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A RIGOROUS REVIEW AND THOROUGH PLANNING FOR THE SHIP INSPECTION SYSTEM IN TAIWAN

Shuen-Tai Ung[1], Chi-Cheng Tsai[2], and Chih-Li Chen[1]

Key words: ship inspection system, port state control, flag state control.

ABSTRACT

The ship inspection system can be regarded as a frontline fighting against substandard ships. However, the ship inspection rate in Taiwan is low and the vessels under the flag are categorized in the grey list by Paris and Tokyo MOUs according to statistics. Thus, the current status of the ship inspection system of the country should be examined and improved. In this paper, the ship inspection system is evaluated in terms of the system structure, legislation, mechanisms and training patterns. The shortcomings are appreciated under the Hierarchical Task Analysis structure. A list of the alternatives for improvement and the priority are accordingly established based on the Value-Focused Thinking and Analytical Hierarchy Process methods. In addition, the training courses capable of creating prompt effects on ship inspection performance for short terms are also proposed. It is believed that the solutions proposed in this paper will enable the government to establish an integrated scheme for ship inspections.

I. INTRODUCTION

For the purpose of providing member states with a comprehensive and objective assessment of their performances of the International Maritime Organization (IMO) instruments, Resolution A.946(23) *Voluntary IMO Member State Audit Scheme* was adopted in November 2003. The audit standard, framework and procedure of the scheme were initially established in 2005 through the adoption of Resolutions A.973(24) *Code for the Implementation of Mandatory IMO Instruments* and A.974(24) *Framework and Procedures for the Voluntary IMO Member State Audit Scheme* [6,7]. A number of amendments have also been developed to update the Code since 2007 and the latest resolution was A.1054(27) *Code for the implementation of mandatory IMO instruments, 2011*[8,10]. Such resolutions enable member states to evaluate the effectiveness of their performances with regard to the IMO standards in the aspects of flag, port and costal states. This facilitates the harmony and consistency of the global implementation of the IMO standards.

Based on the ship operation practice, the maritime safety scheme of a country may be divided into three systems, namely, ship inspection, vessel traffic service and search and rescue. Among these systems, the ship inspection system can be regarded as the frontline of maritime safety against substandard ships. According to the IMO conventions, member states should ensure that vessels flying their flags and those sailing within their territorial waters are of seaworthiness. Taiwan, although not a member of IMO, has been endeavoring to establish an integrated ship inspection system and attempting to banish substandard ships from her territorial waters. The Taiwanese government began to plan and devise the port state control (PSC) scheme in 1998 and came into effects in 2003 [2]. However, the annual examination rate of the vessels calling at Taiwanese ports is less than 10 percent and is relatively lower in comparison with the members within Tokyo and Paris MOUs. This is due to the fact that the duties of the most PSC Officers (PSCOs), apart from Port of Taichung, are treated as part-time tasks according to the interview conducted. This inevitably affects the ship inspection performance. Furthermore, the vessels under Taiwanese flag are categorized in the grey list according to the annual reports published by Paris and Tokyo MOUs [18,22]. This implies that the country is unable to effectively enforce the international regulations and the domestic laws onto the vessels visiting its waters and under the flag. It is noted that inadequate implementation of the IMO conventions by flag states is one of the factors often criticized for ship accidents [14]. Allowing for maritime safety, the ship inspection system in Taiwan needs to be examined and improved if necessary.

Taiwan Ministry of Transportation and Communications (TMOTC) has been planning to reform the maritime scheme in particular the ship inspection system. By virtue of a public bidding held by TMOTC in 2008, the authors were entrusted to

Paper submitted 07/20/11; revised 07/13/12; accepted 09/24/12. Author for correspondence: Chih-Li Chen (e-mail: clchen@mail.ntou.edu.tw).
[1]Department of Merchant Marine, National Taiwan Ocean University, Keelung, Taiwan, R.O.C.
[2]Department of Systems Engineering and Naval Architecture, National Taiwan Ocean University, Keelung, Taiwan, R.O.C.

conduct a research project of which the objective was to develop an integrated planning for the ship inspection system. This is achieved by the rigorous reviews, analysis, the identifications of measures and decision-making process. This paper reveals the crucial findings of the project. In this paper, the current practice of the ship inspection system of the traditional maritime countries and Taiwan in terms of system structure, legislation, mechanisms and training patterns is first compared. The shortcomings will secondly be appreciated and the measures will also be developed. After consulting with the personnel participating in the system, the priority list of the alternatives will finally be provided based on the decision-making process. In addition, the training courses that are urgently demanded as requested by the interviewees will also be acquired.

II. BACKGROUND

Since the 1970s, the burden of ship safety has been imposed upon flag states which exercise the jurisdictions to ensure that the vessels registered are of seaworthiness. Flag states, on the other hand, rely upon classification societies to regulate and control the standards and good practices established by the IMO [16,27]. Despite the development of such IMO standards in the shipping industry, enforcement could be weak due to its international nature and can vary greatly from states to states [20]. The control mechanisms applied by some of flag states and classification societies may be ineffective in eradicating substandard vessels form the industry. Following the Amoco Cadiz disaster, the PSC scheme was originated in the form of memorandum of understanding, known as the European Memorandum of Understanding on Port State Control, signed in Paris between 14 European countries in 1978. The Paris MOU coming into effect in 1982 which emphasizes on the enhancement of marine safety, environmental protection and facilitation of the working and living conditions onboard vessels. This is achieved by the inspection of foreign ships in national ports to verify that the conditions and the equipments of the most deficient ships based on previous records comply with the requirements of international regulations and that such ships are manned and operated in compliance with these rules [1,12,13,17,26]. Several PSC schemes have been established since the advent of Paris MOU. In November 1995, IMO adopted the first resolution in relation to the PSC schemes [4]. A number of amendments have been proposed to update the PSC practices. The latest resolution was A.1052(27) *Procedures for Port State Control, 2011*[9]. The resolution provides the basic guidance on the conduct of the PSC procedures. It ensures the consistency of the inspections, the recognition of the deficiencies in equipment and crew as well as the control procedures. Although PSC stands in the frontline fighting for the elimination of substandard vessels, the primary responsibility to safeguard ship safety lies with flag states.

Due to the fact that some countries may lack the expertise, experience and resources to implement the IMO conventions, a special Sub-Committee on Flag State Implementation (FSI) was established in 1992 and its primary aim is to improve the performance of aforementioned member states. Some member states launched a new flag state control (FSC) scheme assisted by FSI. The objective is to decrease the deficiency and detention rates of the vessels flying their flags in foreign ports. Similar to PSC, FSC is the inspection of the national vessels to verify that the ships under registrations comply with the domestic laws and international regulations.

Therefore, a state that intends to enhance maritime safety shall implement the FSC and PSC schemes to ensure that the ships flying her flag and the foreign vessels sailing within her territorial waters are of seaworthiness. This is achieved by the periodical ship inspections to verify that the conditions and the equipments of such ships conform to the domestic and international maritime laws and safety standards. Accordingly, in this paper, the ship inspection systems of Taiwan and traditional maritime countries will be analyzed in terms of the FSC and PSC schemes.

Table 1. Annual inspection rates of Paris MOU, Tokyo MOU and Taiwan during 2001-2008.

YEAR	Paris MOU (%)	Tokyo MOU (%)	Taiwan (%)
2001	28.80	71.00	N/A
2002	28.90	78.00	N/A
2003	30.10	77.00	N/A
2004	31.50	69.00	N/A
2005	31.80	70.00	N/A
2006	30.20	69.00	4.62
2007	30.30	66.00	6.70
2008	31.59	63.00	9.30
Average	30.40	70.40	6.88

III. CURRENT STATUS OF THE PERFORMANCE OF SHIP INSPECTION IN TAIWAN

The PSC scheme in Taiwan has been in operation since 2003. The inspection rates of the Taiwanese PSC system in 2006, 2007 and 2008 are 4.62%, 6.70% and 9.30%, respectively. The figure is relatively lower in comparison with Paris and Tokyo MOUs of which the average examination ratios per year between 2001 and 2008 are 30.4% and 70.4%. Table 1 shows the annual inspection rates from 2001 to 2008 for Paris MOU, Tokyo MOU and Taiwan [19,23]. This implies that the performance of the PSC system in Taiwan is needed to be reviewed and improved.

On the other hand, the detention rates of the Taiwanese vessels could be an indicator expressing the performance of the FSC scheme in the country. Table 2 contains the annual detention rates of the Taiwanese vessels from 2001 to 2008 in Paris and Tokyo MOUs [19,23]. It can be seen from the Table that the annual detentions rates of the Taiwan-flagged vessels in Paris MOU region, apart from the years of 2001 and 2007, are higher than that of all nationalities. Thus, the FSC performance of the Taiwanese ships is categorized in the Grey List. In addition, the

Table 2. Annual detention rates of the Taiwan-flagged vessels in Paris MOU and Tokyo MOU during 2001-2008.

YEAR	Inspection no. in Paris / Tokyo MOU (Taiwan-flagged)	Detention no. in Paris / Tokyo MOU (Taiwan-flagged)	Detention rate (%) in Paris / Tokyo MOU (Taiwan-flagged)	Average detention rate (%) of Paris / Tokyo MOU
2001	18 / 213	1 / 20	5.56 / 9.39	9.09 / 7.76
2002	17 / 227	2 / 13	11.76 / 5.73	7.98 / 6.67
2003	11 / 151	1 / 24	9.09 / 15.98	7.05 / 8.49
2004	15 / 123	4 / 12	26.67 / 9.76	5.89 / 6.51
2005	13 / 116	1 / 15	7.69 / 12.93	4.67 / 5.21
2006	17 / 97	1 / 9	5.88 / 9.28	5.44 / 5.40
2007	7 / 81	0 / 6	0.00 / 7.41	5.46 / 5.62
2008	9 / 78	1 / 7	11.11 / 8.97	4.95 / 6.91

annual results of Taiwanese ships in Tokyo MOU are also higher than the average figure of all flags, if excluding the year of 2002. The FSC performance of the Taiwanese vessels is also categorized in the Grey List.

In summary, the performance of the ship inspection system in Taiwan is relatively poor in comparison with the members of Paris and Tokyo MOUs and the flag states whose vessels conduct international trades within the regions. The current practices of the system are therefore needed to be reviewed and diagnosed.

IV. METHODOLOGY

In this paper, the methodology starts with the identification of the problems encountered by Taiwanese ship inspection system under the Hierarchical Task Analysis (HTA) structure. Subsequently, the alternatives are proposed using the Value-Focused Thinking (VFT) method and the priority of such measures is acquired using the Analytic Hierarchy Process (AHP) approach. In addition, the training courses play important roles in causing prompt effects on the performance of the ship inspection system according to the interview. Accordingly, the final stage is the identification of training courses urgently needed using the Rank Order method. Each step of the methodology is discussed in detail in the follow sections.

1. Identification of the problems encountered using HTA

HTA is a systematic method describing how work is organized in order to meet the overall goal of a mission [21]. It involves the identification of the overall goal of the task and the various sub-tasks and the conditions under which such tasks are carried out to achieve the goal in a top down fashion. The process of HTA could be divided into the steps of the definitions of objectives and the corresponding system boundaries, the access of information from a variety of sources, the description of system goals and sub-goals, the identification of the conditions triggering the sub-goals, the verification of the analysis with experts and subsequent revisions if necessary.

The ship inspection system is analyzed and transferred into a hierarchical structure based on the HTA method. According to IMO Resolutions A.1052 (27) and A.1054 (27), the aspects of system structure, legislation, mechanisms and training patterns are essential for the establishment of an effective ship inspection system. Accordingly, the goal for this paper is the enhancement of the performance of the Taiwanese ship inspection system. The four aspects based on the IMO resolutions form the items in the second hierarchy and the sub-goals are therefore to improve the effectiveness of each aforementioned factor. On the other hand, the U.S. is one of the maritime states emphasizing on enhancing ship safety by virtue of an integrated vessel examination mechanism. Thus, under the HTA structure, a comparison analysis of the ship inspection system between the U.S and Taiwan is conducted in terms of such four aspects. Subsequently, the shortcomings in the third hierarchy will be appreciated based on the results.

2. Acquisition of the alternatives using VFT

The VFT approach is a hierarchically structured technique which ensures that decisions are made in the most beneficial manner by emphasizing values over alternatives during the decision making process. Such values are adopted to evaluate the importance and to identify the type of objectives. The objectives are distinguished to fundamental objectives and means objectives by using the WITI test to ask “Why Is That Important?” The former concerns the essential value in the ends of a specific decision context by hierarchy. The latter, which applies networks, provides guidance on what to do to achieve the fundamental objectives. Consequently, the alternatives with the consideration of values could be derived from means objectives [11]. Accordingly, this study utilizes the mean objective approach to acquire the alternatives after realizing the problems generated. This is achieved by frequently producing enquiries and discussing with the interviewees of the degree to which each alternative can ease the problems and the practicability associated once implemented [3].

3. Acquirement of the relative importance of each alternative using AHP

In this stage, the relative weights of the system structure, legislation, mechanisms and training patterns in the second hierarchy and the alternatives proposed in the third level for

each aspect are determined. This will be achieved based on the expert judgment of the ship inspection related personnel stationed in the four international harbors. The information with regard to the alternatives is gathered by the questionnaire based on the results proposed using the VFT method aforementioned. The mission will be accomplished using AHP method. It is such a technique that is based on pairwise comparisons and is capable of producing reasonable results in circumstances where the attributes of the criteria evaluating alternatives are multiple and various.

4. Identification of training courses urgently needed using the Rank Order method

A list of the training courses should be proposed as suggested by the PSCOs based on the interviews and questionnaire. Such courses are the solutions that are urgently requested by the PSCOs for promptly improving the performances when carrying out the tasks onboard ships. The priority of the training courses will be acquired based on the Rank Order method using questionnaires. The method simply classifies the training courses under consideration based on the ranking scales [15].

V. ANALYSIS

1. Comparison of the current practices of the ship inspection system between Taiwan and traditional maritime countries

The comparison analysis is conducted in this stage in terms of the system structure, legislation, mechanisms and training patterns. Such four aspects are the key elements for the establishment of an effective ship inspection system based on IMO Resolutions A.1052 (27) and A.1054 (27). On the other hand, it is not possible to compare with all the countries with outstanding reputations of the ship inspection implementations. Thus, this paper selects one of such countries, the U.S., as the paragon for comparison. This is because the U.S. enacts strict regulations for ship safety and the standard required may be the highest in the world.

1.1 System structure

According to Resolutions A.1052(27) and A.1054(27), a ship inspection system shall be operated by a sole agency and a number of divisions subordinate to it. Some of its divisions should be responsible for the development of new policies, domestic laws and technical requirements corresponding to the latest-developed international conventions. The others should be accountable for personnel recruitment, training and certification, FSC and PSC enforcements. Table 3 is the comparison analysis of the system structure of the ship inspection system between the U.S. and Taiwan. It can be seen from the Table that the U.S. Coast Guard (USCG) is the only agency performing the functions aforementioned. The system structure in Taiwan, on the other hand, is different. The competent authority and operation agencies of the system are TMOTC Department of Navigation and Aviation (DNA) and the harbor bureaus respectively. The former is responsible for mechanism planning while the latter is accountable for implementation. Moreover, TMOTC DNA assumes the functions of policy developments and law makings whereas each harbor bureau remains the missions for personnel recruitment, training and certification. The PSC practice is implemented, apart from Port of Taichung, in a part time manner in most harbor bureaus. This is because the PSCOs have the identities of civil servants with regular duties other than the ship inspection tasks. The FSC practice, however, has not been in operation except for the regular surveys conducted by the classification societies on behalf of the government.

Therefore, the problem of the structure of the ship inspection system in Taiwan is the lack of a sole agency that develops, plans and operates the system and assumes the missions of policy development, regulation making, personnel recruitment, training and certification, FSC and PSC enforcements. Based on the VFT method, the problem described above can be solved by one of the alternatives for system structure (AS) below.

- **AS1**: Establishment of a sole ship inspection agency within TMOTC that develops, plans and operates the system and the subordinate divisions assuming the missions of policy development, regulation making, personnel recruitment, training and certification, FSC and PSC enforcements;
- **AS2**: Assignment of an existing agency operating the ship inspection system and authorizing its divisions to assume the functions aforementioned;
- **AS3**: Authorization of a non-governmental organization to assist TMOTC in developing the training practices and courses and in establishing the divisions solely responsible for FSC and PSC operations.

1.2 Legislation

According to IMO Resolutions A.1054(27), for the purpose of effective implementation of the international conventions, the contents of the mandatory IMO instruments should be considered and incorporated into the domestic laws by flag states. This forms the legal basis for a ship inspection system. The safety requirements of the legislation established and implemented in the U.S. is much higher than that of international conventions. Chapter 33, Part B, Subtitle II of Title 46 of the U.S. Code consolidates the laws governing the inspection and certification of vessels by the Coast Guard that have developed over a period in excess of 140 years. Part 2 of Title 46 (Shipping) of Code of Federal Regulations (CFR) also addresses the ship inspection practices applied by the USCG to both foreign and domestic vessels. The ship inspection system in Taiwan, on the other hand, is implemented based on Articles 58, 59, and 60 of the Commercial Port Law. It is the only regulation that addresses the examination practices for foreign vessels. Rather than the development of the safety requirements specific to domestic and foreign ships, the Article states that any official actions with regard to the PSC exerted by the authority should refer to the IMO international regulations. Table 4 is the comparison analysis of the legislation of the ship inspection system between the USA and Taiwan.

Table 3. Comparison analysis of the systems structure of the ship inspection system between the U.S. and Taiwan.

Items	U.S.	Taiwan
Agency operating the ship inspection system	USCG	TMOTC DNA (Mechanisms planning) Every harbor bureau (Implementation)
Policy development	USCG	TMOTC DNA
Regulation making	USCG	TMOTC DNA
Personnel recruitment, training and certification	USCG	Every harbor bureau
FSC implementation	USCG	N/A
PSC implementation	USCG	Part time missions by the personnel stationed in each harbor bureau

Table 4. Comparison analysis of the legislations of the ship inspection system between the U.S. and Taiwan.

Item	U.S.	Taiwan
Ship inspection regulations	1. Chapter 33, Part B, Subtitle II of Title 46 of the U.S. Code; 2. Part 2 of Title 46 (Shipping) of Code of Federal Regulations.	Article 58, 59, and 60 of the Commercial Port Law.

In comparison with the U.S., the legislation of the ship inspection system in Taiwan is coarse. The government does not have a sound and legal basis for ship inspections. Based on the VFT method, the problem described can be solved by one of the alternatives for legislation (AL) below.

- **AL1**: Establishment of a sound and legal basis for ship inspection;
- **AL2:** Amendment and update of the existing regulations to provide a broader view covering all the legal aspects of the ship inspection system.

1.3 Mechanisms

According to the IMO Resolutions, an effective ship inspection system should be equipped with ship selection schemes, information exchange systems, standard operating procedures and check lists facilitating the ship inspection process. The USCG selects ships which may have higher threats to security, safety and environment based on ISPS/MTSA Security and PSC Safety and Environmental Protection Compliance Targeting Matrices using the Boarding Priority Matrix method. The approach enables the Coast Guard to rationally and systematically determine the probable risks posed by foreign ships calling at U.S. ports. Scores are assessed in the light of owners and operators, classification societies, flag states, ship safety records and ship types for Safety and owners and operators, flag states, recognized security organizations, ship security records and last five ports of call for Security. The outcomes of the Safety and Security aspects are subsequently aggregated for a total point of score. This numerical score, along with other performance-based factors, determine the priority of ship boarding. In addition, the USCG exchanges the port state information using Port State Information eXchange System (PSIX). It is an automated information system that contains specific data on both the U.S. and foreign-flagged vessels operating in U.S. waters. This information is collected and stored in the Marine Information for Safety and Law Enforcement (MISLE) system. Originally, PSIX was designed to provide other countries with Port State Intervention data on foreign-flagged ships, it now contains information on over 650,000 U.S. and foreign-flagged vessels. The standard operating procedures of PSC are developed based on Chapter 33, Part B, Subtitle II of Title 46 of the U.S. Code and Part 2 of Title 46 (Shipping) of Code of Federal Regulations. Moreover, the check lists in terms of safety, security and environment protection are formulated to provide uniform list of inspection items according to the aforementioned Codes.

On the other hand, Taiwan developed its own system for the selection of ships which may have higher risks in safety, security and environment, namely, Vessel Targeting System. However, the ship inspection system in the country does not have any information exchange mechanism with other countries due to the fact that Taiwan is not a member of any regional PSC schemes. Accordingly, the database can only be updated based on the detention list published periodically by the regional PSC systems in the Internet. Furthermore, the Taiwanese PSCOs conduct ship inspections based on the experiences rather than written standard operating procedures. In addition, the PSCOs currently perform the duties without check lists to facilitate the ship inspection process according to the interviews. Therefore, the PSC inspection is time consuming and the efficiency is impaired. Table 5 indicates the comparison analysis of the system between the U.S. and Taiwan in terms of mechanisms.

Accordingly, based on the VFT approach, the problems encountered could be solved by one of the alternatives for mechanisms (AM) proposed below.

- **AM1**: Establishment of an integrated ship inspection system

Table 5. Comparison analysis of the mechanisms of the ship inspection system between the U.S. and Taiwan.

Items	U.S.	Taiwan
Ship selection system	ISPS/MTSA Security and PSC Safety and Environmental Protection Compliance Targeting Matrices	Vessel Targeting System
Information exchange system	PSIX System	N/A
Standard operating procedure	Developed based on Chapter 33, Part B, Subtitle II of Title 46 of the U.S. Code and Part 2 of Title 46 (Shipping) of Code of Federal Regulations	N/A
Check list	Safety, security and environmental protection	N/A

Table 6. Comparison analysis of the training patterns of the ship inspection system between the U.S. and Taiwan.

Items	U.S.	Taiwan
Planning of the training courses	USCG	Assistance by Canadian Coast Guard
Classification of ship inspectors	Marine inspectors and PSCOs	PSCOs
Training period	Higher than the IMO	Lower than the IMO

incorporating database, information exchange system, standard operating procedures and check lists.

- **AM2**: Establishment of an information exchange scheme with other countries to update ship inspection related data.
- **AM3**: Review and enhancement of the current practices in ship inspection procedures.
- **AM4**: Increase of the frequency of updating the ship inspection information.

1.4 Training Patterns

An intact training program should be devised according to the contents of the PSC practices. The specifications and minimum training hours of such a program are required to be in conformity with the model courses developed by IMO. In addition, a certification and promotion scheme also needs to be constructed to ensure the competence of personnel. In the U.S., the ship inspection training courses are developed by the Coast Guard. Ship inspections in the country are enforced by marine inspectors and PSCOs. Marine inspectors are obligated to examine US-flagged vessels whereas PSCOs are responsible for inspecting foreign ships. The numbers of the training days for marine inspectors and PSCOs are 30 and 19 days respectively. The main focuses of the training course for marine inspectors are the basic hull construction and nomenclature, lifesaving, firefighting and engineering systems and familiarization of the U.S. regulations [25]. The training course for PSCOs, on the other hand, emphasizes on port state control concepts, requirements of international conventions and the application of the domestic requirements to foreign freighters [24]. The training periods are higher than that of IMO Model Course 3.09 for which the number of the days recommended is 10. The PSCOs training courses in Taiwan, based on the assistance from Canadian Coast Guard, were developed in 2003 and are periodically adopted by each harbor bureau. However, the consistency of the contents of the training programs between the harbors is questioned due to the lack of a thorough planning and some of the material may be out of date. The number of the training days is between 3 and 5 days and may vary according to each harbor bureau. Thus, the training period is lower than the figure suggested by the IMO. In addition, since the absence of the FSC scheme, Taiwanese government does not appoint any agencies to examine the national vessels. Table 6 contains the comparison analysis of the system between the USA and Taiwan in terms of the training patterns.

Accordingly, the problems identified based on the comparison analysis are the lack of a thorough planning of the courses specific to Taiwan, the absence of an assorted training scheme for ship inspection personnel performing the FSC and PSC tasks and shortage of the training period and outmoding of the contents.

Thus, based on the VFT approach, the problem encountered could be solved by one of the alternatives for training patterns (AT) proposed below.

- **AT1**: Establishment of an agency or authorization of an organization responsible for planning the training courses.
- **AT2**: Construction of an assorted training scheme for ship inspection personnel implementing the FSC and PSC operations.
- **AT3**: Development of a thorough set of ship inspection training courses specific to Taiwan based on the IMO Model Courses.

- **AT4**: Increase of the frequency of attending the ship inspection related international conferences/workshops.

2. Acquirement of the relative importance of the system structure, legislation, mechanisms and training patterns

In order to have a broad view of the opinions from the ship inspection related personnel, all of the international ports in Taiwan were visited by the authors. Therefore, the experts interviewed in this paper are the specialists stationed in Ports of Keelung, Taichung, Kaohsiung and Hualien. 20 copies of the questionnaires were also collected for analysis. In this Section, a hierarchical structure for the study is established using the AHP technique. The top of the structure is the ship inspection system. This is followed by the system structure, legislation, mechanisms and training patterns stationed in the second hierarchy. The alternatives proposed for each aspect are listed in the third level. The relative importance of each aspect and the overall priority of each alternative are subsequently obtained. It is noted that in this paper, the criteria to be applied when conducting the pairwise comparison for all alternatives include costs, effectiveness and the degrees of implementation difficulty. Such three criteria are acquired based on the opinions from the subject-matter experts interviewed.

Based on the AHP method, the most important aspect in the second hierarchy is legislation of which the weight is 0.2720, followed by system structures, mechanisms and training patterns with the values of 0.2657, 0.2324 and 0.2299, respectively. It can be inferred from the outcome that since the legislation factor provides the system structure, mechanisms and training patterns of the ship inspection system with a thorough legal framework, the legislation aspect is the most important component.

2.1 Acquirements of the relative importance of the alternatives proposed for the problems encountered in system structure in the third hierarchy

The relative weights of the alternatives proposed in the third level for each group are also determined. Three alternatives were evaluated by the experts involved in the ship inspection system in Ports of Keelung, Taichung, Kaohsiung and Hualien. The outcome of the relative importance between these measures is summarized in Table 7. It can be seen from the Table that the most crucial alternative for solving the problems encountered in the system structure is “Establishment of a sole ship inspection agency within TMOTC (AS1)” with a value of 0.3492. It is followed by “Assignment of an existing agency operating the ship inspection system (AS2)” and “Authorization of a non-governmental organization to assist TMOTC (AS3)”. According to the experts, the establishment of such a ship inspection agency within the TMOTC would be capable of eliminating the problem encountered. The reason that AS2 is less important is that all the TMOTC agencies have been engaged in the missions already assigned. Thus, the agency to be appointed may not be able to pay full attentions to the ship inspection operation. AS3, on the other hand, may incur enormous costs to the government in the initial stage and the on-going services.

2.2 Acquirements of the relative importance of the alternatives proposed for the problems encountered in legislation in the third hierarchy

Two alternatives were considered in this paper. It can be seen from Table 7 that the experts prefer “Establishment of a sound and legal basis (AL1)” to “Amendment and update of the existing regulations (AL2).”

2.3 Acquirements of the relative importance of the alternatives proposed for the problems encountered in mechanisms in the third hierarchy

Four alternatives were evaluated for solving the problems encountered in the aspect of the ship inspection mechanisms. According to Table 7, the most preferred measure is “Establishment of an integrated ship inspection system (AM1)” of which the weight is 0.2687. It is followed by “Establishment of an information exchange scheme (AM2),” “Review and enhancement of current practice (AM3),” and “Increase of the frequency of updating information (AM4)” with the values of 0.2554, 0.2400 and 0.2359, respectively.

2.4 Acquirements of the relative importance of the alternatives proposed for the problems encountered in training patterns in the third hierarchy

Four alternatives capable of solving the problems encountered in training patterns were considered. It can be seen from Table 7 that the most effective alternative is the development of a thorough set of the ship inspection training programs based on the IMO model courses. According to the experts, the planning of a complete set of the training courses (AT3) would be the first priority that would directly facilitate the ship inspection performance. On the other hand, “Establishment of an agency or authorization of an organization (AT1),” “Increase of the frequency of attending conference (AT4)” and “Construction of an assorted training scheme (AT2)” may not be as effective as AT3 in improving the training practices.

2.5 Acquirement of the overall priority of each alternative for the problems encountered in system structure, legislation, mechanisms and training patterns

The overall weight of each measure is obtained in this stage. This is achieved by multiplying the value of relative importance of each alternative in the third hierarchy by the weight of each aspect acquired in the second hierarchy. Table 7 contains the results. The Table shows that after the normalization process, “Establishment of a sound and legal basis (AL1)” is the alternative that should be treated as the first priority to be implemented. The second and third most important measures are “Amendment and update of the existing regulations (AL2)” and “Establishment of a sole ship inspection agency within TMOTC (AS1).”

3. Ship inspection courses urgently needed

A number of interviews were also conducted in this paper

Table 7. Overall priority of each alternative for the problems encountered in system structure, legislation, mechanisms and training patterns.

Aspects	Alternatives	Relative importance	Priority
System structure (0.2657)	**AS1 (0.3492)**	**0.0928**	**3**
	AS2 (0.3392)	0.0901	4
	AS3 (0.3115)	0.0828	5
Legislation (0.2720)	**AL1 (0.5429)**	**0.1477**	**1**
	AL2 (0.4571)	**0.1243**	**2**
Mechanisms (0.2324)	AM1 (0.2687)	0.0624	6
	AM2 (0.2554)	0.0594	8
	AM3 (0.2400)	0.0558	11
	AM4 (0.2359)	0.0548	13
Training patterns (0.2299)	AT1 (0.2554)	0.0587	9
	AT2 (0.2404)	0.0553	12
	AT3 (0.2604)	0.0598	7
	AT4 (0.2438)	0.0560	10

with regard to the shortages of the current ship inspection training courses in comparison with the IMO and the USCG courses. After consulting with the PSCOs, 9 ship inspection courses are urgently demanded for the ship inspection practices in Taiwan and shown in Table 8. It is noted that the number of the training hours is predicted based on the IMO model courses or the USCG programs and the PSCOs in this paper.

4. Acquirement of the relative importance of the ship inspection courses urgently needed

In this section the relative importance of each ship inspection course urgently needed is acquired using the Rank Order method. Based on the questionnaire using the Rank Order method from the experts stationed in Ports of Keelung, Taichung, Kaohsiung and Hualien, a list of the priority of the relative importance of the courses is established as shown in Table 8.

It can be judged that the most important training course that should be placed in the first position is “Main focuses of the international conventions” with 170 scores in total. According to the specialists, such a course provides PSCOs with the fundamentals of the conventions for exercising appropriate course of actions. “Ship construction and equipments” and “Progress of the approval of newly-developed conventions” are regarded as the second and third most important training courses that should be devised. It should be noted that the scores of these two courses are close to each other (148 for the former while 146 for the later). This is because the courses enable the Taiwanese PSCOs to be equipped with up-to-date information of new conventions and the shipbuilding technology based on the opinions from the experts.

VI. CONCLUSION

The ship inspection system of a flag state is an important indicator expressing the performance of ship safety of that country. According to the IMO conventions, member states should ensure that vessels flying their flags and those sailing within their territorial waters are of seaworthiness. Therefore, the ship inspection system can be regarded as a frontline fighting against substandard ships. In this paper, the ship inspection system in Taiwan is evaluated in terms of the system structure, legislation, mechanisms and training patterns aspects.

According to the comparison analysis with the U.S., the shortcomings of the ship inspection system are summarized in the following.

- **System structure**: lack of a sole agency that develops, plans and operates the relevant affairs of the ship inspection system;
- **Legislation**: absence of a sound and legal basis;
- **Mechanisms**: shortages of information exchange channels, standard operating procedure and check lists;
- **Training patterns**: lack of a thorough planning of the courses, the absence of an assorted training scheme, and the shortage of the training period and outmoding of the contents.

Accordingly, the four sets of the alternatives have been proposed based on the VFT method. The result shows that “Establishment of a sound and legal basis (AL1)” in the legislation aspect is treated as the first priority derived based on the AHP method. Besides, the alternatives that are recommended to solve the problems encountered in the aspects of system structure, legislation, mechanisms and training patterns are showed in the following.

- **System structure**: establishment of a sole ship inspection agency within TMOTC (AS1);
- **Legislation**: establishment of a sound and legal basis (AL1);
- **Mechanisms**: establishment of an integrated ship inspection system (AM1);
- **Training Patterns**: development of a thorough set of training course based on IMO Model Courses (AT3).

Finally, “Main focuses of the international conventions”, “Ship construction and equipments” and “Progress of the approval of newly-developed conventions” are regarded as the most imperative courses that should be devised.

The problems identified, the alternatives proposed and the training courses urgently demanded have been formally submitted to and under consideration by TMOTC. It is believed that the findings obtained in this paper will enable the government to establish an integrated scheme for ship inspection.

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Table 8. List of the priority of the ship inspection courses urgently needed by the Taiwanese PSCOs.

Ship inspection courses	Training hours	Scores
Progress of the approval of the newly-developed conventions	**1***	**146**
Ship construction and equipments	**6***	**148**
Main focuses of the international conventions	**13.5***	**170**
Maritime English (conversations and English writing of deficiency reports)	8**	143
Application of check lists	4**	113
Key points of bulk carrier inspections	8**	135
Common deficiencies causing detentions	4**	107
Concentrated Inspection Campaign of Paris and Tokyo MOUs	4**	131
Key points of purpose-built vessels	Varies depending upon ship types	113

Note: * based on the recommendation of IMO model course
**estimated by this study

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