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Original article

Design and Establishment of Database on the AtoN Properties for AtoN Simulator*

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Abstract

This study investigated the design and establishment of AtoN(Aids to Navigation) in the AtoN Simulator. In recent years, IALA(International Association of Lighthouse Authorities) has raised the need of a system which could verify whether AtoN is appropriate for the design of AtoN and placement planning. An AtoN Simulator provides simulation circumstances, including the topographical and environmental characteristics of a primary harbor and the characteristics of a navigating ship and the maritime traffic. In the present study, we have developed an AtoN simulator system, including the integrated system design and the construction of an AtoN database. The AtoN Manager was developed as a virtual AtoN to manage the AtoN simulation. However, the data and materials are difficult to manage. Hence, an AtoN Manager and an AtoN simulation system have been needed for an effective managing of the AtoN properties database data. For the database structure design, we have analyzed the database design methodology. The AtoN properties have been analyzed for the effective data management. The AtoN properties designed in the present paper were classified into 19 categories. The status and properties database of AtoN were installed in 14 major ports, those were applied to the AtoN Manager. Designing the AtoN properties database was defined to reduce confusion of the use of English terms and abbreviations. The terms and acronyms have been defined in the AtoN properties and designed to the properties database structure for each AtoN. Before structuring the database for the AtoN Manager, the data of the AtoN properties for each harbor have been organized in accordance with the Excel system. The regulated data were converted into the AtoN properties database in use for the AtoN Manager. The database based on the AtoN properties table structure to each AtoN was designed. The AtoN simulator was implemented by the AtoN Manager applied to the AtoN properties database.

Keywords: AtoN, AtoN properties, AtoN Simulator, Database Design

I. Introduction

With the advent of higher speeds of harbor departures and a larger amount of vessel traffic in the world's major countries there has been a dramatic increase in the number of marine accidents. In this context, ensuring the safety of maritime traffic in coastal waters ports becomes crucial. Recently, ship size, vessel traffic, and the complexity of harbor areas have all been on the increase, which enhances the need of elaborating scientific design techniques for planning the distribution of AtoN.

The AtoN Simulator provides simulation circumstances, including the topographical and environmental characteristics of a primary harbor and the characteristics of a navigating ship and the maritime traffic. The AtoN planning expert can design a safer and more efficient distribution of AtoN using the simulator. The AtoN Simulator is based on a ship handling simulator and has been developed by KAAN (the Korea Association of Aids to Navigation) and KRISO (the Korea Research Institute of Ships & Ocean Engineering) funded by MOF (Ministry of Oceans and Fisheries) in Korea. In recent years, IALA has raised the need of a system that could verify which is appropriate for the design of AtoN and placement planning (Seo Jeong-Min, p180), (Kim Yeon-Gyu, p111-p112). The AtoN Manager was developed as a virtual AtoN to manage the AtoN simulation. The effective use of the program raised the need for AtoN properties data. However, the AtoN data are too complicated and large to handle. Hence, an AtoN Manager and an AtoN simulation system have been needed for an effective management of the AtoN properties data.

In this paper, the AtoN properties were searched and analyzed for effective data management and AtoN simulator operation via the AtoN Manager and AtoN simulator's classification and analysis of the AtoN properties data uses. 19 categories of the AtoN properties were identified and a database structure has been designed. The AtoN properties database structure was designed on the basis of the AtoN properties analysis. Furthermore, terms and abbreviations were defined for using the AtoN properties in the database. We designed the AtoN properties database structure for each AtoN. Before building a database for the AtoN Manager, the AtoN property data for the major 14 ports were classified and organized. The data were written with Excel. The organized data were then converted to the AtoN properties database.

II. Related Work

2.1. Analysis of the database design methodology

According to A. Silberschatz, H. F. Korth and S. Sudarshan (1997), Stonebraker Michael and Moore Dorothy (1999), in recent years, the range of the databases has increased from a relational database to an object-relational database. An object-relational database is extended to relation query language to process. Extension of the relational data model and additional data types provide a variety of data types, such as SQL(Structured Query Language) (Joo Kyung-Soo, p27), (Joo Kyung-Soo, p64). Also, the properties of each tuple can be used as a complex object type. Figure 1 shows the object-relational database design methodology configuration (Joo Kyung-Soo, p155).

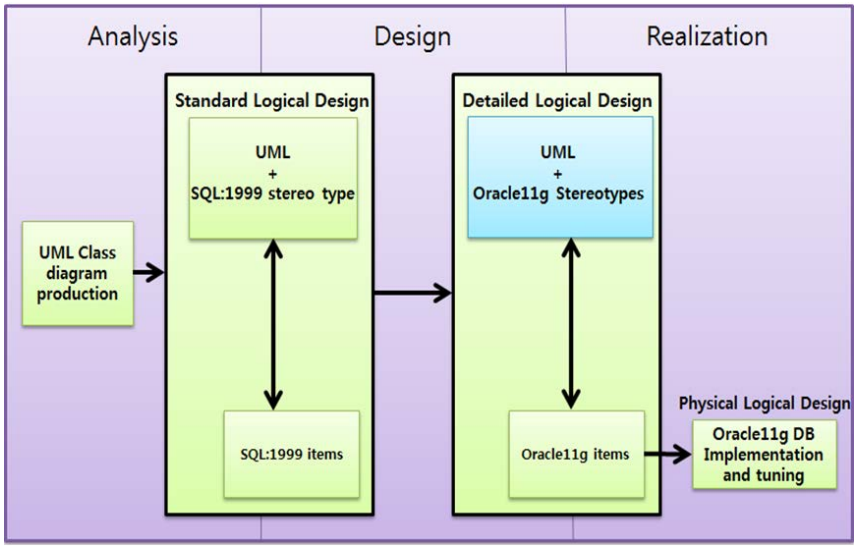

Figure 1: Object-relational database design methodology configuration

Source: Joo Kyung-Soo (2011), p.155.

The object-relational database methodology consists of three steps: analysis, design, and implementation. The analysis step uses an extended UML class diagram for a conceptual schema design. The design step is divided into two steps. The first step is to convert to the object-relational standard model SQL:1999 by the previously derived UML class diagram. The second step is converted to a particular product such as Oracle 11g schema converted SQL:1999 by way of an object-relational database design methods in the previous step. Finally, the implementation step includes a physical design process and improves the schema obtained in the previous step (Ju Kyung-Soo, p155), (Lee Seong-Dae, p186). AtoN constitutes a single entity to combine multiple properties. These objects can be used alone and consist of multiple elements. These were reference and object inheritance. Those were features of the object relational database. Through this analysis, the object-relational database is more suitable than the relational database.

2.2. Analysis of the AtoN

According to Yeo Ji-Min (2014), Ministry of Oceans and Fisheries (2006) and Kim Jong-Uk (2012), AtoN were divided into visual aids, shape aids, audible aids, radio aids, and special signal aids. Visual aids display the location and function of AtoN using the shape and color in daytime and light color in night. Shape aids display the function and location of AtoN using shape and color. Audible aids display location of AtoN using the sound in poor visibility conditions, such as in fog or snow. Radio aids display the location of AtoN using a number of properties of the radio and special signal aids that provide information about tidal currents, ship navigation, and weather conditions using radio and shape.

III. Design and Establish of AtoN Properties Database

3.1. Definition of AtoN English abbreviations

In order to use the database, AtoN terms and abbreviations were defined. Table 1 shows some of the abbreviations used in the 88 AtoN properties database.

Table 1: AtoN Terminology Abbreviated

Term	Abbreviations
AtoN ID	AtoNID
AtoN Name	AtoNName
Class	Class
Manned Lighthouse	MannedLH
Unmanned Lighthouse	UnmannedLH
Beacon	Beacon
Leading Lights	LeadingLight
Projector Light	ProjectorLight
Direction Light	DirectionLight
Light Staff	LightStaff
Light Buoy	LightBuoy
Bridge Light	BridgeLight
Traffic Signal Lights	Traffic Signal Lights
Unlighted Beacon	UnlightedBeacon
Buoy	Buoy
Bridge Daymark	Bridge Daymark

3.2. Definition of Data Type

Prior to the design database, the data types of the AtoN were defined. Definition of the data type is necessary for the effective storage and management of the data. Table 2 shows the items and data type required for the configuration data of the manned lighthouse. A Text type (5) is composed of AtoN ID, AtoN Name, Shape, Comment, and Period. Port ID, Managed office ID, Latitude, Longitude, Direction, Light Rhythm Chart ID, Light height, Nominal Range, Geographical Range, Height, Vertical Angle, Horizontal Angle, VisibilityArc Start, VisibilityArc End, FogSignal ID, Racon ID, Weather Signal ID, Projector Light ID, AtoN AIS ID, 2D ID, and 3D shape model ID are defined as an Int type (20). An Enumeration type (17) includes Class, Type, Status, Office Name, Harbor Name, Light Color, Surface Color, Function, Lantern Type, Flashing Type, Fog Signal, Racon, Weather Signal, AtoN AIS, Projector Light, Monitoring & Control system and the VTS Area.

Table 2: Definition of Data Type

DATA Type	Column Name	DATA Type	Column Name
Text Type	AtoNID	Int Type	Projector Light ID
	AtoNName		AtoN AIS ID
	Shape		2D ID
	Comment		3D shape model ID
	Period	Enumeration Type	Class
Int Type	Port ID		Type
	Managed office ID		Status
	Latitude		Office Name
	Direction		Harbor Name
	LightRhythmChart ID		Light Color
	Light Height		Surface Color
	Nominal Range		Function
	Geographical Range		Lantern Type
	Height		Flashing Type
	Vertical Angle		FogSignal
	Horizontal Angle		Racon
	VisibilityArc Start		Weather Signal
	VisibilityArc End		AtoN AIS
	FogSignal ID		Projector Light
	Racon ID		Monitoring&Control system
	WeatherSignal ID		VTS Area

3.3. Design of AtoN Properties Database Structure

From the analysis of the common attributes of the AtoN, the AtoNInfo table was configured to a relationship between the AtoN properties. When AtoN has affiliated facilities, those facilities were collected to the same amount. The diagram in Figure 2 demonstrates the database structure and relationship.

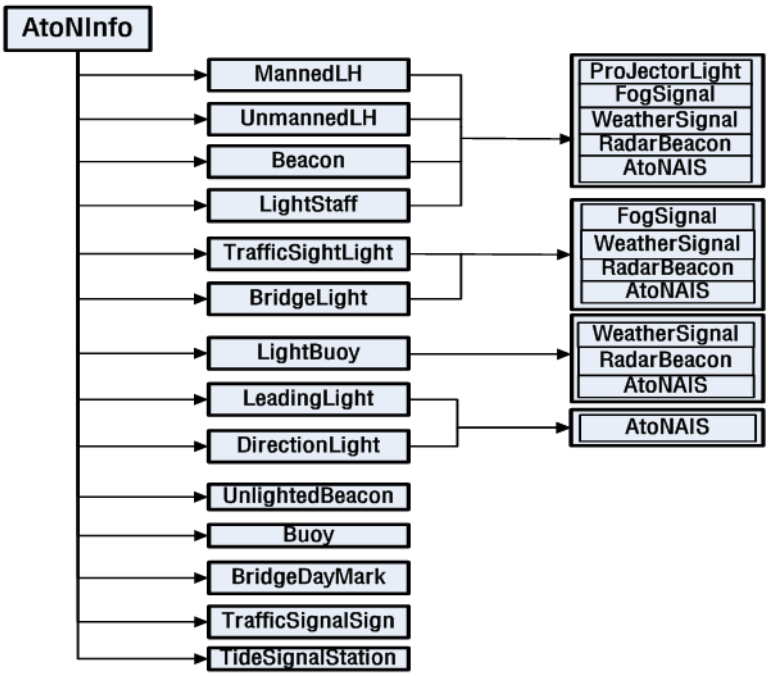

Figure 2: AtoN properties database diagram

In order to use 19 kinds of AtoN for the AtoN Simulator, the AtoN properties for the manned lighthouse are described. AtoN ID was classified in accordance with the AtoN status information. The existing facilities are denoted by the EF. New facilities are denoted by the IP. Position fills in degree, minute, and second. In case of Rhythm Characteristics, the light color should be chosen by the user afterwards, Rhythm Characteristics are largely classified for 10 species. 20 kinds of detailed Rhythm Characteristics could be chosen. It applies to the way of entering the flashing cycle of the selected rhythm characteristics. Light and height refer to the average height of the base surface. Nominal Range refers to the light of the geography of the light house, using ships, function, and light brightness. Surface color and shape fill in the contents of the lighthouse list. A function could record functional contents of the lighthouse list. The name of the lantern refers to the currently used name. Vertical and horizontal divergence angles of the light refer to the current value. Flashing type refers to using flashing type that is divided into rotate, flashing, etc. Visibility fills in the visibility contents of the lighthouse list. Fog signal, Radar beacon, Marine weather station, AtoN AIS, Projector Light, Monitoring and Control system could register the contents of the lighthouse list. VTS management authority refers to the name of the VTS main body. Port and fairway refer to the name of the port and the fairway management authority. 2D and 3D numbers refer to the serial number. The AtoN condition is divided into virtual, expansion, relocation, revocation, etc. Figure 3 represents the attribute table structure of the manned lighthouse. The value of AtoN ID has a primary key and a foreign key. In addition, it refers to the attribute table such as Fog signal, Radar beacon, Marine weather station, AtoN AIS, and Projector light.

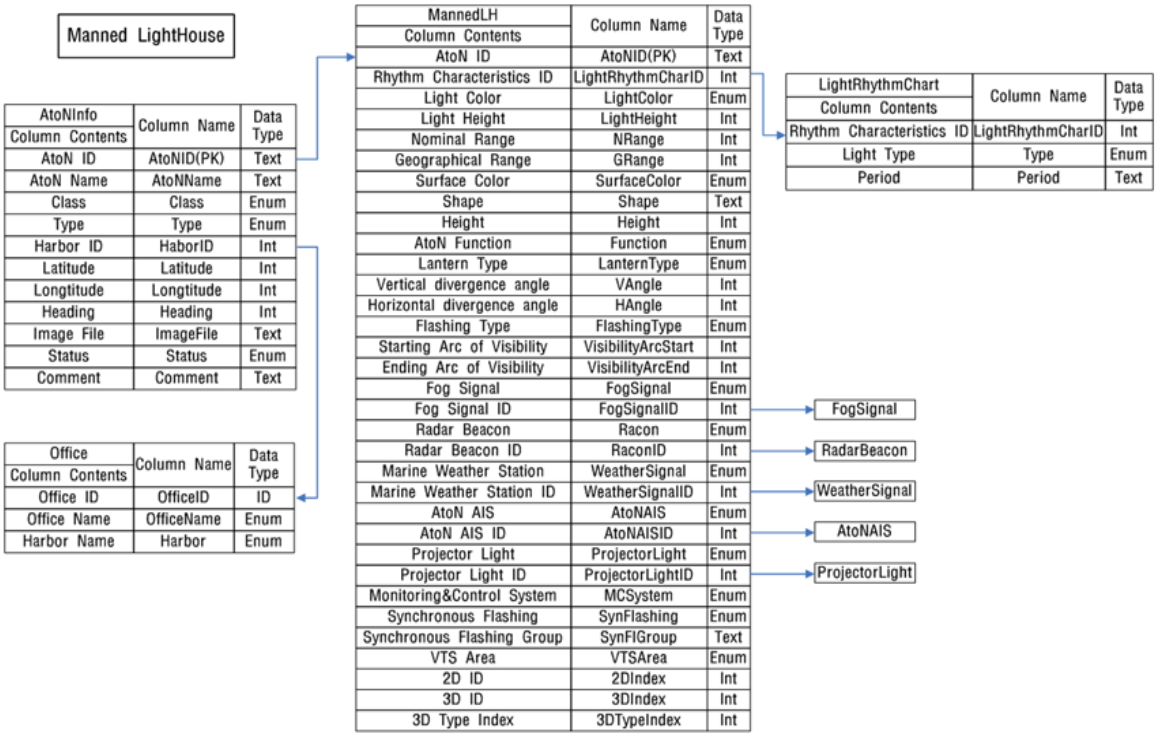

Figure 3: Attribute table structure of Manned Lighthouse

3.4. Establishment of AtoN Properties Database

For the inspection and efficient conversion of the collected data, the data were classified with Excel. The collected data were converted to a database record for the AtoN Manager. Figure 4 shows an excerpt of the Excel data of the manned lighthouse.

Manned lighthouse

AtoNID	AtoNName	Class	Type	Harbor	Office	Latitude	Longitude	LightRhythmCharIndex	LightColor	LightHeight	NRange	GRange
EF-3399	Budo lighthouse	Visual aids	Manned lighthouse	Incheon Hang	Incheon Regional Maritime Affairs and Port Office	37.1495555556	126.3475000000	57	White	42	27	18.16
EF-3363	Seonmido lighthouse	Visual aids	Manned lighthouse	Incheon Hang	Incheon Regional Maritime Affairs and Port Office	37.2873333333	126.0775000000	55	White	176	18	32.29
EF-3555	Palmido lighthouse	Visual aids	Manned lighthouse	Incheon Hang	Incheon Regional Maritime Affairs and Port Office	37.3583333333	126.5110000000	53	White	85	27	23.86

SurfaceColor	Shape	Height	Function	LanternType	HAngle	VAngle	FlashingType	VisibilityArcStart	VisibilityArcEnd	FogSignal	FogSignalID	Racon	RaconID
White	Circular Concret	16	Landfall Mark)	750mm	360	±4	Rotation	0	360	TRUE	EF-4400	TRUE	EF-4145
White	Circular Concret	19	Landfall Mark)	750mm		±4	Rotation	351	281	TRUE	EF-3363	TRUE	
White	Circular Concret	26	Landfall Mark)	750mm	360	±4	Rotation	0	360	TRUE	EF-4415	FALSE	

WeatherSignal	WeatherSignalID	AtoNAIS	AtoNAISID	ProjectorLight	ProjectorLightID	MCSystem	VTSArea	Status	2DIndex	3DIndex	3DTypeIndex	ImageFile	Comment
FALSE		FALSE		FALSE			TRUE	Exist					
FALSE		TRUE		FALSE			TRUE	Exist					
FALSE		FALSE		FALSE			TRUE	Exist					

Figure 4: Excel data sheet of Manned Lighthouse

The AtoN properties data for each port were converted to the established database. The AtoNInfo table converted to the database is shown in Figure 5.

AtoNID	AtoNName	Class	Type	Harbor	Office	Latitude	Longitude	Heading	Status
EF-3306	Uldo lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.02	126	0	Virtual
EF-3306.2	Uldo Hang W.B'water lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.0291096474	126.0039040265	0	etc
EF-3306.3	Uldo Hang E.B'water lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.029801696	126.0065590314	0	etc
EF-3308	Seongapdo lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.0920166667	126.08465495484	0	etc
EF-3308.1	Pungdo Hang N.B'water lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.1125615102733	126.39473903631	0	Relocation
EF-3308.2	Pungdo Hang S.B'water lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.1123380775521	126.39407009942	0	etc
EF-3361	Gakheuldo lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.1148333333333	126.021494866173	0	Relocation
EF-3365	Deokjeokbukri B'water lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.2536826261579	126.122195753169	0	Relocation
EF-3368	Soyado lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.2081666666667	126.193875524624	0	Relocation
EF-3369	Dongbaekdo lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.1971666666667	126.20972361225	0	Relocation
EF-3402	Pungdo lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.1158837115364	126.385597213406	0	Relocation
EF-3524	Incheon Korea Gas Corporation No. C Lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.3379166666667	126.588347625577	0	etc
EF-3525	Incheon Korea Gas Corporation No. D Lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.3380666666667	126.593416247926	0	etc
EF-3540.7	Incheon Korea Gas Corporation No. A Lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.338	126.58117294371	0	Relocation
EF-3540.8	Incheon Korea Gas Corporation No. B Lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.3380333333333	126.585924777162	0	etc
EF-3543.1	Incheon Hang E1 port No. A lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.3381408271028	126.60605	0	etc
EF-3543.2	Incheon Hang E1 port No. B lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.3381714030032	126.609833333333	0	Relocation
EF-3545	Incheon Korea Gas Corporation N.B'water Lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.3444486976217	126.601529332353	0	Relocation
EF-3574	Incheon Nam Hang Dongyang Cerment lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4341735283452	126.612550594751	0	Relocation
EF-3575	Incheon Nam Hang Daewoo Cerment No. A lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4335152946411	126.609056930717	0	Relocation
EF-3576	Incheon Nam Hang Daewoo Cerment No. B lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4329029062863	126.610871048484	0	Relocation
EF-3577	Incheon Hang Coal Wharf No.A lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4384368876697	126.58670882867	0	Relocation
EF-3578	Incheon Hang Coal Wharf No.B lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4415514446832	126.587422142315	0	Relocation
EF-3579	Incheon Nam Hang Ssangyong Cement No.A lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4389699139891	126.612004411571	0	Relocation
EF-3580.9	Incheon Nam Hang Container Wharf No.A lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4383750537429	126.594326844279	0	Relocation
EF-3581	Incheon Nam Hang Container Wharf No.B lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.438349296024	126.601	0	Relocation
EF-3584	Incheon Nam Hang Ssangyong Cement No.B lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4381972041204	126.613889287881	0	Relocation
EF-3586	Incheon Hang Sk lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.445934013369	126.591021794929	0	Relocation
EF-3593	Incheon Hang Yeonan Hang S. B'water lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4619228414752	126.591019790429	0	Relocation
EF-3598	Incheon Hang Yeonan Hang N. B'water lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4641928340567	126.591129982324	0	Relocation
EF-3599	Incheon Hang S-Oil lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.450611623986	126.591027837325	0	etc
EF-3601	Incheon Hang Port Service Ship Wharf B'water lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4544032859457	126.5912437959	0	Relocation
EF-3602	Incheon Hang International Ferry Wharf No.A lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4548796258977	126.593462225863	0	Relocation
EF-3603	Incheon Hang International Ferry Wharf No.B lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4553744867692	126.594262560016	0	Relocation
EF-3604	Incheon Hang N.B'water lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4569123934884	126.5949873519	0	Relocation
EF-3607	Incheon Hang Lock gate S.B'waster lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4652132310681	126.593766035042	0	Relocation
EF-3610	Incheon Hang Lock gate N.B'waster lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.4689209110857	126.594864548115	0	Relocation
EF-3612	Incheon Hang LG-Caltex oil No.A lighthouse	Visual aids	Unmanned lighthouse	Inchon Harbor	Incheon Regional Maritime	37.477594306214	126.594297475641	0	Relocation

Figure 5: Established to AtoN properties database

3.5. Application of Database to the AtoN manager

The database can be created and edited to AtoN through the AtoN properties database management software. The software that manages the AtoN properties database is called the AtoN Manager. AtoN Manager was used for management and deployment capabilities for AtoN and quantifying function of the AtoN layout. The AtoN Simulator was applied to the AtoN Manager for managing AtoN.

IV. Conclusions

The present study describes the design and establishment of the AtoN properties database for the AtoN Simulator. In order to design the AtoN properties database, the database design methodology was analyzed. Furthermore, the database analyzed AtoN and the AtoN properties. The AtoN abbreviations were defined for their use in the database. The database based on the AtoN properties table structure to each AtoN was designed. The AtoN simulator was implemented by the AtoN Manager applied to the AtoN properties database. In this study, the structure of the database was established for the AtoN simulator. A new direction for the operating aids navigation simulators that are required for the objective function of the proposed AtoN placement. In addition, with the established database it has become easier to manage the vast amount of AtoN properties data for the AtoN simulator.

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