Easement spatialization with two cases based on BIM

Shen YING, Yifan XU, Chengpeng LI, RenZhong GUO and Lin LI

Key words: easement; LADM; BIM; IFC

SUMMARY

An Easement is a kind of usufructuary right, and its main purpose is that one party wants to use the property of others to improve the benefits and interests of his own real estate. With increasing population and accelerating urbanization, the limitation of urban space has gradually become prominent problem. To use the spatial resources fully, urban planners have focused on the development and utilization of three-dimensional urban space, namely, underground, ground and aboveground vertical space. The traditional 2D cadastre only using floor plans cannot meet the current 3D cadastre management needs. Therefore, the jurisprudence-confined planar easement must be combined with spatial information from 2D to 3D, as well as the 2D cadastre bounds to be extended to 3D to adapt to urban development. This study focuses on the property owner in 3D cadastre, therefore "easement of access" is chosen as the key topic, which is the right to cross the property to go to and from another. The conceptual models of easement spatialization based on building models of IFC (Industry Foundation Class) standards are constructed and analyzed. This study takes the condominium as an example, which displays how to access the semantic information associated with the geometric information of 3D property object in BIM (Building Information Model). Besides, the servant and the dominator of the easement are able to be linked because they are both attached to the same physical space. The research result shows that BIM can optimize the complex presentation of 3D property attributes and is an effective carrier of easement spatialization. The combination of legal information and spatial information of 3D property not only optimizes the operation and maintenance of buildings, but also improves land management, accelerates the development of 3D cities; thereby these will enlarge effective urban space, improve its utilization efficiency, and help resolve the contradiction between the rapidly expanding urban population and the limited shortage of space resources.

Easement spatialization with two cases based on BIM

Shen YING, Yifan XU, Chengpeng LI, RenZhong GUO and Lin LI

1. INTRODUCTION

Cities, as gathering places for human beings, are the most densely populated areas of population, politics, and economy. With accelerating urbanization and increasing population, the limitation of urban space has gradually become prominent problem.

Currently, in China, the major urban form pattern is still traditional and two-dimensional. However, there are many defects in this two-dimensional urban form, and the first to bear the brunt is the low utilization rate of land resources. To use the spatial resources fully, urban planners have focused on the development and utilization of three-dimensional urban space, namely, underground, ground and aboveground vertical space, forming a new concept of modern urban development, which is the 3D expansion of urban space (Guo et. al, 2013; Liu, 2014; Ying et. al, 2015). With its reasonable and effective organizations of urban functions, the three-dimensional city pattern can not only expand the urban capacity, but also improve the managing and operating efficiency, helping to solve piles of urban space problems.

The formation of three-dimensional cities has driven the development of three-dimensional cadastre (Guo et. al, 2013; Van Ooterom, 2013; Ying et. al, 2015). However, the unclear division of space rights will directly lead to economic and right disputes over interests.

After the literature review, the trend is that, though there are many discussions about the essence of the easement, the legal system and characteristics of easement all of them stay in the perspective of law, which is rather abstract and sometimes confusing. Besides, the very specific analysis is always needed, when refers to a practical application, and there is no geographical significance. In the process of information technology development, the city is becoming more and more intelligent, and the collected and managed information also tends to be three-dimensional. Therefore, the easement limited to the concept of law must be combined with spatial information to adapt to 3D development.

The purpose of this study is to implement the abstract meaning of easement into physical city space, making it concrete and expressible, to relate the servants and dominators of easement together and to combine and promote the 3D technology and cadastral management.

2. RELATED WORK

2.1 Basic Concepts

2.1.1 Concept for Space Right

Space right in China is a concept, referring to the rights in a certain range of space above or under the ground (Wang, 2007). Space right is a type of interests of real estate and property.

Space right is generally composed by space ownership, space useship and space utilization rights. Among them, the space utilization right is divided into two types, one for property and the other for credit. The space utilization rights of the property mainly include superficies easement and space easement.

2.1.2 Concept for Easement

Easement is a kind of usufructuary right generated in accordance with the contract or under certain legal context (Cui, 2011). The main purpose to set up the easement is that one party wants to use the property of others to improve the benefits of his own real estate. This study focuses on the property owner in 3D cadastre, therefore "easement of access" is chosen as the key topic, which is the right to cross the property to go to and from another. In future studies, this concept could be amplified and expanded, to find the general research method for all kinds of easements.

Easement of access, that is, the easement for the purpose of reaching his/her own real estate through the immovable property of others. It is a legal concept, relatively abstract, and has certain ambiguity. In order to better represent the practical significance of the easement, this study discusses how to assign it to geospatial space and combine the legal concept with the physical space, relating the servants and dominators of the easement. And we construct a comprehensive conceptual model containing the concept of property rights and physical concepts. Then a spatial model for condominium easement is presented for instantiating the spatial presentation of the easement.

2.2 Current Work

2.2.1 Easement

The easement originated from ancient Roman law and is the earliest form of usufructuary right in human history (Zhang, 2004; Zhu, 2005). In 2007, China enforced the Property Law, which stipulates that easements belong to a kind of usufructuary right that uses the land of others to facilitate the use of their own land (Zhai, 2013).

Regarding the subjects of the easement, Wu Wanjun et al. (Wu, 2007) believe that there are three types: the servants/dominators of easement and the owner. The servant of easement refers to the real right holder who owns the land/building, including the right to use, contracted management rights of rural land, etc.; while the dominator of easement refers to person who uses the real estate of others to improve his/her own benefits, including the land or building owner, usufructuary, creditor (land leaseholder, contract user), etc.; and the owner is the right holder when the dominant tenement and the servient tenement have the same subject.

2.2.2 LADM

The LADM (Land Administration Domain Model) was proposed by the 211 Technical Committee (TC211) of International Standardization Organization (ISO). After a long period of evolution, the current LADM includes LA_RRR (rights, restrictions, and responsibilities), LA_Party (right holder group), LA_BAUnit (basic management unit) and LA_SpatialUnit (spatial unit) four core classes (Figure 2.1). The international LADM standard was introduced

by Christiaan Lemmen (Lemmen, 2015), Peter van Oosterom (van Oosterom, 2015) and Rohan Bennett.

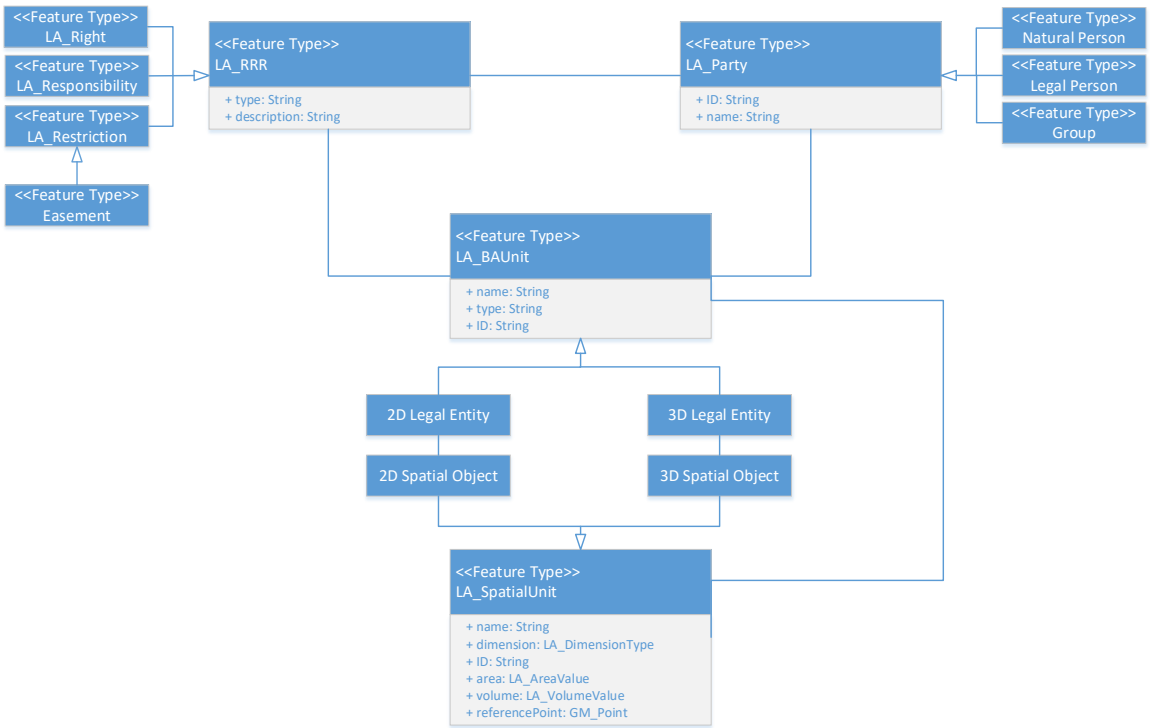

Figure 2.1 Simplified LADM Concept Model

LA_RRR describes the rights, restrictions and responsibilities of land, and has high versatility and expansibility. LA_Party corresponds to cadastral subjects, which can be natural persons, unnatural persons, etc. LA_BAUnit manages property rights concept. According to the UNECE (United Nations Economic Commission for Europe), the Basic Administration Unit is the land within the ownership unit and may include one or more adjacent or geographically separated parcels (Paulsson, 2015). LA_SpatialUnit, managing physical entity concept, is a more comprehensive presentation unit that can express buildings, attachments, parcels, and so on. In this method, correspondence and combination of legal concepts and physical concepts are accomplished through the association of 2D/3D legal entities inherited from LA_BAUnit with 2D/3D physical objects inherited from LA_SpatialUnit.

Changbin Yu et al. (Yu, 2017) used LADM to introduce the typical eight models of China's immovable property rights (e.g. the right to use constructional land/ forest/ sea area, the ownership of housing/ forest/ marine building, and the contracted management rights for cultivated land/ grassland). Based on LADM, Karel Janecka and Petr Soucek (Janecka, Soucek, 2017) provided a national overview of the Czech Republic's cadastre, including legal and spatial components, to promote the development of 3D cadastre in the Czech Republic, and to guide the Czech Republic in developing a spatial information infrastructure strategy by 2020. Zulkifli et al. (Zulkifli, 2015) discussed the applying significance and value of LADM in Malaysia. By analyzing the existing cadastral management model, Ding Yuan et al. (Ding, 2013) proposed a LADM conceptual model suitable for China's three-dimensional cadastre,

and developed a three-dimensional cadastral management prototype system, which was applied to the cadastral management of Taizhou City to verify the feasibility of the model.

2.3 BIM and IFC

2.3.1 Getting to Know

The concept of BIM (Building Information Model) was first proposed in the 1970s by Professor Chuck Eastman of the Georgia Institute of Technology. BIM is a fine three-dimensional model, including rich spatial and semantic information such as geometry, physics and rules (Ni, 2015). It is widely used in construction, machinery, manufacturing and other fields to provide professional help for the design, manufacture and management of engineering life cycle.

The standard data format of the BIM model is the IFC (Industry Foundation Class), which is a building data representation and exchange standard that computers can handle, for sharing and exchanging of information throughout the lifecycle of an engineering project or among different projects. The IFC standard was formally proposed by IAI in 1995 and is independent of any particular system.

As an open BIM data model, IFC contains physical entities that describe the entire life cycle of a building (Liebich, 2000). It is also a general model designed to standardize BIM data and enable communication and interoperability of building model data.

In terms of land management and three-dimensional cadastre, BIM, with its rich spatial and semantic information, can present the corresponding legal rights of housing owners in three-dimensional space. It contributes a lot to the three-dimensional development and management of the city, thus having attracted great attentions. The earliest research on land management using BIM was proposed by Clemen and Grundig in 2006 (Clemen, Gründig, 2006). They proposed to manage indoor cadastral information based on measured and observed data and imported different entity types into IFC files. However, they did not provide a data model for managing cadastral information in the IFC model. Behnam Atazadeh et al. (Atazadeh, 2017) explored how to extend the IFC standard to accommodate various cadastral legal information and used cadastral entities to verify the validity of the extended IFC standard.

2.3.2 Physical Entities Organization in IFC

The organization of physical entities in IFC files is shown in Figure 2.2. All physical entities in IFC are defined as subclasses of the "IfcProduct" entity, indicating that "IfcProject" is the "highest container" of all information in the IFC file. This entity provides background information about the physical entity, such as the default unit of measure, the coordinate system, the accuracy of the geometric information, and the true north direction relative to the world coordinate system, etc.

"IfcSpatialStructureElement" and "IfcBuildingElement" are the two main parent classes, "IfcSpatialStructureElement" is used to define the concept of the spatial structure of the IFC standard file, and "IfcBuildingElement" can define all building elements.

The subclasses defined in "IfcSpatialStructureElement" are:

1. "IfcSite": Presents one or more venues that may be connected or disconnected from each other contained in the IFC project. This sub-category contains background information about the building site, such as the land number and site address, and can represent the terrain around the site, etc.
2. "IfcBuilding": Presents the building itself, including background information about the entire building, such as the height of the ground floor relative to sea level, the minimum height of the terrain surrounding the building, and the building address, etc.
3. "IfcBuildingStorey": Provides information about the building floor, such as the elevation of each floor, etc.
4. “IfcSpace”: Focus on the functional management of space. Therefore, “IfcSpace” can be used to express and manage 3D space cadastre. When used indoors, "IfcSpace" is related to "IfcBuildingStorey"; when used outdoors, it can be directly related to "IfcSite".

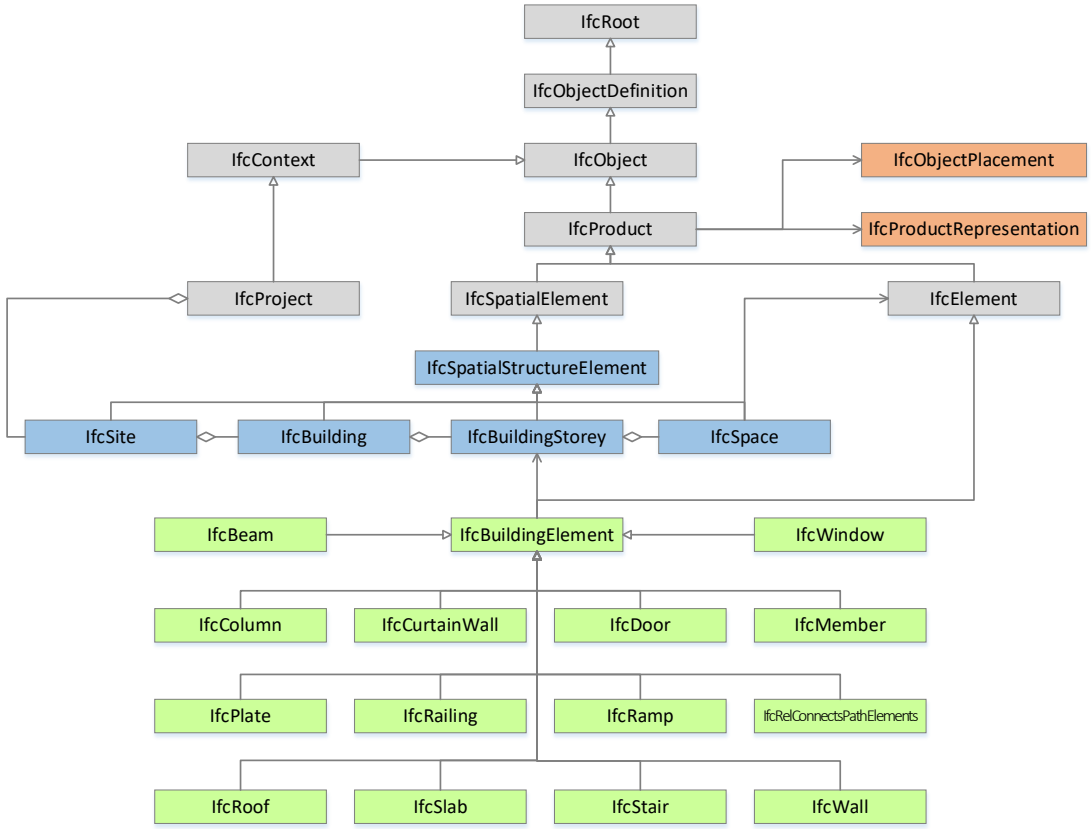

Figure 2.2 Physical Entities Organization in IFC

3. MODELING

The three-dimensional digital management of land and property requires two main components, which are legal information and physical information. Legal information, referring to ownership information, property boundaries, joint property and easements, are

prerequisite for managing RRR in the construction breakdown process, and are associated with the concept of legal space, including statutory cadastre objects. In this study, legal information is presented by LADM. While physical information, for which the IFC data model stands, includes geometric and semantic information. Geometric information refers to the shape and geometric features of architectural elements, such as accurate measurement data, coordinate systems, and measurements, etc. Semantic information refers to a physical description of architectural elements, including various building components (such as walls, roofs, doors and windows, floors, etc.) and components in different operational systems (e.g., pipes, valves, connectors, etc.).

The easement explored in this study is the one for the purpose of reaching a territory through others. Therefore, it only makes sense when referring to two or more different tenures. So we first need to use IFC data format to divide the architectural space, then spatialize various legal concepts, matching and fitting of legal meanings with property space. Next, it is necessary to judge the easement attribute of the space occupied by the passage path, that is, whether space is the dominant tenement or the servient tenement, and to whom space belongs. By comparison of the space, the owner of space, namely, the servant and the dominator of the easement, is related.

3.1 Legal Concept Spatialization – Legal Concept Modeling

The nature of the easement is actually a limitation, for the exclusive or shared part of the servient tenement must be obliged to allow the dominators to pass. Therefore, when modeling legal concepts based on LADM, the concept of the easement is expressed by the LA_Restriction class that inherits LA_RRR. The easement is also associated with LA_Party and LA_BAUnit. In particular, the association with LA_BAUnit is the basis and premise of the easement spatialization. LA_SpatialUnit and its subclass LA_LegalSpaceBuildingUnit can be associated with the class describing the physical entity. As shown in Figure 3.1.

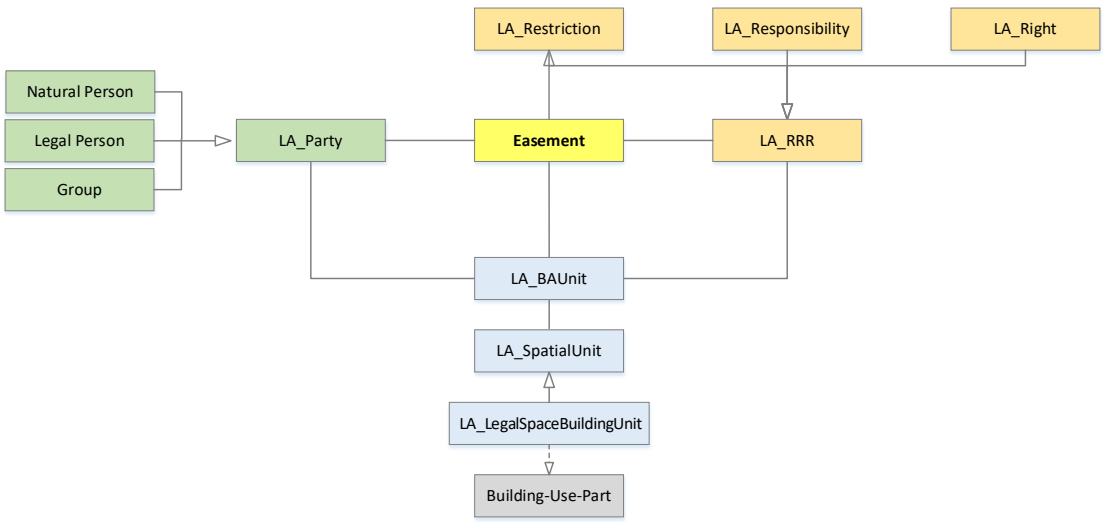

Figure 3.1 Legal Concept Modeling Based on LADM

3.2 Relationship between Dominant and Servient Tenement

Further considering the two subjects in the easement – the servant and the dominator, the easement can be subdivided. Therefore, the easement and its subjects and objects can be analyzed from two perspectives.

In concept, the subjects of the easement are connected through the objects of the easement, that is, the physical space. The servants, who provide space to access, and the dominators, who require accessible space, are in the first place two separate individuals with no connection. The spatialization of the easement allows them to combine with corresponding physical space, and further combine with each other. It facilitates the determination of rights and obligations in the analysis of the easement.

The UML diagram (Figure 3.2) is used to display the modeling relationships between entities. For the servants of the easement, they hold the land/building ownership. These legal rights' attributes are included in Easement_Servient and are associated with LA_Restriction_S. The attributes for servants themselves are expressed by LA_Servient, which inherits from LA_Party and is associated with LA_BAUnit. Meanwhile, for the dominators of the easement, their attributes are described by LA_Dominant, and the rights and restrictions contained are expressed by Easement_Dominant and are associated with LA_Restriction_D. Similarly, LA_Dominant is also associated with LA_BAUnit. Due to the relationship between the servants/dominators and the physical space, the two subjects of the easement finally have relationships with each other.

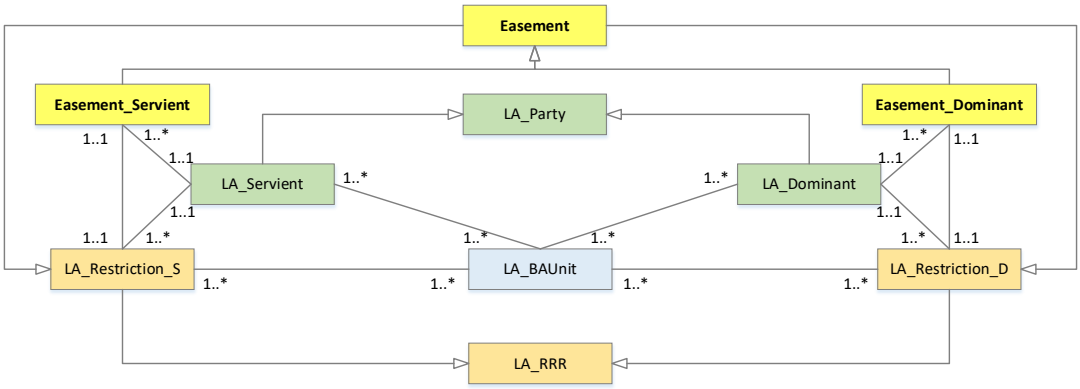

Figure 3.2 UML Diagram for Legal Modeling

4. CASE STUDY

To spatialize the easement, it is necessary to assign various legal meanings to the entity, forming a conceptual model for expressing the property space. In this study, we instantiate the spatial presentation of easements by using a four-story condominium containing underground space. And two situations that are often encountered in the reality of containing the necessary points and multiple layers of underground space above the ground are analyzed.

4.1 Modeling based on IFC

By the BIM, legal entities can be defined and added legal attributes by extending the IFC data model. Referring to the concepts proposed by Aien (Aien, 2013) in 3DCDM, the conceptual model based on IFC is shown in Figure 4.1. These entity types include 3D Legal Property Objects, different types of Document Information, and Interest Holders.

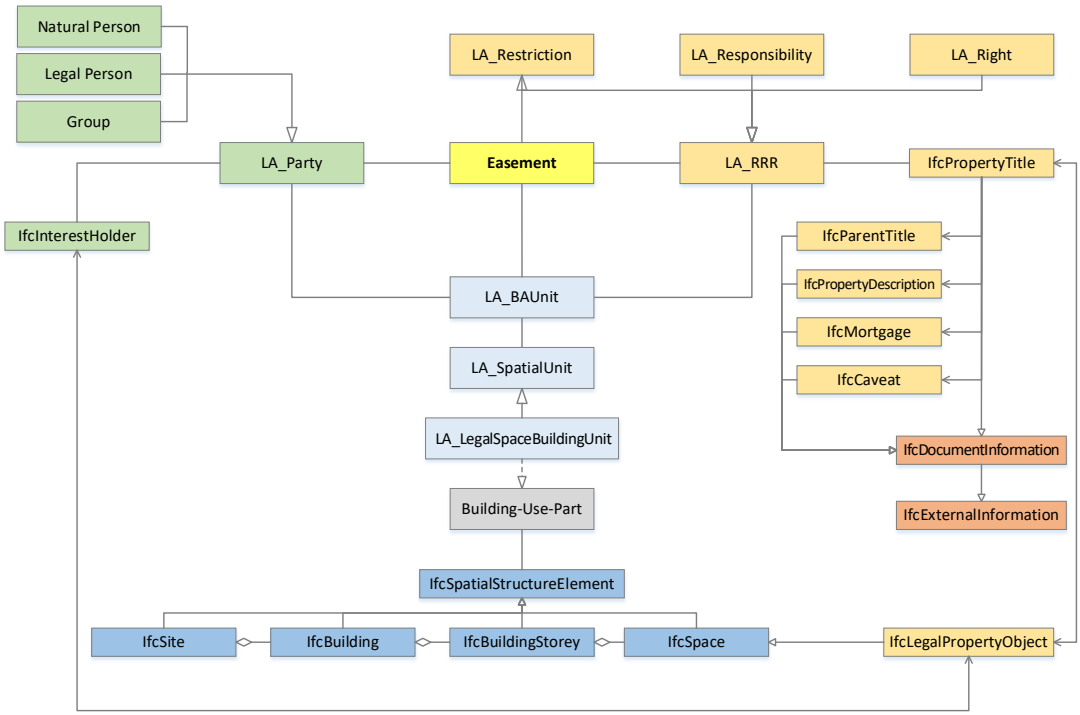

Figure 4.1 Conceptual Model Based on IFC

The 3D Legal Property Object refers to the three-dimensional representation of the legal space of ownership, which represents a certain spatial property and function, and therefore belongs to the entity of the "IfcSpace" subclass. In addition to inheriting all the attributes of "IfcSpace", it also has its own semantic information. The "IfcLegalPropertyObject" entity represents all types of legal property objects, such as unit 3D ownership space, public ownership, and easements, etc.

Different types of legal documents may be in the form of statements or spreadsheets that are not of the IFC file type and therefore cannot be presented directly in the IFC data model. However, in the resource layer of IFC, there is an "external reference resource" sub-mode, which has entities for referencing external resources and managing meta-information, and can be used for externally referencing legal documents such as reports and forms.

"IfcExternalInformation" is a parent class for managing external resource meta information. "IfcDocumentInformation" is a subclass of "IfcExternalInformation" that manages the meta information of documents associated with IFC files. Therefore, meta-information about legal documents can be presented by defining a new subclass for "IfcDocumentInformation". Each 3D Legal Property Object has five legal documents: Title, Parent Title, Property Description,

Mortgage, and Caveat. Therefore, the entities of the legal document are "IfcPropertyTitle", "IfcParentTitle", "IfcPropertyDescription", "IfcMortgage" and "IfcCaveat".

An Interest Holder is a participant who has a specific interest in the three-dimensional legal property, such as an individual, organization, or group. In the IFC model, “IfcActor” represents all Interest Holders and manual agents involved in the IFC project development cycle. Therefore, the interest holder "IfcInterestHolder" should be treated as a subclass of the "IfcActor" entity. Its specific attributes are "Person", "Group", "Organization", "Association", "Tribe" and "Family".

Table 4.1 3D Legal Attributes in IFC

	Attribute	Description	Value Type	Multiplicity
IfcLegalPropertyObject	RRR	The type of legal property object	IfcRRREnum	1
	LegalObjectUnit	The unit of legal property object	IfcLegalObjectUnitEnum	1
	LegalObjectClass	The class of legal property object	IfcLegalObjectClassEnum	1
	Volume	The volume of legal property object	IfcSolidMeasure	0..1
	LotEntitlement	The entitlement of legal property object	IfcText	0..1
	LotLiability	The liability of legal property object	IfcText	0..1
	LandUse	The land use of legal property object	IfcLandUseEnum	0..1
	LeaglObjectState	The state of legal property object	IfcLeaglObjectStateEnum	0..1
IfcPropertyTitle	Volume	The volume of the title for the property	IfcInteger	1
	Folio	The folio number of the title for the property	IfcInteger	1
	SecurityNumber	The security number of the title for the property	IfcText	0..1
	CreationDate	The creation date of the title for the property	IfcDateTime	0..1
	NumberOfParentTitle	The number of the parent title for the property	IfcInteger	0..1
IfcInterestHolder	Name	The name of the interest holder	IfcLabel	0..1
	Share	The share of the interest holder’s ownership	IfcInteger	1
	InterestHolderType	The type of the interest holder	IfcInterestHolderTypeEnum	0..1

4.2 Case 1: Path Particularity – with Necessary Points

For the first case, the part of the main entrance is set as the “Security Check Room”, which is the necessary point for each passer to enter and exit the building. The overall appearance of the condominium is shown in Figure 4.2, where the highlight is the “Security Check Room”.

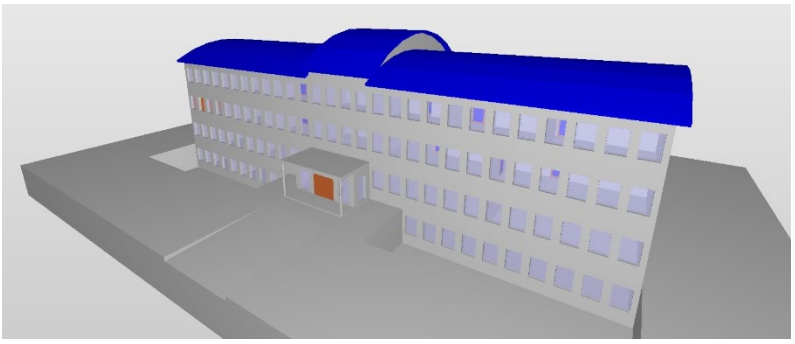

Figure 4.2 Overall Appearance of the Condominium

Then, to analyze the path of a person starting from home, passing through the security check room, and finally leaving the building, we select an apartment from the second floor as the starting point, and the main entrance on the first floor as the destination, and the path is planned by the floor plan of the building.

In Revit, the BIM editing and processing software, the "Space" tool is used to divide the ownership of each room according to the inner wall, which is generally a section of the corridor in front of the door and has the same width with the room. The rest of the corridor and the stair part are divided into "Public Part". All public and private tenure spaces are grouped into two major categories, “Public Part” and “Private Part ". In Revit, first, create the required ownership attribute fields, and then enter different ownership information into the corresponding partitions and spaces. Finally, using different tenure information to color the space, the visualization of different spatial ownership information is initially completed on the two-dimensional plan (Figure 4.3).

Figure 4.3 2D Floor Plan in Revit

The area through which the passer passes includes public parts and private parts. For private parts, the ownership of the area can be subdivided into individual. Therefore, in the walking process from the home to the outdoor, the area of the other person who needs to go through is shown in the colored part of Figure 4.3, and the ownership of each area is also different.

In visualization software SMV (Solibri Model Viewer), we add 3D visualization of the passing ownership space (Figure 4.4). Using the marker pen function, we can express the

walking route (as shown in Figure 4.5), and the ownership information of the space passing through it can be selected by clicking and view the information obtained from the column (Figure 4.6).

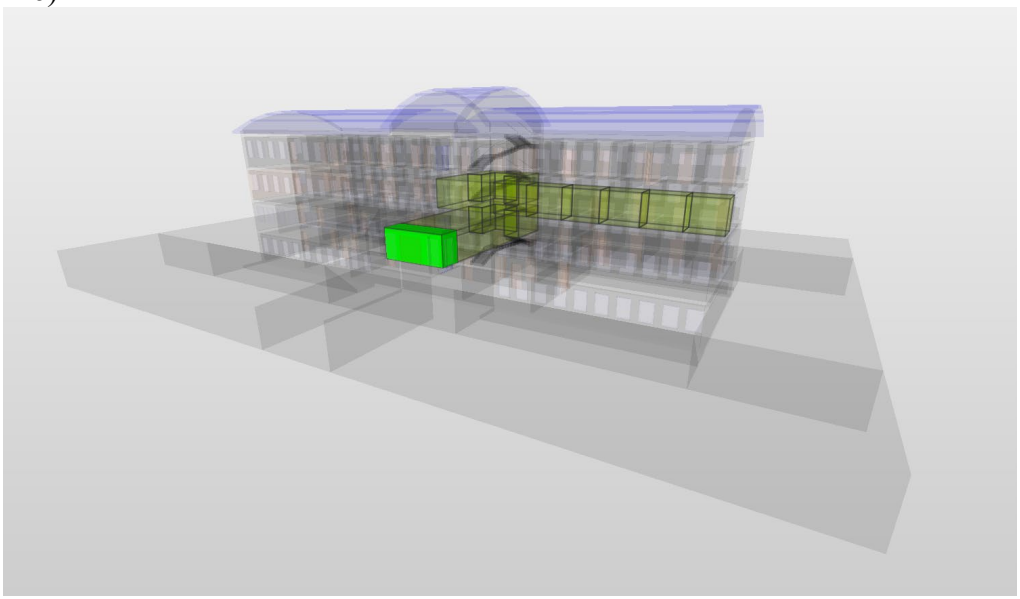

Figure 4.4 3D Path in SMV with Security Check Room

Figure 4.5 3D Walking Route

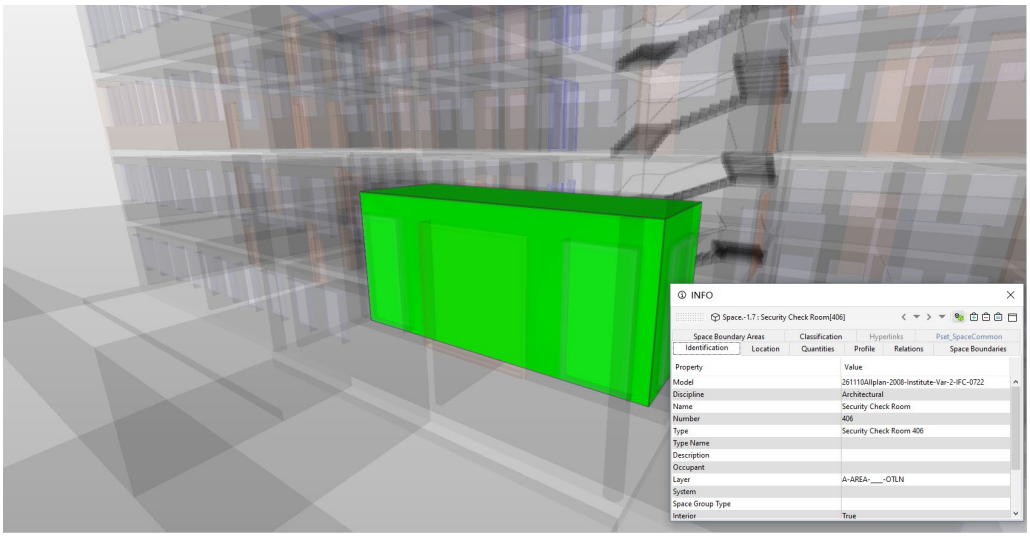

Figure 4.6 Security Check Room with Information Column

It shows the results of visualizing 3D property objects with building elements. Each stereo displays a space of private attribute or of public attribute.

This model demonstrates how to manage and access semantic information associated with a three-dimensional tenure attribute object in a BIM environment. Users can quickly find information about the ownership space, such as its height and area, and the owner of the property. In addition, the model shows that BIM can optimize the spatial complexity of 3D legal property objects in multi-story buildings. In the 3D environment of BIM, the representation of such a three-dimensional attribute object can help non-technical people to accurately understand the boundary of three-dimensional ownership and avoid unnecessary disputes.

Moreover, in this example, the necessary point is set to simulate the application situation in the real scene. With the help of the indoor navigation system, the optimal path can be designed and analyzed, and the results can be visualized in the BIM environment, and can add more three-dimensional ownership information to the passed space.

4.3 Case 2: Space Particularity – with Aboveground, Surface and Underground Space Parts

For the second case, select a certain room in the basement as the destination, and proceed from the apartment on the third floor to examine the general easement from aboveground to underground space. The path is as shown in Figure 4.7.

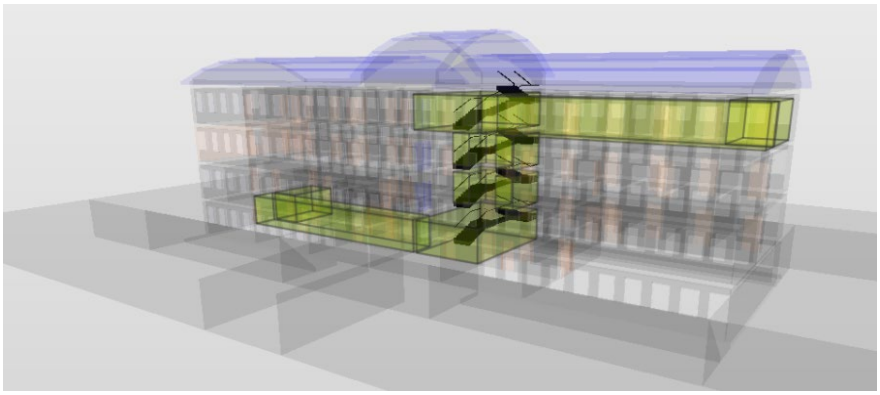

Figure 4.7 3D Path in SMV

Assume that a resident needs to reach the storage room in the basement from his/her home on the third floor, we designed a route on the two-dimensional floor plan (Figure 4.8). In SMV, the 3D visualization of the ownership space on the path is realized, and the query for ownership attribute is also implemented (Figure 4.9).

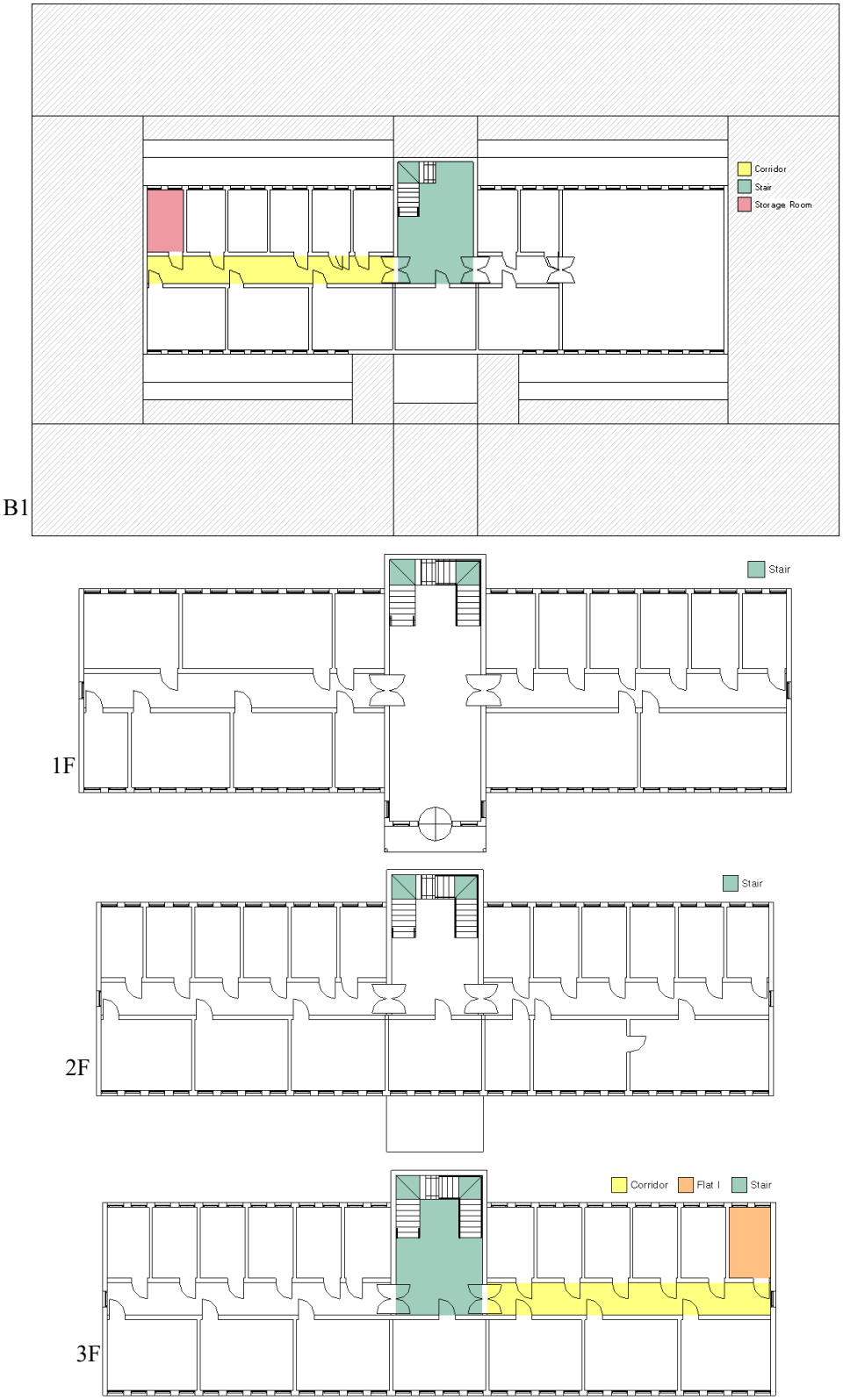

Figure 4.8 2D Floor Plan in Revit

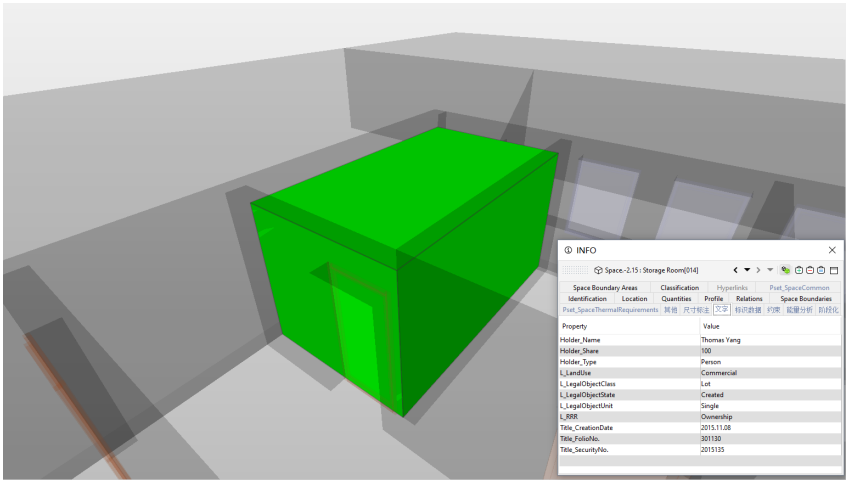

Figure 4.9 Storage Room with Information Column

This example shows that the research route of easement not only refers to reaching the surface from a selected location, but also includes a location from the aboveground to the underground. Previous studies on easements have paid little attention to the connectivity of aboveground, surface and underground spaces in a three-dimensional environment. They may be limited to the access plans from the ground to the surface or underground to the surface. Based on the realistic needs, this study expands the concept of the easement, integrating the idea of the easement of space. The starting points and ending points of the easement are now free to define, thus increasing the diversity and flexibility of the definition of the easement itself.

The expansion of the concept of the easement will also cause corresponding changes and developments in the fields of law, policy, and technical systems, etc.

5. CONCLUSION

This study is in line with the current shortage of urban space resources and the needs of three-dimensional cadastral management. We discuss the feasibility and specific implementation methods of spatializing easement by using existing industry standards and data formats. On the basis of the LADM model, the relationship between the servants and the dominators of the easement are presented. This paper introduces the easement modeling method based on the IFC standard. In the instantiation stage, the first case displays a situation when a necessary point is set. In the future, with the help of the indoor navigation system, the best path can be designed and analyzed. Then the results are visualized in the BIM environment, supplementing the three-dimensional ownership information. The second case, based on the realistic requirements of the multistory travel, extends the concept of easement from the original mode of the ground to the surface. By taking the underground space into account, it expands the starting and ending points of the easement into arbitrary spatial points, thus increasing the diversity and flexibility of the concept of easements.

The research result supports the spatial analysis of the subjects and objects of easements. The study focuses on the spatial presentation of easements. Then the servants and the dominators of easement relate to each other through equal physical space, highlighting the importance of space in easements.

The cases show that IFC can optimize the spatial presentation of 3D legal property objects in multistory buildings, which demonstrates that IFC is an effective carrier for the easement spatialization. In a 3D digital environment, this kind of representation can help non-technical people to understand the boundary division of three-dimensional ownership accurately and avoid unnecessary ownership disputes.

Therefore, the combination of legal information and architectural entities is conducive to the development of the application of both disciplines. It can not only optimize building operation, management and maintenance, but also improve land management, accelerate urban three-dimensional space development. It can also improve urban space utilization, thus helping to resolve the contradiction between the rapidly expanding urban population and the limited shortage of space resources.

REFERENCES

- Alien A. 3D cadastral data modelling[D]. University of Melbourne, Department of Infrastructure Engineering, 2013.
- Atazadeh B, Kalantari M, Rajabifard A, et al. Building Information Modelling for High-rise Land Administration[J]. Transactions in GIS, 2017, 21(1): 91-113.
- Changbin Yu, Lin Li, Biao He, Zhigang Zhao, Xiaoming Li. LADM-based modeling of the unified registration of immovable property in China[J]. Land Use Policy, 2017,64: 292–306
- Clemen C, Gründig L. The Industry Foundation Classes (IFC)–ready for indoor cadastre? [C].Proceedings of XXIII International FIG Congress, Munich. 2006, 18.
- Cui Jianyuan. Interpretation of Easement Rights[J].Journal of Law,2009,30(2):42-45.
- Cui Wenxing.The Popularization Interpretation of Easement[J].Citizens and Law (Legal Edition),2011,(1):22-24.
- Ding Yuan,Sun Zaihong,Wu Changbin, et al. Construction and Application of 3D Cadastral Management Model Based on LADM[J].Journal of Geo-Information Science,2013,15(1):106-114.
- Guo Renzhong, Li Lin, Ying Shen, et al. Developing a 3D cadastre for the administration of urban land use: A case study of Shenzhen, China [J]. Computers, Environment and Urban Systems. 2013.40:46-55.
- Janecka, Karel and Petr Soucek. “A Country Profile of the Czech Republic Based on an LADM for the Development of a 3D Cadastre.” [J]. Geo-Information, 2017, 6: 143.
- Lemmen Christiaan, van Oosterom Peter, Bennett Rohan. The Land Administration Domain Model [J]. Land Use Policy, 2015, 49: 535-545.
- Liebich T., Wix J. IFC Technical Guide [EB/OL] 2000. http://www.buildingsmart-tech.org.

- Liu Changfei. A New Probe into the Ownership of Parking Space and Garage in the Real Right Law[J]. Legal System and Society, 2014(05): 13-14.
- Ni Wei,Wang Wei.Discussion on the Unified Viewpoint of BIM and 3D GIS Integration[J].Railway Technology Innovation,2015(03):69-72.
- Paulsson, Jenny, Paasch, Jesper M.. The Land Administration Domain Model - A literature survey. [J]. Land Use Policy, 2015, 49: 546-551.
- Tang Dahao.A Comparative Study of the Easement System[J].Journal of Mianyang Normal University,2008,(6):45-48,51.
- Van Oosterom Peter, Research and development in 3D cadastres [J]. Computers, Environment and Urban Systems, 2013, 40:1-6.
- Van Oosterom, Peter, Lemmen, Christiaan. The Land Administration Domain Model (LADM): Motivation, standardisation, application and further development [J]. Land Use Policy, 2015, 49: 527-534.
- Wang Liming. Space Right: A New Type of Property Rights[J]. Legal Science: Journal of Northwest University of Political Science and Law, 2007, 25(2): 117-128.
- Wu Wanjun, Qu Yanqing.The Legal Relationship of Easement[J].Legal System and Economy (The second half of the month),2007, (12):14-15,17.
- Ying Shen, Guo Renzhong, Li Lin, Van oosterom Peter, Jantien Stoter. Construction of 3D Volumetric Objects for a 3D Cadastral System. Transaction in GIS [J]. 2015,19(15):758-779.
- Zhai Zhuo.The Modern Development of Easement and Its Influence[J].Global Law Review,2013,(6):5-16.
- Zhang Baogui,Li Chaolong.A Brief Discussion on the Easement System of Roman Law[J].Journal of Zhoukou Normal University,2004,21(3):62-65.
- Zhu Yanghua.Investigation and Analysis of the Easement System of Roman Law[J].Journal of Heilongjiang Administrative and Administrative Cadre College,2005,(3):78-80.
- Zulkifli Nur Amalina, Rahman Alias Abdul, Van Oosterom Peter, et al. The importance of Malaysian Land Administration Domain Model country profile in land policy [J]. Land Use Policy, 2015, 49: 649-659.

CONTACTS

Shen YING
School of Resource and Environment Sciences
Wuhan University
Wuhan 430079
CHINA

Yifan XU
School of Resource and Environment Sciences
Wuhan University
Wuhan 430079
CHINA

Chengpeng LI
School of Resource and Environment Sciences
Wuhan University
Wuhan 430079
CHINA

RenZhong GUO
School of Resource and Environment Sciences
Wuhan University
Wuhan 430079
CHINA
and:
Shenzhen University
Shenzhen 518060
CHINA

Lin LI
School of Resource and Environment Sciences
Wuhan University
Wuhan 430079
CHINA