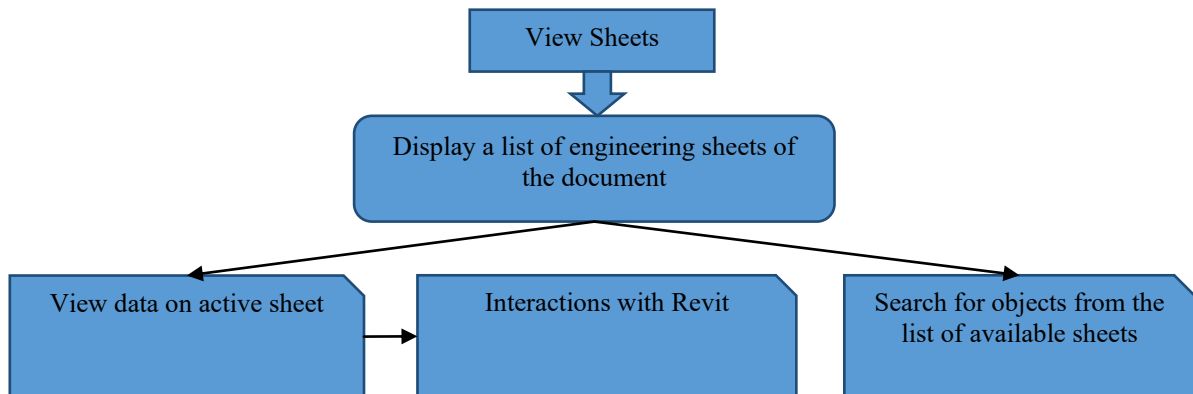


Figure 5. Business process for working with a sheet of an active document

2. Business process for working with a sheet of an active document (figure 5):
 - display a list of engineering sheets of the document;
 - view data on active sheet;
 - interactions with Revit: function of connection of the active engineering sheet;
 - search for objects from the list of available engineering sheets.

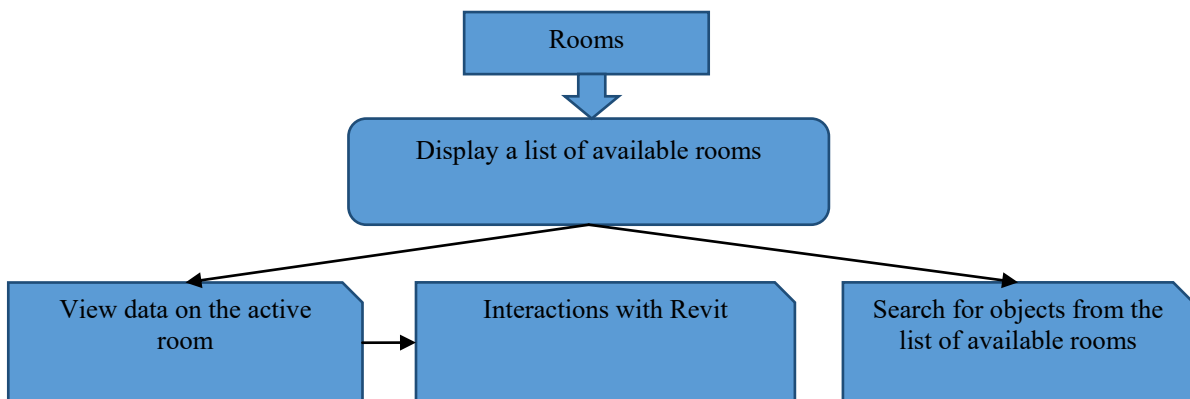


Figure 6. Business process for working with rooms at the level of active view

3. Business process for working with rooms at the level of active view (figure 6):
 - display a list of available rooms;

- view data on the active room;
- interactions with Revit: zoom function to the active room;
- search for objects from the list of available rooms.

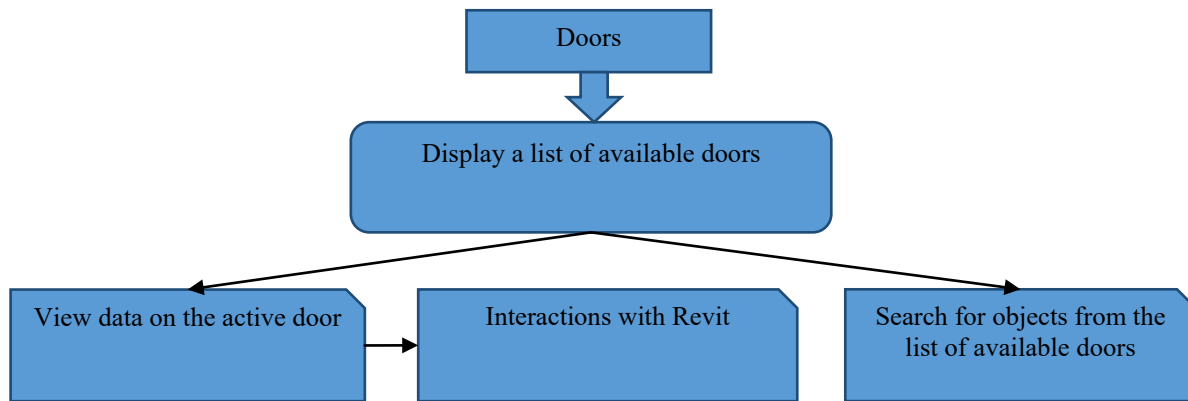


Figure 7. Business process for working with doors at the level of active view

4. Business process for working with doors at the level of active view (figure 7):

- display a list of available doors;
- view data on the active door;
- interactions with Revit: zoom function to the active door;
- search for objects from the list of available doors.

5. Business process for working with linked documents (figure 8):

- display a decision tree for linked documents;
- display rooms and doors for each linked document;

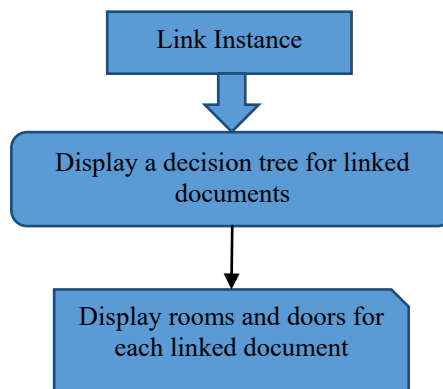


Figure 8. Business process for working with linked documents

6. Business process for working with metadata generation (figure 9):

- display a list of engineering sheets at the level of the active document;
- give the user the opportunity to select sheets before sending to the resources of the Azure cloud service;
- review of current information on the created data;
- generate metadata and their images based on selected engineering sheets.

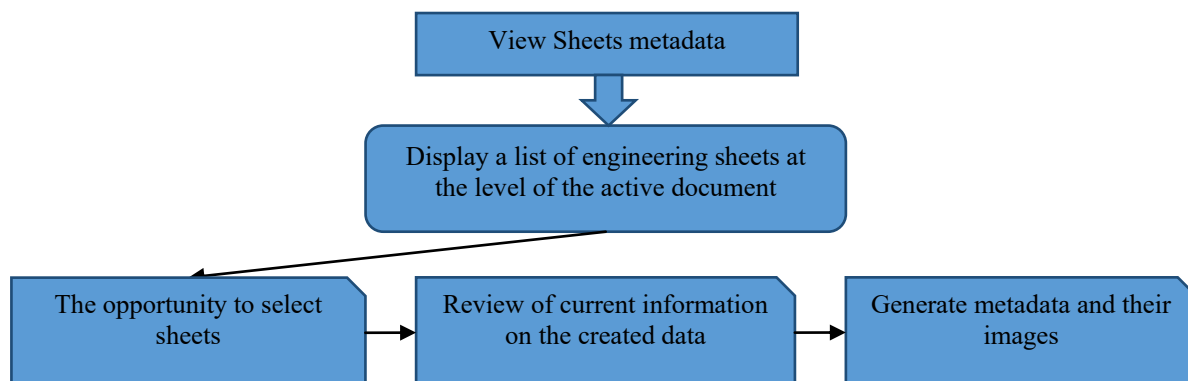


Figure 9. Business process for working with metadata generation

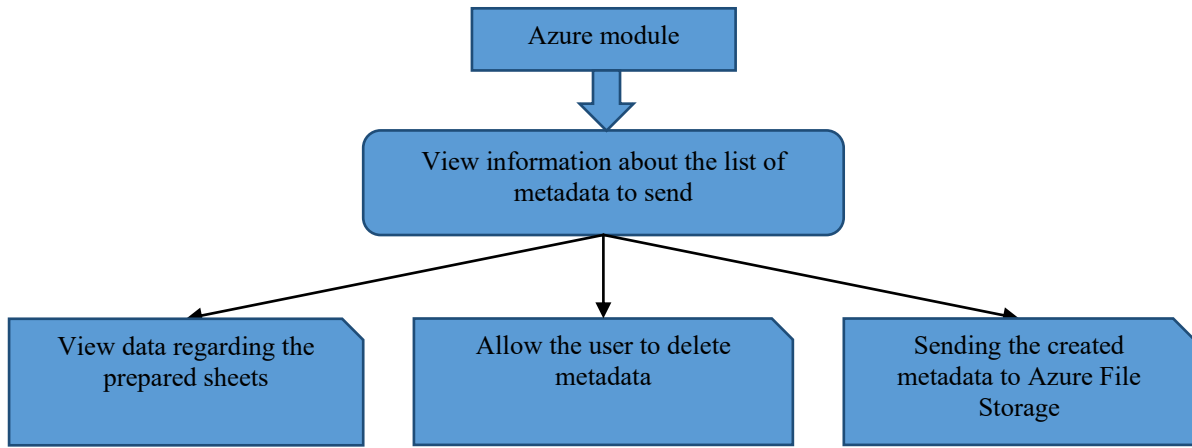


Figure 10. Business process for working with sending data to Azure File Storage

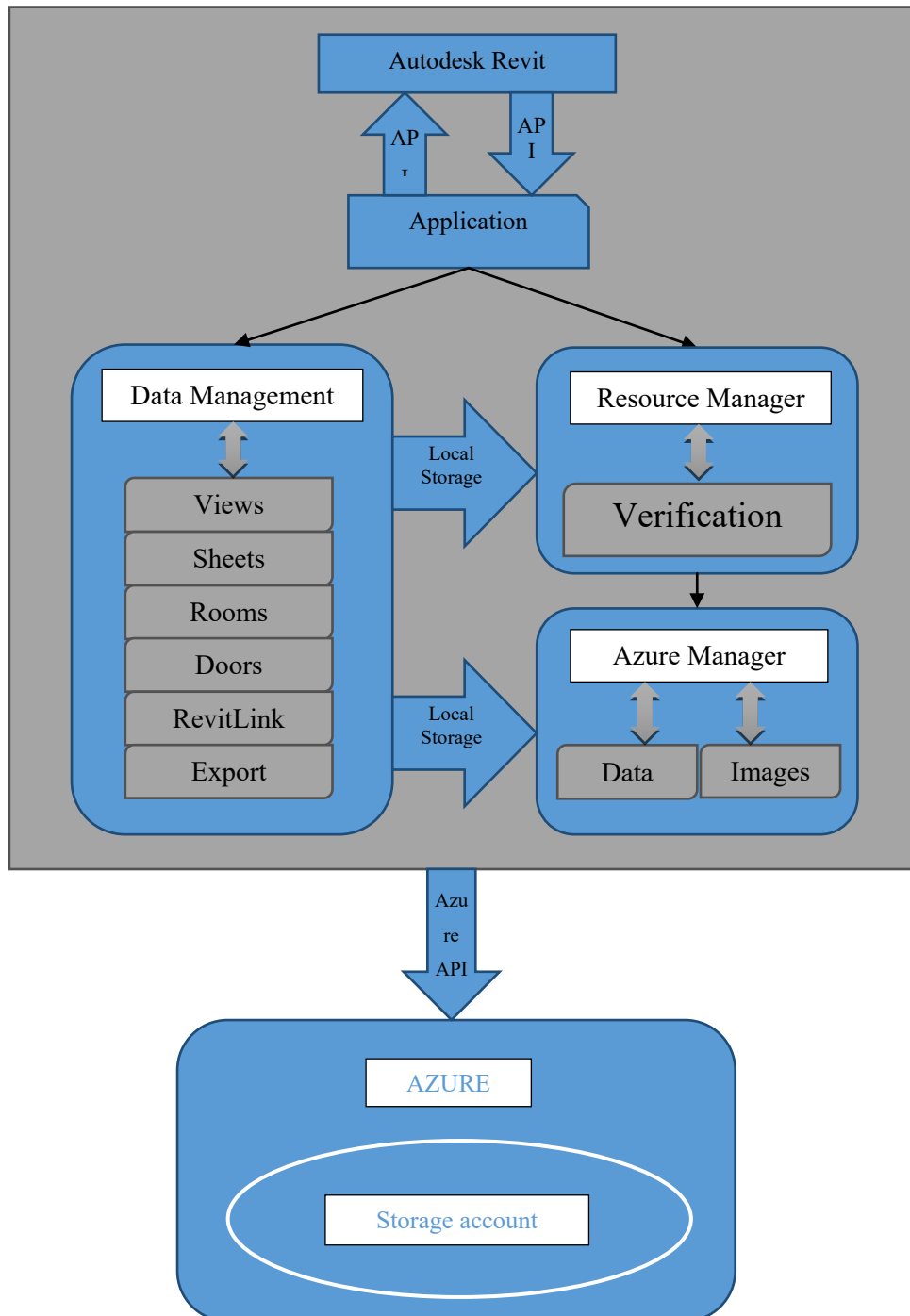


Figure 11. Functional user diagram of the engineering add-in

7. Business process for working with sending data to Azure File Storage (figure 10):

- view information about the list of metadata to send;
- allow the user to delete metadata;
- sending the created metadata to Azure File Storage.

The user of the computer-aided design system must perform a certain sequence of actions to activate the engineering superstructure and further work with the data on the connected architectural and construction 3D models.

Queries with subsequent information modeling of architectural and building elements of 3D models engineering add-in in the structure of Autodesk Revit should be carried out due to the integrated software interface Revit API. To work with the business processes of the active document, the end user must first approve the installation of the main library of the add-in in the functional infrastructure of the computer-aided design system.

It is expected that the implementation of the information module, resource manager and cloud service Azure will be implemented through the components of the user interface from the Windows operating system. The above set of elements will prepare the data of the geometric specification when transferring between visualization systems.

CONCLUSION

Thus, after analyzing the processing of information flows, the engineering technology of model parameters conversion was determined by a complete list of business processes that are subject to automation algorithms. Given the object-oriented feature groups and the organized functional diagram of the computer-aided design systems user, it is possible to configure the structure of the information system, which will be designed to work with the elements of the level with the subsequent generation of their geometric data at the local paper-space coordinate system.

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