e-Navi

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e-Navigation Journal

Original article

Performance and Analysis of AtoN properties and 3D Modelling for AtoN Simulation System

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Abstract

The AtoN Simulator provides simulation circumstances, which include the topographical and environmental characteristics of a primary harbor, as well as the characteristics of navigating a ship and maritime traffic. The AtoN planning expert can design a safer and more efficient distribution of AtoN using the simulator. AtoN simulation system is a system that adds AtoN part such as AtoN attribute and modeling to ship handling simulation system. AtoN 3D modeling and motion characteristics implemented in existing ship handling simulations were not perfect. Therefore, there was inconvenience in 3D simulation. Therefore, AtoN attribute construction and 3D modeling are required for AtoN simulation system. This study researched the AtoN 3D modeling for AtoN simulator. The AtoN analysis surveyed the AtoN for 3D modeling. Modeling design was designed to be similar to the actual AtoN on the basis of such an analysis of the AtoN scale. Modeling was AtoN 3D modeling based on the design drawings. Each AtoN was grouped into a Main Category and Sub Category. Specific data were easily changed using the 3D tools.

Keywords: AtoN, AtoN properties, AtoN simulation system, 3D modelling, Design

1. Introduction

Since the marine safety accidents have increased due to the large and higher speed of the harbor departures and vessel traffic in the world's major countries, it is strongly required to make sure to ensure the safety of maritime traffic in coastal waters ports. Recently the size of the ships, the vessel traffic and the complexity of the harbor area are increasing, and so the need for a scientific design technique for planning the distribution of Aids to Navigation (AtoN) is increasing.

The AtoN Simulator provides simulation circumstances, which include the topographical and environmental characteristics of a primary harbor, as well as the characteristics of navigating a ship and 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 KATON (Korea Institute of Aids to Navigation) and KRISO (the Korea Research Institute of Ships & Ocean Engineering) funded by MOF (Ministry of Oceans and Fisheries) in Korea. The AtoN planning expert can design a safer and more efficient distribution of AtoN using the simulator (Song Byoung-Ho, 2010), (Kim Yeon-Gyu, 2013). The simulation environment should be similar to the actual implementation. The implementation of the AtoN appearance is also important. The properties and appearance of the AtoN play important roles in the efficient arrangement of the AtoN and the safe operation of the ship.

According to the IALA Guideline 1058 on the use of simulation as a tool for waterway design and AtoN planning, the system needed to verify the design and planning aids to navigation, which can support a decision on AtoN design and placement planning. Simulation is the relatively low-cost method that used to meet user needs in an efficient manner for AtoN design. Improvements in the simulation of operating results help to demonstrate. The seaway design and operate the relevant aids to navigation before the ship sailing. In addition, it is recommended for final Aids to navigation placement verification to use the Full Mission Bridge Simulation System. According to the IALA Guideline 1097 on Technical features and technology relevant for simulation of AtoN, AtoN simulation system is system for support for decision for optimal aids to navigation utilization and efficiency of sea conditions and maritime traffic environment. The simulation system can perform research and development of existing and future systems and aids to navigation system. The simulation system described that it is important to users (designers, sailors) to participate in the simulation analysis and evaluation for the establishment planning of AtoN.

The AtoN Simulation system is the management software package (SW) which can place an AtoN and assign it to properties such as the shape, colour, light and function, etc. ~~Two types of~~ FMS (Full Mission Simulation) ~~and Desktop Simulation~~ were installed at the Buoy Management Office (Korea Government) in Yeosu. Full Mission Simulation was more realistic than other simulation and could be evaluated into various scenarios accurately and mainly used in 3D mode. ~~Desktop Simulation has the advantage of being easy to using in other scenarios, which can be simulated at low cost and mainly used in 2D mode rather than 3D mode.~~

In this paper, we analyzed the properties of visualizing aids to navigation, and designed the 3D model based on the 19 kinds of AtoN. In addition, we produced 1,982 kinds of aids to 3D navigation model. The production model was easily separated by ID for management and applied in the simulation. The production model was applied to the AtoN simulator.

2. Related Work

2.1 Analysis of the AtoN

The AtoN is divided into visual aids, shape aids, audible aids, radio aids and special signal aids. Visual aids display the location and function of AtoN using shape and color in the daytime and light color at night. Shape aids display function and location using shape and color. Audible aids use sound for bad visibility in bad weather conditions, such as fog or snow. Radio aids use a number of radio properties and special signal aids that provide information about tidal currents, ship navigation and weather using radio signals and shapes (Yeo Ji-Min, 2014), (Kim Jong-Uk, 2012).

2.2 Analysis of the IALA maritime buoy system

The maritime buoy system was one of the major contributions of IALA (International Association of Lighthouse Authorities) to promote safety in navigation. The system uses seven types of markers, which can be used in combination. A navigator can distinguish between identifiable characteristics. The marks are classified as cardinal mark, side mark, isolated danger mark, safe water mark, special mark and new dangerous mark. Table 1 displays the type, color and shape of the maritime buoy system.

Table 1: IALA maritime buoy system

Name		Color	Shape	Top mark	Color of light
Side mark	Port hand	Green	can, pillar, spar	Green, can, 1	Green
	Starboard hand	Red	can, pillar, spar	Red, Cone, 1	Red
	Mark for preferred channel to starboard	Green with horizontal red band	can, pillar, spar	Green, Can, 1	Green
	Mark for preferred channel to port	Red with horizontal green band	can, pillar, spar	Red, Cone, 1	Red
Cardinal mark	north cardinal	Black about yellow	pillar, spar	Black, Upward, cone, 2	White
	east cardinal	Black with Yellow band	pillar, spar	Black, Facing the bottom, cone, 2	White
	South cardinal	Black about Yellow	pillar, spar	Black, Downward, cone, 2	White
	west cardinal	Yellow with Black band	pillar, spar	Black, Opposite top, cone, 2	White
Isolated danger mark		Black with Red band	pillar, spar	Black, rectangular column, 2	White
Safe water mark		Red & White vertical stripes	spheres, pillar, spar	Red, sphere, 1	White
Special purpose mark		Yellow		Yellow, X, 1	Yellow
Mooring mark		Blue horizontal bands on white background	can, cone	-	White
New danger mark		Dimensions same blue and yellow vertical stripes	pillar, spar	Yellow, +, 1	Cross the yellow and blue

3. Analysis of the AtoN properties for AtoN modeling

3.1 Properties of light height and height

The AtoN light-height standard was applied to the height of the center of the light source from the mean sea level. The lighthouse and light beacon were applied to the height of the center of the light source from the mean sea level. The buoy and unlighted beacon were based on the top of the structure. In this case, the height of less than 10 m was one decimal place, and more than 10 m was one integer place. The standard for the height of the AtoN was defined as being from the ground to the top. The light buoy, buoy and LANBY were floating and were based on the height of the center of the lantern from the flotation section draft. The height of the light depended on the tide level and wave height, because the flotation section is connected to the sinker. The light-heights of the light beacon, lighthouse, light pole, leading light, and direction light were measured from the center of the lantern to the mean sea level. The light-height of unlighted beacon and buoy were based on the length from the top of the structure to the mean sea level.

3.2 Properties of AtoN light color

In AtoN, the light-color range and attributes of IALA using the AtoN light-color are recommended by specifying a range of white, red, green, yellow and blue light. AtoN surface colors are recommended by specifying a range of white, red, green, yellow, black and purple (IALA Recommendation E-200).

3.3 Properties of lantern types

Lanterns are divided into rotating and flashing types. There are several types according to type of light source, flash method, purpose of use and function.

3.4 Properties of top mark

Top-mark installed to Shape-aids and visual-aids used suitable AtoN type and function. It is used as shown in Table 2(MOF, 2006). In the case of the cone, the length from the bottom surface of the vertical height of the cone to the peak is about 90% of the bottom diameter. In the case of the buoy, the diameter of the bottom is at 25-30% of the flotation section diameter waterline. In the case of the cardinal mark, the separating distances between the cones are more than 35% of the diameter of the bottom. In the case of the cylinder, the vertical height is 1 to 1.5 times the diameter of the bottom surface. In the case of the buoy, the cylinder of the diameter is a minimum of 25% to 30% of the flotation section water line diameter. The lowest points of the intervals of the mark flotation section and the cylinder have their diameters defined to be more than 35%.

In the case of the spherical top-mark, the isolated danger mark is a sphere with a diameter interval of 50%. In the case of buoy, the diameter of the sphere is more than 20% of minimum flotation section diameter. Flotation section and the lowest part of the sphere of interval is more than 35% of the sphere diameter. In the case of the X and + types, the length of one side of the X and + types were set to about 33% of the body diameter. This should be the diagonal (X) and height (+ type) of a square. One side of the width of the X-type and + type is 15% of the side length.

Table 2: Type and number of application-specific top-mark

<table>
<tr><th colspan="2">Utilization</th><th>Shape of Top mark</th><th>Counter</th></tr>
<tr><td colspan="2">Cardinal mark</td><td>cone</td><td>2</td></tr>
<tr><td rowspan="2">Side mark</td><td>Port hand mark</td><td>cone</td><td>1</td></tr>
<tr><td>Starboard hand mark</td><td>can</td><td>1</td></tr>
<tr><td colspan="2">Isolated danger mark</td><td>sphere</td><td>2</td></tr>
<tr><td colspan="2">Safe water mark</td><td>sphere</td><td>1</td></tr>
<tr><td colspan="2">Special purpose mark</td><td>X</td><td>1</td></tr>
</table>

4. Design and Making of AtoN 3D Modelng

4.1 Design of the 3D model

In the photos and drawings of AtoN, the AtoN 3D objects have been modeled with the same scale. The separations of the AtoN Main and Sub-categories can be easily done by using the 3D tools that were designed for specific data to facilitate future changes. The lantern was designed to be produced by the animation according to the properties of the rhythm characteristics, and it was implemented according to the LOD and the light-color. In addition, the models of the flotation section, lantern, characteristic of light and top-mark are separated by a switch node. The model was designed as a single model. The flotation section, lantern, character of light and top-mark model were produced as a child node of the Switch node. The model was allowed real-time control, and the AtoN shape data was collected when the design was used as reference materials. Table 3 is a summary table that classifies the collected AtoN shape material into port and material types (Pyun, Hae-Gul, 2015).

Table 3: The collected AtoN shape material into port and material types

Division		Bu san	Jeju	Incheon	Yeosu	Masan	Ulsan	Donghae	Gunsan	Mokpo	Jindo	Pohang	Pyeongtaek	Daesan	Total
Picture		414	108	226	257	301	71	18	105	211	126	125	96	130	**2,188**
Record card		427	164	337	253	333	59	85	105	21	137	134	92	5	**2,152**
Blue print	Lighthouse	56	3	36	101	3	6	4	14	11		3	17	18	**272**
	Light beacon	14	18	16	43	8	2	2	29	5	2	1	4	4	**148**
	Leading light													1	**1**
	Illuminating light· Direction light													1	**1**
	Light pole	1											1	3	**5**
	Light buoy	11	11	11	11	11	11	11	11	11	11	11	11	11	**11**
	Unlighted beacon			2					1						**3**
	Buoy	8	8	8	8	8	8	8	8	8	8	8	8	8	**8**
2D blue print		75	9	21	25	11	7	6	32	8	2	4	9	10	**219**

4.2 Making AtoN 3D model

4.2.1 Making a model

The collection of data such as photographs and drawings were based on modeling 3D objects in that framework. At this time, the 3D objects were modeled with the unpainted structure and on the same scale as the figures. The texture map was prepared according to the UV coordinates of each site. We mapped the manufactured objects onto the textures. In order to implement a similar surface with the actual AtoN, the manufactured objects gave the material properties to the texture. The manufactured objects stored the produced model in the 3DS file format and it was (3DS file) imported into the "Multi-Zen Creator" software creating a real-time 3D models for visual simulation. The produced model gives the detailed properties, and is saved in the FLT file format. Figure 1 is a diagram showing the model authoring shape control switch and positioning process.

4.2.2 Making the shape control switch model and setting position

AtoN model was imported into "Multi-Zen Creator". AtoN model set up face properties of model and material. It was added to manufactured parts model and saved to set the location where we want to position it.

The models set the characteristic rhythmic cycle. After being generated to the group node, the group node was granted a total cycle time, and made to sequence type in accordance with the lantern rhythmic characteristics. In this case, the properties of the rhythm characteristics were set to the lantern of the operation time and rotation time. The switch node controls 256 species created by a sequence type. Figure 2 shows the manufacturing process of the characteristic rhythmic cycle.

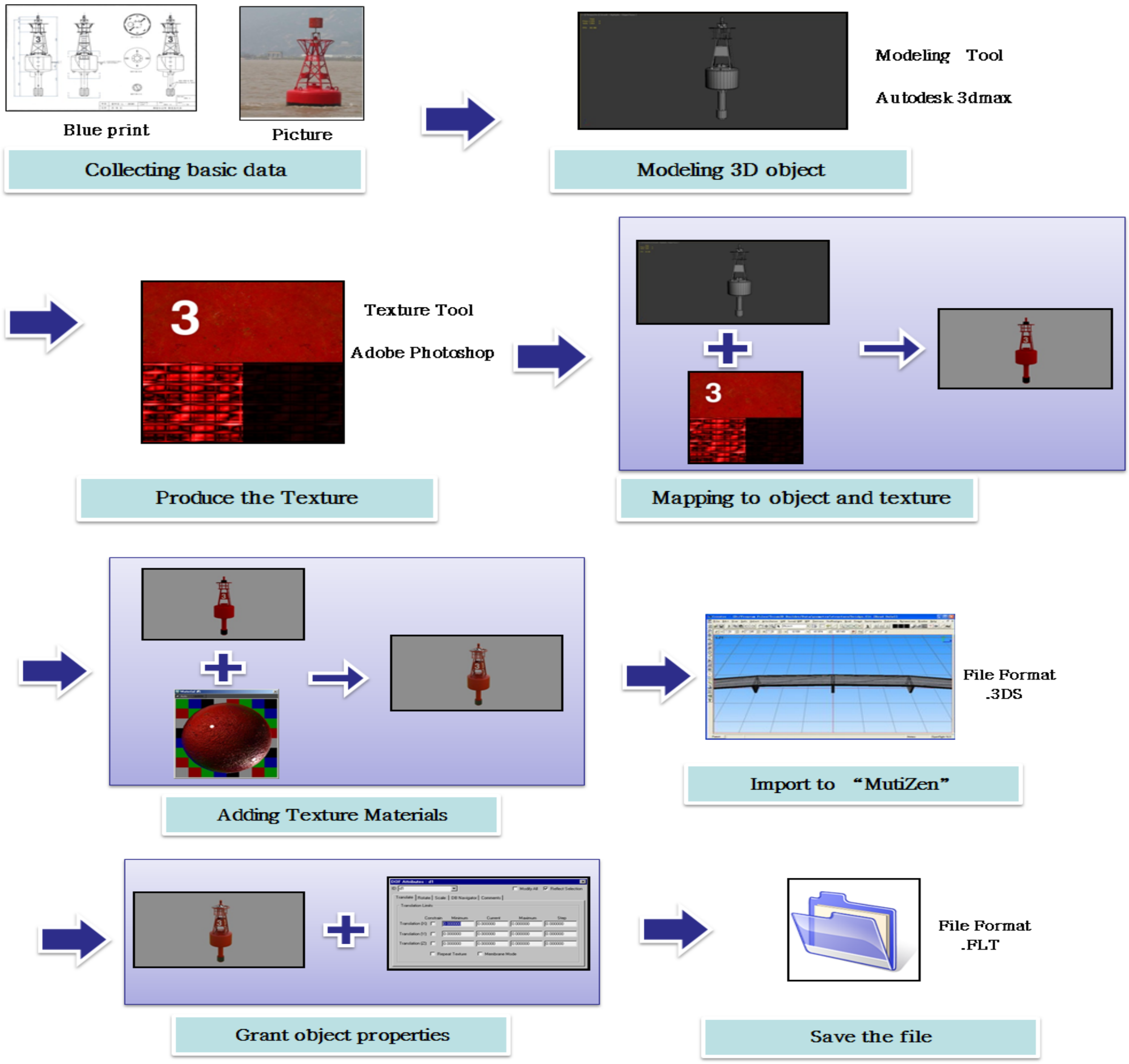


Figure 1: The model authoring shape control switch and positioning process

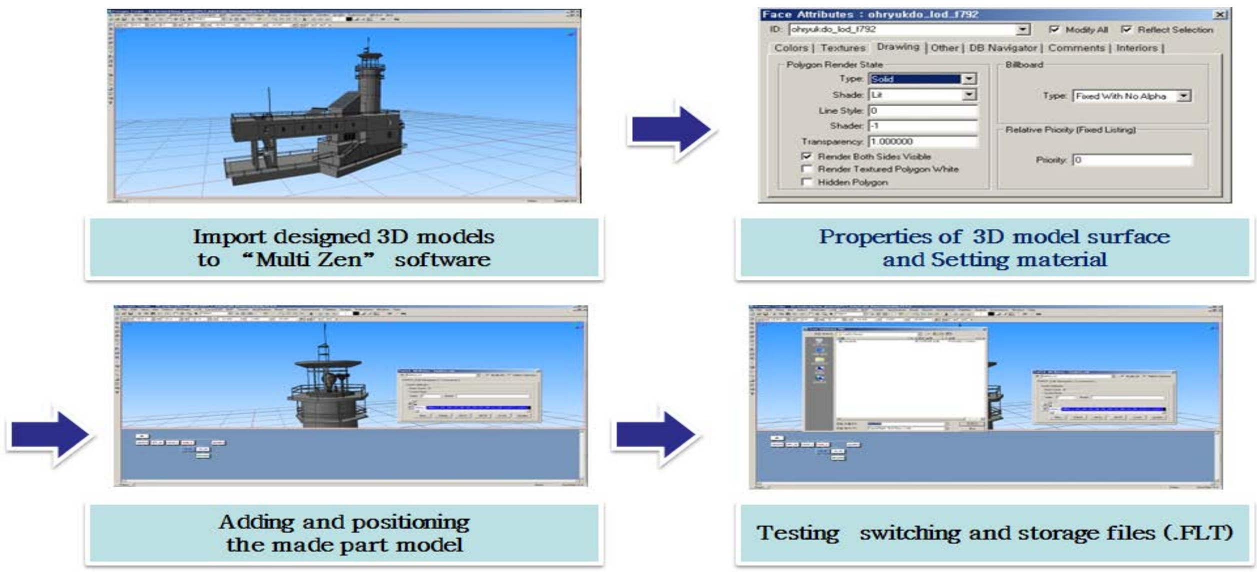


Figure 2: The manufacturing process of the characteristic rhythmic cycle

5. Application to AtoN simulator

5.1 AtoN 3D model

The modeling files were divided into the AtoN and model types for efficient management and implementation simulation. Table 4 shows an example of a 3D model file name that differentiates by AtoN type and model. The manufactured AtoN 3D model was applied to the AtoN simulator. Figure 3 is example what the visualization of the various AtoN 3D models displayed to the AtoN Simulation System in 3D.

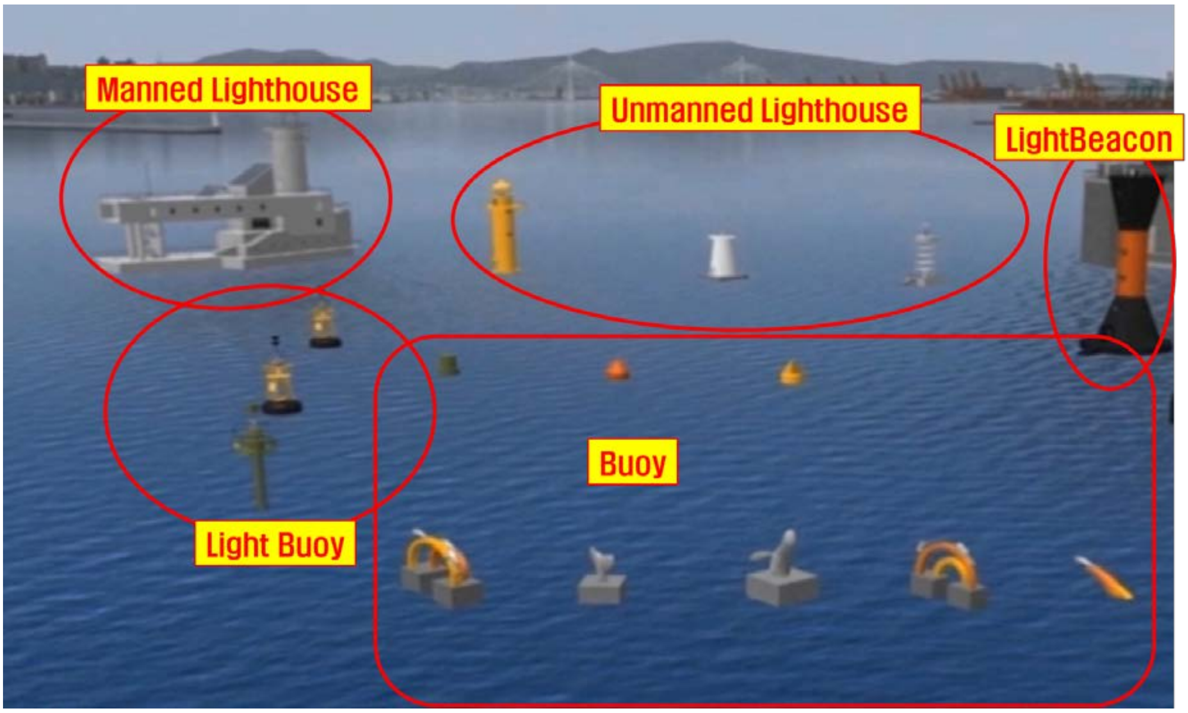


Figure 3: AtoN 3D Models apply to AtoN simulation system

5.2 System configuration

The objectives of the AtoN Simulation system are to develop the design and construction technology of an AtoN simulation system with full mission bridge, AtoN manager and operating equipment. Full mission simulation validates the effectiveness of the mix of aids to navigation in combination with specific maneuvering aspects and definition of Standard Operating Procedures. The full mission simulation system is characterized by a typical 210 degree field of view projected onto screens. Instrumentation, handling and communication equipment are real. The AtoN simulation system is developed to assist the decision making in AtoN design and placement plan, taking into account the impact of topographical, environmental and maritime traffic characteristics of a targeted navigation area. The AtoN Simulation system consists of ship handling simulator parts and AtoN operation parts. Ship handling simulation part consists of sea area DB, Ship DB, Operating SW, HW. Sea area DB and ship DB are simulation target area and target ship data. Operating SW and HW are required for the ship handling and navigation. AtoN part consists of AtoN DB, IG, modelling AtoN, and AtoN Manager. The database stores the properties (type, specifications, colour, visibility of light, etc.) of the various AtoN existing in Korea. AtoN Manager is the database management software that allows users to easily modify and edit the database and intuitively checking in conjunction with simulators and systems. Advancement of the three-dimensional image can be identified intuitively as a number of effects on the establishment and relocation of the AtoN. Modelling AtoN should look similar to the real in simulation.

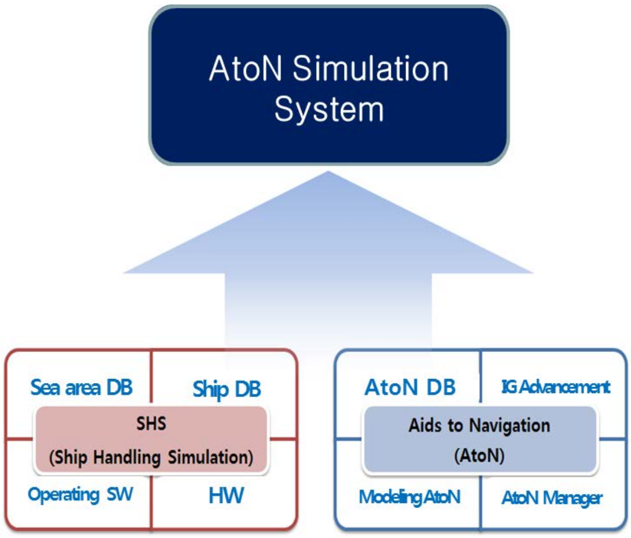


Figure 4: Configuration diagram of AtoN simulation system

5.3 Software configuration

The operational software and the implementation of the integrated systems for AtoN simulation system. The configuration of the operating software in the system is as follows:

- IOS (Instructor Operation Station) SW

- Simulation Setting and Management

- Simulation Operation

- AtoN Management SW (AtoN Manager)

- AtoN Database Management (Properties, Placement Scenario)

- AtoN Placement (Real-time Control of Properties and Placement)

- AtoN Database Print and Import/Export

- Quantification of AtoN Visibility

- Motion Solver SW

- Motion Solver for Ship and AtoN

- RADAR SW

- Radar Beacon Support (ARPA RADAR emulator)

- ECDIS SW (Electronic Chart Display and Information Systems)

- S-57/S-52 compliant ENC

- 3D Graphic SW

- Visualization of Terrain/Harbor, Ocean, Ship, AtoN, Environment, etc.

- Sound SW

- Fog Signal Support.

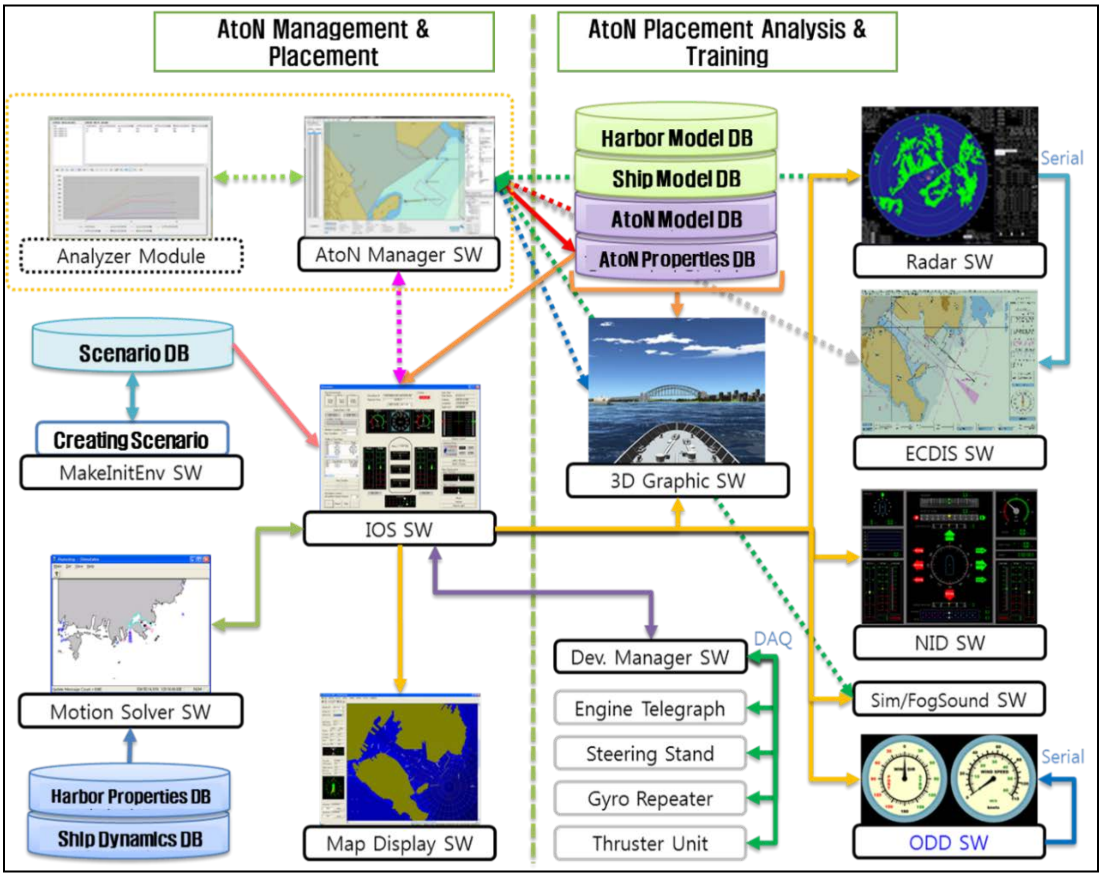
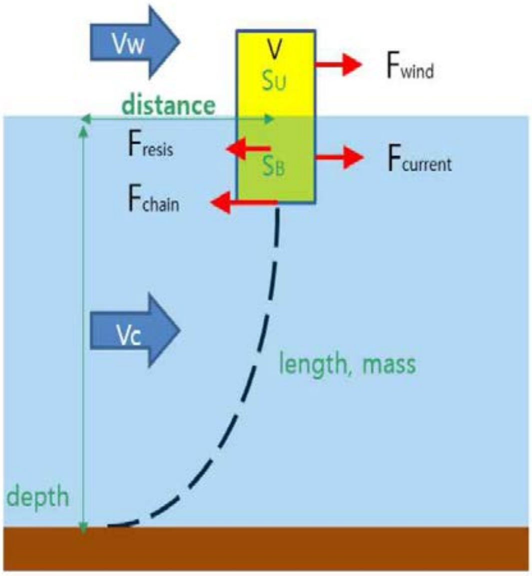


Figure 5: Software configuration diagram of AtoN simulation system

5.4 Motion of buoy modelling

In the case of a light buoy floating on the sea, the position and inclination angle are changed by waves, algae, and wind. It is implemented to analyze the vertical angle movement of the buoy by increasing its width and weight, and to show its reflection on the simulation system and each reflects the characteristics between three and eight sea conditions.

If there is wave, the light buoy will perform the pitch, roll and heave movements depending on the wave condition. In this system, the function is implemented by using the motion module provided by the 3D visualization program. In the motion module of the 3D visualization program (Mantis), various motion by waves can be realized by adjusting three parameters of the mass, width, and length of the object. Three parameters must be properly input to realize a motion satisfying the maximum inclination angle of the light buoy. Sway motion of light buoy is caused by tidal current and wind force. The motion of the generated light buoy is limited by the power of the chain and the resistance of the light buoy. The front and the rear waver and left and right waver of lightbuoy are generated by current and wind forces. The movement of the generated lightbuoy is limited by the strength of the chain, the resistance of the lightbuoy. Therefore, each force is modelled as follows. Also, the movement distance of the lightbuoy has a constraint on the length and depth of the chain, and the maximum travel distance is calculated as follows. The movement of light buoy by tidal current and wind can be controlled by "AtoN Manager" and when the function is implemented, the maximum movement distance of the light buoy is indicated by a circle as shown below.



$$F_{wind} = \frac{1}{2}\rho_A C_w S_U V_w^2$$

$$F_{current} = \frac{1}{2}\rho_W C_c S_B V_c^2$$

$$F_{chain} = f(depth, distance, length, mass)$$

$$F_{resis} = \frac{1}{2}\rho_W C_{D_1} S_B V^2 + \frac{1}{2}\rho_W C_{D_2} S_B V$$

$$Distance_{Max} = \sqrt{length^2 - depth^2}$$

Figure 6: Light buoy motion modelling by wind and tidal current

Figure 7: Light buoy motion result by wind and tidal current (2D screen)

5.5 Acquired certification for AtoN simulation

We promote international certification of AtoN simulation system to utilize AtoN design and plan for AtoN simulation system that can support decision making about AtoN design and placement plan. However, there is no international certification standard for the AtoN simulation system, so we obtained S Class (Special Task) of ship handling simulator.

In order to obtain the certification of the simulation system, we examined the application of the class sign for the approval of the simulation system of CIRCULAR as defined by the Korean Register of Shipping and the application of the marking sign simulation system of the acceptance criteria. We reviewed the detailed design requirements related to the simulation system construction, and "Category S" grade international certification, which allows the maintenance of specific mission equipment, defined navigation and manoeuvring scenarios, to be submitted to Korean Register of Shipping.

We obtained the simulation system certification on April 21, 2017 through document examination and onsite examination of AtoN simulation system.

6. Conclusions

In this study, we described the analysis of the AtoN properties and the AtoN 3D modelling for AtoN simulator. For Analysis of AtoN properties, we analysed AtoN types and IALA maritime buoy system. In addition, we analysed the properties such as AtoN light-colour for AtoN modelling. AtoN 3D objects were designed with the same scale that refers to the photos and drawings of AtoN. We produced designed 3D object model and set the position and model control switch. In addition, character of light properties was prepared and applied to 3D object. It was applied to the aids to navigation simulator.

This AtoN simulation system can be utilized for analysis of the installed AtoN system and establishment of technical base for providing high quality port service, and when using the planning and design for AtoN deployment, reduce the time and cost of AtoN design. And it can be used as educational equipment for the International World Academy (WWA), which is the IALA-sponsored AtoN training program.

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