Chapter 6

Human Factors

This chapter is intended as a general guide on the investigation of the human contribution to marine occurrences. An understanding of the predictable human capabilities and limitations and the application of this understanding to the investigation of occurrences can help to identify sources of safety deficiencies needing rectification, in order to prevent repetitive occurrences.

In keeping with the IMO Resolution A.849(20), Code for Casualty Investigation (1997), this chapter advocates a systems approach to the investigation. The use of a systems approach will ensure that the investigation of human factors is integrated within the investigation proper.

OBJECTIVE OF THE HUMAN FACTORS INVESTIGATION

The objectives of the investigation of human factors in occurrences are to advance marine safety by:

* Discovering how limitations in human performance could have caused or contributed to the occurrence.

* Identifying safety hazards conducive to human error or arising out of limitations in human performance.

* Making recommendations designed to eliminate or reduce the consequences of faulty actions or decisions made by any individual or groups involved in the occurrence.

SCOPE OF THE HUMAN FACTORS INVESTIGATION

The size and scope of the investigation of human factors will depend on the circumstances of the occurrence; it can involve one investigator who is also responsible for all other aspects of the investigation, or one or more investigators dedicated solely to the investigation of human factors. Whether the investigation is large or small, the investigator(s) assigned to the investigation of human factors should adopt a team approach, taking advantage of the expertise of human factor specialists and others, who, although not physically present at the site, are available for consultation.

The collection and analysis of human factors information should be as methodical and complete as any other traditional area of the investigation. The investigation should extend beyond the

examination of the actions of front-line operators such as masters, pilots, ship=s officers, ratings, and maintainers, etc. to include an analysis of any individual or group involved in the occurrence, be it management, the regulator, or the manufacturer.

In a complex, interactive and well-guarded transportation system such as the marine industry, accidents rarely originate from actions or non-actions of the front-line operators alone; accidents are a result of the combination of failures or deficiencies in organizational policy and procedures, human actions, and equipment (Cox and Tait, 1991). In almost every facet of an investigation, from management and supervisory decisions to maintenance activities and ship crew=s performance, one can identify human factors which may help to identify and explain the effects of the interaction of latent unsafe conditions on the occurrence event sequence. An investigation that focuses on only the front-line operators becomes a barrier to the identification of systemic safety hazards and the opportunity to eliminate or reduce the consequence of safety hazards.

The information contained in this chapter is based upon several human factors frameworks: SHEL (Hawkins, 1987) and Reason's (1990) Accident Causation and generic error-modelling system (GEMS) frameworks, as well as Rasmussen's Taxonomy of Error (1987). These frameworks are discussed in IMO Resolution A.849(20), Code for Casualty Investigation (1997). Additional references for all frameworks are cited in Appendix B.

GATHERING HUMAN FACTORS INFORMATION

The success of the investigation of human factors depends largely on the type and quality of the information collected. As no two occurrences are the same, the investigator will need to determine the type and quality of data to be collected and reviewed. As a rule, the investigator should be over-inclusive in gathering information initially and set aside superfluous data as the investigation unfolds.

SOURCES OF HUMAN FACTORS INFORMATION

Information relevant to an marine occurrence can be acquired from a variety of sources. Primary sources relating specifically to human factors include hardware evidence, paper documentation, voyage recorders, Marine Communications and Traffic Services recordings, interviews, direct observation of marine personnel activities and simulations. Secondary sources include marine occurrence data bases, reference literature and human factors/ergonomics professionals and those from associated disciplines such as psychologists, medical practitioners, and sociologists.

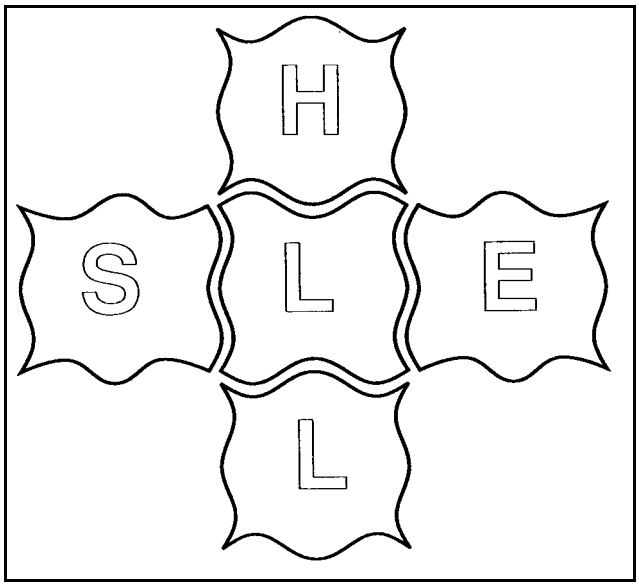
Some common primary sources of human factors information are presented in the body of this chapter.

DATA COLLECTION USING THE SHEL MODEL

The SHEL Model was originally developed by Edwards (1972) and modified by Hawkins (1984, 1987). It has been found to be a useful means of defining information requirements during an occurrence investigation. Once the information requirements are identified, the investigator can gather the facts from appropriate sources.

There are four components to the model:

Liveware - L
Hardware - H
Software - S
Environment - E



The SHEL Model is commonly depicted graphically (see Figure 6.1)[1] to display, not only the four components, but also the relationships, or interfaces, between the Liveware and all the other components. Figure 9.1 attempts to portray the fact that the match or mismatch of the interfaces is just as important as the characteristics of the blocks themselves. A mismatch can be a source of human error and identification of a mismatch may be the identification of a safety deficiency in the system.

Liveware (Central Component)

The most valuable and flexible component in the system is the human element, the Liveware, placed at the centre of the model. Each person brings his or her own capabilities and limitations, be they physical, physiological, psychological, or psychosocial. This component can be applied to any person involved with the operation or in support of the operation. The person under consideration interacts directly with each one of the four other elements. The person and each interaction, or interface, constitute potential areas of human performance investigation.

Liveware (Peripheral)

The peripheral Liveware refers to the system's human-human interactions, including such factors as management, supervision, crew interactions and communications.

Hardware

Hardware refers to the equipment part of a transportation system. It includes the design of workstations, displays, controls, seats, and all other physical parts of a vessel or system.

[1]From Hawkins, F.H. Human Factors in Flight. 1987.

Software

Software is the non-physical part of the system including organizational policies, procedures, manuals, checklist layout, charts, maps, advisories, and increasingly, computer programs.

Environment

Environment includes the internal and external climate, temperature, visibility, vibration, noise and other factors which constitute the conditions within which people are working. Sometimes the broad political and economic constraints under which the marine system operates are included in this element. The regulatory climate is a part of the environment in as much as its climate affects communications, decision making, control, and coordination.

DATA GATHERING GUIDELINES

The investigation of human factors attempts to determine what people did and why they did it. The investigator concentrates effort on the behaviour of the people involved. Key events or actions are highlighted, and often these key actions will be unsafe acts. It may be tempting to stop when these unsafe acts are identified, but safety is not well served by doing so. As noted by Chapanis (1965), when causes of accidents are attributed to carelessness, faulty attitude, inattention, or some other such label, little is achieved in preventing recurrence. Safety can be better served by explaining the behaviour behind the label.

To this end, the following guidelines are structured to help investigators determine whether a factor, such as attention, was an antecedent to an occurrence, by providing the possible effects of the factor on performance. Following the performance effects for each factor is a listing of the type of information to consider gathering during the data collection phase to corroborate the factor's existence and effect. Primary sources for this information are also provided. Some of the information to be considered for corroboration will be self-evident to the investigator; the relevance of other information may be found in standard texts (such as those found in the bibliography); still other information may require consultation with a human factors specialist to determine that information's significance on performance. It should be noted that the listing of factors for consideration is not definitive.

For ease of use, the guidelines are structured to reflect the components of the SHEL Model, beginning with the central component, the Liveware, followed by the SHEL interfaces.

The Liveware (Central Component)

This area is concerned with the physical, physiological, psychological, and psychosocial factors unique to the central component, the individual.

Liveware Physical Factors

This area deals with the physical capability of the individual to perform required actions and movements; physical limitations influence the ability to see, to act, to move, to reach, and to grab.

Consider such factors as age, sex, strength, weight, sitting height, reach, etc.

Information Sources

Information on physical factors may be obtained through medical records and interviews with the individual concerned, or in the event of a fatality through interviewing a personal physician, a spouse, or family members and/or through the post-mortem examination.

Liveware Physiological Factors

This area is concerned with the physiological condition of the individual, including stable and transitory states such as disease, fatigue, stress or other internal factors which could affect the individual's situational awareness and/or behaviour. Discussion of several physiological factors which can affect performance follows.

Nutritional Factors can potentially affect an individual's ability to respond to action, concentrate on a task, or resist fatigue.

Consider factors such as time since last meal, food intake in last 24 hours, recent weight loss, recent dietary habits, etc.

Health can have an effect on the individual's ability to perform. Health problems can lower performance, reduce motivation, lead to distraction.

Consider such factors as the effects of diseases, pains, dental conditions; pregnancy; obesity; recent blood donation, etc.

Stress can have an impact on health, resulting in sleep disorders, gastrointestinal problems, headaches etc.; on behaviour, causing restlessness, impulsive behaviour, etc.; on cognitive processes, making it more difficult to concentrate on a task, to perceive cues, to determine priorities, etc.; on feelings, making one anxious, aggressive, moody, etc.

Consider stressors such as environmental stressors, domestic stress, bereavement, financial and time commitments, work stress, relationships with colleagues and management, etc.

Information Sources

Information on nutrition, health and stress are normally obtained through medical records and interviews with a personal physician, a spouse, family members. Colleagues and supervisors may provide additional information.

Fatigue chronic or acute fatigue can have an impact on memory, consistency in performance, motivation, concentration, information processing and decision-making, cooperativeness,

communication skills, mood, reaction time, error rates, risk-taking, etc.

Consider such factors as time on duty, shift schedule, workload demands, time zone shifts, previous schedules, layover schedule, travel time to and from work, and other operational demands such as those found in pilotage or cargo loading and off-loading. Also consider time of rest, hours of rest, quality of rest, off-duty activities, stress, and sleep disorders.

Information Sources

Information about fatigue is normally obtained through a 72-hour history taken during interviews (The 72-hour period is the minimum recommended sleep history period and in some cases a longer period is preferable). If necessary, it can also be reconstructed through examination of personal logbooks, company duty rosters, examination of the sleep location, and interviews with anyone who may have come in contact with the individual in the last 72-hour period such as a spouse, family members, colleagues, and supervisors. Additional data may be obtained from hotel records of telephone calls and room key card entry/exit data.

Alcohol affects the ability to discriminate and perceive visual and auditory stimuli; it has an impact on memory, decision-making processes, judgement, coordination; it slows reaction times and increases risk-taking.

Consider such factors as time since last drink, alcohol consumption rate and amount, body weight, consumption of food, type of drink, blood/alcohol concentration, hangover effects, evidence of alcohol addiction; i.e., medical records, drinking and driving violations, etc. Consider also stress, fatigue, sleep and biological rhythm disturbance, and circadian effect.

Drugs can cause drowsiness and dizziness; they can affect mood and coordination; they can reduce mental functions and sensory perceptions.

Consider over-the-counter medication, prescriptions, illicit drugs, and other stimulants such as coffee, cigarettes, etc. Factors such as fatigue, stress, sleep and biological rhythm disturbance, circadian effect might be antecedent conditions to the use of drugs.

Partial Incapacitation can be hard to detect and can result in a wide-range of symptoms such as dizziness, loss of consciousness, decrease in judgement and decision-making processes.

Consider such factors as carbon monoxide or food poisoning, medical conditions, fumes, motion sickness, hypoglycaemia, fatigue, stress, sleep and biological rhythm disturbance or medication.

INFORMATION SOURCES

Factors related to alcohol, drugs and incapacitation can be investigated through interviews with a spouse, family members, neighbours, friends, colleagues, supervisors, and a family or personal physician. Additional information can be obtained from toxicological analysis, medical records, motor vehicle records, law enforcement records and, in the case of a fatality, the post-mortem examination and personal effects.

Sensory Limitations include visual, auditory, olfactory, kinaesthetic limitations.

Consider such factors as visual acuity requirements, focus time, light adaptation, depth perception and external cues, requirement for glasses or contact lenses; auditory threshold and range, etc.

INFORMATION SOURCES

Factors related to sensory limitations can be investigated through interviews with the individual, a spouse, family members, or a family or personal physician. Documentary information can be obtained from medical records and employer records.

Illusions occur when an individual's mental model differs from the real world. There are three sensory systems that contribute to the perception of orientation: the kinaesthetic sensors, vision, and the vestibular organs in the inner ear. Illusions of orientation can be brought on by misinterpretation of visual information, by limited peripheral vision, and by the sensitivity of the vestibular organs to linear and angular acceleration.

Consider such factors as expectancy and experience, anthropometric considerations, instrument monitoring and actions, environmental conditions at the time of the occurrence, geographical peculiarities of the location.

INFORMATION SOURCES

Factors related to illusions can be investigated through interviews with the individual and other crew members. Information relating to the environment can be obtained from sources such as weather reports and charts.

Liveware Psychological Factors

Maintaining an accurate mental model, that is, maintaining situational awareness, is paramount to ensuring safe voyage. Situational awareness develops on three different levels. First the person must perceive the situational elements from information displays, communication, or from viewing the scene; the person then integrates the information by using his/her experience and knowledge; finally, the person projects the information into the future to make and modify plans as tasks are completed or delayed and new developments arise (Endsley, 1994). The following factors directly influence the individual's ability to process information so that accurate situational awareness is maintained.

Information Processing The way in which humans process information can be represented by a series of stages wherein information is received, decisions are made, and responses are selected and executed. Failures can occur at any of the mental operations involved in information processing; as a result, situational awareness becomes faulty and errors are made. The stages and limitations of information processing are discussed below:

Sensing The sensory receptors (e.g., eyes, ears) detect physical stimuli in the form of sounds and shapes which is stored for a brief period of time. Should the stimuli not be sensed by the sensory receptors or should the information decay before it is processed, decisions and actions will be made and carried out without all the information.

Consider such factors as sensory system threshold and range, distractions, workload, expectation.

Perception involves converting the sensory information into meaningful messages. Delayed perceptions and inaccurate perception (mental picture) of a task to be performed can lead to slow or wrong reaction.
Consider such factors as clarity and accuracy of information received, expectation, experience, habit, workload, opportunity for visual and vestibular illusions.

Decision-making follows perception. Decision-making can be appropriate or inappropriate depending upon a number of factors such as the conclusions about the meaning of the message, the type and amount of information available to the individual, previous experience, group influences, etc.

Consider such factors as experience and expectation, training, distractions, workload, fatigue, stress, medication, motivation, operational pressures.

Action and Feedback are the stages in the information process where decisions are translated into responses (or non-responses) and mechanisms that provide the individual with feedback are activated. Responses are in the form of actions or words or both, or execution of automatic motor programs. Feedback can be direct as in the form of tactile feedback or it may be indirect as takes place in advanced bridge layouts where crew members must monitor instruments to obtain feedback of his/her actions.

Consider sources of error at this stage as those errors that originated earlier in the processing system, design-induced error, errors due to attention limitations, distractions, etc. or inadequate or inappropriate feedback.

Information Solicited

Failures related to information processing can be investigated through interviews with crew members and observation of individuals performing the involved task sequences. Examples of supporting documentary information are procedural manuals, voice recordings, human factors simulations and models.

Attention limitations of the central decision-maker restrict the number of stimuli humans are able to attend to. Normal limitations can be further exacerbated by such factors as the operating environment, causing the individual to omit, mistime, misorder, forget, repeat or commit the wrong action.

> Consider such factors as sources of interruptions and distractions, design-induced errors, previous experiences, ambiguous cues, delays between planning an action and executing that action, stress, fatigue, workload, etc.

Memory, both working and long term, can potentially limit the processing of information. Working memory is limited in how much information it can retain; information is maintained by a process of rehearsal. If it is not rehearsed, information will be lost in 10 to 20 seconds. Memory of events stored in long term memory is not static but is influenced by many factors, including what the individual expected should have happened. Automatic motor routines stored in long term memory can be carried out without conscious control. Errors can occur when the automatic motor routines are not monitored.

> Consider the number of unrelated items presented, whether the information, related or not, was chunked or clustered, whether the stimuli were verbal or visual, whether delays occurred, whether biases were induced as a result of long term memory, as well as such factors as previous experiences, training, distractions, etc.

Workload can limit the processing of information. Low workload levels can induce boredom, inattention, cause slow reaction time, and lead to poor monitoring; high workload can result in missing of important cues, stress/panic, incorrect prioritization of tasks, task shedding, etc.

> Consider such factors as task priorities, operating procedures, equipment design, phase of voyage, crew complement, distribution of duties, crew actions that might have increased or decreased the perceived workload, actions of others, stress, fatigue, etc.

Information Sources

Human related factors, memory and workload can be investigated through interviews with crew members and observation of individuals performing the involved task sequences. Examples of supporting documentary information are procedural manuals, voice recordings, and human factors simulations and modeling.

Attitudes of individuals toward their work, mission, others, and themselves can affect performance. Attitudes can influence quality of work, judgement, decision-making, motivation, risk taking, etc.

> Consider such factors as knowledge about the object of the attitude, strength of belief held about the attitude, and, if applicable, the behaviour displayed. Consider the influences of group, job demands, monetary gain, training,

previous experiences, etc.

Personality traits may predispose an individual to a certain response pattern in a given situation.

Consider such factors as risk assessment, risk taking, interactive styles of personnel, experience levels, training, etc.

INFORMATION SOURCES

Factors related to attitudes and personality traits can be investigated through interviews with individuals, their colleagues and their families. Documentary evidence relating to risk taking may be obtained through company records (e.g. infractions, accidents and incidents) and through external records such as motor vehicle and law enforcement records.

Experience/Recency includes suitability of individual's experience, knowledge, and training for the situation.

Consider the individual's overall or recent experience in the position, on the type, for the mission, on instruments, with the procedures, in the environment, etc.

Knowledge on the part of the individual may be inadequate, resulting in reduced confidence, confusion, or inappropriate actions.

Consider such factors as the individual's knowledge about the equipment, systems, procedures, or environment. Consider previous experiences, that is, the individual's or the influencing effects of others' experiences, training, etc.

Training relates to developing skills, knowledge or attitudes. Insufficient, irrelevant and non-applicable training can affect performance. Poor learning and reduced performance may originate in the training programme itself, in the work situation, or in social or domestic factors.

Consider such factors as the type of training received, training methods used, instruction materials, quality of instruction, instructor selection and training qualifications; any indications of positive or negative transfer, weaknesses observed during training, motivation, anxiety, stress, fatigue etc.

INFORMATION SOURCES

Factors related to experience, knowledge and training can be investigated initially through interviews with crew members, supervisors, training personnel and previous employers. Supporting documentary information can be obtained from current and previous employer training records and from certification documentation.

Liveware Psychosocial Factors

These factors may have a role in the investigation as they influence an individual's approach to a situation. Psychosocial factors include any event or condition in the individual's social environment (friends, family, peers, money, activities, life-style, work) which are important enough to influence on-the-job behaviour. Typically, these factors are not directly causal, but they can manifest physically as in loss of sleep, in poor eating habits, in feelings of anxiety, stress, etc.

Consider such factors as personal loss, interpersonal conflicts, financial problems, significant lifestyle changes, family pressure, culture differences.

Investigation Source

Psychosocial factors can be investigated through interviews with individuals, spouses, family members, and personal physicians.

The SHEL Interfaces

The central component, the liveware or individual, does not act alone, but interacts directly with each of the other SHEL components. Data collected during the investigation should include these interactions.

Liveware-Hardware Factors

This area includes any physical or mental interactions between the human and the machine, design limitations and peculiarities in work-station configuration. Design of system hardware can contribute, through design-induced errors, to unsafe acts. A hazard at the liveware-machine interface can increase the likelihood of error; increase the likelihood of non-use or misuse of the equipment; increase reaction time; induce negative transfer; increase delays and costs; increase workload; cause a decrease in operator satisfaction, cause discomfort, confusion, distractions, and lead to fatigue, injuries and attrition rates.

In evaluating the liveware-hardware interface, normal patterns of human behaviour should be taken into account. A sampling of these behaviours is as follows: most people cannot judge distances, clearances, or velocities very well, tending to over-estimate short distances and under-estimate large distances; people expect something to operate in a certain manner; many people carry out most tasks while thinking about something else; most people perform in a mechanical manner, employing previous habit patterns (under stress they almost always revert to these habit patterns); most people are reluctant to recheck their operational or maintenance procedures for

errors or omissions; in emergency situations people often respond irrationally and with seemingly random behaviour patterns; and people are unwilling to admit errors or mistakes of judgement or perception and thus will continue a behaviour or action originally initiated in error (Nertney and Bullock, 1976).

In investigating the liveware-hardware interface, the following considerations can be evaluated: **Workspace and Comfort** are concerned with ensuring that **human variability considerations** are taken into account in the design of the workspace. Although people vary in body size and shape, there can be considerable variability in other measurements such as in physiological and psychomotor abilities, e.g., endurance and reaction time. Typically, design of a workspace, as in a bridge, will accommodate the 5th to 95th percentile range of the population. Use of anthropometric data in design is fundamental in determining whether given equipment design has appropriate clearance, reach, and visibility characteristics.

> Consider such factors as adequate clearance for headroom, shoulders, and lower limbs, including space for entry and exit; adequate reach, both hand and foot, for operating controls; a common eye reference point for correct positioning relative to internal and external workstation sightlines to displays, environmental conditions, other operators, etc.

Physical Space and Arrangement Considerations are concerned with workplace components, such as controls, displays, manuals, etc. being located and arranged to optimize vision, reach, and clearance requirements.

> Consider the following four general principles for evaluating physical space and arrangement considerations: **importance principle** - the most important components should be placed within the primary reach envelope and field of view; the **frequency of use principle** - the most frequently used components are placed within the primary reach envelope and field of view (should frequency and importance conflict, importance should supersede); the **functional grouping principle** - related components should be grouped according to function and in accordance with importance and frequency of use principles; and **the sequence of use/operation principle** - after the initial three principles have been applied, components should be arranged in the order of their use and operation.

Control Considerations are concerned with the transfer of information from the operator to the equipment.

> Consider, in addition to the physical space and arrangement considerations listed above, control considerations such as visual or tactile dissimilarity for controls located in proximity to one another; symbolism in control design, wherein the control mimics the function; prevention of inadvertent use of control by recessing, guarding, locking, or isolating the control; control-display compatibility wherein the display actions match the control movements; control loading wherein controls do not require undue force to

operate; and standardization of controls in their location and sense of use.

Display Considerations are concerned with the transfer of information from the equipment to the operator. Primarily, there are two types of displays: visual and auditory. Visual displays include lights, markings, scales, alphanumerics, icons, and pictorial representations. Auditory displays include horns, bells, whistles, music, and synthesized speech.

Consider, in addition to physical space and arrangement considerations, display considerations such as display-control compatibility; standardization of displays; the match between the type of display and how the information the display provides is put to use by the operator; illumination of visual displays based on environmental conditions; location of displays that allows for acceptable viewing or hearing distances from the operator; viewing angle of visual displays; the size, font, resolution, contrast, etc. of alphanumeric displays.

User Acceptability Considerations are concerned with those factors that contribute to the determination by the operator as to what is acceptable for use.

Consider such factors as comfort, efficiency, reliability, safety, maintenance, mission, cost and aesthetics, etc.

Liveware-Hardware Factors

Liveware-Hardware Factors can be investigated through examination of the bridge layout, workstation and equipment used by ship and shore-based personnel, vessel wreckage, similarly configured vessels, manufacturer=s data, drawings and pictures, company records and logs, maintenance and servicing equipment, marine communication and traffic services facilities and equipment, maintenance recorders, electronic components with non-volatile memory, event recordings and radar tapes, simulator training systems.

Liveware-Liveware Factors

This field explores the nature of human interactions and communication breakdown between individuals.

Verbal Communication can lead to misunderstandings, misinterpretations, etc., when information necessary for safe and effective operations and maintenance is not sent, received, or understood by the intended recipients in a clear, unambiguous and intelligible form. Communication involves all parties involved in the operation: deck crew, engineering crew, repair crew, catering crew, shore personnel, etc.

Consider such factors as language barriers, ambiguity, pronunciation, improper language usage, frequency of word use, length of words used, relevancy of words, phraseology, noise interference, noise exposure, content and rate of speech, readback/hearback, language barrier, stress, fatigue,

workload, operational pressures, quality of communication equipment, personal hearing deficiencies, age, hearing expectations, etc.

Information Sources

Factors related to verbal communication can be investigated through interviews with crew, voice recordings (where available), examination of the capabilities and limitations of communications equipment, and through medical records (hearing acuity).

Visual signals can replace, support, or contradict oral and other information, and may include body language or other "non-verbal" cues.

Consider such factors as body language which can direct an action, cause confusion, stress, misunderstanding, or create negative emotions or pressures.

Crew Interaction may cause individuals to work for or against each other, or fail to use all available resources.

Consider such factors as crew compatibility/pairing in terms of personality, experience level and working habits, cultural differences, language differences, training, briefings, crew coordination, task assignment, age, trans-bridge authority gradient, group influences on decision-making, peer pressure, etc.

Information Sources

Factors related to crew interaction can be investigated through interviews with ship and shore personnel, marine communication and traffic services personnel, and through examination of employer staffing and training records.

Passenger behaviour can have an impact on crew actions, attitudes, and behaviour.

Consider such factors as passengers who are physically challenged, as well as passenger pressure, cooperation, intoxication, apprehension, anxiety, etc.

Information Sources

Factors related to passenger behaviour can be investigated through interviews with catering crew and interviews with and questionnaire surveys of passengers. The passenger manifest is invaluable in identifying and locating passengers.

Worker-Management factors include the level where decisions and plans are formulated and resources allocated. Also included is the supervisory level where actions are monitored and instructions followed. Crew behaviour cannot be accurately assessed in isolation of the organizational climate. A discussion of the effects of the organizational climate on performance and the factors to consider follows.

Organizational factors may affect human performance by causing excessive workload

or an unhealthy work environment, etc.

Consider such factors as organizational philosophy, policies, procedures and practices, compatibility of organizational goals with safety, the effect of the structure of the organization on internal communications between management and operations or maintenance. Consider the safety climate of the organization in terms of the identification and dissemination of information about known risks and their management, the provision, for personnel, of adequate detection and warning systems, commitment to ensuring an error-tolerant system. Consider personnel selection and recruitment policies, staffing policies, personnel policies, training policies, remuneration/incentive structure, scheduling policies, seniority policy, etc.

Supervision factors are concerned with the practices that reflect the philosophy and policies of the organization. Deficiencies in an organization's operating philosophy and policies can lead to deficiencies in its procedures and/or practices.

Consider such factors as the existence, implementation, availability, currency, completeness, and accuracy of company policies, prescribed procedures, and quality controls. Consider also accepted operating or maintenance practices which differ from prescribed procedures, the adequacy of personnel monitoring and support programmes, scheduling practices, remuneration practices, supervisory presence (or absence), supervisory style, supervisory duties, etc.

Work Environment Organizational policies can set up conditions that are conducive to committing unsafe acts or making safety-related errors due to psychological as well as physical conditions in the workplace which influence individual or team performance.

Consider such factors as real or perceived pressures due to operational policies, peers, management. Consider also turnover rates, company morale, compatibility of company policies and work practices, and work settings including reliable equipment, adequate lighting, etc.

Associations and Unions can create conditions conducive to human error and unsafe acts.

Consider the effect of union philosophies, policies, and practices on workers, management, work habits; consider also post-merger negotiations, contract negotiations, etc.

INFORMATION SOURCES

Factors related to worker-management can be investigated through interviews with crew members, supervisors, management, and union. Observation of practices can support a comparison of prescriptive procedures versus actual practices and the reason behind mismatches. Supporting documentary information can be obtained from company policy documents, procedures manuals, manning records, and accident/incident reports, as well as records detailing contracts and contract negotiations.

Regulatory Requirements and Overview include both the reaction of the operating organization to regulatory requirements as well as the adequacy of the role of the regulatory organization with respect to governing transportation operations and maintenance.

Consider, in so far as the operating organization is concerned, if regulatory requirements are relegated to a low importance in the organization's values or if members are encouraged to bend the rules. Consider, for the regulator, if there are deficiencies in the rules and regulations governing transportation operations and maintenance, deficiencies in the certification of equipment, personnel, and/or procedures, and deficiencies in surveillance, audit and inspection of transportation operations and maintenance.

Information Sources

Factors related to regulatory requirements and overview can be investigated through interviews personnel from regulatory agencies. Examples of supporting documentary information are regulations, certifications, and records of audits.

Liveware-Software Factors

This field deals with the nature of the information transfer between the human and supporting systems found in the workplace. Data requirements span such subjects as regulations, signage, manuals, checklists, publications, standard operating procedures, and computer software design.

Written Information includes manuals, checklists, standing orders, or any other written documentation. Poorly designed documentation can lead to increased response time, can create confusion, can increase the risk of items being missed, can be susceptible to distractions, can be conducive to shortcuts, etc.

Consider such factors as length, format, and content. Consider font type, font size, pitch, type face, character spacing, and use of colour. Consider also consistency, accuracy, availability, completeness, ordering of items, and redundancy of written information as well as timeliness of revisions. Consider appropriateness of checklist response requirements; i.e., a value vs status, especially for critical items. Consider conflict of operational time constraints and use of checklists, etc. Consider stowage of documentation on the bridge, etc. Consider knowledge and training of individuals on documentation.

Consider mechanism for dissemination of safety critical information.

Information Sources

Human related information can be investigated through interviews personnel from regulatory agencies. Examples of supporting documentary information are company standard operating procedures, standing orders, equipment operating manuals, checklists, repair work cards, technical manuals, ship safety bulletins, and regulatory documentation.

Automation ideally reduces operator's workload; however, automation can affect individuals' attitudes toward their work and their mental picture of the task, sometimes by impacting workload at critical times. Missing of important information, over-reliance, mode confusion, increased reaction time, monotony and boredom, lack of knowledge to deal with failures of automatic systems, or blatant errors can be byproducts of automation.

Consider rate of false alarms, loudness of auditory warnings; consider also keyboard accessibility, compatibility of keyboards and displays, physical space and arrangement characteristics of automated equipment, control and display considerations, number of modes. Consider workload, training, knowledge, skill, procedures, etc.

Information Sources

Human related information can be investigated through interviews with crew members. Observation of tasks and associated equipment is an excellent means of understanding how individuals are interacting with equipment. Supporting documentary information are manufacturer technical specifications and drawings and user manuals.

Regulatory Requirement issues centre on individuals' essential qualifications and certifications for the task.

Consider such factors as current licences or ratings, qualifications in position and on equipment type, infraction history, medical certification, etc.

Information Sources

Human related regulatory requirements can be investigated through interviews with crew members and also with personnel from regulatory agencies. Examples of supporting documentary information are regulations and certification documentation.

Liveware-Environment Factors

This area deals with the relationship between the individual and the internal and external environment.

The **internal environmen**t is that of the work area. Physical environmental factors can effect

the liveware-hardware interface of a system either by compromising the health or safety of an operator, or by causing a failure of the structure or function of the workstation. The physical environment can have an effect on the human component by contributing to a degradation in operator performance, which in turn could lead to a hazardous situation.

> Consider such factors as noise, its intensity, the individual's exposure rate to noise, and its effects on the ear, on the ability to communicate, and as a cause of fatigue and stress. Consider the detrimental effects of vibration - fatigue, stress, headaches, and muscular discomfort. Consider the stressful effects of temperature that is too hot or too cold, on the body - tiredness, difficulty in concentrating and a decline in decision-making ability. Consider also ambient light and air quality.

INFORMATION SOURCES

Human-related factors in the internal environment can be investigated initially through interviews with the crew members. Supporting documentary information can be obtained from manufacturer=s records or technical specifications. If there is an indication that any environmental factors may have contributed to the occurrence, then specific measurements (e.g. noise levels or lighting)can be taken to determine the extent of the problem.

The **external environment** includes the physical environment outside the immediate work area. This area also includes the broad political and economic constraints under which the marine system operates, which can lead to the taking of shortcuts, biased decisions, etc.

> Consider the effect of delays, on the operator, caused by weather, dispatch, port infrastructure. Consider the effects of geographical peculiarities of the location, harbour characteristics, lighting intensity, etc.
>
> Consider economic or regulatory pressures. For maintenance facilities, consider equipment, availability of parts, operational standards, procedures and practices, quality assurance practices, servicing and inspection practices, training, and documentation requirements.

INFORMATION SOURCES

Human-related factors in the external environment can be investigated initially through interviews with crew members, and later with company personnel outside the immediate work area and with members of associated outside agencies. Supporting documentary information can be obtained from agencies such as Port State Control, Weather Services, Marine Communications and Traffic Services.

Summary

The guidelines in this chapter are focused on gathering data using the systematic approach that the SHEL model provides. The chapter has dealt primarily with understanding the effect that various factors can have on performance; in addition, the chapter has provided a listing of the

types of information investigators need to gather to determine if any of those factors were antecedent to an occurrence.

The next section of this chapter provides examples based on the process described in IMO Resolution A.849(20), Code for Casualty Investigation (1997). The process takes investigators from the data gathering phase of an investigation into the identification of unsafe acts and conditions and the latent factors that facilitated their development, and culminates in the identification of potential safety problems.

WORKED EXAMPLES

To be developed

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Recommended Readings

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