Development of a Safety Management Assessment System for the International Safety Management Code

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Numerous studies have identified that the vast majority of high-consequence maritime accidents are largely attributable to human and organizational factors. Some would argue that human and organizational factors play a significant role in all maritime accidents. In an industry where technological equipment and hardware solutions have typically been applied to improve and promote shipboard safety, it has become increasingly important to examine and exploit human and organizational factors as an area fruitful for overall safety improvement. This paper summarizes the development and application of an International Safety Management Code based Safety Management Assessment System (ISM-SMAS) for shipboard systems. The ISM-SMAS provides a framework and the opportunity to focus on the human and organizational factors that have a major influence on the safety of marine operations. Presentation

BACKGROUND

Marine casualties persist despite the maritime industry's technical improvements and innovations (redundant systems such as tanker double hulls). In light of this, the International Maritime Organization adopted the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) contained in Resolution A.741(18) in 1993. The ISM Code provides a unique opportunity for shipping companies to improve their safety through its implementation. The ISM Code, unlike a vast majority of governmental rules and regulations is not prescriptive; instead, the seven-page document provides guidelines for the basis of a safety management system. This Code focuses proactively on the safety of life at sea and environmental protection not through additional equipment or mandatory provisions, but rather outlines what a company's safety management system must functionally address.

The objective of this study was to develop an assessment instrument and protocol that focuses on human and organizational factors of marine operations. It was envisioned that this instrument and its protocol could be used in periodic or random first and third party assessments of marine operations in determining compliance with the International Safety Management Code and ultimately in developing reasonable mitigation measures and management strategies for addressing identified factors of concern. This assessment instrument and its protocol are also well suited to the offshore industry where technological solutions have traditionally prevailed.

Dating back to the 1940's, quality control and quality assurance were first introduced in strictly land-based industries and later developed to encompass the entire

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The opinions and conclusions found herein are not necessarily those of the U.S. Coast Guard or the Department of Transportation.

spectrum of a company's activities, including marine and offshore operations. Similar principles were adopted by the offshore industry in the early 1970's in the North Sea, but for various reasons failed in practice, leading to an inflation of documentation and paperwork. Once again, quality came to the fore in the early 1990's in the form of the ISO 9000 series of quality systems. Developed as a common set of international standards, the ISO 9000 series are now widely accepted and promoted by authorities and industry worldwide.

Unquestionably, the safe and reliable operation of a ship and its cargo should be defined within the scope of quality management for any transportation service. However, the fact that safe shipping traditionally has been governed by an international safety regime with the primary objective to protect *lives at sea* and *the environment* seems to draw less attention when quality in shipping is discussed. The two, however, are vitally linked. In this context, quality is defined as resulting from the combination of four attributes: serviceability (fitness for purpose), compatibility (meets economic, schedule, and environmental requirements), safety (freedom from undue exposure to injury or harm), and durability (freedom from unanticipated degradations in the other quality attributes).

Typically, stricter rules and regulations result from serious disasters in an effort to prevent similar disasters in the future, often concentrating on passenger safety and pollution prevention. Based on this pattern, it is not difficult to predict that further attention will be given to the shipping and offshore industries as a whole. History has given clear examples of this. Total loss statistics expressed in number of losses per ship year show a steady decline over the last ten-year period. Despite this rather favorable trend, bulk carrier losses have shown a steady increase over the same period, which is a matter of great concern because of the associated loss of lives and cargo. Statistical figures of lives lost in maritime casualties are normally presented as lives lost in total losses. Except for the year 1987, when the incredible number of more than 3000 passengers were killed in the *Dona Paza* accident, the number of lives lost per year have been fairly stable (DNV 1997).

Three accidents in particular with major loss of lives have aroused public resentment of the standards of safety in shipping, namely the Herald of Free Enterprise, the Scandinavian Star, and the Estonia. The annual accidental pollution of oil from ships is slightly more than 100,000 tons. The *Exxon Valdez* accident, which received global around-the-clock media coverage, has exposed the world to the fact that a concentrated oil spill from a tanker accident may have catastrophic ecological consequences on a sensitive area. The less sensational, but more recent *Erika* accident off the coast of France has reminded us of this potential risk. The public has also become aware that even relatively minor spills of bunkers from accidents with other types of ships may pollute the environment and eliminate endangered species.

Accident causes can be grouped into two broad categories: technical failures and human errors. Even still, these immediate causes are typically symptoms and seldom represent the ultimate cause. For example, substandard acts as well as substandard conditions are symptoms of basic causes such as lack of training, motivation, or lack of standards. Experience from loss control principles has shown that most substandard actions are caused by factors over which only the management has control. Most loss control experts place this number at 80%. Maritime accidents correspond very well to these results. In the end, safety, or control of accidental loss, is primarily a function of management control.

In shipping, this means both shipboard and shore-based management. This focus on the human element when disasters occur makes it necessary to achieve reduction of risk and loss control through new approaches. Gradual focus has been put on the human element to avoid accidents through better control of the human side in shipping. A general consensus has been that management systems will improve the safety and quality in shipping in this manner.

Today, the task facing all shipping companies is to minimize the potential for poor human decisions that contribute, directly or indirectly, to a casualty or pollution. Decisions made ashore can be as important as those made at sea and must be included. Therefore, every decision and action that effects safety or the prevention of pollution must be based on sound organizational practices, regardless of the level within the company.

INTERNATIONAL SAFETY MANAGEMENT CODE

Adopted by the International Maritime Organization in 1993, the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) contained in Resolution A.741(18) provides a unique opportunity for shipping companies to improve their safety through its implementation. This need for a systematic approach to control safety and quality management has been realized by the international shipping community. The development of the ISM Code is a reflection of this on the part of the various governments. The ISM Code established an international standard for the safe management and operation of ships by setting common standards for the organization of company management in relation to safety and pollution prevention, as well as the implementation of a safety management system. The International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) was adopted by the 18th

International Maritime Organization Assembly November of 1993 as Resolution A.741(18). In May of 1994, the Conference of the Safety of Lives at Sea decided to make the ISM Code mandatory and placed it in Chapter IX of the SOLAS Convention.

The ISM Code, unlike a vast majority of governmental rules and regulations is not prescriptive; instead, the seven-page document provides guidelines for the basis of a safety management system. This Code focuses proactively on the safety of life at sea and environmental protection not through additional equipment or mandatory provisions, but rather outlines what a company's safety management system must functionally address. The ISM Code addresses a philosophy and the policy of safety and environmental protection, the responsibilities and authorities of the company, personnel with key designations in safety and environmental protection, Master's responsibilities and authority, resources and personnel, develop of plans for shipboard operations, emergency preparedness plans, reports and analyses of accidents and hazardous occurrences, maintenance of the ship and equipment, documentation, company verification, review, and evaluation and certification, verification, and control.

In addition to the Code itself, a set of guidelines has been developed. These guidelines called the *IMO Guidelines on ISM Certification* were needed for a number of reasons. First, they define the purpose of the mandatory application of the ISM Code. They also serve to clarify real or perceived discrepancies in the Code that help to ensure uniform implementation. Also, they provide qualification requirements for the assessors and requirements for the management of the various certification schemes.

SAFETY MANAGEMENT ASSESSMENT SYSTEM

The ISM Safety Management Assessment System (ISM-SMAS) is a framework and model for evaluating and subsequently improving marine operations. Initially developed by the Marine Technology & Management Group at the University of California at Berkeley for the marine industry (Bea 1996), (Hee and Bea 1997), (Hee and Bea 1998), SMAS has been modified specifically for shipboard use. In addition to determining compliance with the intentions of the ISM Code, the SMAS incorporates a process that focuses on the influence of human and organizational factors on the safety of marine operations.

The ISM-SMAS is comprised of two basic elements: a safety assessment model (or instrument) and a detailed protocol for using the instrument including a baseline assessor training program, a human and organizational factors overview, and details on how the process information can be disseminated and used to best advantage. The SMAS model encompasses six general categories and a linking category. The categories are considered the primary influences of the safety of marine operations. Figure 1 represents how the categories are inter-related.

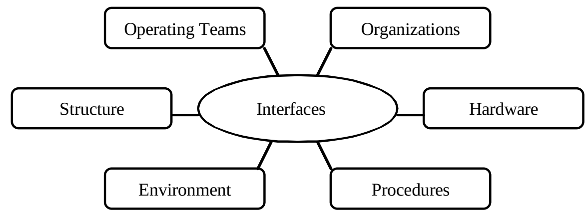

Fig. 1: Components of Marine Operations Influencing Safety

Note that each component interacts with all others through the interface component. The interface category may be considered a six-by-six matrix where there is an interaction in each location except the main diagonal. For example, there are important interface factors that address the interaction of operating teams and hardware. Considerable time is devoted to analyzing that interaction within the ergonomics discipline.

There are three phases of the ISM-SMAS process. Figure 2 depicts the different phases of the ISM-SMAS process.

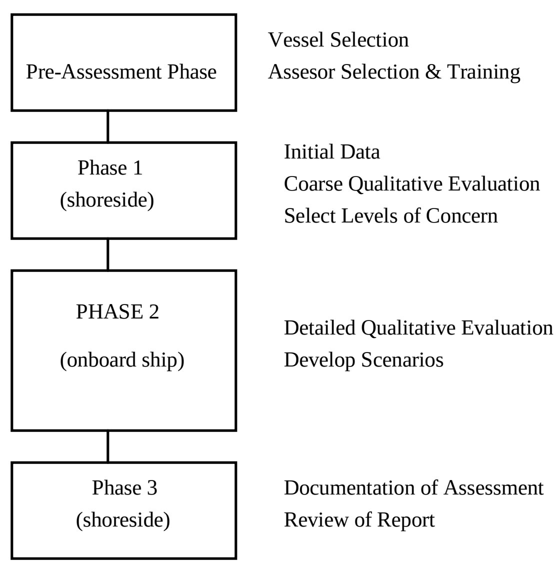

Fig. 2: SMAS Process

Prior to the formal phases of the assessment, there is a pre-assessment period. During this preliminary phase, such administrative items as vessel selection, assessment team selection, and assessment team training take place. The assessment team may be comprised of operating personnel, third party authorities, or shore-based personnel. It is critical that those selected have adequate experience of the operation and the proper motivation to accomplish the task.

The first phase requires initialization of the assessment including review of the first tier documents (e.g. certification, safety management system documentation, environmental policy), a coarse qualitative evaluation of the attributes based on that review, and interviews of shore based management as appropriate. This phase of the assessment serves to demonstrate how the safety management system at large operates, gives indications of operating personnel and organizational attributes, and provides a broad overview of the marine system.

The second phase is the most important and entails the actual assessment of the vessel and its crew. During this phase, a detailed qualitative evaluation is conducted based on the findings of the first phase assessment and previous assessments. Additionally, scenarios are developed during this phase to further evaluate identified concerns.

The final phase takes place ashore and is primarily a documentation phase and dissemination of assessment findings. Ultimately mitigation measures are developed and noted at this stage.

The safety assessment tool contains a database that is comprised of a series of layers (Figure 3). There is a module for each of the seven categories or components. These modules are used to organize the assessment. Each of these modules are broken down into a second layer of factors. Factors are broad categories that help determine the state of the marine operation in that specific component. For example, the communications factor may be a category within both the operating teams component and the organization component.

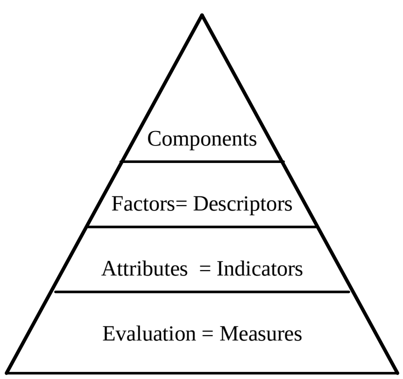

Fig. 3: ISM-SMAS Instrument Layers

The next layer is the attribute layer. Attributes are specifically designed for grading the factors. They are observable and measurable. These attributes are partially based on the ISM Code, the STCW guidelines, principles of the Prevention Through People approach, and quality standards. An example of the attribute that could be used to grade the factor of communication might be that a common language exists or that there is sufficient English proficiency.

The final layer is the evaluation layer. This layer provides a benchmark against which to grade a specific factor based on an attribute. Using the same example from above, opposite ends of the spectrum for evaluating the English proficiency attribute would be that on the low end of the scale there were eight different languages used on board and that an interpreter was needed, and on the other end, English was the native language of the entire crew.

Based on experience and judgment combined with grading evaluation guidelines, the assessment team assign numeric values to each attribute. These numeric values are based on a seven point scale (Figure 4) as anchored by linguistic variable and descriptors provided by the evaluation layer of the instrument. The seven-point scale is indicative of performance in regards to industry standard, minimum Code requirements, and good marine practice.

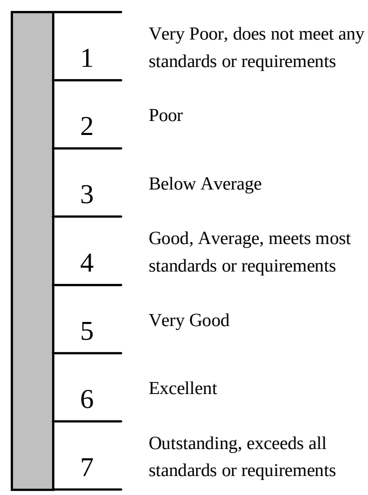

Fig. 4: Seven Point ISM-SMAS Grading Scale

This process of measuring attributes by evaluation for specific factors in a general component is repeated for all seven categories and the numerous factors beneath those. This iterative process is summarized in Figure 5.

Once the entire marine operation has been evaluated the grades are analyzed (via the ISM-SMAS Microsoft EXCEL® software on which the assessment modules have been stored) and synthesized to provide overall scores in each of the major components. This is intended to give the ship operations personnel and a company an assessment of the condition of their safety management system. Equally important to the trends are the comments provided by the assessment teams that justify their evaluations, record their observations, and the individual marks which will help focus on specific shortcomings.

The design of the ISM-SMAS paralleled that used to define the one for marine terminals, however, it had to also capture the aspects unique to ships and ship operations including the complex relationships between shipboard and shore based operations within one organization. A detailed review of the ISM Code, the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (as amended in 1995), and related guidance such as the Port State Control Inspection Routine Maintenance Checklist for Owners and Masters (ABS 1995) provided insight into how each of the ISM-SMAS components could be tailored or adapted to the shipboard working environment.

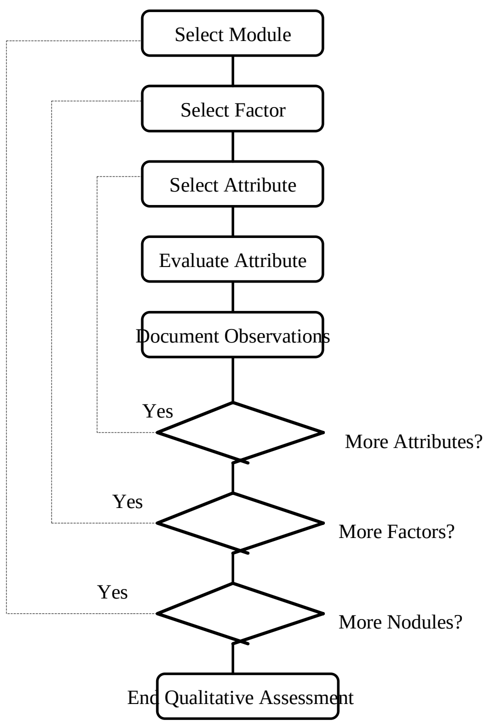

Fig. 5: Quantitative Evaluation Process

The following definitions were developed to characterize the seven ISM-SMAS components:

- Structure - ship structure and associated strength members, typically those considered in a periodic hull examination,
- Procedures - operating and maintenance procedures,
- Equipment/Hardware - mechanical or physical systems on board which support the operations or overall function,
- Environment - external (weather) and internal (social and climate control) conditions throughout the ship and extended to the organization,
- Organization - company that owns the ship or the many other organizations or persons such as the manager, bareboat charterer, etc. who have responsibility for the operations of the ship,
- Operating Teams - ship's Master and crew, and
- Interface - the linkages between the above-defined components.

For each attribute two numeric scores are assigned based on the assessment team's evaluations. There are specific attribute evaluation remarks which detail where the attribute might fall on the continuum. For example, the following evaluation information for the impairments attribute section of the team composition factor (organization module):

1: No mandated rest periods; Unlimited OT
3: Limited rest periods or conflicting assigned duties that interfere with rest
4: Daily rest periods totaling 10 hours in 24, 6 hours uninterrupted
5: Rest periods in addition to mandate when necessary
6: Relief personnel assigned when needed to ensure adequate rest
7: Policy for fitness on watch

These are linked to the dialog box used for evaluating a particular attribute and show up in the scoring criteria box as shown in Figure 6.

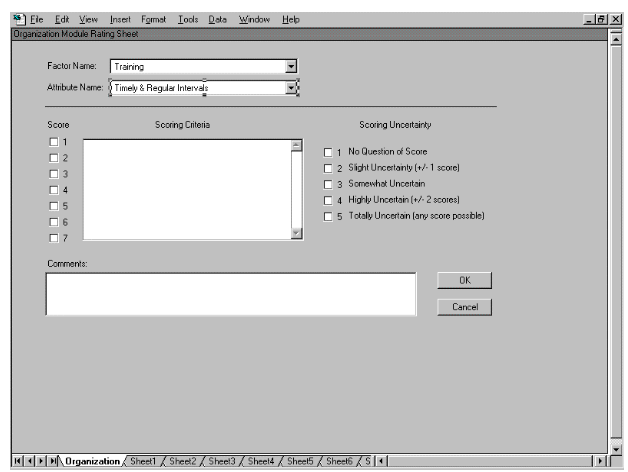

Fig. 6: Dialog Box for Scoring Attribute

Next to that window of the dialog box is a checkbox for assigning a score of 1 to 7. An uncertainty scoring box is located next to the window and provides the following comments regarding criteria for uncertainty:

1: No Question of Score
2: Slight Uncertainty (+/- 1 score)
3: Somewhat Uncertain
4: Highly Uncertain (+/- 2 scores)
5: Totally Uncertain (any score possible)

Assessor selection and training is the most important step in the entire ISM-SMAS process. Without qualified, motivated, and skillful assessors that have high integrity, much of the work behind the ISM-SMAS can be lost. The ISM-SMAS is meant to be a springboard for questioning and probing, and the quality of the results from the assessment is a direct function of the skills, qualifications, and motivations of the assessor.

It is important to note that it is very desirable, if not essential, that the assessment team include members of the ship operating crew. This is important for two reasons. First, the real experts about a particular ship safety management system are the members of that system. Second, the true benefits of the assessment are in the residual understanding and actions that are left onboard the ship after the assessment. The primary product is not intended to be a report. The primary product is intended to be changes in behaviors and operations processes that can lead to improvements in the safety and quality of the ship operations. This strategy is known as 'participatory ergonomics.'

Assessor teams were composed of a lead assessor and a number of assisting assessors. The lead assessor was responsible to ensure the various concerns on their team had the requisite knowledge to accomplish the tasks at hand. Therefore, training of the assessors was vital to the success of an assessment of a safety management system. In this stage of development, training is accomplished using a correspondence course format that includes sections on:

- Introductory material
- Safety and quality system requirements
- Overview of SMAS
- Review of human and organizational factors
- Assessor traits and techniques for assessment
- Assessment process
- SMAS protocol
- Review and workshop

Following study of the training manual, an interactive hands-on ISM-SMAS demonstration and question and answer session are provided. Each assessment consists of as many as 143 attribute evaluations. Not all attributes are necessarily rated based on the needs of the assessment team and the focus of the assessment. In some cases, a full and complete ISM-assessment may be in order. However, if such an overall assessment had been done recently and there was a suspected weakness or possible non-conformity in a particular area, the ISM-SMAS may be used as a tool for identifying problem areas leading to the suspected weakness and from that develop a scenario or strategy to address the suspected weakness.

One area in which human and organizational factors assessment have typically fallen short is that uncertainty is not usually adequately addressed. For this reason, an uncertainty measure of the evaluation score was incorporated in the ISM-SMAS protocol and instrument. Using a linear transformation, the attribute scores are converted to a standard deviation. These uncertainties and best estimate evaluations are then propagated through the calculations and aggregations. Given the mean of the score (or the evaluators best estimate) and the standard deviation (to capture uncertainty), the sum of groups of attributes is found. The average for a factor group is established by taking the arithmetic mean while the respective standard deviation is the Euclidean sum.

RESULTS AND ANALYSIS

The ISM-SMAS was successfully tested on three different ships by two different assessment teams. Three ships of very different services were examined using the ISM-SMAS (Table 1): a high-endurance Coast Guard cutter with a military complement, a domestic container ship, and a domestic tanker.

Table 1: Description of Ships Assessed with ISM-SMAS

Service	Age (years)	Registry (Flag)	Crew Make-up	ISM Code ?
Coast Guard Cutter	26	N/A	U.S. Coast Guard Personnel	N/A
Container Ship	21	U.S.	U.S. Officers/ U.S. Ratings	In Process
Tanker	12	U.S.	U.S. Officers/ U.S. Ratings	Yes

The assessment teams were comprised of a cross section of the maritime industry. Members included a Master Mariner with over twenty years of shipboard experience and training in quality systems, a manager with extensive ISM Code implementation experience, a line duty officer acting in the capacity of Operations Officer, and a experienced marine inspector with training in safety assessments and experience as a shipboard engineer. The assessors selected were experienced in shipboard operations and they were felt to have credibility within their respective organizations. Each had high levels of interests in quality improvement and was interested in learning about the ISM-SMAS. Table 2 summarizes the credentials of the lead assessors.

The first vessel assessed was a U. S. Coast Guard Cutter. Although not required to obtain ISM Code certification or adopt a safety management system per se, a Coast Guard Cutter was chosen for accessibility. It was felt that this opportunity would prove useful in that Coast Guard Cutters are typically in port for extended periods in comparison to the commercial vessels that the ISM-SMAS was designed to evaluate. This type of in-port schedule would allow ample time to go through the instrument and assessment protocol in detail. This was, by far, the longest assessment at about six hours. Figure 7 provides an overview of the results of the assessment.

Table 2: Lead Assessor Backgrounds

Team A - Lead Assessor	Team B - Lead Assessor
Maritime academy graduate Mariner experience (>20 years, >15 years as Master) Quality management (3 years) Human factors exposure	College Degree Shipboard Experience (2 years) Marine Inspector (8 years) Lead Assessor Certification Human factors background Risk assessment background

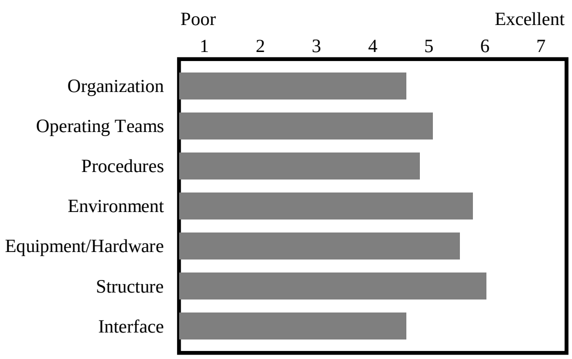

Fig. 7: ISM-SMAS Module Summary for Coast Guard Cutter

The second field test was conducted on a domestic container ship which was undergoing its certification for obtaining its ISM Code documentation at the time. The company's safety management system documentation had recently been placed aboard the vessel. Therefore, there was an awareness of the system, but not at the intimate level of a fully matured system. It was a good opportunity to compare a vessel with some awareness against a vessel such as the first visited with little or no awareness.

This test was conducted in about three hours. There were considerable demands upon the Master and crew and, therefore, time was at a premium. The company's ISM implementation coordinator also attended the test and provided additional information regarding company policy, history of their safety management system, and their goals regarding this system. Figure 8 presents a summary of the results of the second assessment.

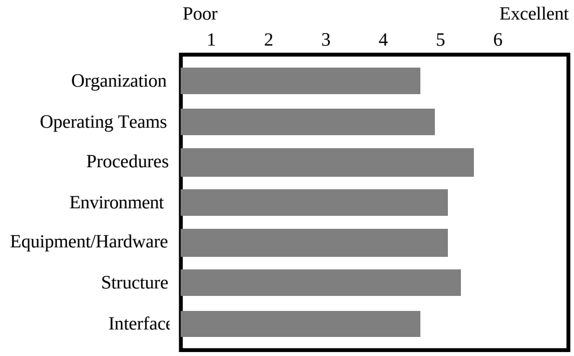

Fig. 8: ISM-SMAS Module Summary for Container Ship

The final test of the ISM-SMAS instrument and protocol was performed aboard a commercial tank vessel. This time there was a different assessment team including a different lead assessor. This test took approximately 6 hours to complete. The results of that test are contained in Figure 9.

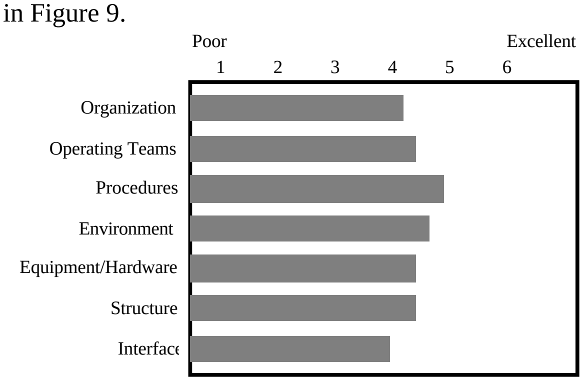

Fig. 9: ISM-SMAS Module Summary for Tanker

Table 3 provides an overview of the three assessments. Table 3 summarizes the ISM-SMAS module mean and standard deviation scores. The ISM-SMAS module mean scores ranged from a low of 4.69 for the structure evaluation of the tank ship to a high of 5.92 for the structure evaluation of the Coast Guard Cutter. Uncertainty ranged from a low of 0.89 standard deviations for the environment score of the container ship to a high of 2.31 standard deviations for the organization score of the bulk carrier. This restates the presumption that mariners are more comfortable scoring technical aspects and equipment than they are human factor related items.

Some overall trends include the greatest uncertainty found in scoring interfaces. Also, it seemed that there was generally the least uncertainty in scoring equipment and structure, those items that the maritime community traditionally has scored or rated.

The Coast Guard Cutter seemed to be rated higher for most categories, particularly in four categories: environment, equipment/hardware, structure, and operating teams while the bulk carrier consistently scored lower in most categories. The container ship with its newly implemented safety management system scored generally higher than the tanker with its established safety management system. The maturity of the systems is relative as these are reputable companies within the industry and the "new" systems may represent what was already in place. Also, a different assessor rated the tanker and since there was no common vessel to compare over, no strong conclusions can be made about these differences.

Table 3: Evaluation Score and Uncertainty by Vessel Type

SMAS Module Evaluated	C.G. Cutter		Container Ship		Tank Ship	
	Score	σ	Score	σ	Score	σ
Organization	4.7	1.2	4.8	1.5	4.3	1.1
Operating Teams	5.0	1.4	5.0	1.3	4.6	1.0
Procedures	4.8	1.6	5.5	1.1	5.0	1.1
Environment	5.8	1.1	5.2	1.1	4.8	0.9
Equipment	5.6	1.3	5.2	0.9	4.6	1.0
Structure	5.9	1.1	5.3	0.7	4.7	1.1
Interface	4.4	1.8	4.7	1.4	4.1	1.4

Throughout these field tests, comments and feedback were solicited from the assessors and those involved in the assessments. Feedback was sought both in the assessment and about the overall ISM-SMAS process and how it might be improved. The assessors and those assessed provided valuable insight into the practicality of the ISM-SMAS process and protocol. The following are some of the more significant comments regarding the ISM-SMAS instrument:

- "Thinking about each attribute score and uncertainty and then having to enter them into the computer takes away from the natural flow of the assessment."
- "The software is pretty crude and could be made better to speed things up."
- "The reports are useful to get a general idea of where we stand."
- "Editing scores in another module after they had been assigned was easier than I had expected. Using a simple spreadsheet format makes it accessible."
- "The check boxes were effective and the scoring criteria was very helpful in assigning scores."

There were many more comments about the process itself. The following are some of the most telling comments:

- "I will always put my best foot forward when an outsider comes aboard my vessel."
- "It was very tedious to enter every score and uncertainty and there seemed to be too many. Some were redundant. Needs more scoring criteria."
- "I got bored filling all the scores and as the process went on I found myself guessing at some."
- "Assessors should be mariners. This will allow a common bond and language up front which helps in having an honest assessment."
- "The methodology used in the ISM-SMAS is well structured and organized. It gave the assessor the framework to get at the heart of the matter. But if the assessor doesn't get beyond his initial personal impressions, he might miss important information. It seems like there is an opportunity for the people being interviewed to be furtive."
- "This is all well and good, but it all boils down to a few professionals building a trust and comparing notes…working together to make their shipboard environment safer. It seems like if you don't have the right assessor or the assessor is talking to the wrong person, this won't work."

Not all comments were captured, but the foregoing represents some of the recurring themes and impressions. Many such comments were acted upon and improvements implemented during the course of the ISM-SMAS development.

CONCLUSIONS

Analysis of the field test results and experiences indicates that the ISM Code SMAS is a practical process that can produce meaningful and useful results. The most striking finding in this study was that no matter the degree of technical success of the instrument and its processing, the value of the assessment lies in the hands and minds of the assessors. Not only do the assessors need requisite skills and training, but they also need to possess personal qualities to be successful assessors. This presents a human factors consideration in addressing the original human and organizational factors problem. Without realizing this, we could again try to apply a technical "fix" where a more encompassing one is needed. Therefore, during the course of this study, emphasis was shifted from devoting significant effort to instrument development and programming to protocol development, specifically assessor selection and training.

Analysis of the field test data showed that the ISM-SMAS can produce consistent results. Again, the selection and training of assessors is of paramount importance here. Properly selected and trained, assessors can determine with some confidence the overall status of a ship's safety management system using the ISM-SMAS instrument. A good evaluation of a vessel's safety management system can be obtained in a relatively short period of time (i.e. about eight hours).

As noted earlier, the comments provided by the assessment teams proved most beneficial to developing scenarios and assessing the safety management system.

In fact, the comments became a means of interpreting the scoring data once the assessment was completed. Therefore, the comments should be highlighted and given special importance.

Following completion of the study, a link has been developed between the results from the index – grading based SMAS protocol and instrument and a quantitative probability based instrument and protocol identified as SYRAS (System Risk Assessment Software) (Bea 2000). The SMAS to SYRAS link allows SMAS to be used to help evaluate the human and organizational aspects that are not easily characterized and assessed with quantitative methods (e.g. organic and non-mechanical aspects) and then apply these evaluations in modifications of normal rates of failures or malfunctions required in quantitative probability based analyses. (Bea 2000) Research is underway to further develop this link for design, construction, operation, and maintenance activities.

RECOMMENDATIONS

There are several areas where improvements can be made or questions to be answered to make the ISM-SMAS instrument and protocol that much more effective in future applications. These include:

Team composition is essential to the successful outcome of the SMAS assessment. The teams that were particularly effective had complementary skills and chemistry. Teams are more than just groups bound together in a common effort. It is difficult to identify why some teams excelled while others strained. Study into the area of team composition and assessment success would prove useful.

Even though the eight hours allotted to conduct the ISM-SMAS is substantially less than the period necessary for the SMAS for marine terminals and offshore platforms (Hee et al. 1998), some assessors felt this amount of time was excessive. Considering the duration of like assessments in similar industries, this amount of time appears about correct. However, once the ISM-SMAS has matured and its process becomes routine, it might prove useful to study the effects of varying the duration. The eight-hour period was not selected based on any scientific reasoning; it was selected in an attempt to facilitate commerce and may not be optimal.

Scenarios, as defined before, are synoptic events designed to simulate potential undesirable outcomes such as oil spills or collisions. Scenarios continue to be useful tools in addressing weaknesses or perceived shortcomings. Often, similar scenarios were used to address very different factors of concern. Therefore, as the ISM-SMAS continues through its growth and development and into maturity, a library of successful (as well as unsuccessful) scenarios will prove useful for future scenario development.

There was a consensus among the assessors that evaluating 143 attributes was time-consuming and occasionally tedious. Although not used at this stage of the development, a form of prioritization is probably in order. In previous studies, the Q-Sort method[3] was used to effectively reduce the number of attributes. Another approach may be to have multiple tiers of evaluation so that when the system is suspected of being weak, additional measures can be used to evaluate it.

Factors of concern are an arbitrarily assigned threshold. It is used to identify weak points and in turn develop scenarios that target those areas. Generally, a score of ‘4’ indicates compliance with the appropriate standards or “meets requirements.” This value of factor of concern was chosen for the purpose of being consistent with previous studies. Other values or more refined assignments may be useful in meeting the goals of a particular assessment.

SMAS can be tailored to a great many systems: e.g. helicopter transportation, manual underwater welding operations, and design of marine systems. The approach is robust and versatile. It can be applied to a number of other safety-quality critical operations to assess the health of the particular system. However, the majority of the conversion effort should not be in instrument detailing, but rather in the area of assessor selection and training.

ACKNOWLEDGEMENTS

The authors are extremely grateful to the U. S. Coast Guard for providing financial and personnel support to perform this project, and to those people and organizations that gave their time and volunteered their assets for the purposes of this study. Additionally, the authors are thankful for all those who helped in the research of this complex issue, particularly those whose extensive experience provided a reality check so that the ISM-SMAS could be a practical means of improving safety.

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