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PUB-WOOD

Building Use and Maintenance

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Fundamentals of Building Use and Maintenance

Goals of building management, maintenance and administration

1. to ensure the operation and maintenance of buildings and structures (physical preservation throughout their life cycle) in accordance with the requirements of the regulatory enactments of each country;
2. to promote the improvement of buildings and structures throughout their operation;
3. to ensure the continuity of the management process of each building and structure;
4. to preserve and develop the aesthetic values of buildings and structures as environmental objects and, consequently, also the aesthetic values of the respective environment;
5. to prevent risks related to public and environmental safety during the operation of buildings and structures;
6. to improve the qualification of persons involved in the management of buildings and structures in order to improve the organisation and efficiency of management work.

Management principles of buildings and structures

1. the continuity of the management process ensures the preservation of the use properties (quality) of buildings and structures throughout their life cycle;
2. the selection of the most optimal possible management work methods, including the formation of optimal management expenses of buildings and structures, comparing them with the solvency of the owner of the building and structure;
3. the content and quality of the provided services ensure the preservation of the use characteristics (quality) of the managed buildings and structures throughout their operation;
4. inadmissibility of an infringement of the safety or health of an individual in the management process;
5. ensuring the preservation and improvement of the quality of the environment in the management process.

Management of buildings and structures includes:

1. mandatory management activities;
2. other management activities.

Mandatory management activities (1)

1. maintenance (physical preservation) of buildings and structures in accordance with the requirements of regulatory enactments specified in each country, which includes:
    a. sanitation of buildings and structures;
    b. the supply of heat, including natural gas, the provision of water and sewerage services, the disposal of municipal waste by concluding an appropriate agreement with the service provider;
    c. the supply of electricity to the part of the buildings and structures jointly owned (including the operation of the jointly owned facilities);
    d. inspection, maintenance and repair of buildings and structures, as well as their equipment and engineering facilities;
    e. ensuring the fulfilment of the requirements set for buildings and structures as an environmental object;
    f. ensuring compliance with minimum energy performance requirements for buildings and structures;

Mandatory management activities (2)

2. planning, organisation and supervision of management work, including:
   a) drawing up a management work plan, including a plan of maintenance measures;
   b) drawing up the draft budget for the year in question;
   c) organisation of financial accounting;
3. management of building and structure cases;
4. conclusion of an agreement regarding the use of the attached land plot with the owner of the land plot (in accordance with the legislation of the relevant country);
5. provision of information to state and municipal institutions.

Regular cleaning works of the territory:

1. cleaning of sidewalks, paths and driveways;
2. mowing of the grass growing in the territory;
3. collection of fallen leaves, dead plants and branches;
4. care of greenery.

During the winter period, additional regular cleaning works of the territory should be done:

1. cleaning of sidewalks, paths and driveways, if necessary, cleaning also other parts of the territory from snow and ice, spreading anti-slip materials on sidewalks, paths and driveways;
2. removal of snow and ice (including icicles) from the facade and roof of the building in order to prevent ice and snow from falling from the roof of the building, cornices, water drains, loggias and balconies;
3. demarcation of dangerous places for the safety of pedestrians and vehicles. Measures to prevent the risk must be taken in good time, using all possible safety measures.

The provision of water supply and sewerage services must comply with the requirements of each country's legislation, which stipulates:

1. the competence of public institutions in ensuring the availability of water management services;
2. general requirements and procedures for the provision and use of water management services;
3. the rights and obligations of the service provider and the service user.

Repairs

- Repairs are carried out to ensure the continued operation of the building, its equipment and engineering networks.
- Types of repairs:
  1. extraordinary repairs – timely prevention of the above-mentioned damage;
  2. planned repairs – prevention of damage within the term specified by the manager of the building.

Principles of environmental protection (1)

1. the “polluter pays” principle – a person shall cover the expenses related to the assessment, prevention, limitation and elimination of the consequences of pollution caused by his or her activities;
2. the precautionary principle – it is permissible to restrict or prohibit an activity or measure which may affect the environment or human health, but the effects of which have not been sufficiently assessed or scientifically proven if the prohibition is a proportionate means to protect the environment or human health. The principle does not apply to urgent measures taken to prevent the threat of injury or irreparable damage;

Principles of environmental protection (2)

3. the principle of prevention – a person shall, as far as possible, prevent the occurrence of pollution and other effects harmful to the environment or human health, but if this is not possible, shall prevent the spread thereof and the negative consequences thereof;
4. the principle of evaluation – the consequences of any such activity or measure which may have a significant effect on the environment or human health must be evaluated prior to the authorisation or commencement of the relevant activity or measure. An action or measure which may adversely affect the environment or human health, even if all environmental protection requirements are complied with, shall be permissible only if the expected positive result for society as a whole exceeds the damage caused to the environment and society by the action or measure.

Environmental policy planning

- When developing draft policy planning documents and regulatory enactments, the developer must evaluate their impact on sustainable development and the environment in the abstract of the draft planning documents or regulatory enactments. Draft policy planning documents (including buildings and structures) must be subject to a strategic environmental assessment, if this is specified in the regulatory enactments regulating environmental impact assessment.

General public environmental rights

- Every individual, associations, organisations and groups of persons, have the following rights:
  1. to require that state institutions and municipalities, officials or private entities terminate such an activity or inactivity, which deteriorates the quality of the environment, harms human health or endangers their life, legal interests or property;
  2. to support environmental protection measures and cooperate with state institutions and municipalities in order to prevent the performance of such activities, including the adoption of such decisions, which may worsen the quality of the environment or are in conflict with the requirements of environmental regulatory enactments;
  3. to provide information to state institutions and municipalities regarding activities and measures that affect or may affect the quality of the environment, as well as information regarding the negative changes observed in the environment that have arisen due to such activities or measures;
  4. to submit proposals to state institutions and municipalities regarding the legal framework and the developed draft documents in the field of environment.

Public right to environmental information

- The society has the right to receive environmental information from state and municipal institutions in writing, audio recording, visual, electronic or other form. In addition, the public shall have the right to receive information, where available, on measurement procedures, including methods of analysis, sampling and pre-treatment methods, or on any other standardised procedure used to compile information on environmental factors.

Public participation in environmental decision-making

- The public has the right to participate in the decision-making and drawing up the planning documents, including drawing up the amendments to those documents that may affect the environment. The public has the right to make proposals or express an opinion before taking the relevant decision or drawing up the final version of the document.

Requirements for ensuring energy efficiency of buildings and structures (1)

- When planning the renovation of the building, the manager must take energy efficiency measures that:
  1. ensure such a reduction in the heat energy consumption of the building that the heat energy consumption is less than the above-mentioned level of heat energy consumption;
  2. ensure the highest heat energy savings in relation to the funds necessary for the implementation of the measure.

Requirements for ensuring energy efficiency of buildings and structures (2)

- If conditions are found that contribute to the release of heat into the environment, the manager must take the following measures to increase energy efficiency:
  1. the external door must be equipped with a closing mechanism;
  2. heating system pipes and hot water pipes located in unheated premises shall be provided with thermal insulation;
  3. windows and doors must be sealed or replaced.

Maintenance file (documentation) of buildings and structures

- The information to be included in the maintenance file (documentation) of buildings and structures shall be summarised in the following sections:
  1. basic documents of buildings and structures – a document certifying real estate rights, a cadastral survey file of buildings and structures, a boundary plan of the attached land plot and an agreement regarding the use of the attached land plot;
  2. the owner (owners) of buildings and structures, the possessor of state buildings and structures (list);
  3. technical documentation – technical passport of buildings and structures (plans, schemes), project documentation, energy passport and energy plan, opinions of technical survey of buildings and structures, etc.;
  4. documents related to the maintenance and management of buildings and structures – the management agreement of buildings and structures, decisions taken by the owner (owners) of buildings and structures, including decisions adopted at general meetings of owners of buildings and structures, agreements applicable to management activities, management work plans, budget reports, etc.

Liability of the owner of buildings and structures

- The owner of buildings and structures shall be liable for the management of buildings and structures, including non-performance or improper performance of mandatory management activities, in accordance with the procedures specified in the legislation of each country.

Responsibility of the manager of the building

- The manager is responsible to the owner of the buildings and structures for the performance of the management task given to him/her in accordance with the requirements specified in the legislation of each country and in accordance with the provisions of the concluded management agreement. The manager shall be liable for non-compliance with the requirements of law when performing the management task in accordance with the procedures prescribed by the law of the respective country. The liability of the manager of buildings and structures shall take effect from the moment specified in the management agreement.

Use of Digital Technologies in Real Estate Management

Digital technologies in real iestate management

- Digital technologies in Real Estate Management is one of the tools for analyzing the quality of the lifecycle of the buildings. With the quality we are not thinking only visual design of the view but also see full management of the property, like the climate , ergonomic, design, environmental, building construction, construction properties, analysis etc. Digital technologies help to understand the real situation to collect regularity of information with several tools and put in database
- Wooden public buildings use the very specific construction elements and environmental materials for protecting the wood from climate but also we can look at the visual aesthetics. es and give the results of analysis.

Main factors that affect life quality inside of buildings

1. thermal comfort;
2. indoor air quality;
3. visual comfort;
4. aural comfort.

Objectives of buildings

1. to provide a good comfort level: learn the comfort zone from the user's preferences if possible; ensure satisfactory comfort level (thermal, air quality and illuminance) with good dynamic performance;
2. to increase energy savings: combine the comfort conditions control with an energy saving strategy;
3. to improve air quality control: provide enough ventilation to keep CO_2 levels low – possible use of controlled ventilation (DCV) systems.

Main factors that affect life quality inside of buildings and Standards

- thermal comfort can be measured by the Predictive Mean Vote (PMV) and PPD (predicted percentage of dissatisfied), presented in ISO 7730:2005;
- visual comfort is about having enough luminance level either by solar radiation or by lighting based on EN 12464-1 and EN 12464-2 standards;
- aural comfort is related to the acoustical environment inside a building, which means speech intelligibility and privacy;
- CO_2 concentration inside a building characterizes the level of indoor air quality (IAQ).

Digital inspection tools

- Visual inspection is one of the oldest and most widely used tools for inspecting and monitoring buildings. Visual inspection provides only part of the information that the human eye can see. Thus, we obtain only information that can be interpreted in RGB colors or visually understand whether the wood material is intact or damaged. Visual inspection also allows you to touch the material and understand its internal structure from the touch. Digital tools allow you to look deeper into the building elements by identifying the key parameters needed for a wooden building to last for a long time. The parameters to be determined are the internal climate data of the environment and the building element, geometric information, optical-visual information, and the resistance of the protective layers to the effects of the environment. This sub-chapter provides an in-depth look at tools that help inspect wooden buildings using digital visual inspection and climate control tools to obtain geometric information.

Visual and geometrical digital inspection tools

- The use of digital tools to collect visual and geometric information from buildings is one way to gather information that is available long after the fieldwork has been completed.
- There are many ways to get and save data. Photogrammetry and laser scanning tools are widely used to obtain data. These tools complement each other to produce both high-precision geometric information and high-resolution visual information. Digital tools that can be used are both simple for everyday use: a camera, a laser rangefinder, as well as high-end - laser scanners and unmanned aerial vehicles. This section discusses the use of laser scanners, drones, and simple rangefinders or cameras for digital survey of buildings.

3D Laser scanning

- Laser scanning is the measurement of the distance to the surface and back using a visible or invisible laser. This method for surveying buildings has been widely used since the 21st century. With the development of technology and data processing software, laser scanning is becoming one of the leading methods for collecting geometric information data about terrain - buildings, structures, vegetation, surfaces, soil, etc. combining laser scanning data with photogrammetry data results in a high photorealistic set of 3D points.

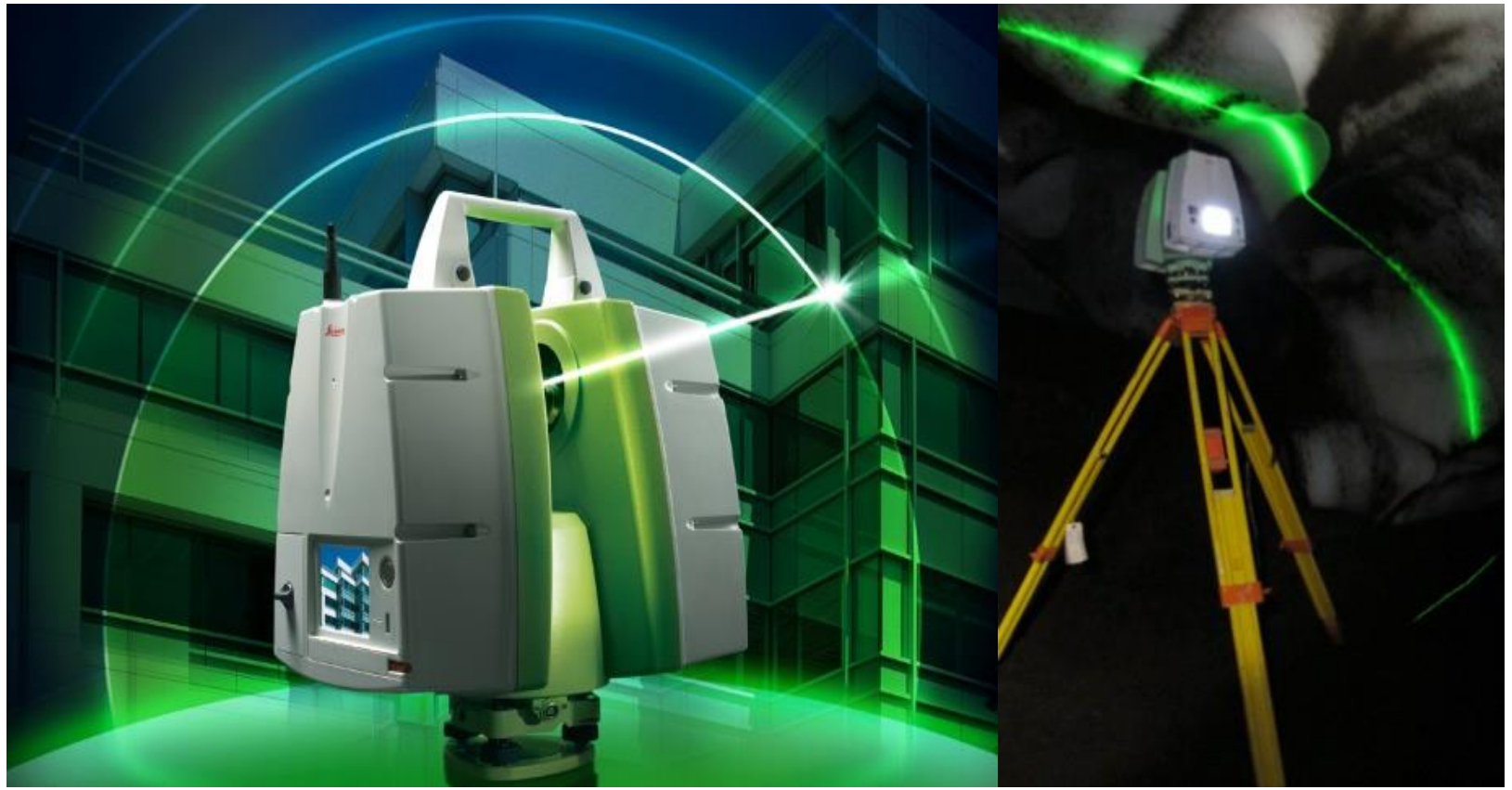
Wood building in 3D point cloud after renovation

Cyrax laserscanning system: a) Prototype, b) model *Alpha* (Cheves, 2014)

Laser scanners divided by wavelength

1. visible laser scanner (laser beam is usually green): 532 nm;
2. near-infrared scanner: 700–1300 nm;
3. infrared scanner: 1330-1550 nm.

Laser scanner with visible laser (LEICA Geosystems, 2020)



Laser scanners

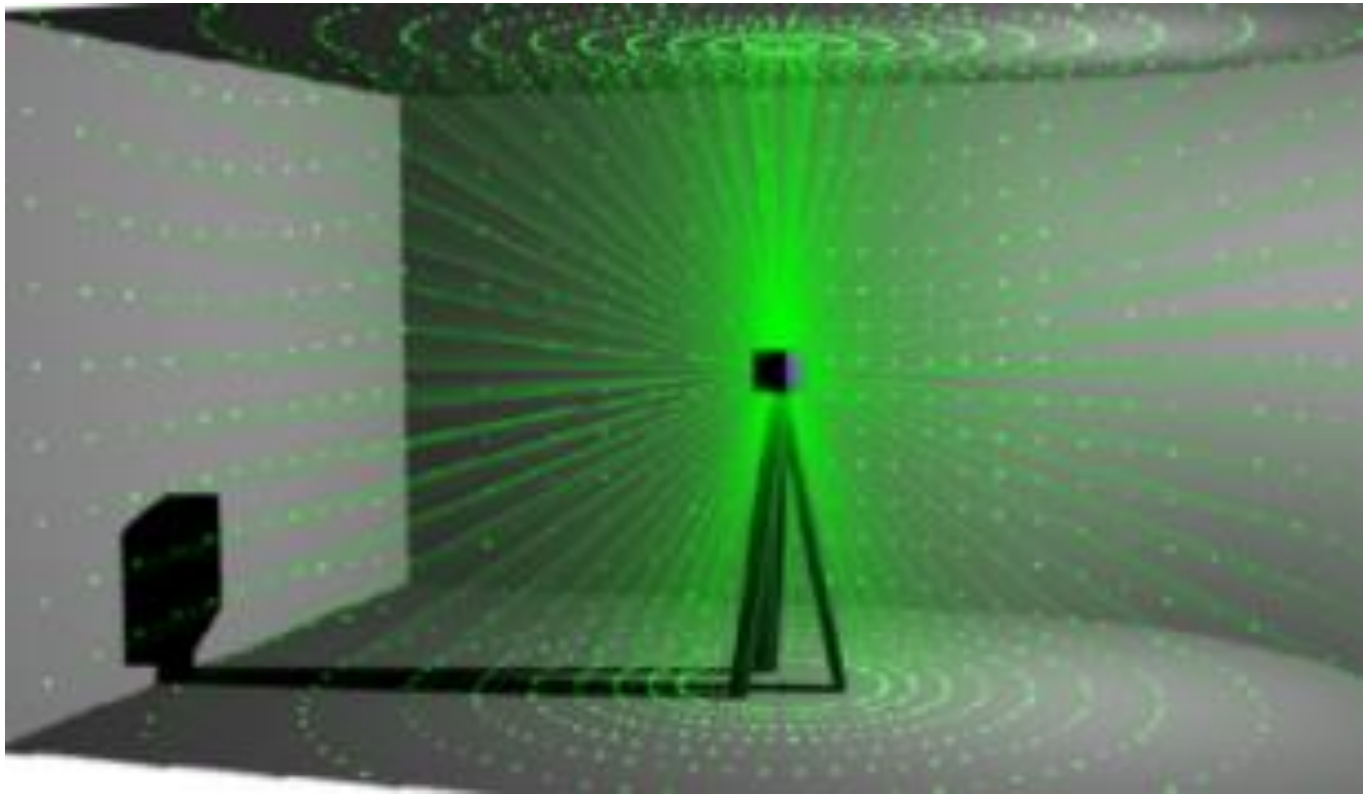
1. ALS – Airborne Laser Scanning
2. TLS – Terrestrial Laser Scanning
3. MicroLS
4. Dynamical-moving scanners

ALS – Airborne Laser Scanning

- Scanners used from aircraft to obtain large areas of 3D data, such as in agriculture, forestry, urban areas, etc.

TLS – Terrestrial Laser Scanning

- Scanners used for static ground surveying. The scanning distance can range from a few meters to several kilometers.



MicroLS

- Scanners used to scan objects at close range, such as reverse engineering, prototyping, documentation of cultural monuments, etc. The scanning distance is from a few millimeters to a few meters.

Dynamical-moving scanners

- Allows you to scan the surroundings while moving. The data is provided with an accuracy of a few centimeters.

Errors of laser scanner measurements

1. angular accuracy;
2. distance accuracy;
3. resolution;
4. boundary effects;
5. effect of surface reflectivity.

Angular accuracy

- The laser beam in the scanner is curved (refracted) by a mirror or prism and directed at the object. To bend the beam on another surface or perpendicular to the first, the axis of rotation of the instrument or additional optical devices are usually used. Angle reports on a specific surface are used to calculate spatial coordinate points. Any measurement errors of these angles will lead to errors in the direction measurements, perpendicular to the propagation of the laser beam line. It is for this reason that errors can occur, which can only be minimized by calibrating the instrument.

Distance accuracy

- Laser scanning systems, which are based on distance measurement, measure the distance with time after the output signal or by comparing the phases between the output and incoming beams. Such scanners are designed to work when the object is up to 100 m away, but even over longer distances they are accurate.

Resolution

- From the user's point of view, this explanation refers to the ability to find small objects or their components in a set of points. But from a technical point of view, two different technical parameters for laser scanning systems correspond to this explanation. And they are - the minimum angle between two adjacent points and the size of the laser print on the object itself.

Boundary Effects

- When the laser beam falls on the edges or edges of an object, only a portion of the reflected signal will return to the system. The remaining part of the received signal is the reflection from the mixed surface behind the edge or behind a surface that has nothing to do with the object to be scanned. Systematic effects can be observed when cylindrical and spherical objects are scanned from a close distance. In such cases, in the peripheral areas of the objects, their geometric center may not coincide with the center of the reflected beam.

Effect of surface reflectivity

- White surfaces are able to reflect the signal much more strongly than darker surfaces. When reflected from colored surfaces, the signal intensity depends on the spectral characteristics of the laser in the green, red and near infrared range. Glossy surfaces make it difficult to register signals. Surfaces with uneven reflectivity have been found to form systematic errors at distances. For some types of materials, these errors can reach a few times the VKK for single-distance measurements. To study the accuracy of the measurements, flat objects in white can be used by placing the material to be analyzed between them. After determining the approximate surface for this middle part and performing the same operation for the remaining white part of the object, regardless of the average object, a difference can be determined between these two surface types, which will allow to evaluate the effect of the given factor.

Environmental impact of laserscanning

- effect of temperature
- atmospheric effects
- influence of internal radiation sources

Effect of temperature

- Temperature has little effect on the operation of laser scanners because the distances are relatively short. Rather, it is possible to overheat the equipment where the internal temperature differs from the outside temperature.

Atmospheric effects

- When measuring short distances, the speed of light propagation due to temperature fluctuations and / or atmospheric pressure will not have a significant effect on the measurement results. When measured in conditions with high concentrations of vapor or dust in the air, results equivalent to the same effects as for edge and edge measurements are possible.

Influence of internal radiation sources

- Lasers operate in a rather narrow frequency band, so filters should be used at a certain frequency in the signal acquisition module. If the radiation comes from another object (sunlight or artificial lighting) and is quite strong compared to the work signal, then a significant part of this radiation can pass through the filter and affect the accuracy or even the overall result of the work.

Laser scanning workflow process

Laser scanning involves a series of steps:

- laser scanning process on field;
- data processing;
- visualization of results.

Stages of data processing process

1. matching scans (automatic and manual);
2. attachment to the coordinate system;
3. quality control;
4. scan cleaning;
5. creating a point cloud.

Point cloud file format

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103410724
18.12036 0.98179 24.56456 171 61 37 73
18.1667 1.06529 24.55429 168 63 43 80
18.09796 0.9647 24.58594 166 54 34 71
18.12745 0.98659 24.56544 172 62 38 72
18.23223 1.14699 24.64957 172 9 13 104
18.21556 0.94589 24.65992 159 1 11 70
18.17538 0.96645 24.59508 176 53 39 75
18.18456 1.04066 24.58462 170 60 43 85
18.18249 1.0862 24.58713 168 59 41 81
18.07549 0.95044 24.65836 165 29 22 66
18.16118 1.0643 24.55642 168 63 43 80
18.15135 0.95073 24.65052 162 12 7 74
18.18798 1.11787 24.59633 168 59 41 81
18.18266 0.96987 24.59394 166 55 39 78
18.17528 1.05935 24.57103 161 60 42 80
18.22757 1.15763 24.6518 173 0 2 71
18.20385 0.98217 24.64157 133 47 40 74
18.14335 0.98641 24.56905 168 63 37 72
18.11504 0.96121 24.58449 169 54 33 72
18.07836 0.95301 24.6143 164 48 36 76
18.10363 0.96197 24.59377 166 51 34 68
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Point cloud and 360-degree images

Digital close-range photogrammetry

- Photogrammetry is the science of taking measurements from photographs. This method has been used for more than 100 years, but mainly to meet the needs of cartography and architecture.
- In the last decade, with the development of digital photographic and imaging technologies, as well as unmanned aerial vehicles (UAV, drones), the scope of photogrammetry is expanding and becoming one of the leading methods for mass data collection on terrain - buildings, structures, vegetation, surfaces, soil etc.

Photogrammetry: 3D reality model of wooden building complex

Basic principle for taking the photography

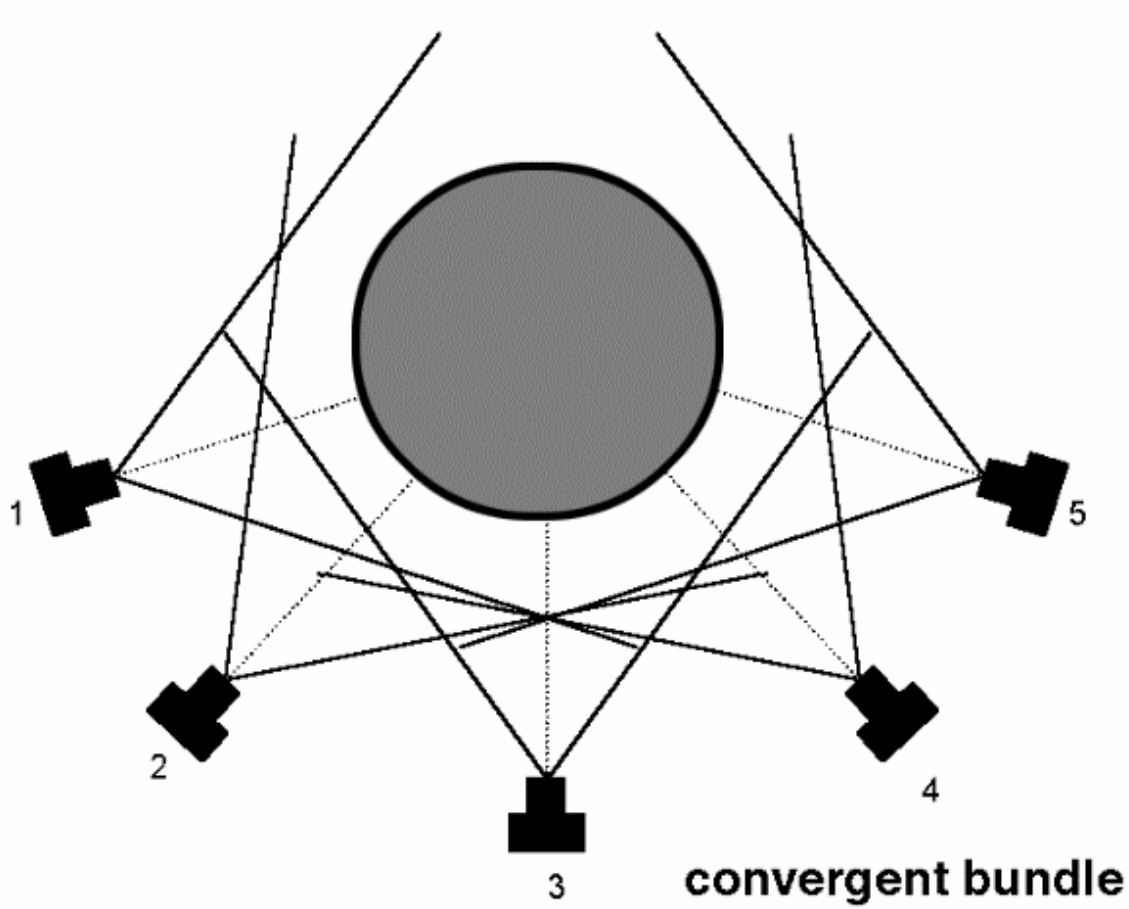
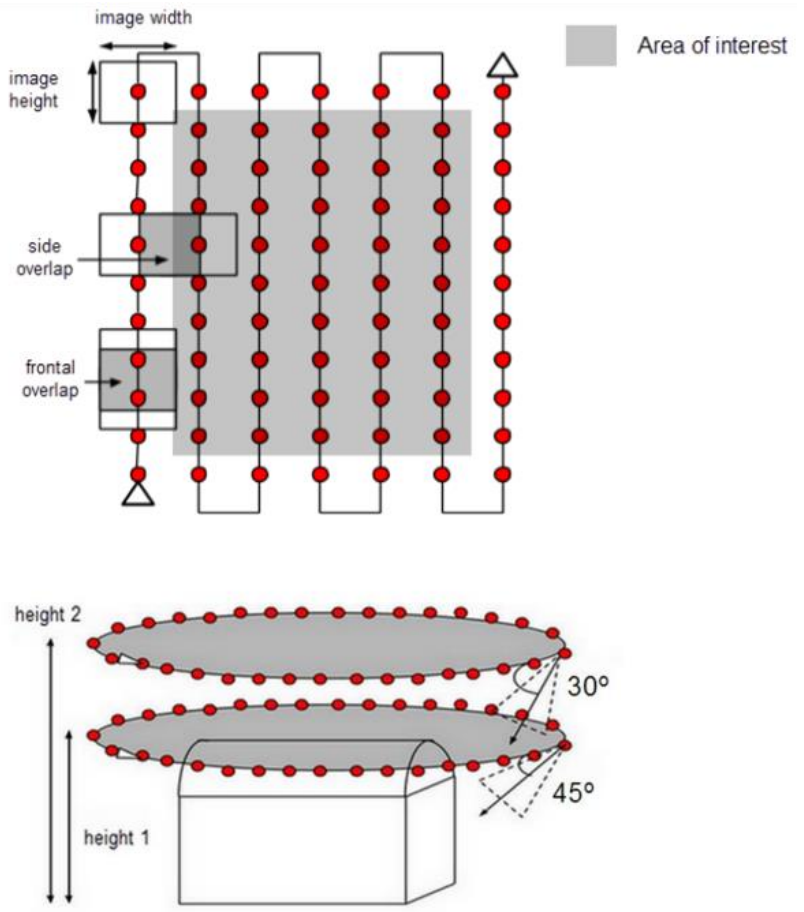


Photo-take planning

- Photo-take planning is a very important stage to ensure sufficient coverage and informative content of the acquired images in relation to the terrain objects, separate structures, linear corridor objects (roads, railways), high vertical objects (towers, chimneys, masts), interiors. For each type of object must choose the most suitable plan and its parameters, the most important of which are:
  - distance to the object or flight altitude;
  - the size of the overlay between adjacent images;
  - camera orientation.

UAV (Unmanned Aerial Vehicles) trajectories

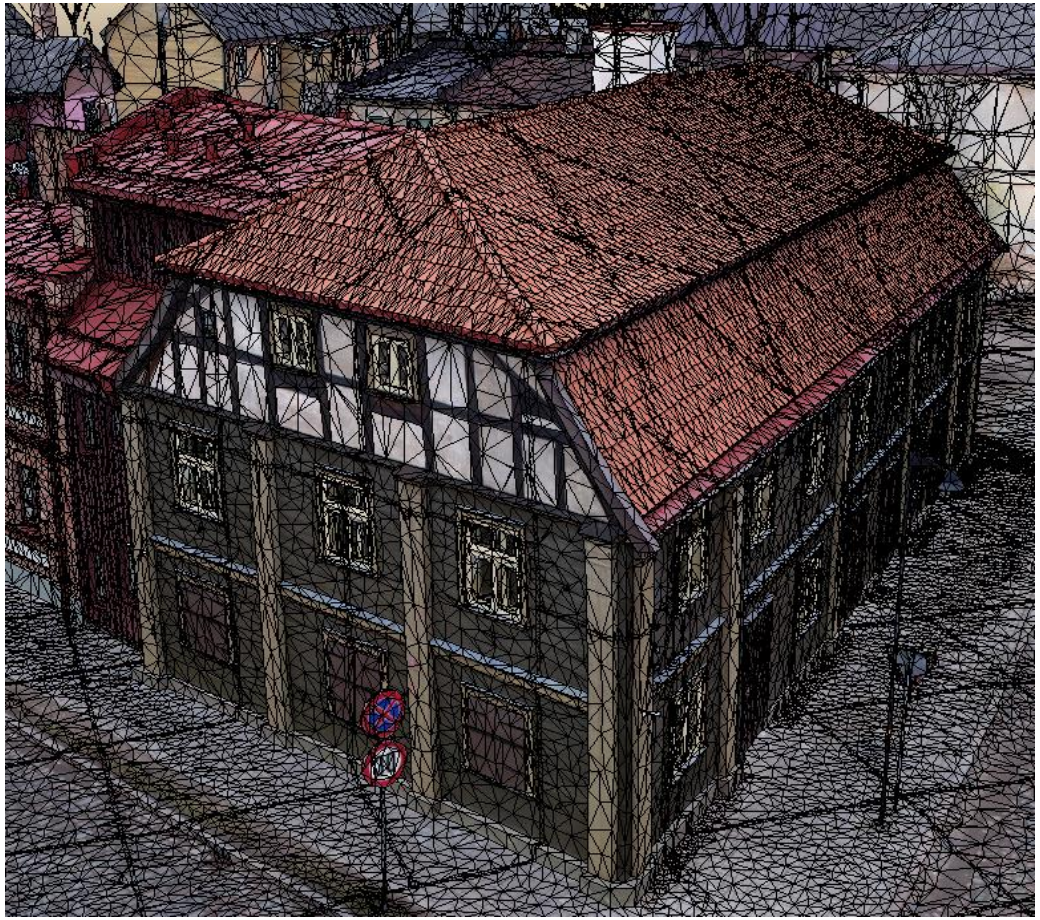


3D reality model before renovation process

3D reality model during renovation process

3D reality model after renovation process

3D reality model in mesh format



Laser distance meters

- Laser distance meter is a device that measures distance using a laser beam. Such devices are widely supplied in engineering surveying, topographic surveying, navigation, architecture and construction. Laser distance meter is very compact with many features as well as operating in a short time.

Simple laser distance meter

3D laser distance meter

Simple photo measure tools

- Measuring images is one of the fastest tools for getting both image and geometry information at the same time. Such tools can be combined with both a photo taking function and a distance detection function between the objects shown in the images. Another tool is 360 degree images providing full around image.

Photo 3D measurement tool

Digital tools – key remarks

- Digital tools help to understand the building during its maintenance period and make it possible to understand the behavior of structures, including the most important components such as foundations and the roof. Wooden structures are affected by practically any geometric change that exceeds the limit value and the wood breaks. Ground stability or the movement of structures is mainly influenced by meteorological parameters such as wind, snow, rain and temperature.

Control strategies for climate and energy systems

- On/Off control (Thermostat)
- Feed forward control (Weather compensator)
- PID control (Feedback)
- Model predictive control (MPC)

ON/OFF technique

- **ON/OFF** technique examples: thermostat, humidistat, and pressure switch. Commonly found in home heating systems and domestic refrigerators. Most used in HVAC systems due to the advantages it offers. However, intensive oscillations during operation and low energy efficiency reflect high cost of both maintenance on actuators and energy.
- Advantages:
  - simplicity;
  - low initial cost.
- Disadvantages:
  - high maintenance cost;
  - low energy efficiency.

Weather-compensated (Equithermal) control

- A feed-forward type of control, known in the market as Equithermal controller for HVAC systems. The disturbances are measured and accounted for before they have time to affect the system. This strategy responds to its control signal in a pre-defined way without a feedback technique (not-error based), which means it is based on the knowledge of the process or measurements of its disturbances.
- In heating systems, weather compensation is a communication between the source of hot water (boiler, for example) and an outside temperature sensor. Since the weather is the main influence on the heat demand of a building, the controller adjust the heat supplied according to the weather conditions and inside temperature set point, via pre-defined heating curves, ensuring a more constant temperature in the rooms and better energy savings (15 % according to some system manufacturers).

PID controller

- **PID controller** continuously calculates the error between desired setpoint and a measured process variable, and adjusts the control signal accordingly. It is also known as Feedback control for HVAC systems.
  - “Proportional” accounts for present values of the error. For a large and positive error, for example, the control signal will be proportionally large and positive.
  - “Integral” accounts for past values of the error. For example, if the current control signal is not strong enough, error will accumulate over time and the controller will respond by applying a stronger action.
  - “Derivative” term predicts the future offsets based on the actual rate of change of the process and suppresses oscillations.

Model predictive control (MPC)

- Predictive control applied to building automation systems provides increased energy savings, being often more cost-effective than non-predictive control applications and providing some other benefits too. They can be applied to both single-zone and multi-zone buildings, whether residential, commercial or public buildings.
- While controlling the process according to the model, MPC generates a cost function control vector to minimize it over the prediction horizon, disturbances and constraints that might be present. Model identification is the bottleneck of the whole MPC application procedure and there are not any strict requirements on the model structure. It is possible to use any black box, grey box, or white box model.

Digital sensors for building construction stability control

- The main task for the stability of digital sensor structures is to follow the behavior-deformation of structures under the influence of external processes. Possible external processes can be weather conditions: wind, temperature and precipitation, as well as soil stability. The most popular are *tilt meter* and *joint & crack meter.*

Geosense MEMS Tilt beam

Geosense Joint & crack meter between two constructions

Public wooden building with wood construction elements

Digital Tilt Logger

- The Digital Tilt Logger is a simple, battery-powered data logger and tilt meter in a single compact unit. It measures tilt in either one or two perpendicular axes in the plane of the base. The unit is intended to be permanently installed to provide long-term observation with maximum resolution and sensitivity, and is conveniently designed for manual monitoring or remote data acquisition.

Digital building surveillance tools – key remarks

- Digital building surveillance tools help manage a building as a safe place for people to stay and as protection of structures against damage. Using digital sensors, we obtain data in real time or very close to real time by pre-processing it. Sensor indicators and processing results should be published on web services. Digital technical tools help to quickly determine the safety performance of buildings and at the same time monitor the climatic parameters in the building.

Data Base for Management Purposes

Building Management Database

- The main task of the building management database is to ensure the management of the processes related to building management and the timely execution of building maintenance tasks. Various database management systems can be used for building management: building information modeling systems, building management systems, facilities management systems, geographical information systems. Guided by the type of database structure, we can divide building management into the following groups: textual or analytical databases, graphical databases, and combined systems of both databases.

Building Information Modeling (BIM)

- Building Information Modeling (BIM) is a process that begins with the creation of an intelligent 3D model and enables document management, coordination, and simulation during the entire lifecycle of a project (plan, design, build, operation and maintenance).

Main functions of Building Management System (BMS)

- event logging
- data storage
- process traceability

Facilities management

- The term “facilities management” (FM) has been the subject of much debate since its conceptualization.
- “Facilities management brings together knowledge from design and knowledge from management in the context of buildings in everyday use” (Finch & Zhang, 2013).

Geographic Information System (GIS)

- GIS is one of the tools that helps to manage a building through both visualizing and analyzing building information. It is a system that helps to identify the scene and display it in space. The key functions of GIS use in facilities management are spatial visualization and geodatabase management functions. It has been used extensively for facilities management in the public sector and has great potential for use in the private sector as well. GIS has been used to assist in the management of building spaces and facilities in recent years.

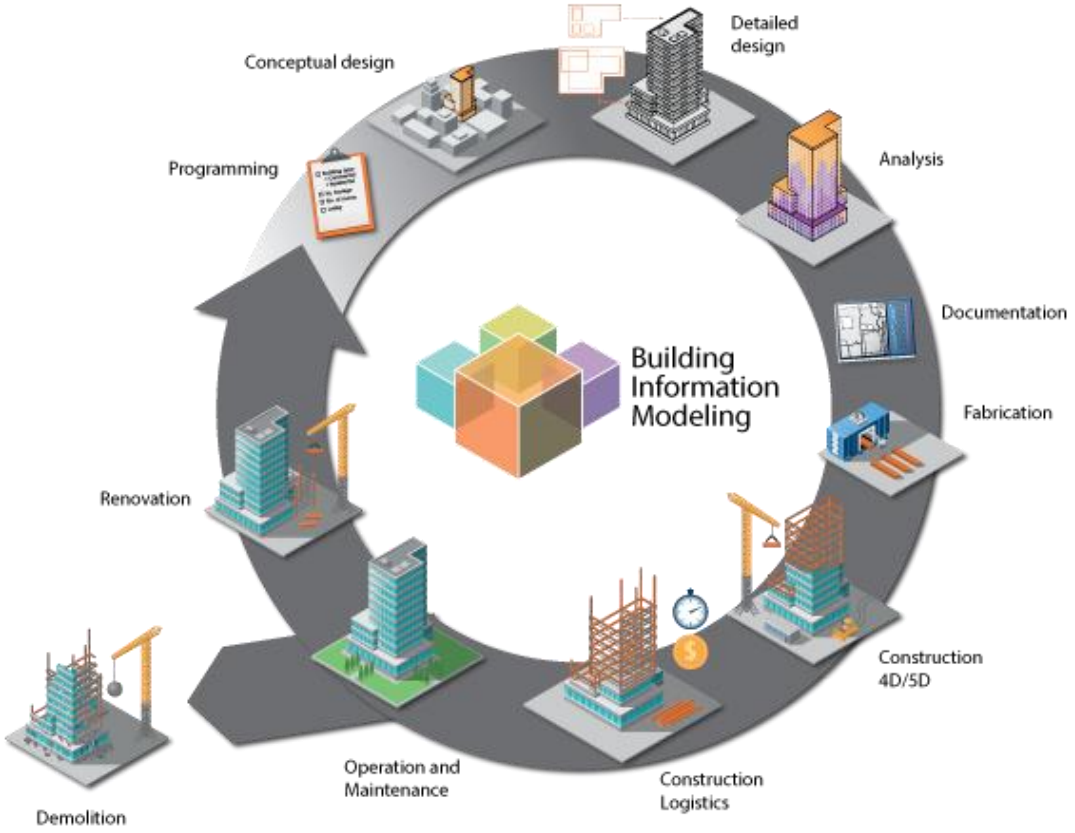
Building Information Modeling

- BIM (Building Information Modeling) is the process of creating and managing data over the life cycle of an object. The obtained information model is used as a basis for decision-making, as it includes objective information, from the idea to the conclusion of the operation phase of the building.

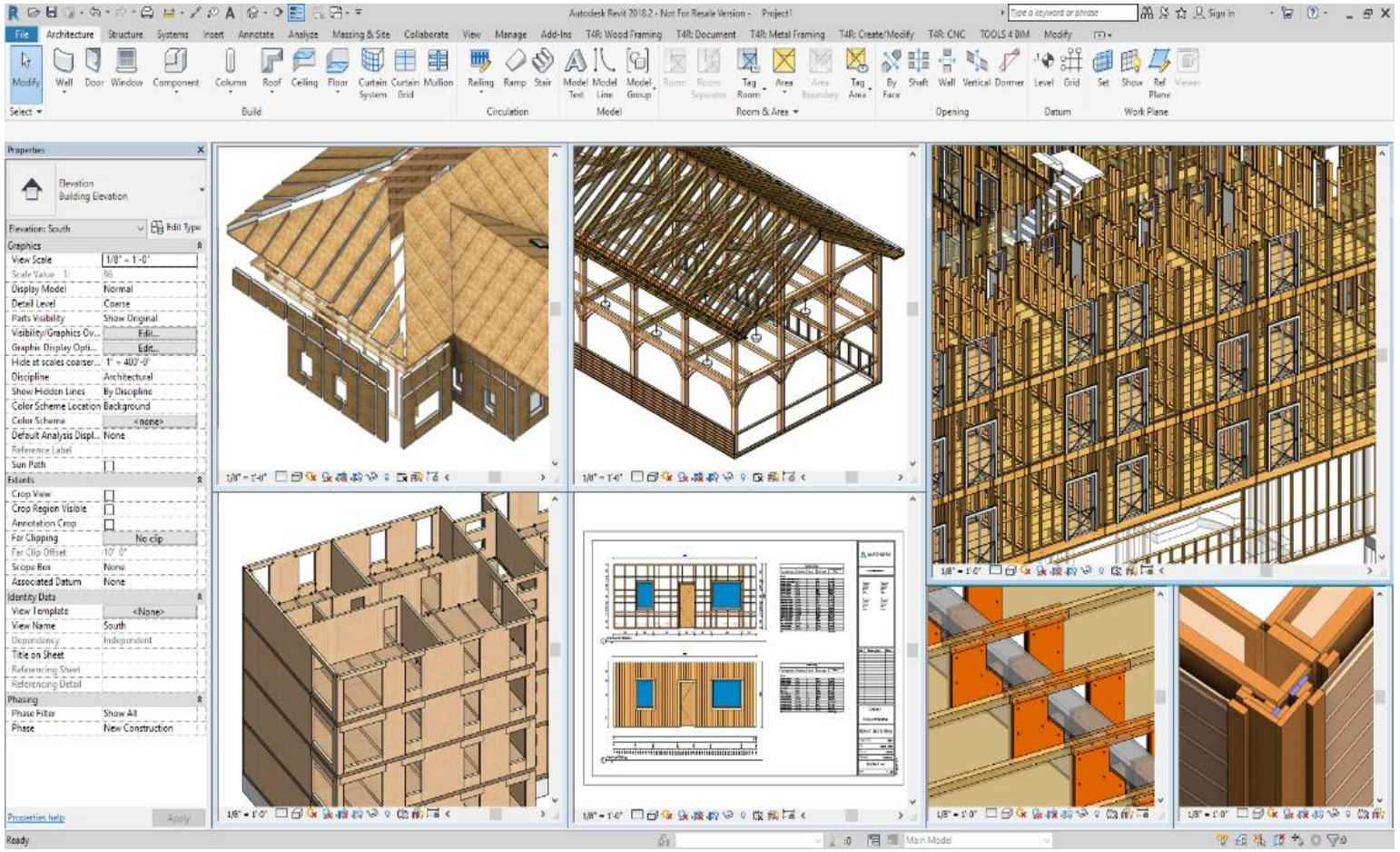
Processes included in BIM lifecycle

- Planning - reality capture and real-world data are used for project planning to generate context models of the existing built and natural environment;
- Designing – conceptual designing, analysis, detailing, and documentation are carried out. The preconstruction process begins using BIM data to inform scheduling and logistics;
- Building – fabrication begins using BIM specifications. Project construction logistics are shared with trades and contractors to ensure optimal timing and efficiency;
- Operating – BIM data carries over to operations and maintenance of finished assets. BIM data can be used down the road for cost-effective renovation or for efficient deconstruction.

Lifecycle of an enterprise in BIM



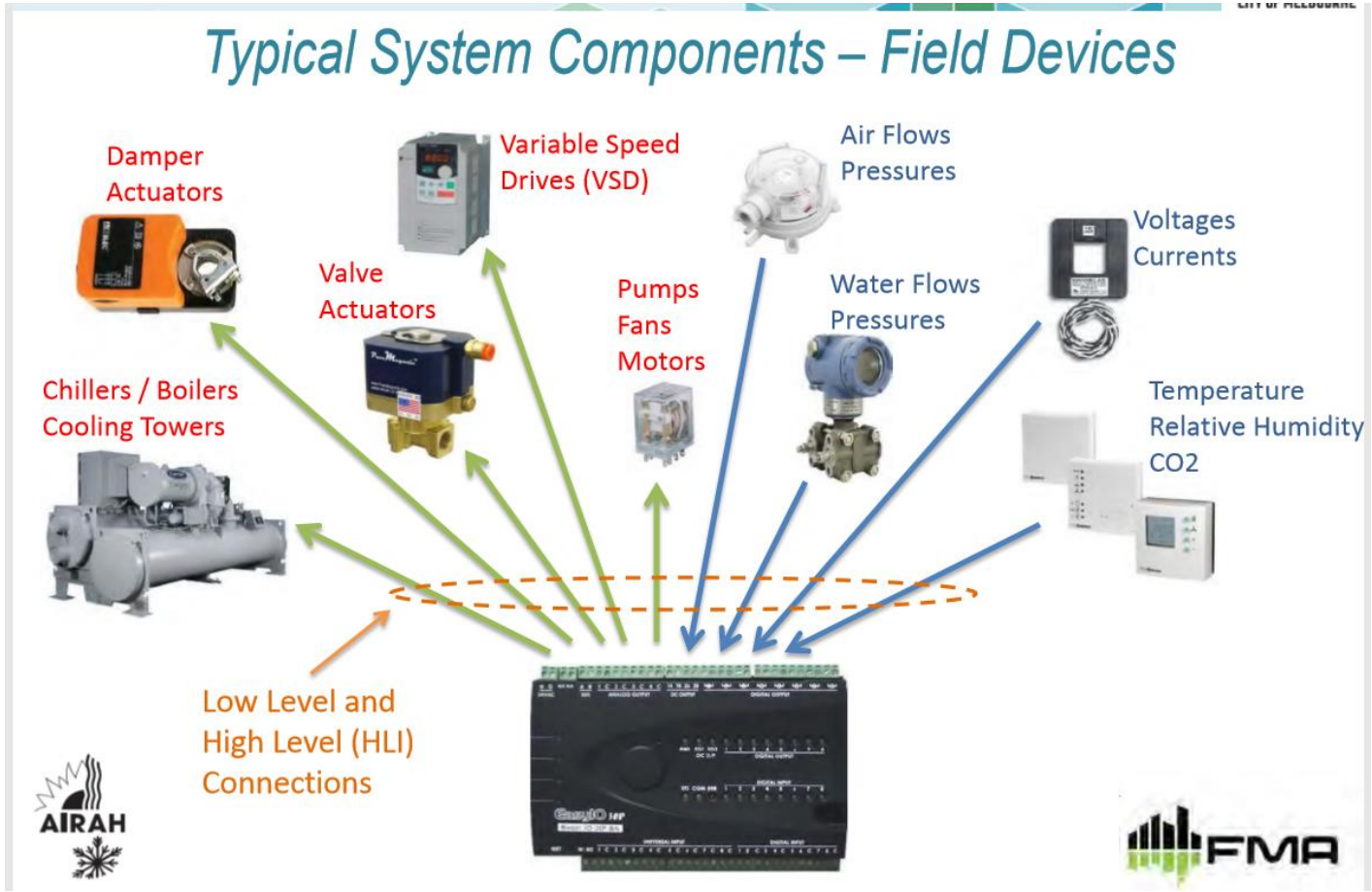
Wood constructions in BIM



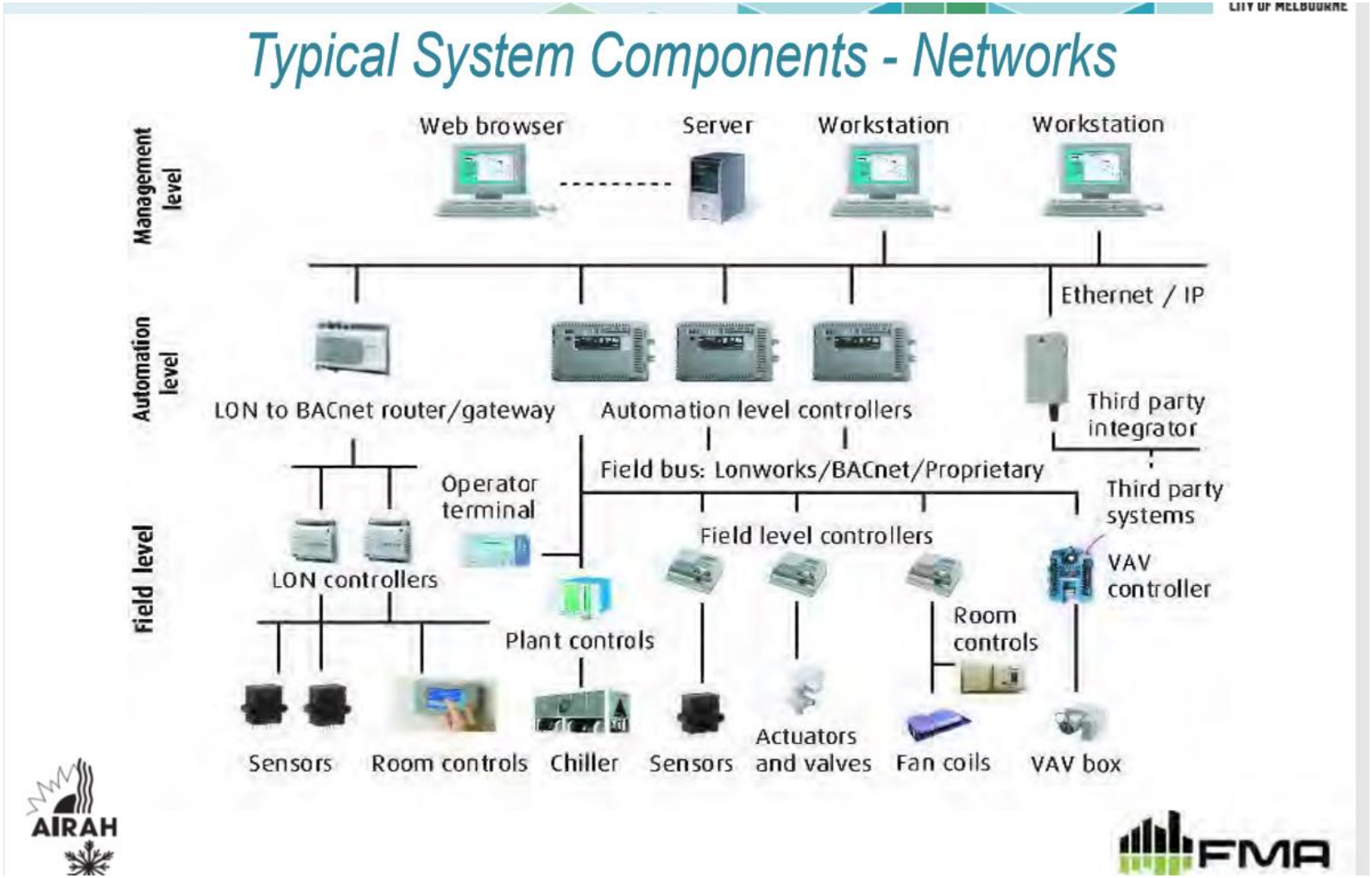
Examples of the major subsystems controlled by the BMS

- HVAC System. The duct temperature, pressure, and humidity, as well as exhaust temperature are connected to the BMS, and if their value exceeds defined limits, an alarm is generated;
- Central Fume Collection, Laminar Flow Units, Dust Collection System, Central Vacuum System, Heat blowers. The BMS monitors the performance of these systems, allowing for early identification of units requiring maintenance;
- Technical Steam System. Should, for instance, the pressure or temperature in the piping system fall below the defined regulatory values for clean steam, the BMS shall trigger an alarm, indicating a threat to product quality;
- Hot Water System and Central Heating. Temperature and pump control monitoring via the BMS allows for a proper functioning of hot water distribution through the facility;
- Chilled Water System. Control of the facility chillers could be supervised by BMS to monitor proper behavior of the system in terms of water/coolant temperature control or pump control to assure proper distribution within the distribution loop;
- Sprinkler System (for fire safety);
- Electrical Monitoring System. The BMS may monitor the consumed electrical power and the state of main electrical switches.

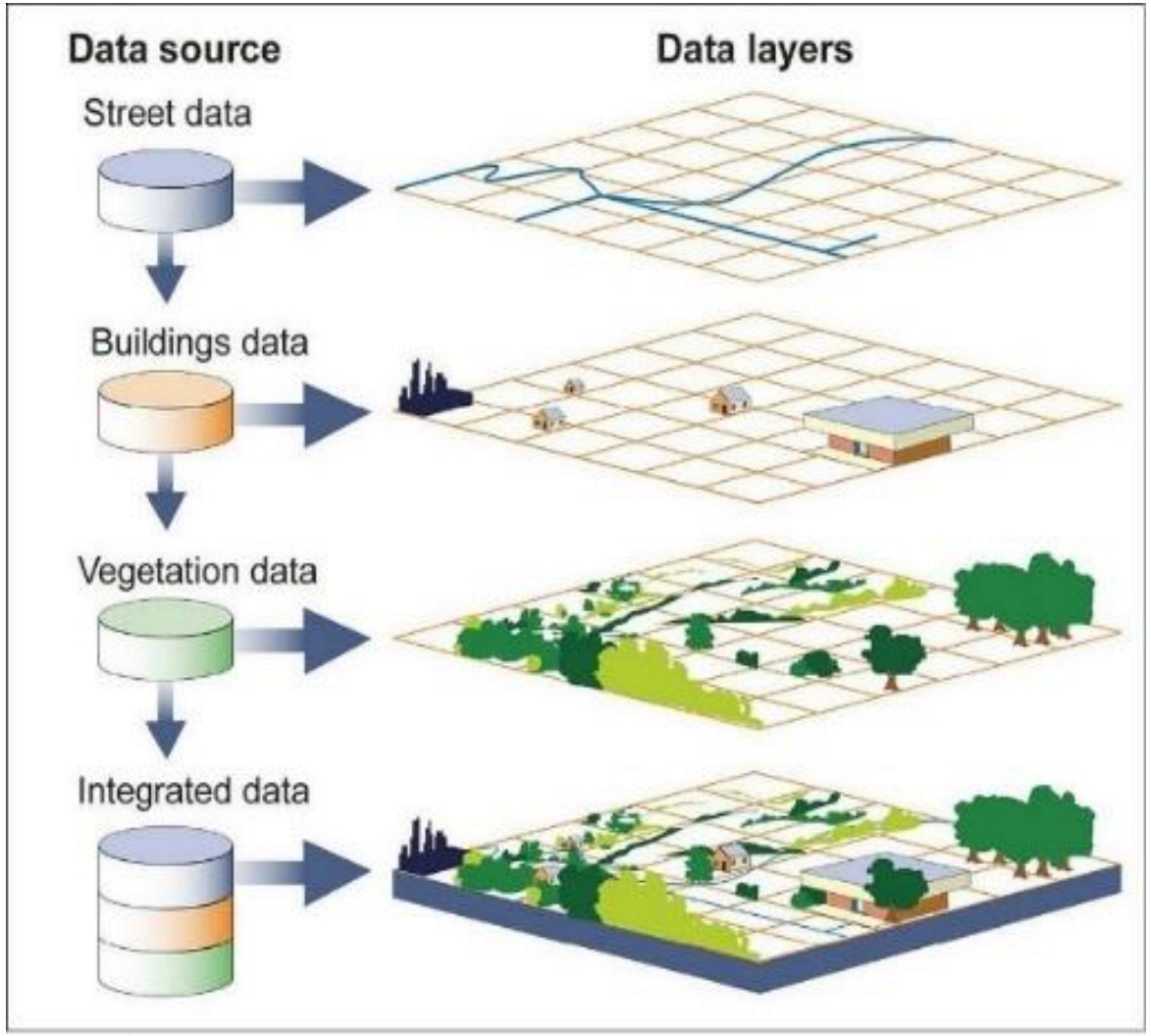
BMS system components - field devices



BMS systems components - Networks



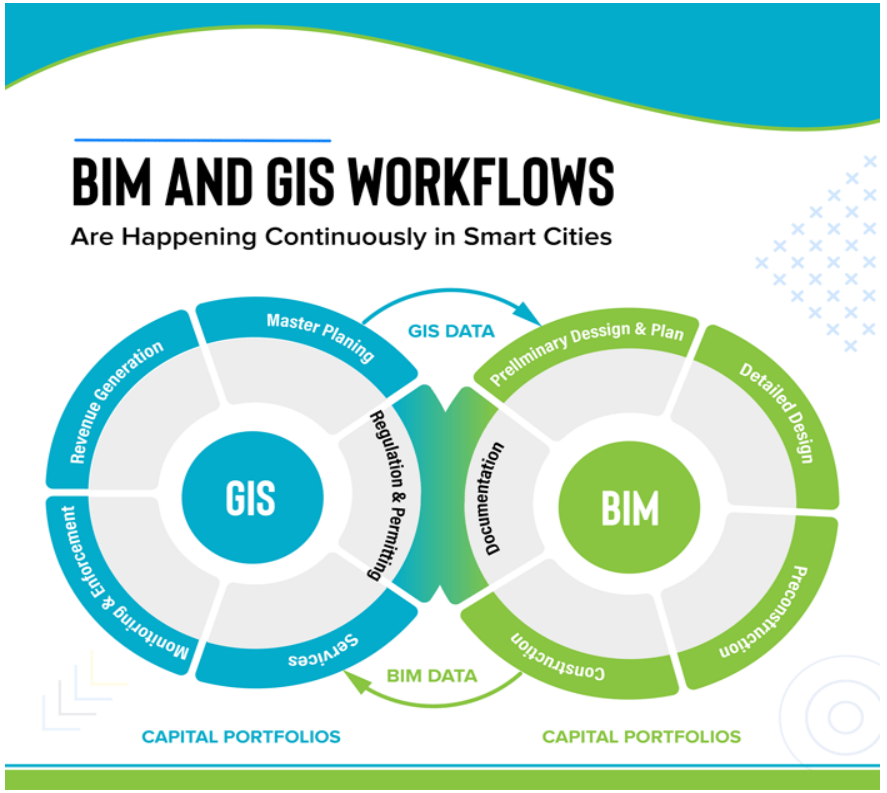
Main elements of GIS



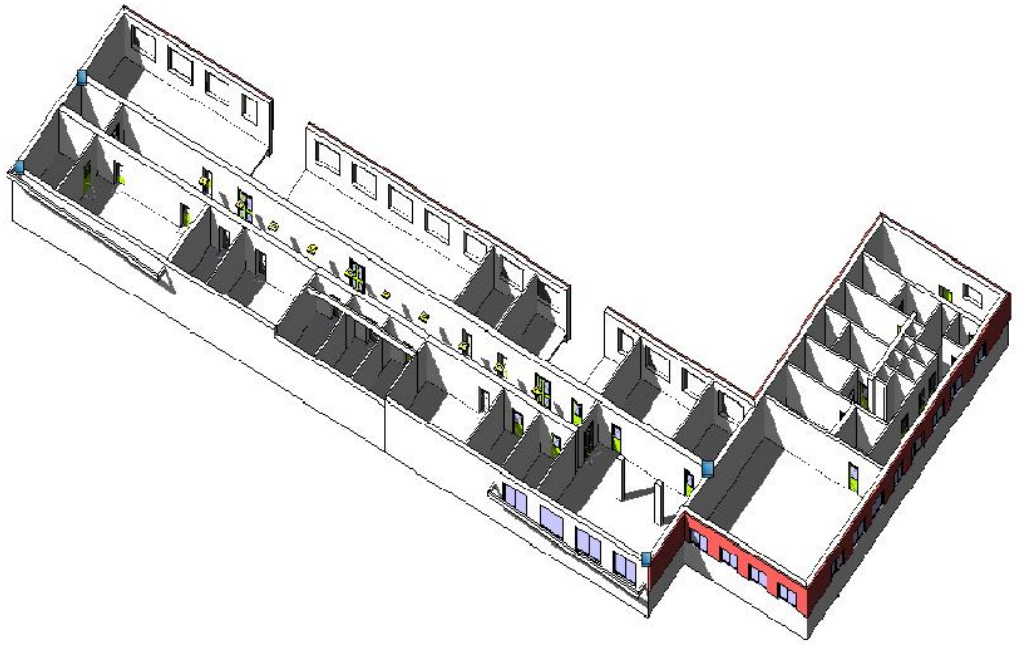
Source: GAO.

BIM and GIS integration

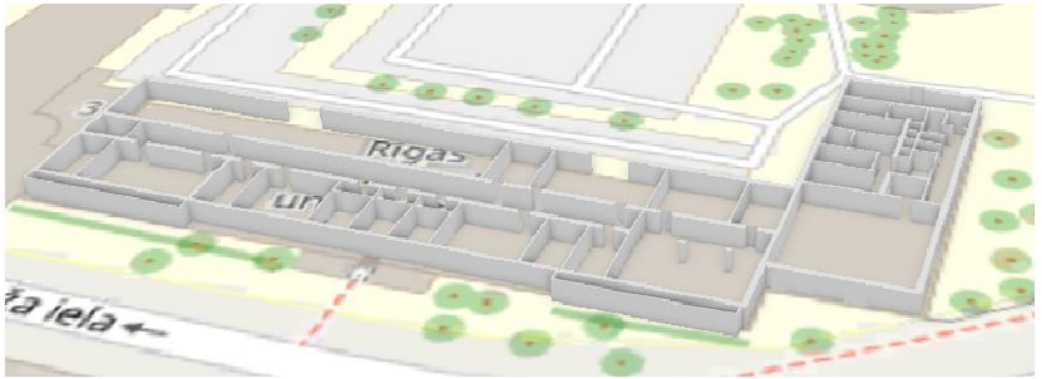
- Integrating GIS and BIM data allows design and construction companies to collect accurate and valuable data that will lead to much more effective and efficient design and project management.



BIM and GIS integration example



a) BIM 3D model



b) GIS 3D model

GIS and BIM advantages and disadvantages

- GIS and BIM advantages:
  - 3D spatial model;
  - attribute data;
  - analysis of possibilities;
  - dynamical data.
- GIS and BIM disadvantages:
  - problems related to big data;
  - BIM models are very complicate.

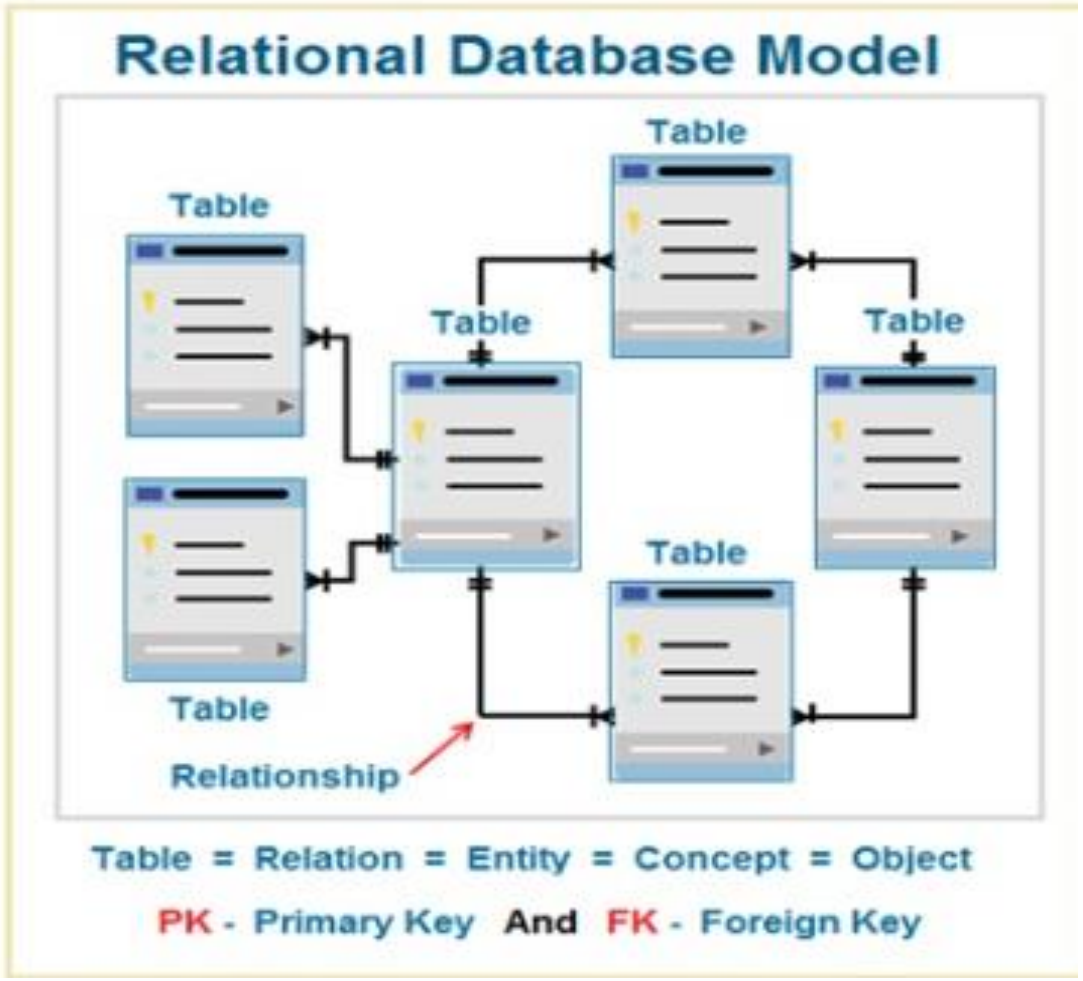
Data obtained in building maintenance processes

- annual building surveys;
- various repair and maintenance works;
- service works;
- other works.

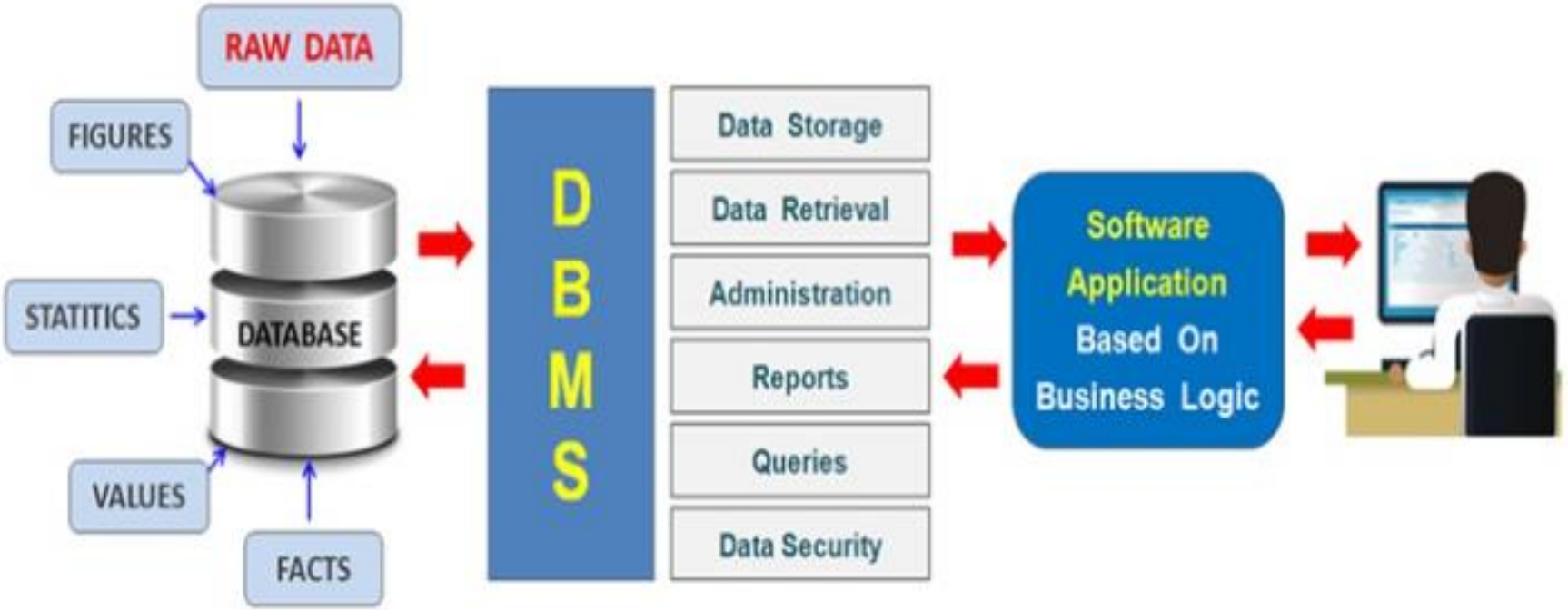
Relational database management system (RDBMS)

- A relational database management system (RDBMS or just RDB) is a common type of database whose data is stored in tables.
- The most used databases in businesses these days are relational databases, as opposed to a flat file or hierarchical database.
- Benefits of relational databases:
  - manageability: for starters, an RDB is easy to manipulate. Each table of data can be updated without disrupting others;
  - flexibility: if you need to update your data, you only must do it once – so no more having to change multiple files one at a time;
  - avoid errors: there's no room for mistakes in a relational database because it's easy to check for mistakes against the data in other parts of the records.

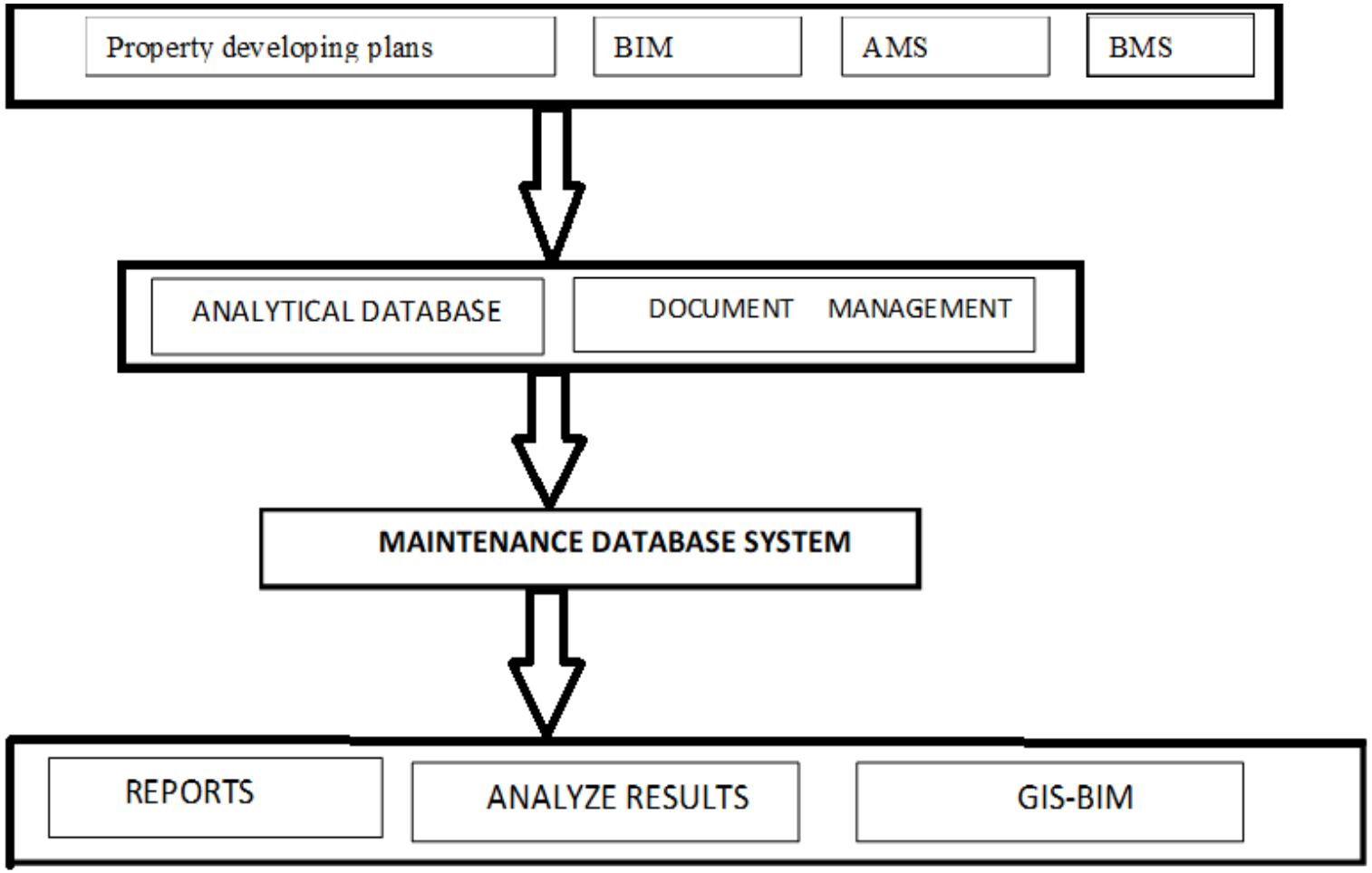
Principle of the relation database model



Database Management System



Maintenance database system principal schema



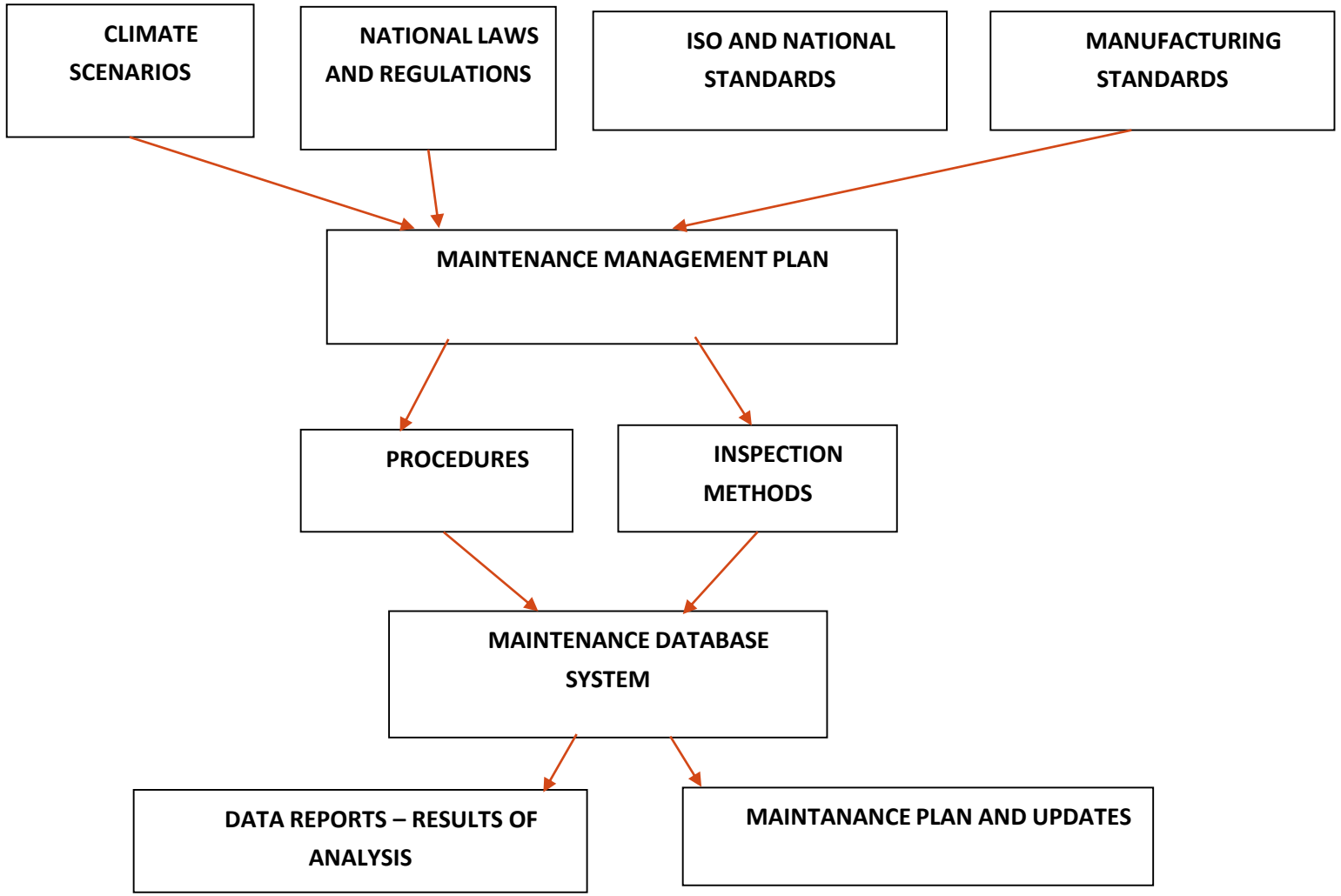
Maintenance policy

- The maintenance policy consists of five major components, and different maintenance strategies which are developed from these components. Without defining this policy, maintenance operation processes will be in a random order. The five major components are as follows:
  - the length of time for maintaining for their present use;
  - the life requirements of the buildings and their fittings and services;
  - the standard to which the building and its services are to be maintained;
  - the reaction time required between a defect occurring and a repair being carried out;
  - the legal and statutory requirements shall also be considered.

Maintenance plan

- Maintenance plan includes three main parts:
  - maintenance procedure manuals;
  - inspection methods;
  - maintenance period.
- Maintenance plan shall identify each element of the building, like roofs, foundations, walls etc., demanded maintenance tasks and the frequency. Frequency may depend on the condition of the identified building element, and could be:
  - occasional (after the storm or specifical reasons);
  - regular (for tasks carried out at least once a year);
  - cyclical (for tasks carried out less than once a year).

Framework of maintenance plan



Types of inspection

- routine inspection
- periodic inspection
- unscheduled inspection

Routine inspection

- Routine inspection is a daily inspection to quickly find out any unusual incidents and defects on the building facilities. It generally consists of visual inspections while walking in and around building facilities.

Periodic inspection

- Periodic inspection is applied to the following cases: to survey damages including deterioration and defects; to diagnose deterioration and defects; to select the suitable repair methods for light damages and deteriorations.
- Also, it should make judgment on the need of a further survey on the heavy damages and deterioration. With this, it is carried out at a fixed interval. The periodic inspection provides base information to the planning of maintenance and repair works.

Unscheduled inspection

- Unscheduled inspection is applied to the following cases: to survey and evaluate the effects of unexpected incidents occurring such as floods, strong wind, fires, and other natural disasters which are making impact to building facilities.

Detailed survey

- Survey and design are applied to the following cases:
  - to further specify causes of structural defects and damages;
  - to find out the most suitable repair works for the damages;
  - to evaluate the performance of repair works;
  - to survey unidentified incidents arising after repair works and a final inspection;
  - to ensure structural safety when facilities are to be used with greater loading conditions than the design conditions;
  - to evaluate structural safety when facilities are to be used more frequently than design periods.

Inspection methods

- visual inspection
- operation tests
- check of embedded pressure gauge
- check by tapping with a test hammer
- check by touching
- check with crack scales;
- check with dossiers of drawings and measurement with steel tapes, etc.
- check with plummet
- non-destructive equipment, etc.
- interlocking function test
- measurement with a Voltmeter
- measurement with steel tapes, 3D laser scanner, drones, etc.
- visual inspection and check by touching
- visual inspection with binoculars, etc., as needed

Occasional and regular tasks

- area - foliage and large trees close to walls, slope;
- basement - water leakage, air circulation and exchange;
- rainwater disposal - rainwater goods generally, rainwater goods, below ground drainage;
- external walls - external walls generally, external walls, copings and parapets, ventilation, bird screens, window flashings;
- doors - bird screens, window flashings;
- internal structure - internal spaces generally, internal structure and fabric, exposed woodwork, roof and floor voids, wood constructions;
- attic - attic general, ventilation;
- roof coverings - roof areas generally, connections and parapets, slate and tile roofs, sheet metal roofs and cladding, cleaning of the dirt, nails, amount of the snow;
- building services - lightning protection installation, firefighting equipment, burglar alarm system, emergency notification system, sewer system and water supply, outdoor watering system, heating system general, heating system, stoves.

Maintenance tasks of Building Area

- Check and report any dead branches and signs of ill health, or root damage to the building or below ground drainage.
- Check and report the slope of the ground around the building for water flowing off walls.

Maintenance tasks of Basement

- Check the basement for moisture or leakage.
- Check the basement for sufficient air circulation.
- Provide ventilation of cellars by opening ventilations hatches in spring and close the hatches before winter.

Maintenance tasks of Rainwater disposal

- Inspect rainwater goods from the ground and accessible high points and report any loss or damage.
- Clear rainwater goods of debris and ensure overflows are clear. Rod if necessary.
- Check that stainless steel guards are secure.
- Inspect rainwater goods for cracks and leaks. Repair or replace any cracked sections.
- Clear drainage channel of vegetation and debris.
- Inspect drainage channel for cracks and open joints. Seal with appropriate sealant.
- Open up inspection chambers. Check that all gullies and gratings are free from silt and debris and that water discharges freely to main sewerage or soakaway.

Maintenance tasks of External walls

- Inspect external walls from the ground and accessible high points and report any damage, cracks and signs of movement.
- Remove any vegetation, ivy etc.
- Ensure that ventilation grilles, air bricks, louvres etc. are free from obstruction.
- Check that tower, roofs and windows are bird-proof before nesting starts. Do not disturb bats.
- Check for leakage and if necessary make minor repairs.

Maintenance tasks of Windows

- Check operation of hinges, bolts and locks and lubricate as necessary. Check security of locks.
- Inspect windows and make essential minor repairs to glazing.
- Check the wooden frames for signs of moisture damage, insect infestation and/or rot, cracks and opened joints.
- Check the paint of the window frames and repaint if necessary.
- Check the glazing sealants for damages (cracks and loses) and and make essentials minor repairs.
- Check for missing fastenings, parts and any signs of rust. Make essential minor repairs.
- Inspect lead cames, putty, glass and wire ties and report any problems. Clear condensation drainage channels and holes.

Maintenance tasks of Doors

- Check operation of hinges, bolts and locks and lubricate as necessary. Check security of locks.
- Check the paint/varnish of the wooden parts and repaint if necessary.
- Check the wooden parts for signs of moisture damage, insect infestation and/or rot, cracks and opened joints.
- Check for missing fastenings, parts and any signs of rust. Make essential minor repairs.

Maintenance tasks of Internal structure

- Inspect roof voids and internal spaces, particularly below gutters. Report on any evidence of roof or gutter leaks.
- Inspect internal structure and fabric including roof timbers and bell frames, and report on any signs of structural movement or damp, fungal growth and dry rot.
- Inspect exposed woodwork and surfaces below for signs of active beetle infestation. Report any beetles or fresh wood dust.
- Check roof and floor voids, inspect for signs of vermin and remove. Avoid using poison when bats are roosting.
- Ventilate the building.

Maintenance tasks of Attic

- Check the attic and roof ventilation, check for condensation.
- Provide the ventilation of the attic.
- Check the wood construction for signs of moisture damage, insect infestation and/or rot.
- Check the wood construction for cracks, opened joints or pins for pull-out.

Maintenance tasks of Roof coverings

- Inspect roof areas from the ground and accessible high points and report any loss or damage to the roof coverings.
- Check roof joints and chimney connections for damage.
- Inspect for cracked, displaced and broken slates and tiles. Replace to match.
- Inspect condition of panels, joints, and clips. Make temporary repairs to cracks and splits.
- Cleaning dirt, moss leaves, vegetative matter and mildew.
- Checking the nails that attach the shingles to the roof for corrossion and pullout.
- Clean the roofs from snow.

Maintenance tasks of Building Services (1)

- Visually inspect the lightning conductor system including spikes, tapes, earth rods and all connections and fastenings.
- Check service fire extinguishers.
- Test system and visually inspect wiring. Qualified engineer to service alarm.
- Test functionality of the emergency notification system.
- Ensure that all exposed water tanks, water pipes and sewer system are protected against frost.
- Check that water tanks, pipes and radiators do not flow.
- Check for leakage in the sewer system for cleaning of inspection holes.

Maintenance tasks of Building Services (2)

- Check if outdoor watering systems are switched off.
- Service the heating system and update the service schedule.
- Ensure that all heating pipes are protected against frost.
- Clean the chimneys.
- Check the condition of heating stoves, stoves and chimneys for cracks with soot.
- Record temperature and humidity in different building parts.

Key remarks

- Maintenance is very dynamic process. Maintenance plan must be updated periodically. Periodical updates dependent on the lifecycle of the building – renovation process, repairs - must be included in maintenance procedures. Whole maintenance process must be reported and analyzed. Building maintenance requirements cannot be fixed but are based on procedures that are based on regulatory requirements, national standards and factory requirements. Procedures need to be regularly reviewed and updated based on survey results. Combining the procedures with the building maintenance database, it is possible to fully trace the physical condition of the building and the stability of the structures. Main tasks of the maintenance are ensuring the safety of people and wooden constructions.

Thank you for attention!