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The Future Tasks of GICOMS in Preparation for the Age of e-Navigation

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Abstract

This paper aims to find out future tasks of GICOMS(General Information Center on Maritime Safety & Security) through identification of required system for implementation of e-Navigation. We derive nine advancement subjects for model of advanced GICOMS through brainstorming with experts of maritime safety. And then, we analyze the structure of extracted nine advancement subjects using by fuzzy structural modeling method, and propose a structural model that grasps the correlation between elements. As a result, we find out that "advancement of GICOMS" is the final goal in preparation for the age of e-navigation in the highest level, and "improvement a system of information production", "improvement a scheme of information providing", "linkage between GICOMS and VTS" and "building global networks for safety cooperation" are located in the lowest level. Especially, "advancement of GICOMS" is influenced by "advancement function of VMS" and "Activation of usage" in the middle level. We suggest that state-of-the-art IT facilities, equipment and expertise should be utilized to improve and enhance the user-centered transition such as maritime workers for advancement of GICOMS based on proposed structure model.

Keywords: GICOMS, Maritime Safety Information System, e-Navigation, FSM, Future tasks

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1. Introduction

Korea constructed and has operated the GICOMS (General Information Center on Maritime Safety & Security) for Maritime Disaster Management and Safety since 2001. The main functions of GICOMS are preparing cross nationally general management on maritime disaster, safety and security; preparing to cope with distress accidents of vessels and fishing boats effectively; preparing to ensure safe navigation of Korean flag ship from pirates and any forms of terror. If GICOMS is operated smoothly, it will minimize human and property damage on marine accidents and improve efficiency of disaster management.

The improvement of GICOMS for e-Navigation service means that: it requires improvement on operating GICOMS and an investigation system, and needs to have an afresh construction. Also, the GICOMS means to realistically and gradationally be prioritized when setting up(Lee, Han, Jo & Park., 2012).

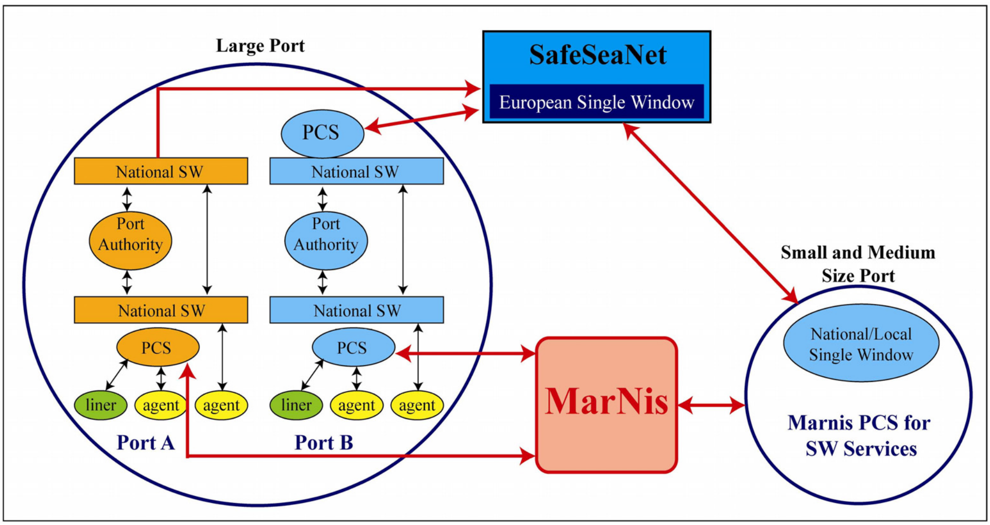
Therefore this paper aims to structure the target system and analyze the systematically influencing relationship between elements on each stratum in building the advancement structural model of GICOMS by using the Fuzzy Structural Modeling (FSM) method. Chapter 2 discusses the current state of Information system on Maritime safety and security in domestic and abroad pivots on e-Navigation. In chapter 3, analyzes a survey targeting marine experts for considering the hierarchy of proposing the advancement structural model of GICOMS for future tasks of the age of e-Navigation and grasping the hierarchical distribution and connection relations from the surveyed data.

2. A trend of maritime safety information system

2.1 International trends

The Domestic Information System on Maritime Safety and Security has sparked the interests of universities, institutes, and government and now active in international conferences. Moreover, it continues to research the strategy of e-Navigation, which is based on the aid of a navigation installer and management since 2006(Park.,2006). The Korean Coast Guard is currently operating the Vessel Monitoring System (VMS) to fulfill its task of sea surveillance from GICOMS in order to save lives and prevent marine accidents(Ryu.,2013). Also, they constructed the Intelligent Marine Traffic Management System for preventing anticipative marine accidents and improving countermeasure ability to crisis.

Developed oceanic countries, such as Europe, are proceeding with a study on developing and constructing the Information System on Maritime Safety & Security. Europe specially established the European Maritime Safety Agency (EMSA) for improving security of the Jurisdiction Sea Zone in 2002. EMSA is comprised of a 6 steps framework with 44 partners and 12 sub-partners for developing a navigation information service of Pan-European, and started the MarNIS (Maritime Navigation and Information Services) for the object of safety, security, environmental protection, and economics improvement of maritime traffic. The information system of MarNIS was formed by SSN (SafeSeaNet), NSW (National Single Window), PSW (Port Single Window), PCS (Port Commercial community System), MOS (Maritime Operational Services), etc(MNIS., 2009). (See Figure 1).



Source: Drawn by the author data from MarNIS (2004)

Figure 1. Composition of MarNIS

The Global Environment Facility (GEF) and International Maritime Organization (IMO) is pushing ahead with the MEH (Maritime Electronic Highway) Project in Asia-Pacific(Kang, Jeong., 2008). This project will prevent marine accidents through the vessel's safety and will be joined by the Pacific Basin of Malaysia, Singapore, Indonesia, etc, for life, property and maritime environmental protection on the sea. MEH is a system of VTS, VMS, ENC, AIS and Maritime Meteorological Information System, etc, around ECDIS.

2.2 Domestic trends

2.2.1 A current condition of operation on GICOMS

GICOMS (General Information Center On Maritime Safety and Security) is the National Maritime Crisis Management System for strengthening safety, security and protection of the environment using information and communication technologies. The purpose of this system is to minimize marine accident using general information about vessels, sailors, traffics, security, port facilities and freight, etc,. Therefore, this system can contribute for establishment of scheme of e-Navigation as the beginning design.

The past safety and disaster system was a prompt action and delayed status report due to hindering accessibility and sharing information dispersed by organizations. According to the Maritime and Fisheries Information Implementation Plan on the basis of 「Framework Act on Information Promotion」 article 6, GICOMS is constructed for integration of information system and efficiency of maritime safety work. Table 1 shows that the configuration of GICOMS made from 33 information systems of maritime disaster safety such as the National Security Council(NSC), Ministry of Oceans and Fisheries(MOF), Ministry of Security and Public Administration(MOSPA), Korea Coast Guard(KCG), Korean Navy, etc., and GICOMS provides the Vessel Monitoring Service (VMS)(Ryu., 2013).

Table 1. A configuration of GICOMS

Classification	Main function	Main system	Related agency
GICOMS	Integrated Database	Ship's information	MOF
		Port information	MOF, Port Authority
		Seafarer's information	MOF
		Security information	MOF, KCG
		Accident information	MOF, KMST
	Vessel Monitoring System	AIS (Automatic Identification System)	MOF(VTS)
		Satellite system	MOF, Telecommunication service provider
		Smartphone	Telecommunication service provider
	Information Exchange	System linkage with external agency	NSC(National Security Council), KCG, MOSPA, MOF etc.
		Providing of accident information	Shipping company, Shipowner, citizen etc.

2.2.2 GICOMS analysis

① Information environment analysis

The government prepared a system for securing maritime safety and protecting maritime environment through a maritime safety management structure, maritime traffic environment improvement, prevention of maritime accident, strengthening of vessel security, etc. This is the main contents of the Future National Maritime Strategy, promotes the next generation of development motorization of e-Navigation and constructs enhancement of national competitiveness and a high-grade of integration maritime safety management through the strengthening of IMO activities (Ryu., 2013).

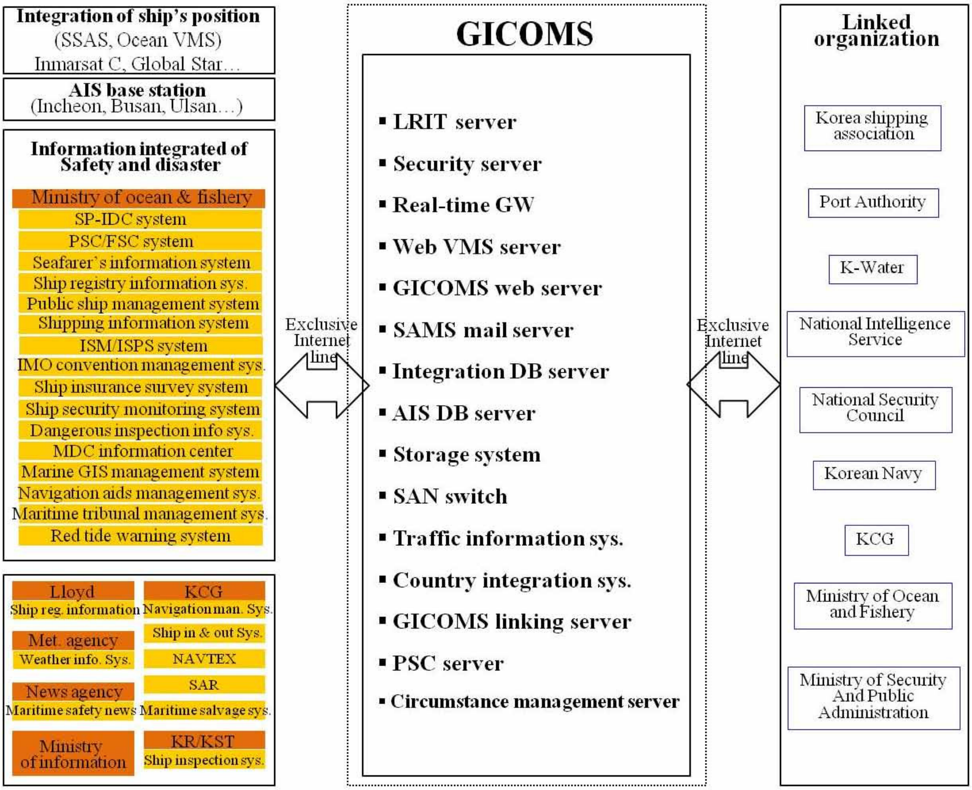
② Software system analysis

The maritime safety system is connected to the information system of the Ministry of Oceans and Fisheries and related organizations, which creates a huge system. Maritime safety province is a typical information system on maritime safety and related organizations include Marine Traffic Management System, Shipping and Port-logistics Information System, Hazardous Material Information System, Vessel Registration Information System, Maritime Rescue and Disaster Information System, Navigation Safety Information System, Commercial Marine Accident Management System.

The main functions of GICOMS, which is a typical maritime safety information system of maritime safety province, are contextual information management on maritime accident, vessel movement, international vessels and the ISPS Code, that can check the security content of vessels and ports, ISM Code and the port state control information, etc.

③ Network System Analysis

GICOMS is operated with the Location Cooperative Information System, AIS base stations, Safety and Disaster-related System through a satellite network by utilizing the internet, and administration network. GICOMS network system in Figure 2 consists of LRIT server, Security sever, Real-time GW, Web VMS server, GICOMS web server, SAMS mall server, integration DB sever, AIS DB sever, Storage system, SAN switch, etc(Ryu., 2013). And GICOMS has integrated the systems of the Ministry of Security and Public Administration (MOSPA), Ministry of Oceans and Fisheries(MOF), Korea Coast Guard(KCG), Korea Shipping Association(KSA), etc. In real time, GICOMS is equipped with standardized systems of organization to collect, supply, integrate, and propagate a navigating situation of vessels in the national coast.



Source: Drawn by the author from Ryu (2013)

Figure 2. A network system configuration of GICOMS

3. Model for construction of advanced GICOMS

3.1 FSM method

Using the valid FSM technique as an object to structure the investigation of the complex social problems(Zadeh., 1965 & Yang., 2002), expresses the various elements and uses the results to analyze the consciousness structure of the GICOMS advanced propulsion items.

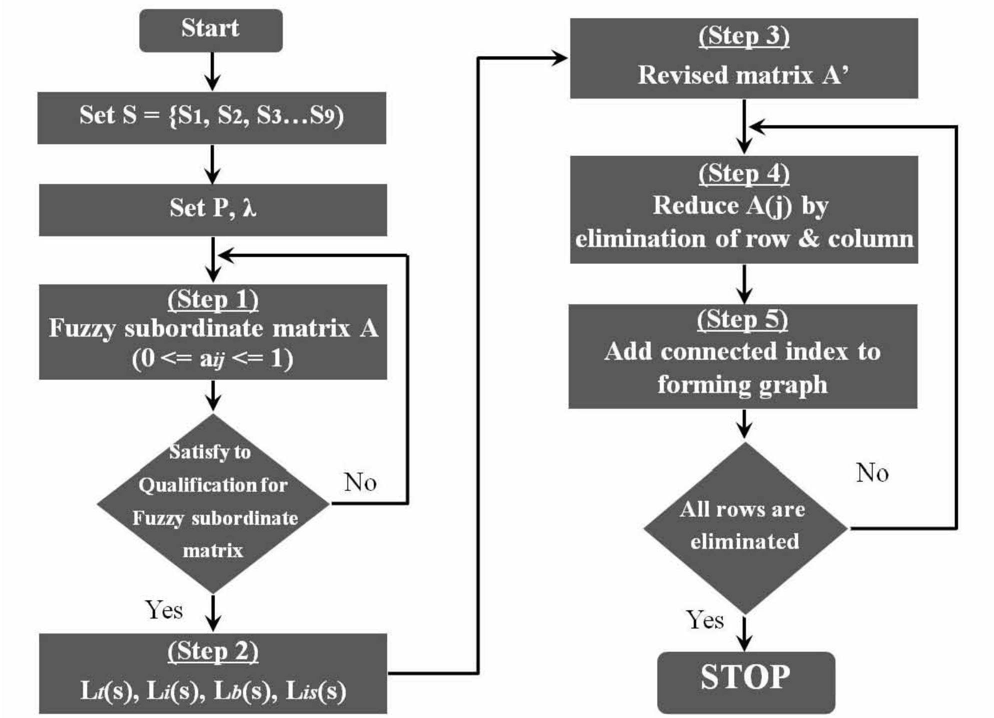


Figure 3. A flowchart for FSM algorithm

The system indicates $S=\{S_1, S_2....S_n\}$ in the FSM method and the fuzzy subordinate matrix A of the fuzzy subordinate relationship between extracted elements in response to textual relation indicates A=[0,1]. A is n x n matrix and elements aij(i,j=1,2,...,n) of A is drawn by fuzzy binary relationship of calculation in (1). Lastly Aji indicates the subordinative extent. The structural model composed of the FSM algorithm is in Figure 3 and details as follows:

$$a_{ij} = f_r(S_i, S_j), 0 \leq a_{ij} \leq 1 \ (f_r : S \times S \rightarrow [0,1]) \quad (1)$$

In step1, fuzzy subordinate matrix $A=[a_{ij}]$ to satisfy fuzzy non-reflux ratio and fuzzy asymmetric rate sets up and modifies A to satisfy fuzzy interest rate rumination, fuzzy non-reflux ratio, asymmetric interest and interest rate rumination are defined as follows. Threshold value is a real number of the pre-given half open interval or semi-open interval (0,1].

First, fuzzy non-reflux ratio is established to satisfy $f_r(S_i, S_j) \leq P$ about $\forall(S_i, S_j) \in S \times S$.

Second, fuzzy asymmetric rate is established to satisfy $f_r(S_i, S_j) \prec P$ or $f_r(S_j, S_i) \prec P$ about $\forall(S_i, S_j) \in S \times S(i \neq j)$.

Third, fuzzy interest rate rumination is established to satisfy $f_r(S_i, S_k) \geq M$ about $M = \vee_{j=1}^{n} \left(f_r(S_i, S_j) \wedge f_r(S_i, S_k)\right) \geq P$ on the $\forall(S_i, S_j), (S_j, S_k), (S_i, S_k) \in S \times S, (i \neq j, j \neq k, i \neq k))$.

In step2, the highest level($L_t(s)$), middle level($L_i(s)$), the lowest level($L_b(s)$) and independent level($L_{is}(s)$)gives combined relationships between levels and indicates extracted elements, each belonging to a level. They have determined, by definition, as calculation (2), calculation (3), calculation (4), calculation (5) respectively.

$$L_t(s) = \{S_k | \vee_{j=1}^{n} a_{kj} < P \leq \vee_{i=1}^{n} a_{ik}\} \quad (2)$$

$$L_i(s) = \{S_k | P \leq \vee_{i=1}^{n} a_{ik}, P \leq \vee_{j=1}^{n} a_{kj}\} \quad (3)$$

$$L_b(s) = \{S_k | \vee_{i=1}^{n} a_{ik} < P \leq \vee_{j=1}^{n} a_{kj}\} \quad (4)$$

$$L_{is}(s) = \{S_k | \vee_{i=1}^{n} a_{ik} < P, \vee_{j=1}^{n} a_{kj} < P\} \quad (5)$$

$\vee a_{ij}$of each definition of levels means $\max(a_{ij})$, the block is defined element unit $B(s_i)$ from element unit $L_t(s)$ depend on the element S_i in level unit $L_b(s)$.

In other words the block matrix is the highest level of single hierarchy, which designates Q_j, and establishes $Q_j \subseteq L_t(s)$.

Elements belong to the same block Q_j when the matrix denominates. The subordinate relationships between the elements, which are constructed by the fuzzy subordinate matrix. At this time, the small matrix is configured to correspond to each blocks that is defined to the single-layer matrix $A^{(j)}$.

In the step3, for subordinate relationships between elements to analyze, remove the column of $L_t(s)$, row of $L_b(s)$ and column & row of $L_{is}(s)$ for step 2 and Structure A as A'using line and row. The reason to remove the line and row, are due to the fact that they are unnecessary for structure analysis depending on the level of matrix definition.

In step4, from step3, a reconstructed A' is made from the single-layer matrix $A^{(j)}$ depending on the block matrix Q_j. The single-layer matrix defines the combinable elements matrix to perform a structure analysis.

In step5, choose the fuzzy structure parameter λ and structure the structural graph of the single-layer matrix A(j). The nonsingular matrix of S_j is $S_{ik}(k = 1, 2, \ldots, n')$, S_{ik} substitutes $a_{\bullet j}*$ from $a_{\bullet j}$ and is eliminated according to calculation (6) and draws the structural graph that decides directly the subordinate elements about Sj. [ ] indicates column vector.

$$[a_{\bullet} j *] = [a_{\bullet j}] \wedge [\overline{a_{\bullet j}}] \wedge \cdots [\overline{a_{\bullet in'}}] \quad (6)$$

4.2 Model design

To construct the advancement structural model of GICOMS, experts in maritime safety have been brainstorming to extract and select detailed assignments. Subsections of the discerned nine advancement subjects for Advancement structural model of GICOMS can be seen on Table 2. The survey was implemented by experts in maritime and port.

Table 2. GICOMS improvement propulsion item

Classification	Item details
S_1	Advancement of GICOMS
S_2	Improvement a system of information production
S_3	Improvement a scheme of information providing
S_4	Linkage between GICOMS and VTS
S_5	Building global networks for safety cooperation
S_6	Construction correspondence system for e-Navigation
S_7	Reinforcement prevention system of marine accidents
S_8	Advancement function of VMS
S_9	Activation of usage

The method of the survey consists of about 9 questions from Table 2 and compares the comparative effects instinctively. The effect is, 'an element, S_i and influences another element, S_j. The Grade is the completed results of elements a_{ij} [0,1]. The questionnaire was distributed to a total of 30 respondents who engaged in field of maritime safety and uses the 25 questionnaires to satisfy the fuzzy non-reflux ratio & fuzzy interest rate rumination, which conducted a structural structure analysis about GICOMS advanced propulsion items

4.3 Structural model

Parameter value λ is important to produce the structural graph. Threshold value P decides on the 'subordinate relationships between elements' and class subdivision, and determines the subordinate relationship of dependency class. The P value performs the hierarchy structure to create many levels, depending on the decreasing number, and increases the possibility that it is not the fuzzy asymmetric rate, but establishes assigning and changing of the valid P value gradually, in order to produce valid results. Therefore this analysis conducted a consciousness structure modeling to obtain valid threshold value on all the questionnaires responses in consecutive order.

The fuzzy subordinate matrix $A^k = [a_j^k]_{9\times 9}$ (k = 1,2,⋯,25) is produced by the data of the 25 questionnaire responses used in calculation (7), and rounded to the nearest thousandths. The results can be seen in calculation (8).

$$A = [a_j]_{9\times 9} = \sum_{k=1}^{25} \left[a_j^k / 25 \right]_{9\times 9} \tag{7}$$

$$A = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \\ S_7 \\ S_8 \\ S_9 \end{array} \begin{array}{c} \begin{array}{ccccccccc} S_1 & S_2 & S_3 & S_4 & S_5 & S_6 & S_7 & S_8 & S_9 \end{array} \\ \begin{bmatrix} 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.73 & 0.00 & 0.55 & 0.40 & 0.35 & 0.68 & 0.55 & 0.55 & 0.55 \\ 0.65 & 0.53 & 0.00 & 0.43 & 0.38 & 0.68 & 0.68 & 0.45 & 0.78 \\ 0.65 & 0.55 & 0.40 & 0.00 & 0.38 & 0.68 & 0.70 & 0.65 & 0.63 \\ 0.58 & 0.40 & 0.40 & 0.33 & 0.00 & 0.65 & 0.45 & 0.48 & 0.45 \\ 0.68 & 0.63 & 0.63 & 0.53 & 0.53 & 0.00 & 0.65 & 0.55 & 0.60 \\ 0.65 & 0.28 & 0.48 & 0.58 & 0.30 & 0.53 & 0.00 & 0.55 & 0.65 \\ 0.65 & 0.35 & 0.50 & 0.60 & 0.40 & 0.58 & 0.60 & 0.00 & 0.60 \\ 0.65 & 0.40 & 0.55 & 0.40 & 0.30 & 0.48 & 0.50 & 0.48 & 0.00 \end{bmatrix} \end{array} \tag{8}$$

$A = [a_{ij}]_{9\times 9}$ is the average of $A^k = [a_{ij}^k]_{9\times 9}(k = 1,2,\cdots,25)$, diagonal elements $a_{ij}(i = j)$ presumes 0 as a matter of accommodation. The consciousness structure modeling is conducted by a structure analysis, as the fuzzy structural modeling technique algorithm is based on calculation (8).

4.4 Structural Graph

The structure analysis of all survey respondents is conducted by the 'Advancement Structural Model of GICOMS'. For validity threshold value analyzes the relations between the elements, threshold value P shares 0.60, 0.65, 0.70, and is conducted by the structure analysis as parameter value is 0.5.

The results of the structure analysis is the appropriate level of structure indicated in threshold value P=0.65, and parameter value λ=0.5. A structural graph of the structural model is shown in Figure 4 and indicates the influence of the relationships and priority between subsections.

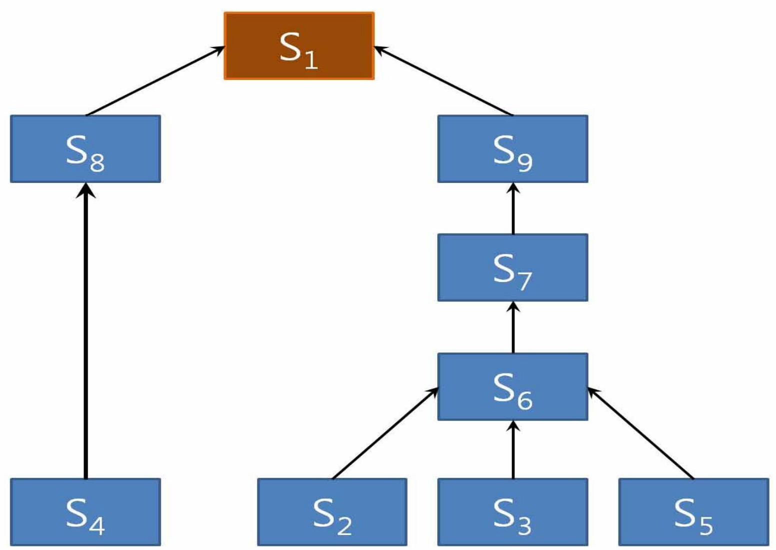


Figure 4. Structure graph by structural model

The ‘Advancement subject’ of the ‘Advancement structural model of GICOMS’ have analyzed the influence of the relationships and priority between the subsections, of the ‘Advancement of GICOMS(S_1)' in the highest level. This is the final goal and indicates the content influenced by another content.

The second influenced content indicate the ‘Construction Correspondence System for e-Navigation (S_6)’, ‘Reinforcement Prevention System of Marine Accident (S_7)’, ‘Advancement function of VMS (S_8)’ and ‘Activation of usage (S_9)’ in the middle level.

Contents influenced by another element in the lowest level are the ’Improvement of a System of Information Production (S_2)’, ‘Improvement of a Scheme of Information Providing (S_3)’, ‘Linkage between GICOMS and VTS (S_4)’, and ‘Building Global Networks for Safety Cooperation (S_5)’, which are influenced and related to the ‘Construction Correspondence System for e-Navigation (S_6)’ in the middle level. The ‘Linkage between GICOMS and VTS (S_4) is influenced and related to the ‘Advancement Function of VMS (S_8)’ in the middle level.

The ‘Construction Correspondence System for e-Navigation (S_6)’ is at the lowest level of middle level 3 grade, which is related to the 3 contents of the lowest level, and influenced by the ‘Reinforcement prevention System of Marine Accident (S_7)’. The ‘Reinforcement Prevention System of Marine Accident (S_7)’ is influenced only by the ‘Activation of Usage (S_9)’ in the middle level. Lastly, the ‘Advancement of GICOMS (S1)’ in the highest level is influenced and related to the ‘Advancement Function of VMS (S8)’ and ‘Activation of Usage (S_9)’ in the middle level.

5. Conclusion

This paper examined a case study of a similar system for the implementation of the e-Navigation internal and external techniques, structured the structural model, and produced nine GICOMS advanced propulsion items in order to develop, operate and construct GICOMS to the e-Navigation platform internally. Moreover, when identifying the process that was conducted, a structural model was suggested. It can grasp the consciousness structure analysis and correlation between elements through the questionnaire survey by targeting experts using the FSM technique. The result of the interrelation analysis about GICOMS advanced propulsion items are as follows:

First, the 'Advancement of GICOMS (S_1)' is an element of the highest level influenced by other element.

Second, the lowest level elements are the 'Improvement of a System of Information Production (S_2)', 'Improvement of a Scheme of Information Providing (S_3)', 'Linkage between GICOMS and VTS (S_4)', and 'Building Global Networks for Safety Cooperation (S_5)'. Middle level elements are 'Construction Correspondence System for e-Navigation (S_6)', 'Reinforcement Prevention System of Marine Accident (S_7)', 'Advancement Function of VMS (S_8)' and 'Activation of Usage (S_9)'.

Third, the 'Improvement a System of Information Production (S2)', 'Improvement a Scheme of Information Providing (S_3)' and 'Building Global Networks for Safety Cooperation (S_5)' are the lowest level elements that effect the middle level elements. The 'Construction Correspondence System for e-Navigation (S_6)' effect the 'Reinforcement Prevention System of Marine Accident (S_7)'. In addition, the 'Advancement Function of VMS (S8)', and 'Activation of Usage (S_9)' are middle level elements that effected by the 'Linkage between GICOMS and VTS (S_4)', and 'Reinforcement Prevention System of Marine Accident (S_7) respectively.

Finally, 'Linkage between GICOMS and VTS (S_4)', and the 'Reinforcement Prevention System of Marine Accident (S_7)' are elements that directly influenced the highest level of the 'Advancement of GICOMS'.

As a result, the following scheme is recommended to obtain a more sophisticated GICOMS which is based on the structure model of the research; but first facilities, equipment and professional manpower are be needed to improve and be supplemented by utilizing the cutting edge IT. Furthermore, it is required to target the active usage and switch to the "Advanced Function of VMS (S_8)".

A decision is needed to promote the "Construction Correspondence System for e-Navigation(S_6)" and "Building Global Networks for Safety Cooperation(S5)".

The constitutive model and analysis result of this research would be able to utilize not only the purpose to efficiently and effectively improved GICOMS but also to investigate the correlations between each elements in preparation for the age of e-Navigation.

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