



GUIDANCE NOTES ON

SAFETY CULTURE AND LEADING INDICATORS OF SAFETY

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Foreword

The mission of ABS is to serve the public interest, as well as the needs of its clients, by promoting the security of life, property, and the natural environment.

The importance of the development of a positive safety culture has been recognized for some time, particularly in large-scale systems where the consequences of losses can be severe.

In safety-critical systems, the use of leading indicators has been proposed to identify areas of weakness in advance of adverse events, affording the possibility of taking action to avoid losses. This is in contrast to lagging indicators, such as numbers of accidents or incidents, which give indications of past performance.

Based on work with ABS clients, these Guidance Notes provide guidance on the self-assessment of a marine organization's Safety Culture, and the development of a Leading Indicators Program.

These Guidance Notes are applicable to all cargo-carrying commercial vessels. Guidance is provided in the form of questionnaires, datasheets, techniques of analysis, and worked examples.

These Guidance Notes become effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of these Guidance Notes is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

GUIDANCE NOTES ON SAFETY CULTURE AND LEADING INDICATORS OF SAFETY

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CHAPTER 1 Introduction

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CHAPTER 1 Introduction

SECTION 1 General

1 Purpose

This document has been developed with the objective of improving safety performance in the management and operation of cargo-carrying commercial vessels. ABS provides this guidance in recognition of the beneficial effect that a positive safety culture can have on safety performance, and the part played by leading indicators in guiding action to improve safety performance. This document provides:

- i) Guidance to maritime organizations on the survey and assessment of their organizational safety culture, both onshore and at sea.
- ii) A process for identifying an organization's leading indicators of safety performance. Leading indicators are safety metrics associated with safety performance. Tracking and improving these metrics may help to maintain and improve safety performance.

The results from the survey, and/or any leading indicators, can be incorporated into the organization's ongoing continual improvement program.

2 Background

2.1 Safety Performance

The goal of the International Safety Management (ISM) Code, and of Safety Management Systems (SMSs) is the attainment of peak safety performance (i.e., no operational incidents, no personal injuries, and no harm to the environment), but the maritime industry is still some way from achieving this goal. Tools such as the ISM Code and SMSs undoubtedly aid compliance with regulation, but they do not necessarily improve safety culture.

There is a general recognition in the industry that encouraging safe working practices does not require more rules, regulations, and procedures. Instead, the industry needs a better understanding of the social and organizational factors that foster professionalism in the seafarer in routine and emergency situations.

2.2 Safety Culture

Original attempts to improve workplace safety, or to minimize risks, focused on the technical and engineering aspects of a system. The focus widened as the role of human error became clear and broadened even further with the publication of the report into the Chernobyl disaster (UNSCEAR, 1988). This report identified the absence of a safety culture as the major contributor to the disaster, and defined safety culture as "That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, [nuclear plant] safety issues receive the attention warranted by their significance".

Subsequent reports into other major disasters produced similar findings. They too recognized the impact of safety culture on the outcome of safety performance, noting that most operational incidents are not solely the result of human error, technical failures, or environmental factors. Often there are more systemic organizational or managerial flaws (e.g., a fatal combination of failure of management, employees not performing their duties, and a breakdown in documented systems).

In all hazardous industries, it is now accepted good practice to have in place an SMS and to institutionalize safe working practices and attitudes through the development of a positive safety culture. There is a close relationship between an organization's safety culture and an SMS. An effective SMS has to take into account all factors that impact safety including the human and organizational; and conversely, the safety culture influences the way in which the SMS is implemented. Consequently, the assessment of safety culture and the SMS are complementary.

2.3 Lagging Indicators of Safety

Safety performance has traditionally been measured by 'after the loss' type of measurements such as accident and injury rates, incidents, and dollar costs. Lagging indicators characteristically:

- Identify trends in past performance
- Assess outcomes and occurrences
- Have a long history of use, and so are an accepted standard
- Are easy to calculate

In the aftermath of catastrophes, it is common to find prior indicators, missed signals, and dismissed alerts which, if they have been appropriately managed at the time, may have averted the disaster.

2.4 Leading Indicators of Safety

Over the past couple of decades, improved safety performance has been associated with a number of measurable activities in various industries, opening up the possibility that some of these metrics may be leading indicators for safety performance. Examples of metrics for these activities are size of safety budget, safety audit scores, number of safety inspections, number of safety meetings involving management, etc.

Leading indicators are safety culture metrics that are associated with, and precede, an undesirable/unexpected consequence such as an operational incident, near miss or personal injury. They can:

- Reveal areas of weakness in advance of adverse events
- Be associated with proactive activities that identify hazards
- Aid risk assessment and management

Leading Indicators are the most important safety culture metrics for the organization as they correlate with the organization's safety performance. ABS has developed a method for identifying potential leading indicators for improving safety performance.

2.5 Key Performance Indicators

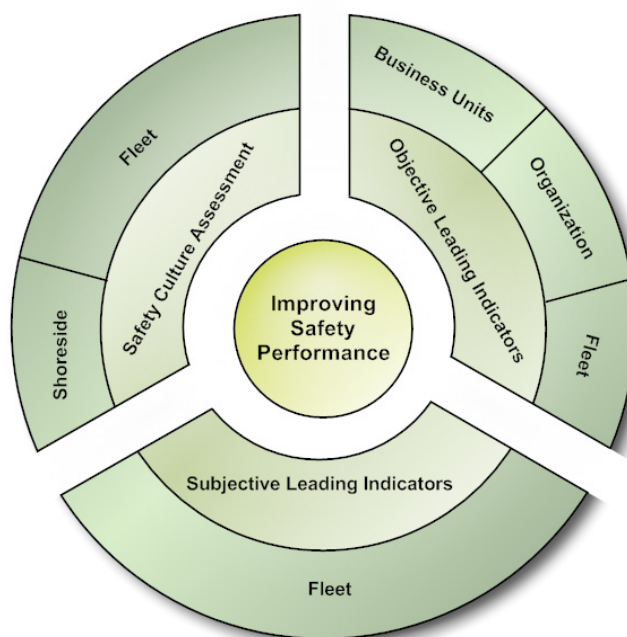
Leading indicators are frequently confused with key performance indicators (KPIs). KPIs are strongly associated with organizational peak performance which may, or may not, be safety-related. Examples of KPIs are: budgetary control per vessel, dry-docking planning performance, and vessel availability (Sleire, 1982). KPIs may be leading or lagging indicators. In contrast, leading indicators are always associated with safety.

3 The ABS Safety Culture and Leading Indicators Model

The central premise of the ABS Model, shown in 1-1/Figure 1, "The ABS Safety Culture and Leading Indicators Model", is that improvements in organizational safety culture can lead to enhanced safety performance. The first step is an assessment of the existing safety culture to identify areas of strength, weaknesses of defenses, and opportunities for improvement against operational incidents, personal injuries, etc.

This can be done using the ABS safety culture questionnaires supplied in these Guidance Notes in Appendices 1 and 2. Details of how to administer the survey and conduct the analysis are supplied in Chapter 2. The findings may reveal strengths which can be built upon, and any weaknesses that need rectifying. Chapter 4, Section 3 provides suggestions for utilizing the results in the organization's continual improvement program.

FIGURE 1
The ABS Safety Culture and Leading Indicators Model



The ABS Model also incorporates a process for identifying an organization's potential leading indicators of safety. There are two ways of conducting this process:

- i) By the identification of *objective* leading indicators. This is done by correlating safety culture metrics with safety performance data. This is the preferred approach because of its objectivity; because it utilizes metrics that the organization has collected; and it does not require a survey of the workforce, which can be time-consuming. This can be done at three levels:
 - At the Organizational level
 - Across Business Units
 - Across the Fleet
- ii) By the identification of *subjective* leading indicators from a safety culture survey. These indicators are based on the values, attitudes, and observations of employees. This method may identify potentially beneficial safety culture metrics not yet tracked by the organization. This approach may be used when the organization lacks sufficient metrics to use the *objective* leading indicators process.

There are a number of criteria for undertaking a Leading Indicators Program, and for each type of assessment. For example, to undertake the organizational level analysis, the organization must have been collecting safety metrics for at least five years. The criteria are discussed fully in the appropriate sections.

4 Scope of the Guidance Notes

The focus of these Guidance Notes is on the self-assessment of an organization's safety culture and the identification of that organization's potential leading indicators of safety (i.e., a set of safety metrics that are correlated with safety performance in that organization.) Guidance is also provided on utilizing the findings as part of an organization's ongoing continual improvement program.

5 Contents of the Guidance Notes

These Guidance Notes are organized as follows:

Chapter 2: Safety Culture

- *Section 1 Safety Factors* defines the safety factors (aspects of safety culture) such as communication and mutual trust, used in the assessment of safety culture in the ABS survey.
- *Section 2 Administering the Survey* outlines the planning and preparation to be undertaken.
- *Section 3 Analyzing the Responses* describes the data analysis to be done, with a worked example.

Chapter 3: Leading Indicators of Safety

- *Section 1 The Leading Indicators Program* provides background information about leading indicator of safety assessments.
- *Section 2 Safety Metrics* describes and categorizes the metrics used in the Leading Indicators Program.
- *Section 3 Safety Performance Data* describes and categorizes the safety performance data used in the Leading Indicators Program.
- *Section 4 Identifying Objective Leading Indicators*, presents the data analysis (correlation of safety metrics with safety performance data), with worked examples.
- *Section 5 Identifying Subjective Leading Indicators*, presents the data analysis (correlation of survey results with safety performance data), with a worked example.

Chapter 4: Next Step

- *Section 1 Interpreting the Results* discusses how to interpret the results obtained from the safety culture survey and from the leading indicators exercises.
- *Section 2 Presenting the Findings* presents basic information about presentation formats.
- *Section 3 Utilizing the Findings* provides guidance on interpreting the results and including them in a continual improvement program.

Appendices

- *Appendix 1* Presents the shipboard safety culture questionnaire.
- *Appendix 2* Presents the shoreside safety culture questionnaire.
- *Appendix 3* Presents the questionnaires categorized by safety factors, and the questions per safety factor.
- *Appendix 4* Presents the safety performance datasheets used the in Leading Indicators assessments.
- *Appendix 5* Provides summary guidance on how to distribute the safety culture survey electronically.

6 Definitions

These definitions were used in the development and piloting of the safety culture survey and Leading Indicators Program described in these Guidance Notes.

Accidents: Undesired events that result in personal injury.

Conditions of Class: The number of deficiencies identified, or recommendations made, by the classification society's surveyor on a vessel.

Conditions of Class (Frequencies): The total number of conditions of class multiplied by 100, divided by the number of port calls of that vessel in the last year.

Data Sub-Setting: The reduction of large datasets to subsets that are more manageable and/or contain only the data that an analyst needs to perform a particular analysis.

First Aid Case (FAC): Minor work-related injuries only requiring simple first aid treatment.

First Aid Case Frequency (FACF): The total first aid injury cases multiplied by 1 million, divided by the number of exposure (working) hours in the last year.

Kruskal-Wallis Test: This is an extension of the Mann–Whitney U Test to three or more groups. It is used as an alternative to one-way analysis of variance when the data is not normally distributed.

Lagging Indicators: Measures of a system taken after events to assess outcomes and occurrences, such as accident and injury rates, operational incidents, and dollar costs.

Leading Indicators: The National Academy of Engineering defines leading indicators as conditions, events, and sequences that precede and lead up to accidents (NAE, 2004). In essence, leading indicators are defined as conditions, events or measures that precede an undesirable event, and have some value in predicting the arrival of the event, whether it is an accident, incident, near miss, or undesirable safety state (Toellner, 2001).

Likert: The most widely used scale in survey research. Respondents indicate their level of agreement with a statement, usually on a five-point scale.

Lost Time Incident of 24 Hours or More (LTI $\geq$ 24 hrs): Any work-related injury other than a fatal injury that results in a person being unfit for work for a period of 24 continuous hours immediately after the occurrence of the incident.

Lost Time Incident Frequency (LTIF): The total Lost Time Incidents multiplied by 1 million, divided by the number of exposure (working) hours in the last year.

Mann-Whitney U Test: This is a non-parametric test to determine whether two samples of data could have come from the same population. The Mann-Whitney U test determines the number of times a score from one of the samples is ranked higher than a score from the other sample.

Medical Treatment Case (MTC): Work-related injuries that are not severe enough to be reported as fatalities, Lost Time Incident, or Restricted Work Accident cases but are more severe than requiring simple first aid treatment; however the injured person is able to carry out all his duties after treatment.

Medical Treatment Case Frequency (MTCF): The total medical treatment cases multiplied by 1 million, divided by the number of exposure (working) hours in the last year.

Metrics: A set of measurements that quantify or qualify aspects of a system (here, organizational safety performance).

Near Miss (NM): An event, or a chain of events, that under slightly different circumstances could have resulted in an accident, injury, damage, or loss of personnel, equipment, or the vessel.

Near Miss Frequency (NMF): The total number of near miss cases multiplied by 1 million, divided by the number of exposure (working) hours in the last year.

Non-parametric Test: A non-parametric statistical test that does not require scores on the outcome variable to be normally distributed.

Operational Incidents: Events that include steering failures, propulsion failures, navigational equipment failures, collisions, groundings, or other navigational or equipment failures.

Operational Incidents (Frequency): The total number of operational incidents multiplied by 100, divided by the number of port calls in the last year.

Port State Deficiencies: The number of deficiencies on a vessel identified by Port State Control.

Port State Deficiencies (Frequency): The total number of port state deficiencies multiplied by 100, divided by the number of port calls of that vessel in the last year.

Principal Components Analysis (PCA): A statistical technique used to reduce the number of variables to a subset that retains most of the substantive information in the original set.

Restricted Work Accident (RWA): Any work-related injury (other than a fatality or lost time incident) that results in a person being unfit to perform all of his/her regular job after the accident.

Restricted Work Accident Frequency (RWAf): The total restricted work accident cases multiplied by 1 million, divided by the number of exposure (working) hours in the last year.

Safety Culture: 1. That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, [nuclear plant] safety issues receive the attention warranted by their significance. (UNSCEAR, 1988). 2. The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management. (ACSNI, 1991).

Safety Climate: A snapshot of the organization taken at a certain point in time, usually obtained by a safety culture survey. Safety climate sometimes refers to local (group) subculture.

Spearman Rank Correlation: The Spearman's rank correlation coefficient, or Spearman's rho, is designed to measure the relationship between two ordered sets of ranks. It is similar to Pearson's Correlation, except Pearson's uses values instead of ranks.

Total Recordable Cases (TRC): The sum of all work-related fatalities, lost time incidents, restricted work accidents and medical treatment cases. $TRCs = LTIs + RWAs + MTCs$.

Total Recordable Case Frequency (TRCF): The total recordable cases multiplied by 1 million, divided by the number of exposure (working) hours in the last year.

Within Groups Analysis: An analysis of a subset of the study participants. For example, an analysis of the differences in job position of one nationality.

CHAPTER 2 Safety Culture

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CHAPTER 2 Safety Culture

SECTION 1 Safety Factors

1 Introduction

Safety factors are important dimensions of a safety culture, such as effective communications or safety awareness. There is no agreed way to segment safety culture and so no definitive set of safety factors exists. Many sets have been developed; all unique in some way, but broadly similar. Examples include: Ryan (1991); The International Civil Aviation Organization (1993); Dufort & Infante-Rivard, (1998); Zimolong & Elke, (2006).

The set of eight safety factors used in the ABS Safety Culture Survey and the Leading Indicators Program described in these Guidance Notes was derived during ABS-funded research conducted with leading clients in the maritime industry.

The ABS safety culture questionnaire contains forty statements; five statements about each safety factor which participants are asked to rate. The responses are analyzed for differences (or agreement) by job position, age, length of service, shoreside staff versus shipboard crews, etc. Suggestions for improving aspects of safety culture (safety factors) are presented in Chapter 4, Section 3, “Utilizing the Findings”.

2 Safety Factor Descriptions

The different safety factors used in ABS’ research are listed below along with descriptions of the intent of each safety factor.

2.1 Communication

Communications are open and effective: Healthy communication channels exist vertically and horizontally within the organization. Managers and masters are prepared to listen as well as speak. Everyone has, and understands, all the information required for safe operations. Communication channels are monitored for their effectiveness.

2.2 Empowerment

Individuals feel empowered to successfully fulfill their safety responsibilities: The organization provides clear delegation of, and accountability for, safety-related responsibilities. Each member of the workforce is provided the authority and resources to allow success in his/her assigned roles. Each member of the workforce accepts and fulfills his/her individual safety responsibilities. Management expects and encourages the sharing of safety concerns by everyone in the organization.

2.3 Feedback

Management responses to safety issues and concerns are timely: Priority is placed on the timely communication of, and response to, outcomes of incident investigations, audits etc., to the workforce. Mismatches between practices and procedures (or standards) are resolved in a timely manner to prevent normalization of deviance. The workforce is encouraged to raise safety concerns, which are resolved in a timely manner.

2.4 Mutual Trust

Relationships are characterized by mutual trust: Members of the workforce trust managers to “do the right thing” in support of safety, and are expected to shoulder their share of responsibility for performance, and to report potential problems and concerns. Employees trust the motivations and behaviors of peers. There is confidence that a just system exists where honest errors can be reported without fear of reprisals.

2.5 Problem Identification

Potential problems are readily identified: Each member of the workforce has experience, and/or training, in how to recognize unsafe acts and conditions, and how to take steps to avoid or mitigate them.

2.6 Promotion of Safety

Managers promote safety as a core value: Managers lead in promoting safety as a core value in the organization. Visible, active, and consistent support for safety programs and objectives exists at all levels of management within the organization. Managers are seen to be committed to doing what is right, demonstrating their values through their communications, actions, priorities, and provision of resources. This value cascades down through all levels of the organization.

2.7 Responsiveness

Crew members are responsive to the demands of the job, including unexpected events and emergencies: Crew members are encouraged to get adequate rest between shifts to maximize their alertness and readiness to respond during their work periods. All crew members are provided with emergency preparedness training and full personal protection equipment (PPE).

2.8 Safety Awareness

A strong sense of safety awareness pervades the organization: Each member of the workforce has an awareness of his/her responsibilities with regard to safety to self, co-workers, the organization, and to the environment. All employees feel accountable for their own actions, and collectively for the actions of their colleagues/crew. There is a strong individual and group intolerance for violations of established safety performance norms.

3 Safety Factor Codes

The codes for each safety factor are shown in 2-1/Table 1, “Safety Factors and Their Codes”.

TABLE 1
Safety Factors and Their Codes

<i>Safety Factor</i>	<i>Codes</i>
Communication	COM
Empowerment	EMP
Feedback	FDB
Mutual Trust	MTR
Problem identification	PID
Promotion of safety	POS
Responsiveness	RSP
Safety awareness	SAW

In Appendix 3, “Questionnaires and Safety Factors”, the statements are presented with their corresponding safety factor codes; and shown in their safety factor groupings.

CHAPTER 2 Safety Culture

SECTION 2 Administering the Survey

1 Introduction

This Section of these Guidance Notes details the planning and preparation required for successful administration of the safety culture survey to crew on board vessels, and to employees who are shoreside.

2 Planning

These are the issues that should be considered during the decision-making process of determining whether or not to proceed with a safety culture survey.

2.1 Costs and Benefits

Undertaking a survey can be costly, so the costs and benefits should be carefully appraised before proceeding.

2.1.1 Costs

This is a labor-intensive exercise, which requires a particular skill-set, including:

- Good organizational and administrative skills to supervise the process
- Purchase of software tools and statistics packages (if required)
- Knowledge of social science statistics, especially the Mann-Whitney U Test
- Experience of using statistics packages and/or spreadsheets
- Cost of employees' time completing the survey

2.1.2 Benefits

- The identification of areas of excellence
- The identification of areas where there are opportunities for improvement
- Foundation for a program to address areas where there are opportunities for improvement
- Public demonstration of management commitment to safety

2.2 Distribution Issues

Once the decision has been made to carry out a survey, the distribution format needs to be determined. The choices are paper-based, electronic, or a mixture of both (e.g., a web-based electronic distribution for shoreside staff and paper-based for vessels). Appendix 5, "Electronic Distribution" discusses the issues of electronic distribution. The considerations for paper-based distribution include:

- Decide when to run the survey. It is inadvisable to launch a safety culture survey when the organization is in a state of flux (e.g., during company acquisitions or mergers, as the culture will be affected), or in the aftermath of fatalities or serious injuries. The survey should be allowed to run for at least four weeks.
- Determine who will be taking the survey, and which ships and offices to include. The Shoreside Safety Culture Questionnaire should be answered by staff who work on the Operations Desks, or in the Fleet Management Department, or who are knowledgeable about fleet management.

- iii) Determine the purpose of the survey. Aim to include as many employees as possible, including crew on shore-leave. However, note that where the survey responses are used for a Subjective Leading Indicators Program, only crew responses from vessels are used. Responses from crew on shore-leave, and shoreside employees are NOT included as the correlations for leading indicators are done by the vessel, not by individuals.
- iv) Estimate the number of copies required; and where and when they are to be printed.
- v) Decide who is to be responsible for the distribution.
- vi) Determine how the questionnaires will be distributed to the ships and offices, and how they will be collected.
- vii) Consider confidentiality issues such as the provision of envelopes for sealed responses, and who will have access to the responses, etc.

3 Preparation

Once a decision has been made to proceed, detailed preparations are required to facilitate a smooth process.

3.1 Prepare Employees

- i) Employees should be given at least four weeks' advance notice of the safety culture survey and encouraged to participate. This applies to crew on board vessels as well as shoreside.
- ii) Ideally, the announcement should come from senior management, and the importance of participation should be reinforced via other communications. For example, place an interview with senior management in the company newsletter.
- iii) It is important that the masters understand the importance of the survey, as it will be their responsibility to announce, explain, and encourage participation in the survey.
- iv) The workforce should be told that the reason for the survey is to find out where the organization should focus on making improvements to its safety culture.
- v) Let the workforce know that the survey can be completed in fifteen minutes.
- vi) Let the workforce know what to expect (e.g., that it covers safety culture on board vessels, health and safety, and job characteristics, plus some demographic questions necessary for conducting the analysis).
- vii) Employees should be told that participation in the survey is voluntary and it will be undertaken during working time at the organization's expense.
- viii) Let employees know that their replies are anonymous and treated confidentially.

3.2 Prepare the Questionnaires

The survey is undertaken using the questionnaires shown in Appendix 1, "Shipboard Safety Culture Questionnaire" and Appendix 2, "Shoreside Safety Culture Questionnaire".

- i) Determine that the terminology in the questionnaires is familiar to the workforce. The definitions of terms used in the questionnaires are provided in Section 1, "Introduction". It may be beneficial to provide definitions and examples with the questionnaire to prevent any misunderstanding.
- ii) Provide a list of departments, job positions etc. to standardize choice.
- iii) Each ship will need a unique identifier for Section D Question 6 (Shipboard Safety Culture Questionnaire). This could be ship name or ship email address.
- iv) Crew who are on shore leave should be told to answer Section D Question 6 with "SL" indicating they are currently ashore.
- v) Print sufficient numbers of copies of each questionnaire.

- vi) Prepare a covering letter for the survey. This letter should include instructions such as the need to answer ALL questions; direction to choose the “Don’t Know” response where a question is unclear or inapplicable, and the end date for the survey. Emphasize that the questionnaire can be answered in fifteen minutes.
- vii) Provide a large self-sealing envelope for the return of each questionnaire.

3.3 Distribute the Questionnaires

- i) Include the covering letter with the instructions.
- ii) There are two questionnaires in the survey, which are complementary. The questions cover the same ground but are framed differently. The questionnaires are shown in Appendix 1, “Shipboard Safety Culture Questionnaire” and Appendix 2, “Shoreside Safety Culture Questionnaire”.
- iii) Allow one month for responses.
- iv) Ten days before the end of the survey, send a reminder.
- v) Be prepared to extend the deadline, if more time is needed.

3.4 Collect Completed Questionnaires

- i) Somebody in each office should be given responsibility for the collection of the sealed envelopes shoreside and for sending them to the analyst.
- ii) Provide clear instructions to the ships as to where to send the responses.

CHAPTER 2 Safety Culture

SECTION 3 Analyzing the Responses

1 Introduction

This Section describes the analysis methodology step-by-step. Worked examples are included to aid understanding of principles but it is recommended that a statistics package, or other computer support, is utilized as undertaking statistics by hand can be very laborious.

2 Analyses

There are two questionnaires, one for the shoreside staff and one for crew members. Each questionnaire contains forty statements that are identical, or equivalent. Respondents indicate their level of agreement to a statement on a five-point scale, known as a Likert scale.

2.1 Demographic Analysis

This analysis is performed to determine any difference in responses on the basis of:

- Age
- Gender
- Nationality
- Job position
- Experience with this organization
- Experience in the maritime industry
- Experience in your current position

2.2 Shipboard versus Shoreside Analysis

This analysis is performed to determine any perceived safety culture difference (i.e., difference in responses to the forty Likert statements) between crew on vessels and shoreside staff.

2.3 Within Groups Analysis

This analysis is performed to determine any difference in responses within each demographic group identified in 2-3/2.1, “Demographic Analysis”. For example, statistical analysis may indicate safety culture differences between crewmembers based on nationality. However, further analysis may need to be performed to determine if this difference is a function of nationality per se or some other factor such as job position. Within group analyses include:

- Job position within nationality
- Job position within experience level
- Job position within age group
- Job position within gender
- Nationality within experience level

- Nationality within age group
- Nationality within gender
- Age group within experience level
- Age group within gender
- Gender within experience level

2.4 Qualitative Analysis of the Free Text Questions

The questionnaires conclude with four questions asking for suggestions to improve safety culture. As the responses are free text, statistical analysis cannot be done. The responses should be carefully collated in terms of recurring themes, good ideas, etc. These findings should be presented to senior management together with the main findings from the statistical analysis.

3 Preparation

The following list contains actions which should be included in preparation for data analysis.

- i) After receiving raw data, develop a plan to format data based on spreadsheet (or statistical package) requirements for analyses.
- ii) Import the response data into spreadsheet software.
- iii) Keep original raw dataset intact and use a copy for sanitization, (i.e., removing any identifying information).
- iv) Sanitize the copy to remove any reference to vessel name, office, and individual employee or crew member.
- v) Keep sanitized dataset intact, and use another copy for analysis.
- vi) Have as few analysts as possible handling the data to reduce error and promote consistent methods and analyses.
- vii) Keep number of dataset files to a minimum, use proper and standardized folder/file names, and have dates on all files.
- viii) Assign one individual to keep all files ('central storage').
- ix) Do not assign one analysis to more than one individual.

4 Statistical Testing

4.1 Outline of Method

A Mann-Whitney U Test is performed for *each* comparison of the demographic factors: age, gender, nationality, job position, and length of time in the organization, in the maritime industry, in the current job, and two groups of workers (shipboard and shoreside). An extension of the Mann-Whitney U Test, called a Kruskal-Wallis Test, can be used for the Within Groups Analysis.

The example described here is for two groups of workers (shipboard and shoreside) and the sixth Likert statement. The steps are repeated for each of the remaining thirty-nine Likert statements. When all responses to the forty Likert statements have been analyzed in terms of shipboard and shoreside workers, the responses to the Likert statements are analyzed in terms of another demographic factor (e.g., nationality).

- i) Establish the hypothesis for the test. The null hypothesis is that there is no difference in shipboard and shoreside response to the statement: "This company has excellent maintenance standards".
- ii) Subset the data in spreadsheet or statistical package of choice. Data sub-setting reduces large datasets to subsets that are more manageable or contain only the set of data that an analyst needs to perform a particular analysis.

- iii) Assign indicator variable (e.g., ‘1’ for shipboard and ‘2’ for shoreside).
- iv) Perform Mann-Whitney U Test (see 2-3/4.2).
- v) Find the average of the responses to show which group (shipboard or shoreside) answered more positively or more negatively.
- vi) Create graphs and output in spreadsheet or statistical package of choice. See Chapter 4, Section 2 “Presenting the Findings”.
- vii) Treat missing data as a “don’t know” response providing this occurs in <5% of the responses. If it occurs in >5% of the responses, exclude this data from the analysis.

4.2 The Mann Whitney U Test

2-3/Table 1, “The Mann Whitney U Test” presents the instructions for running the Mann Whitney U Test where the sample size > 20. A different formula is used for smaller sample sizes – not included here because the sample size (number of people surveyed) will be more than twenty.

TABLE 1
The Mann Whitney U Test

Step	Instructions
1	Assign an unique identifier to the data from each sample, (e.g., use color coding, different fonts, or place identifiers in the adjacent columns).
2	Combine the scores for the two sets of data and sort in ascending order.
3	Assign a rank to each score (i.e., assign “1” to lowest score; “2” to the next lowest score, and so on).
4	Average those ranks that appear more than once. For example, if two scores are equal and would have been ranked in first and second place, the two positions are added together (1 + 2 = 3) and divided by the number of scores (2) to give a ranking of “1.5” for both scores.
5	Sum the average ranks of the smaller sample. If the samples are different sized, assign the indicator n_1 to the smaller sample and n_2 to the larger sample. If they are the same size, it does not matter how they are identified.
6	The Mann-Whitney U statistic is calculated by the following formula, where n_1 represents the smaller sample and n_2 the larger sample: $U = (n_1 \times n_2) + \frac{n_1 \times (n_1 + 1)}{2} - \text{summed rank of } n_1$
7	Calculate the U value for the second sample using the following formula: $U \text{ of second sample} = (n_1 \times n_2) - U \text{ for first sample}$ Note that the two U values combined equal the product of the number of cases in the two samples.

TABLE 1 (continued)
The Mann Whitney U Test

Step	Instructions
8	Use this step when samples sizes are large and there are no ties ($n_1 > 20$ or $n_2 > 20$). U approaches a normal distribution, so the U value can be transformed into a Z value by using the following formula: $Z = \frac{U - (n_1 \times n_2) / 2}{\sqrt{[(n_1 \times n_2)(n_1 + n_2 + 1)] / 12}}$ Where U is the smaller of the two values.
9	Use this step when there are many ties of ranks in the two samples. Z should include the correction factor: $\sum T = \sum \frac{t_i^3 - t_i}{12}$ where t is the number of scores for a given rank. If, for example, there are two scores of rank 4, three scores of rank 2, and four scores of rank 1, then $t_i = 2, 3$, and 4. This correction factor is incorporated into the equation for the Z transformation. $Z = \frac{U - \frac{n_1 \times n_2}{2}}{\sqrt{\left(\frac{n_1 \times n_2}{(n_1 + n_2)^2 - (n_1 + n_2)} \right) \left(\frac{(n_1 + n_2)^3 - (n_1 + n_2)}{12} - \sum T \right)}}$ The correction factor raises the value of Z by a small amount, which may be important when the sample statistic is near a critical value.
10	Because the test statistic U is the smaller U of the two samples, the null hypothesis is rejected when the specific value of z is smaller than the critical value in the left tail of the Z distribution ($< -z_{\alpha}$ for a one-tailed test or $z^* < -z_{\alpha/2}$ or $z^* > -z_{\alpha/2}$ for a two tailed test) where z^* stands for the calculated value and z_{α} is the tabulated value. Normal distribution table can be used for comparison.

5 Worked Example

A safety culture survey is undertaken in a marine organization. Two groups of workers (shipboard and shoreside) participate in this survey. Responses to the statement, “This company has excellent maintenance standards” are tabulated on a five-point Likert scale as:

<i>Disagree</i>	<i>Slightly Disagree</i>	<i>Neutral</i>	<i>Slightly Agree</i>	<i>Agree</i>	<i>Don't Know</i>
1	2	3	4	5	0

There are 21 responses from the ships and 6 responses from the shoreside:

<i>Shipboard</i>	<i>Shoreside</i>
5	3
3	2
3	4
4	1
2	5
1	4
2	
3	
5	
4	
5	
4	
3	
2	
3	
1	
5	
5	
3	
2	
4	

The objective is to test if there is a difference in the shoreside and shipboard responses (at a 95% confidence level) that cannot be attributed to chance.

Steps 1, 2, 3: Rank the scores of both the samples together, using rank 1 for the lowest score, rank 2 for the next lowest score and so on.

Step 4: Average the ranks where the same value occurs more than once.

For example, in the table below, there are three scores of 1, corresponding to ranks 1, 2, and 3. The sum of 1, 2, and 3, is 6. Since there are three scores, divide 6 by 3, resulting in 2. Assign a new “averaged” score (for the purpose of statistical computation) of 2 to each of these (raw score = 1).

Similarly, for raw scores of 2, add the corresponding ranks (4 through 8) to get a sum of 30, divide this by 5 (since there are 5 scores of 2). Each raw score has a corresponding “averaged” score of 6.

<i>Raw Score</i>	<i>Rank</i>	<i>Averaged</i>
1	1	2
1	2	2
1	3	2
2	4	6
2	5	6
2	6	6
2	7	6
2	8	6
3	9	14
3	10	14
3	11	14
3	12	14
3	13	14
3	14	14
3	15	14
4	16	18.5
4	17	18.5
4	18	18.5
4	19	18.5
4	20	18.5
4	21	18.5
5	22	24.5
5	23	24.5
5	24	24.5
5	25	24.5
5	26	24.5
5	27	24.5

Step 5: Sum the ranks for the smaller sample (shoreside).

<i>Shoreside Scores</i>	<i>Averaged Ranks</i>
3	14
2	6
4	18.5
1	2
5	24.5
4	18.5
Sum of ranks = 83.5	

Step 6: The Mann-Whitney U statistic is calculated by the following formula where n_1 represents the smaller sample size and n_2 the larger sample size:

$$U = (n_1 \times n_2) + \frac{n_1 \times (n_1 + 1)}{2} - \text{summed rank of } n_1$$

For this example:

$$U = (6 \times 21) + \frac{6 \times (7)}{2} - 83.5$$

$$U = 63.5$$