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INTEGRATED SPACE AND ASSET MANAGEMENT SYSTEM FOR LARGE SCALE AIRPORT

The case of Incheon International Airport

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Abstract. Large-scale airports such as Incheon International Airport have large-scale terminals, annex buildings, and numerous open spaces. An integrated space management system is required to manage these buildings and spaces efficiently. Thus, Incheon International Airport Corporation developed a 3D computer-aided design (CAD)-based integrated space management system. The major system development goal was to provide intuitive 3D-based visual information, thereby realizing an integrated space and asset management system that does not require expert knowledge of any specific field, such as architecture. This paper discusses the construction of the system and the problems that had to be resolved to achieve this goal.

Keywords. Space and asset management, airport, 3D CAD, BIM

1. Introduction

Large-scale airports such as Incheon International Airport (IIA) have many assets such as lands, buildings, and open spaces. IIA has assets of 2,868 lots comprising 49,739,000 m^2 of land, 185 buildings with 1,291,000 m^2 total floor area, and 9,870 open spaces. However, these large-scale assets were managed using dispersed information such as 2D computer-aided design (CAD) files, drawings printed on papers, various electronic and paper documents, and text-based Enterprise Resource Planning (ERP).

Large-scale asset management using these dispersed pieces of information was very inefficient—exemplified by dissonance between asset-related 2D CAD drawings and their associated ERP information. The major reason for this dissonance is that expert knowledge was required to process the CAD drawings and cooperation with other architecture-related departments, which is necessary, was not smooth because the personnel in charge of asset management did not have the required expertise.

To rectify this situation, Incheon International Airport Corporation (IIAC) developed Airport Map (AMAP) for land management and a lease management system called TWOD, which links 2D CAD and ERP. However, CAD-related expert knowledge was still required, and so it was subsequently abandoned owing to the complexity of its user interface. Consequently, development was carried out on a new land, building, and space management system that was intuitive and easy for nonexperts to use.

Recognising the problems of conventional management methods and the management systems developed, the first basic system development objective was implementation of a 3D object-based simplified intuitive user interface that facilitated intuitive integration of dispersed information and increased space and asset management efficiency. This is a strategy for increasing work efficiency by providing an environment in which the system can be actively used when the asset management personnel, i.e. actual users, carry out the work while reducing resistance against the use of the system.

Two methods were utilized to actualize this strategy. First, a real-time rendering 3D game engine was used, instead of a conventional architectural 3D viewer, to provide increased engagement with the system. To achieve this, a method for processing large-scale 3D files had to be devised. Thus, a new file format was derived for 3D data, and downsized for the space management system. The new file format focused on space and asset management and eliminated unnecessary information, thereby facilitating downsized files. Consequently, operations on the Internet and low-end computers became possible owing to respective improvements in the loading speed and response time of 3D objects and the 3D viewer. Second, to facilitate agreement between drawings and ERP information, a customised 3D CAD system that asset management personnel could use to immediately and easily revise the spaces on drawings and attribute information was adopted. Further, the customised 3D CAD system had the effect of increasing asset information reliability because the shape and information of any areas that were revised were automatically reflected in the 3D viewer in real-time.

However, because the focus of the system is on asset and space management, it has a certain limitation; it may be viewed as being insufficient as the building facilities are not reflected from the aspects of facility management (FM) and building information modelling (BIM). These were actually deliberately excluded in order to reduce the probability of failure because the facilities of IIA are too extensive to construct an entire facility management system all at once in 3D. Hence, IIAC adopted a modular approach, with the first module of the system developed focusing on space and asset management. Further, to actively reflect the requirements of the end-users of the system, the real-estate management team oversaw the development of the system. Because the system was developed to increase the efficiency of end-users and with convenience in mind, it is a bit different from the conventional computer-aided facility management (CAFM) perspective. Thus, the development of a GIS-based 2D Underground Facility Management System was separately carried out. With this approach, risks that can occur during system development were reduced and relevant technologies were accumulated.

The BIM model is being considered for application to expand the system, once the current third stage of expansion, including construction of the second terminal that utilizes BIM, is completed.

2. Facility and space management system

Space management is a component of facility management. According to the International Facility Management Association (IFMA), facility management is defined as a professional field that plans and manages physical work spaces associated with the personnel and works of an organization. In addition, it can be seen as the use of an established plan for management of various equipment and facilities associated with physical work spaces (IFMA, 2014).

From the definition of IFMA, it is clear that the aim of FM is to increase work efficiency by efficiently managing spaces and their associated elements. In the late 1980s, FM incorporated PC technology and evolved to become CAFM (Wikipedia, 2014).

CAFM consists of space management and support modules and has further evolved into the Integrated Workplace Management System (IWMS) by integrating new functions for FM and real-estate management; however, the space management is still treated as a core component. Furthermore, owing to adoption of the BIM concept, methods are provided to dynamically and three-dimensionally manage spaces that were previously two-dimensionally managed with 2D CAD and spreadsheet (IWMSNEWS, 2014).

Various solutions (ARCHIBUS, 2014; dRofus, 2014; EcoDomus, 2014; FM:Systems, 2014; Zutec, 2014; Zuuse, 2014) currently provide services in which the FM method is coordinated with BIM. These solutions use a method in which BIM data are incorporated into FM by providing interoperation functions with BIM authoring tools such as Autodesk Revit and Graphisoft Archicad and, as a major linking method, a method of using IFC files is used. These solutions target not only space management, but also all information related to buildings, including the mechanical, electrical, and plumbing (MEP) of buildings, but information related to land is not provided.

Furthermore, to the best of our knowledge, the solutions outlined above have never been applied to the management of large-scale facilities such as an airport. Actual site visits and analysis of LA World Airport (LAX) and Denver International Airport (DIA), which are examples of newly constructed and completed airport facilities utilizing BIM, confirmed that no indoor space management system was constructed at either LAX or DIA, only construction using BIM data and GIS of the functional facilities of the airports such as runways and moorings. We confirmed that the functioning of the systems used in the two airports, which were developed at AECOM on the basis of Esri ArcGIS and IBM Maximo, was similar to that of the Underground Facility Management System of IIA. Figure 1 shows the system displays of the two airports.

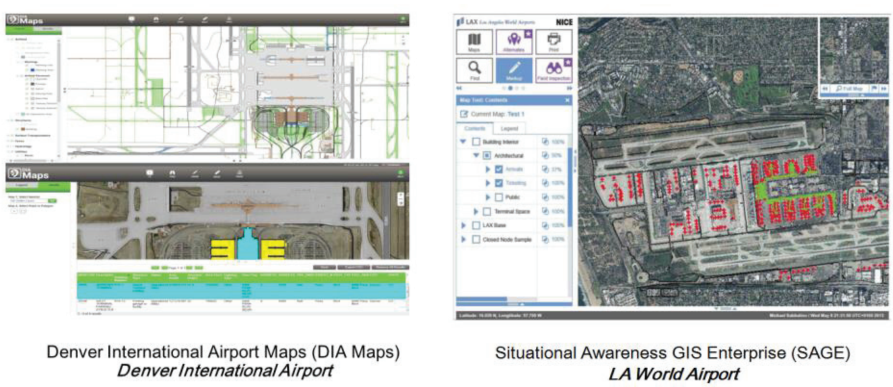

Figure 1. DIA Map (Left) and Situational Awareness GIS Enterprise (SAGE) (Right), the respective airport FM systems for DIA and LAX.

3. IIAC Integrated space management system

IIAC's integrated space management system (ISMS) was developed between December 2013 and September 2014 (a total development period of ten months) by the Real-estate Management Team, an asset management department, after commencing planning at the end of 2012, in order to resolve the inefficiency in space management. A major characteristic of this project is that it was a proactively carried out. More specifically, the departments that actually use the system identified current status and defined requirements for problem solving, unlike conventional system planning and ordering. For this reason, the system is in congruence with the site operations and work processes. Table 1 summarizes the current status and requirements for development of ISMS.

Table 1. Current status of space management at IIAC and required improvements for construction of ISMS

Division	Current status	Direction of improvement through system
Area size management	Manages the leased area sizes only	Establish a classification system by space and manage areas for every space
	Difficult to calculate the area of commonly used space	Establish a calculation logic for the area of commonly used spaces and adopt an automatic calculation function to find the size of commonly used spaces
Drawing management	Dependent on paper drawings	Minimize the use of paper drawings even outside of offices with the e-Drawing function on tablet PCs
	Renews CAD drawings once a year	Update the CAD drawings with 3D drawings in real-time
	Requires expert knowledge to analyse drawings	Identify spatial structures visually and intuitively through use of 3D viewer
Lease management	Requires physical visits to a space when renting	Possible to check spaces in the 3D space management system (location, area size, vacancy, etc.)
	Manages only charged leases	Possible to rationally allocate the limited resources by managing all spaces leased free of charge and at charge
System management	Separately manages lands and buildings	Increase the work efficiency by managing lands/buildings in a consistent user environment
	Not linked to ERP	Link the 3D space technology with actual attribute information by interoperating with the ERP system

3.1. CONFIGURATION OF ISMS

ISMS consists of three main modules: a main, 3D, viewer; a Web-based management module that provides information for specific space management works; and a field survey system that uses a mobile system. Figure 2 shows the architecture of the system.

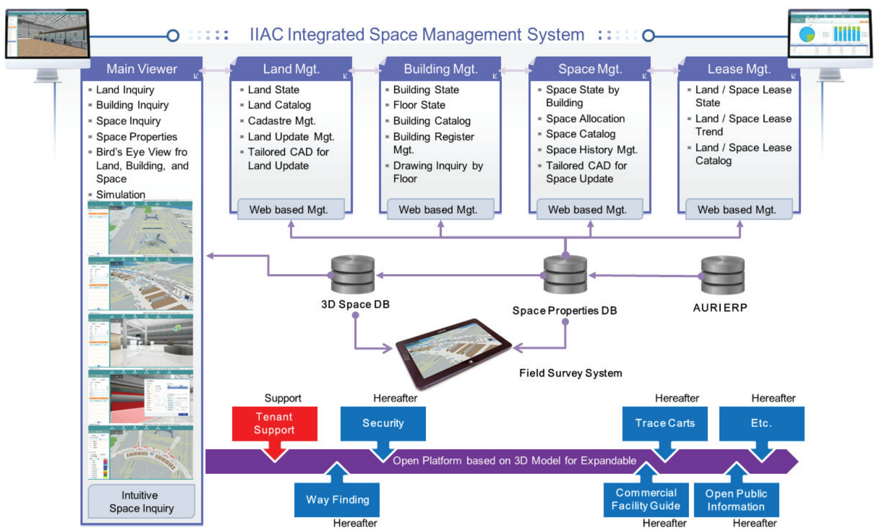

Figure 2. IIAC system architecture

The 3D viewer consists of modules for building and land management, and intuitively provides functions for building search, building information, indoor space search, and space information via a unified interface. The screen of the Web-based management system consists of land, building, space, and lease management, and provides a function for changing various information and drawings for works associated with ERP in terms of management. For security reasons, the field survey system is designed to download and upload data only through a wired communication network and the servers cannot be connected to wirelessly.

For ISMS, because all facilities and assets possessed and managed by IIAC are built with 3D models, it is possible to provide a method for expanding and applying it in various fields in the future. This expandability means that ISMS is an open platform for IIA's 3D model-based management. Based on this platform, a plan is being established to expand it in the future to become an information system for airport security such as CCTV administration, indoor navigation that applies indoor location tracing technology, real-time tracking of assets such as carts that are difficult to manage, and customer services.

3.2. ISMS DB AND CONSTRUCTION METHOD

ISMS is linked to ERP and consists of three DBs, respectively, for land information, building information, and space information for self-information processing. Figure 3 is a schematization of the construction process of the three DBs.

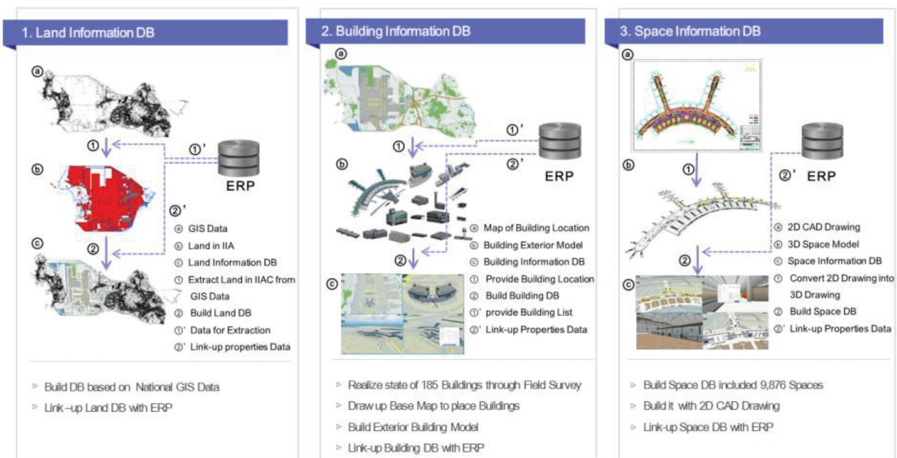

Figure 3. DBs for the system and their construction methods

The construction process for each DB is outlined below.

- **Land Information DB**: This DB was constructed using GIS information associated with the area where IIA is located.
- **Building Information DB**: This DB was constructed after identifying the locations of 180 buildings through existing information and field investigations. The model was constructed using photographs taken during the investigations to increase the identifiability of each building.
- **Space Information DB**: This DB was constructed using the dedicated 3D CAD program specifically produced for ISMS after collecting and organizing the AutoCAD dwg files of every building owned by IIAC. Signage and signboards were produced using the photographs taken during field investigation to increase the identifiability of each space.

3.3. SYSTEM CONSTRUCTION STRATEGY

The basic requirements for construction of ISMS were that every building and space must be implemented in 3D, and the lands, buildings, floors, and spaces must be processed on the same screen instead of being shown in separate windows. When these criteria are not satisfied, users tend to get confused and their concentration decrease. Furthermore, the loading time of the 3D model must be less than or equal to 15 seconds, and the response time for responding to user's command was provided as an important criterion. The requirements are summarized as follows.

- **3D data processing**: 3D data must be downloaded from a server, and the response time for showing it on the screen must not exceed 15 seconds after being requested. However, this criterion is not applied during the editing of a 3D model.
- **Performance of 3D viewer**: The 3D viewer must implement a response time without providing inconvenience when a user uses the system. At least 10 fps must be guaranteed.
- **Editing of space**: Communication must be facilitated with the system for the CAD system used in editing of spaces. In addition, the changed contents must be automatically processed and reflected in the system without a separate manual operation.

The above criteria may present substantial problems in a large scale facility such as IIA. To resolve this, first the format of the 3D model file was optimized. Conventional 3D file formats contain much unnecessary the space management aspect data, and there are cases in which detailed format information is used. Thus, a new file format was designed. Through in-house file format fabrication, complete understanding of the file format became a basis for satisfying the aforementioned criteria. This was achieved through a trial-and-error process because the criteria could not be satisfied initially owing to use of XML type format for development convenience; and the processing speed requirement was met by changing it to a binary type format.

In addition to the need to downsize the 3D data, the 3D viewer also had to be revised. Conventional architectural 3D viewers are not satisfactory for use by ordinary people in terms of speed and degree of visualised expression. Further, there are customisation limitations associated with an integrated system such as ISMS. As a result, we developed a 3D viewer using Unity 3D, which can perform development flexibly and implement satisfactory visualisation. The newly designed 3D file format also facilitated the development of the 3D viewer as it was easy to create an importer for file conversion for the 3D viewer. Figure 4 shows the interoperation processes among the modules of ISMS.

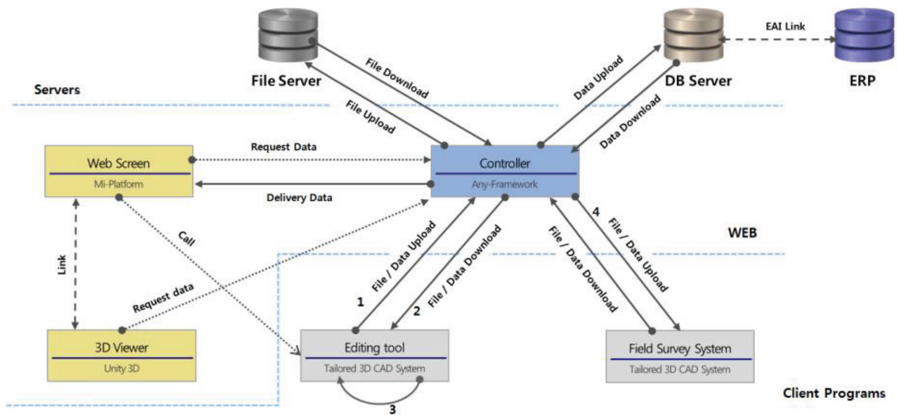

Figure 4. ISMS modules and their interoperation processes

Figure 5 shows screen captures illustrating the operation of ISMS after completion and confirms the efficacy of ISMS.

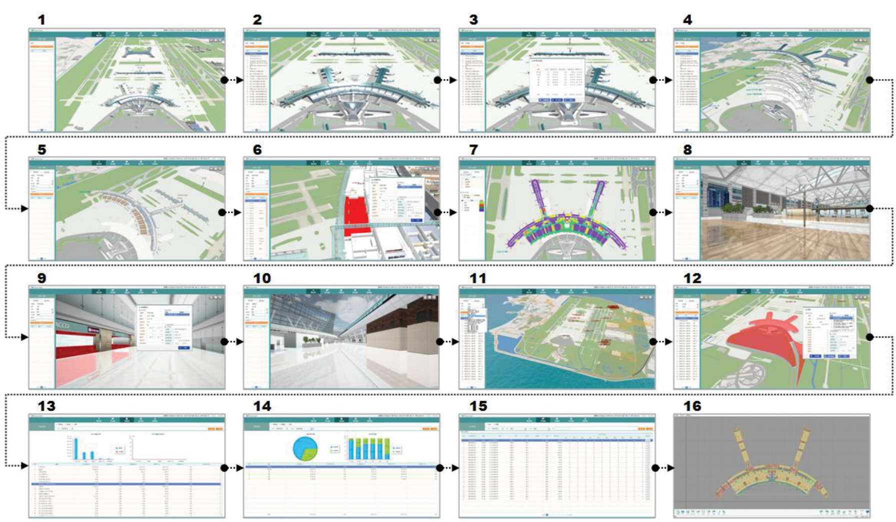

Figure 5. System operation screens

In Figure 5, No. 1 is the initial screen. Nos. 2 and 3 show attribute information resulting from the searching of a building. Nos. 4–7 show the accessing of an indoor building space, searching space, and checking for space information. Nos. 8–10 show the walk-thru screens, which facilitate the recognition of spaces from a walking person's perspective. Nos. 11 and 12 show land management operations; nos. 13–15, the Web-based management function; and no. 16, the dedicated 3D CAD system display of ISMS for compositing and editing of 3D models.

4. Future work

IIAC has developed a 3D integrated management system for lands, buildings, and open spaces called ISMS. The system, which is especially for indoor spaces, covers the entire airport—a first for a large scale airport such as this. Further, it was successfully commissioned into operation. Accumulation of experiences for processing large-scale 3D models through this system was a significant achievement. Using the experience gained from the construction of this system, a method of applying the BIM data for the second passenger terminal, which is currently being constructed using the current BIM, is being devised. At present, a study is being carried out to establish a method of converting IFC file to ISMS-applied 3D file format.

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