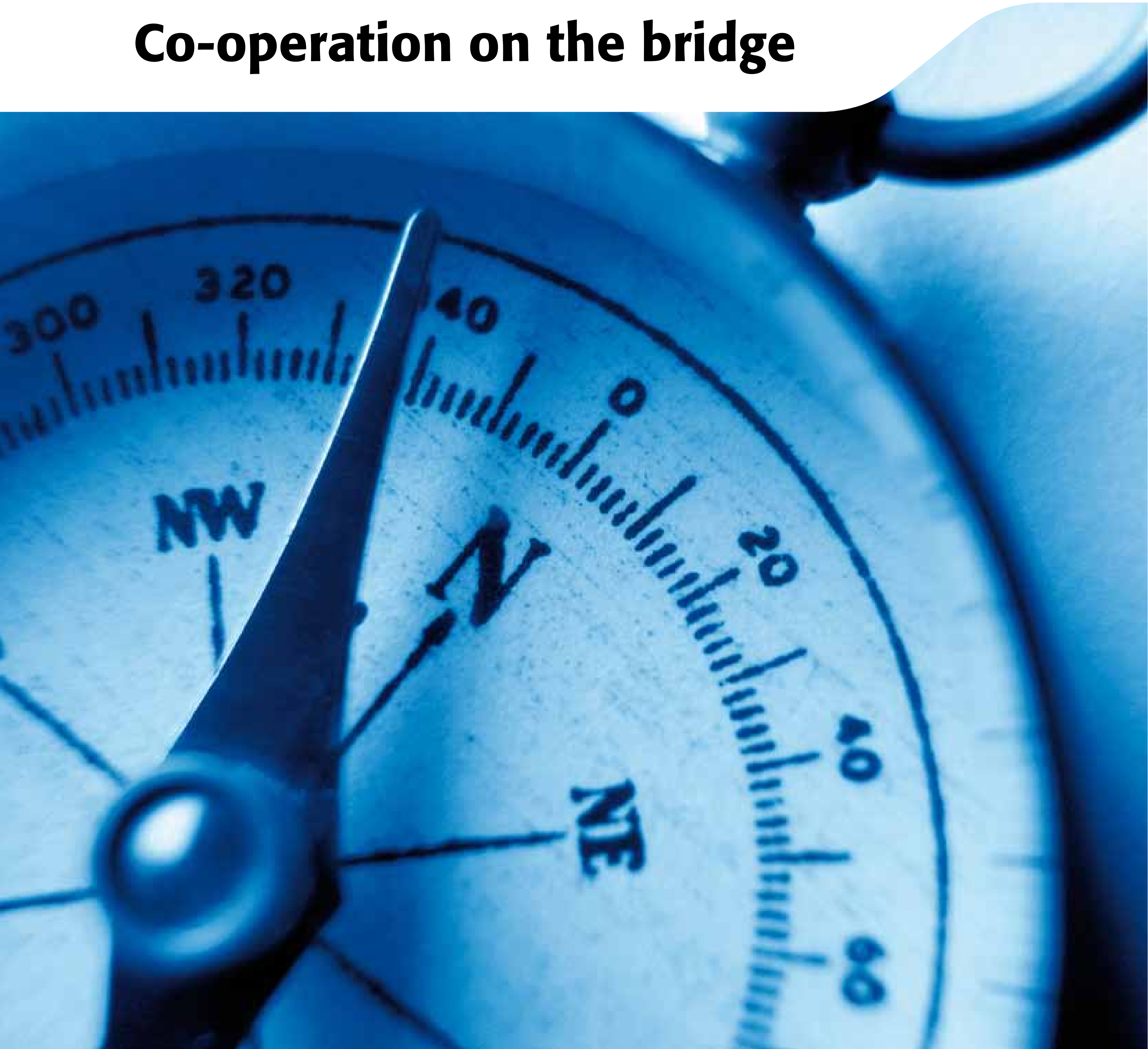
TraFi Maritime

Co-operation on the bridge



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Introduction

Ensuring Safety

Safety is a critical issue for maritime industry, and there are significant safety, environmental and economical risks for vessel traffic. The main task of bridge personnel is to control these risks while operating the ship. This is a challenging task, and indeed, most maritime accidents result from the errors of bridge personnel (IMO, 1999).

It is impossible to completely eliminate the risk of accident, but the likelihood of accident can be reduced by decreasing the risk level of operations. It is difficult to estimate the risk level for normal operations, as the operational weaknesses are not obvious and only become apparent in such situations and circumstances that may lead to accidents. Routine operations may seem safe until a situation emerges where routines do not provide protection from risks. A central part of risk management is to spot the weaknesses in normal operations and to choose compensatory routines. Usually, everyday risk management refers to verification routines which are used to confirm that everything functions normally. Indeed, risk management practices may sometimes feel like frustrating repetitions or tasks that are obvious or already checked. However, the value of these practices is measured in situations where deviant observations are made or corrective measures carried out. The safety level of operations cannot be measured by how much the personnel think about safety. Safety is measured by risk management practices and the priorities that guide decision making. From the worker's point of view, safety means safe routines.

An accident is always a sum of many events, and it is easier to perceive the chain of events retrospectively. There are many underlying events where the personnel could have affected the chain of events, but the factors affecting the accident and their significance were not understood. Hence, the bridge operations were not adjusted to meet the demands of the situation, even though there was a chance to do so. In other words, the accident could often have been avoided, had the working practices better supported the making of observations and the forming of better situation awareness.

In addition to external risk factors, there are often errors underlying the accidents made by bridge personnel as well. It is natural to make errors, and it is impossible to completely remove them from human activities. Circumstances also have an effect on the making of errors. The more demanding the task and the working conditions, the more errors are made, the harder it is to identify them, and the more serious their consequences will be. Being a professional in risk management does not mean that you are capable of performing your task without errors, but rather that you are able to identify situations where errors are made and choose working practices that can affect the identification of errors and their consequences.

Seafarers have always been successful in managing risks, and safe working methods and the identification of the issues relevant for safety are not novel inventions. The ability to identify risks, to distinguish between relevant and irrelevant observations and the ability to modify one's routines according to the situation at hand are the hallmarks of experiential knowledge. Risk management skills that have been accumulated with experience are often instinctive, and top professionals often find it hard to explain the reasons underlying their methods of operation in detail. This complicates teamwork and the formation of shared situation awareness on the bridge. Moreover, the transfer of knowledge and good practices to the inexperienced employees will be slower. The definition of risk management skills will offer extra value to the development of the overall safety of the operations, and it will also provide tools for communication-based teamwork and thus for efficient resource management as well. Moreover, it makes it easier to transfer experiential knowledge and knowhow, and to learn from even smal operational deviations.

Safe co-operation on the bridge is intended as a handbook for bridge personnel. The purpose of the handbook is to help the bridge personnel to apply work regulations to their own work in order to ensure safety.

Background and Aims of the Application Handbook

Maritime legislation places requirements on the development of the working methods on the bridge as well as the training of personnel. These requirements are intended to prevent accidents that are caused by human errors. The instructions and requirements can be found from several sources. This application handbook is a compilation of practices, instructions and regulations related to risk and human error management. It also introduces ways to apply the methods required by law. The general risk and error management principles covered in the handbook can be applied in different operational environments, although the actual working method will always depend on the properties of the actual working environment.

The requirements for the practices discussed in the application handbook are introduced in the following international regulations, for example:

The STCW Code (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers). In part A of the code that introduces the mandatory training requirements, there is a requirement of having a secure lookout to maintain efficient operations of the bridge. Part B of the code contains recommendations and specifications for the requirements, including, for example, instructions for shipping companies regarding lookouts. The shipping companies are recommended to provide instructions of the appropriate operational practices on the bridge and to promote the use of checklists. Additional instructions are also provided, and these include topics such as the sufficient manning of the bridge, division of labour and clear communication.

SOLAS ISM Code requires the shipping companies to compile a safety leadership protocol for the vessels. The aim of the protocol is to make the shipping company define safe working methods and security protocols for all identified risks and also to continually improve the personnel's safety leadership skills. (1.2 Objectives).

Instructions related to the topic can also be found in several other sources. This application handbook refers to the following ones:

IMO's circular that provides instructions for the integrated use of the bridge (MSC/Circ. 1061) recommends, for example, that shipping companies register the practice of the integrated use of bridge automation to the vessel operating manuals (VOM). The circular also discloses several important concepts, including bridge procedures and standard operating procedures.

IMO's guidelines for voyage planning (Res. A.893(21)), which define requirements concerning the contents and execution of a voyage plan. An annex to the guideline (Annex 24) emphasises the role of risk management as part of the planning and execution of the voyage.

IMO's model course for ship simulator and bridge teamwork (1.22) describes co-operation practices concerning the briefing of the personnel, workload management and decision making.

In 2003, IMO compiled the so-called Human Element Vision principles and goals whose aim is to take into account the effect of human factors in the areas related to maritime safety as comprehensively as possible. In the principles of the programme it is mentioned that all material related to the topic should aim at reducing the human errors as quickly as possible (Principles, h).

The main goal of the application handbook is to improve maritime safety by reducing operative risks and the number of accidents and hazardous situations caused by human errors. The guide aims at increasing awareness on the practices applied to risk and error management and providing instructions for their application in different situations. The handbook is intended to be used by maritime professionals, from the operative personnel to management, and by those in charge of the development of safety management schemes.

Composition of the Application Handbook

The application handbook is divided into three parts: risk management, human error management, and bridge resource management.

Risk Management. This section covers risk factors typical of maritime navigation and sea transport as well as risk management procedures and principles. The application handbook concentrates especially on voyage planning and the practices associated with the sharing of the plan.

Error Management. This section focuses on the different types of human errors related to work on a bridge as well as error management procedures and principles. The application handbook covers the following procedures related to error management: monitoring, task sharing, checklists, communication practices, practices for abnormal situations, and co-operation and resource management.

Bridge resource management. All procedures for risk and human error management are based on the efficient use of resources available for the bridge personnel. Bridge resource management also includes principles that cannot be defined as working practices. Bridge resource management and the related principles are discussed in the fourth part of the handbook.

Risk Management on the Bridge

Introduction

From the bridge personnel's perspective, the safety risks of operational work can be divided into two parts: external and internal risk factors. The internal risk factors refer to errors made by the bridge personnel. Consequently, the personnel's activities can also be divided into two parts: risk management and error management (Figure 1).

External risk factors refer to situations and circumstances in maritime navigation and sea transport that are beyond the personnel's influence. These factors can either be very familiar and frequently occurring, or surprising and not experienced before. External risk factors include all circumstances and situations that in some way elevate the risk level of operations. External risk factors are a natural part of operations.

Risk management procedures refer to the bridge personnel's decisions and actions that are used to eliminate or minimise the effects of the external risk factor on operations. A prerequisite for the management of external risk factors is to identify them and understand their significance.

Internal risk factors refer to the errors made by the personnel. Making errors is part of human activities and cannot be completely eliminated. However, it is possible to affect the number of errors as well as their detectability and consequentiality by operational methods that are called error management procedures. A prerequisite for efficient error management is to identify the situations and actions where errors are made and where the consequences of the errors are significant.

External and internal risk factors are interrelated. The more external risk factors there are in a task, the more significant the management of internal risks becomes. In other words, the more demanding the circumstances and the task, the more probable it is to make errors, and the more difficult and slower it is to detect them. Moreover, in more demanding circumstances the consequences of errors are often more severe, and they are also realised more quickly after the error has occurred. Good risk management could be described by quoting an old adage: "Good bridge personnel will avoid the situations that can only be handled by skilled bridge personnel".

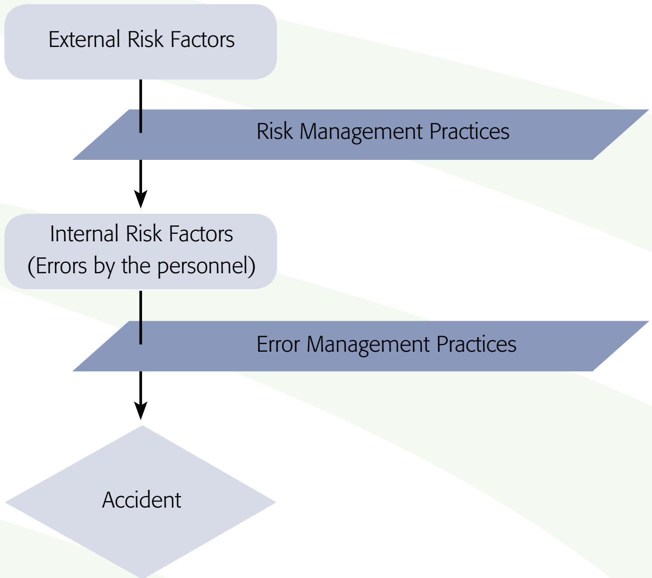


Figure 1. Risk Management on the Bridge (Adapted from Helmreich, R.L. et al. 1999).

External Risk Factors in Maritime Navigation and Sea Transport

External risk factors in maritime navigation and sea transport include all the stages, conditions and situations of the voyage where the risk level has increased (this application handbook does not consider the risk factors included in cargo operations or the transfer of cargo). Examples of the different stages of the sea voyage include ports, archipelagos and other narrow and tight passages as well as congested routes. In these areas, the margin for detecting and managing errors is small. Conditions, on the other hand, include deteriorated weather conditions, darkness, ice conditions and other conditions where it is more difficult to steer the vessel, such as streaming water and other conditions that create suction (squat, bank effect etc.). Risk-increasing situations include locks, towing, support situations in icy conditions and abnormal and emergency situations on the vessel.

A study conducted in Finland in 2007 investigated the effect of risk factors on the accidents that happened in Finland's territorial waters in 1995–2005 (Merenkulkulaitos, 2007). The report found that the accidents or hazardous situations where at least one of the underlying factors was a human error made by bridge personnel had usually occurred in the increased-risk conditions mentioned above. Of the 52 accidents and hazardous situations selected as examples in the report, 94% (49) took place in the archipelago or port area, 38.5% (20) in poor visibility and approximately 60% (31) in dim or dark conditions. Wind was a factor in the accident or the hazardous situation in 35% of the cases. Cases that occurred during dim or dark conditions and/or poor visibility comprised 81% (42) of the cases. 65% of all cases included two or more risk factors (e.g. ice conditions, other traffic, busy radio communications etc.). The report also found that 60% of the chosen accidents and hazardous situations took place during the autumn/winter season, i.e. between October and March.

As underlying causes of human errors, risk factors have an effect on the safety of operations both directly and indirectly. The starting point of safe operations is to identify the risks in the working environment and to modify the operations to meet the challenges in the environment. These risk management principles are discussed in the next section.

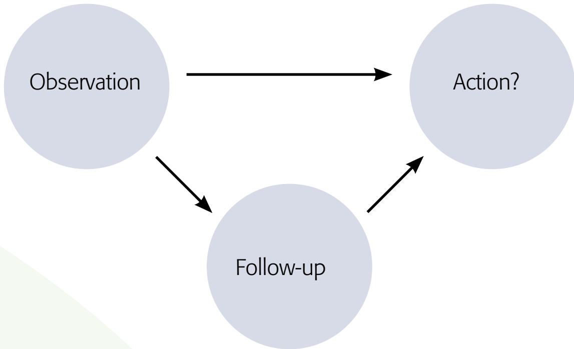


Figure 2. Principle of Risk Management

Risk Management Practices

The starting point of risk management is the identification and recognition of risks. However, even this is not enough in a complex and changing operational environment, as the status and the significance that the identified issues have on safety must be followed and assessed regularly. More generally, one can talk about forming a view of the situation and actively updating it. The more demanding the conditions are and the more risk factors are identified, the more actively the view of the situation needs to be updated through one's own actions.

However, it is not enough just to form a general view of the situation, i.e. just to be aware of the present risks. The identification of risk factors should always be followed by the question: “How should I act in order to minimise the effects of this risk factor?” In principle, each observation should lead into conscious deliberation concerning the way operations are organised. It is, of course, acceptable that in some cases the result of the deliberation may be that there is no need to modify the current operations. In such cases the situation will be monitored more carefully, if necessary, and the operations modified at a later time (Figure 2).

Risk management on the bridge is based on co-operation. It is important that the bridge personnel shares the same view of the situation, i.e. has shared situation awareness, and understands the current risks. The observations and the actions related to them will be discussed among the crew so that everyone will understand the risks and participate in their management.

Once the external risk factor is recognised, there are basically two ways to manage it: its effects can be completely eliminated or they can be reduced. In some cases, such as severe wind conditions in port, the risk factor can be removed simply by delaying entrance to port until the conditions have improved. Similarly, the risks associated with poor visibility or heavy traffic can in some routes be eliminated by choosing another route, if possible.

However, it is often not feasible to remove the external risk factors, which means that the personnel must adapt to the situation. In these cases, the central task in risk management is to define the effects that the risk factor has on operational safety and to modify the personnel's routines in order to minimise these effects. External risk factors often increase the risk level of operations because the operations become more susceptible to errors made by the personnel. This is why error management practices based on conditions are included as part of risk management.

Principle of Anticipatory Risk Management

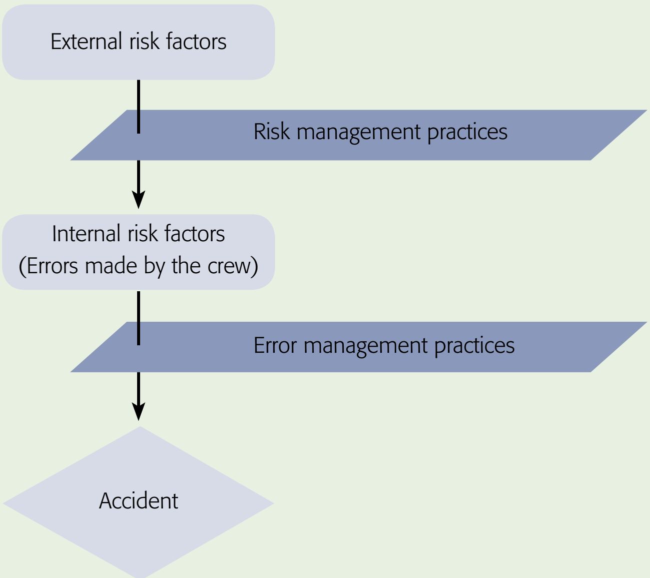
Several external risks that have an effect on the operations are already known before the voyage. It is therefore possible to consider these risk factors beforehand and to decide which of them require special actions in terms of risk management. These actions can then be documented in a checklist, for example, as recommended in the IMO guidelines. The purpose of the checklist is not to describe the actions related to risk management as such, but rather to help the bridge personnel to be sure that every necessary operational modification has been considered when the risk level changes.

EXAMPLE ACCIDENT 1.

A vessel was grounded after passing the turning point, as the officer of the watch made a mistake on the sector lights. The vessel had travelled through the archipelago after midnight. It was dark, but the visibility was good. The officer of the watch had been working on the vessel only for two weeks and had not travelled the route before. The ship's electronic nautical chart had broken down a little earlier after the vessel had left port. Based on these issues, the captain had decided that the conditions were demanding for the officer of the watch, and had remained on the bridge as a lookout. When the captain considered the situation to be peaceful, he went to rest on the bridge's couch.

The officer of the watch paid attention to the VHF traffic just before the next turn. As he started to prepare for the next turn, he thought that he could not match the lights he saw, and therefore informed the captain that the situation seemed to be a little unclear to him. The officer of the watch had mistaken a beacon light for a buoy light after missing the turning point. When the captain arose from the couch, the situation had already escalated to a point where grounding was imminent.

It is possible to recognise several risk factors as well as two human errors contributing to the accident:



Risk factors

- The officer of the watch was inexperienced on the vessel
- The chief watchman was not familiar with the route
- The vessel was operated in the archipelago
- Night-time
- The captain was tired
- A technical fault made navigation more difficult
- External distraction (radio traffic)

Errors

- Missing the turning point
- Incorrect interpretation of the lights

Several external risk factors made operations demanding. The risk for a navigational error had increased, and the detectability of an error had become more difficult. When the officer of the watch was momentarily distracted by radio traffic, he missed one of the turning points. This error was detected too late, as the circumstances made its detection difficult.

External risk factors were partially taken into account when the captain decided to stay on the bridge. However, the task sharing was not agreed upon, and the captain did not take part in steering the ship, nor did he monitor theofficer of the watch. While the captain was on the bridge, he was not utilised as a resource. A clear task sharing and the utilisation of the captain in cross checking navigation would have helped in detecting the navigation error and to prevent grounding.

PRACTICAL EXAMPLE 1.

Dividing the stages of the voyage in different areas according to risk level

The risks related to the voyage that are known beforehand can be taken into account by dividing the different stages of the voyage into risk classes: high risk, increased risk and low risk. Each class can be defined according to the following topics, for example:

- Manning of the bridge
- Task sharing
- Working practices
- Use of automation and other equipment
- Manning of the engine room
- Operations of the main engine and auxiliary engines

In addition to these, further constraints can be put in place for different risk levels. For example, it can be decided that outsiders are not allowed on the bridge in high risk zones, or that it is only allowed to talk about issues related to the steering and navigation of the vessel. These zones can be marked into the route plan beforehand. When moving from one zone to the next, the procedures can be ensured by using a checklist and standardised communications.

The same operating principle can also be used in situations where, for example, weather or other operating conditions result in the change from one risk level to another.

Voyage and Route Plans

Planning forms a central part of risk management. The purpose of planning is to ensure that all future actions are coordinated and that every relevant factor affecting operations is taken into account and recognised by the personnel. In the planning phase, the prospective situation is discussed along with the necessary procedures, risks associated with the situation and their control as well as the co-operation between the personnel during the situation.

Traditional tools for this purpose include voyage and route plans. Standardised planning can also be applied to exit and entrance situations, piloting and other special situations.

"The need for voyage and passage planning applies to all vessels. There are several factors that may impede the safe navigation of all vessels and additional factors that may impede the navigation of large vessels or vessels carrying hazardous cargoes. These factors will need to be taken into account in the preparation of the plan and in the subsequent monitoring of the execution of the plan." (IMO Res. A.893(21) Guidelines for voyage planning, 1.2)

From the point of view of risk management, the most important tasks in planning include:

- Identification of the external and internal risks affecting operations
- Definition of those stages of the voyage that are affected by the identified risk factors
- The possible effects of the risk factors on the personnel's performance
- A risk management plan (manning, use of equipment etc.)
- Procedures and practices related to the monitoring and verification of operations

If the plan is not made jointly, it is important that it will be discussed with all those who are taking part in the operations included in the plan. The aim of planning is to ensure that the whole personnel have shared situation awareness and to allow different perspectives to be expressed and considered during the drafting phase of the plan. In addition to choosing the passage and other issues related to the voyage, it is important to justify the decisions and the risks associated with them during planning and ensure that everyone is aware of them.

Briefing of the Plan

Master shall lead a pre-departure briefing which includes:

- *Presentation of the route plan*
- *Interaction with the bridge team*
- *Setting of stipulated requirements*
- *Identification of possible weak links on the route*
- *Establishing standards and guidelines to be met during the passage*
- *Setting the environment for an effective team oriented operation*
- *Brief the pilot on the ship's characteristics and equipment using the pilot card*
- *Ask the pilot to present his route plan and give information on local conditions*
- *Demonstrate responsibility to brief and coordinate operational factors with the bridge team*

(IMO, Model Course, 1.22, 7 Briefing and debriefing)

Whether there is a documented voyage plan or only an idea about the activities in a prospective situation, it is at least as essential to brief the plan to everyone involved in the activities as it is to make the plan itself. Briefing of the plan will provide the personnel with an opportunity to comment on the safety of the plan and to raise issues that the person drawing up the plan may have missed. Briefing the plan in a standardised form, i.e. introducing all aspects always in the same order, will facilitate the monitoring of the plan in the agreed manner and also ensure that all relevant issues have been taken into account.

Planning and anticipation do not always need to – and indeed, often cannot – be based on a written plan of future activities. There are many situations, such as planning for a meeting with another vessel, that are based on a short briefing among the crew. The question is about the identification of the risks and a plan for their management in these cases as well.

From the co-operative point of view, the briefing should determine:

- The activities and intentions related to the plan
- The planned order and timing of the activities
- Task sharing for the planned activities
- Responsibilities related to the monitoring of the operations
- Critical phases and deviations that require a change in the plan
- Alternative plans and reasons for their deployment

EXAMPLE ACCIDENT 2.

A vessel was grounded during a turn. The master and the pilot were on the bridge. There was a thick fog, and the pilot made a mistake on the starting point of the turn. The master could not help the pilot because he had made a voyage plan for a different route from the one the pilot eventually took. The route taken by the pilot was not familiar to the master.

Before leaving port, the master had introduced his plan to the pilot. At this point, the pilot had not mentioned that he planned to use another route because of the ice conditions. The master found this out only when the vessel diverted into the detour the pilot had planned.

The co-operation between the master and the pilot was insufficient especially in relation to the briefing of the plans. A briefing before the piloting voyage would have provided the master with a better opportunity to help the pilot in navigating the vessel and to monitor the pilot's actions. Better co-operation and a clearer task sharing on the bridge would also have facilitated safe operations in demanding conditions.

Master shall during the voyage, brief the team on any significant situations encountered (IMO, Model Course, 1.22, 7 Briefing and debriefing)

Summary

Active risk management creates the prerequisites for safe operations. The most important issue is to try to identify the operative risks beforehand and to form a clear plan that will help to minimise the consequences of the risks. The majority of external risks can be identified well in advance, and they can be taken into consideration as part of normal operative planning. The traditional planning practices, such as formulating a voyage plan, can be complemented with the identification and management of those risk factors that can be anticipated efficiently.

Human Errors and Their Management

Introduction

"To err is human."

Errors are a natural part of human activities. The strength of human activities lies in their flexibility and adaptability to changing conditions, but the price of this is the chance of failure. This section aims at answering the question: what kinds of human errors are there and how can we manage them?

Humans will always make errors, but it is possible by one's own actions to try to ensure that they will not endanger the safety of others. These actions are called error management procedures. Thus, successful error management does not refer to error-free operations, but rather to the fact that errors are recognised on time and their impact on safety is minimised. Understanding this is a prerequisite for the personnel to be motivated to develop and apply error management practices in their work.

Human Errors on the Bridge

Errors can occur in diverse ways, and they can also be classified accordingly. Understanding different kinds of errors will provide a basis for perceiving weaknesses in human activities. This is important as different factors are relevant for the emergence of different kinds of errors. Moreover, errors are of a different kind in different tasks, and consequently, different kinds of errors can be managed in various ways.

Errors may seem similar at a first glance even if they have occurred for different reasons. An erroneous choice of speed may, for example:

- be intentional, yet erroneous, if the choice is based on an incorrect assessment of the situation (mistake)
- be a result of a slip during the speed selection task, which means that the choice was not deliberate (slip)
- be a result of a deliberate choice to proceed at a speed that breaches regulations, which may mean that the decision is based on a general practice, or that it is a circumstantial decision not to comply with the regulations (violation)

All three errors mentioned above will lead into different actions to prevent or manage errors in the future. Therefore, it is essential for the development procedures to understand the types and background of the different errors.

The starting point for the definition of the error type is always to find out whether the chosen action was intentional or not. Next, the error can be classified further into one of the four categories depicted in Figure 3.

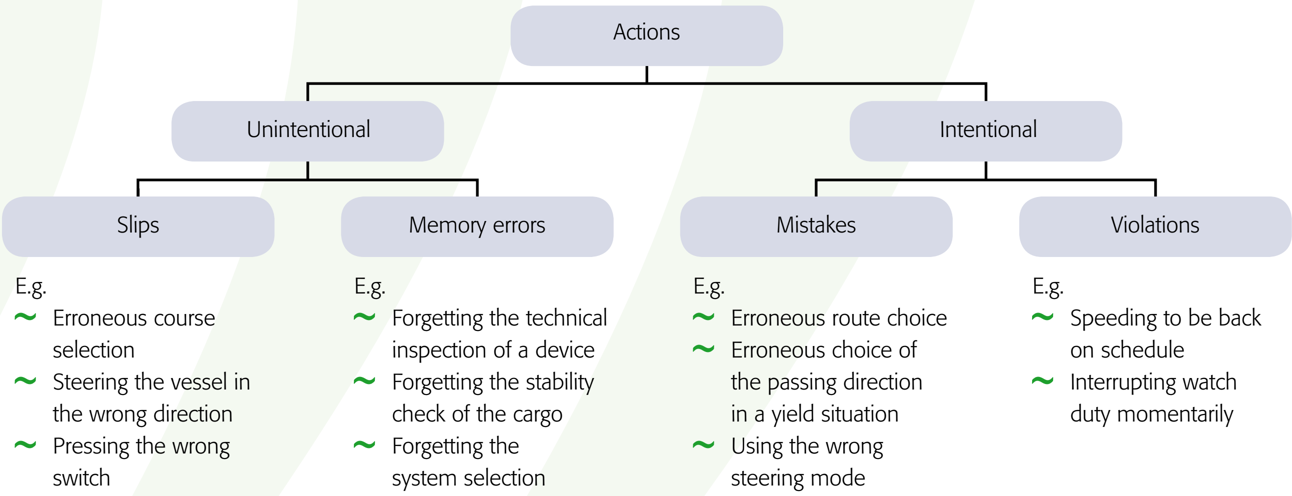


Figure 3. The Basic Error Types (Adapted from Reason, J. 1990).

Different error types require different procedures to avoid and identify the errors. An erroneous choice of direction in a planned route resulting from a slip can be identified and corrected by good monitoring. If the choice of direction was a result of a misunderstanding, the proper error control method can be found in the development of planning practices. The next chapters focus on each of the error types, the factors related to them and their management.

Slips and Memory errors

Slips and memory errors occur in normal and routine activities. A slip refers to an error where a person tries to accomplish a result through their activities, but they fail in their performance. Slips occur even in activities that have been learned well. Advanced skills will lead into fluent, fast and effortless activities, but they will also result in decreased awareness of the activities and the concentration required for them. This, in turn, will make the skills vulnerable of slips.

Slips are probably the most common type of error on the bridge. Typical slips include, for example, incorrect expression or execution of helm orders (or setting the autopilot). Perception errors form another common group – other vessels or other objects, such as sea marks are not detected early enough for one reason or another.

A memory error is a dysfunction of performance that results in omitting a task, one part of the task or a single issue. Memory errors occur both in well-mastered routine tasks and new tasks. Sometimes they may have fatal consequences for safety. For example, an omission has caused an accident in a situation where the personnel forgot to transfer the controls of the vessel from one wing to another (or to midship) and also in another situation where steering was not transferred from autopilot to manual steering.

There may be several factors affecting a person's performance that underlie slips and memory errors, such as too low (monotonous) or high (busy) workload, stress or fatigue; all of which are recognised problems for work on bridge. In addition to the factors mentioned above, the probability of routine errors is affected by the difficulty of the work, ergonomics of the work environment and external distractions, among others.

Slips and memory errors cannot be completely avoided, which means that their possibility must be taken into account when assessing the safety of operations. Consequently, the procedures that are critical for safety should be assured with verification procedures that will help to detect a slip or a memory error quickly enough. These procedures typically include:

- X-checking
- Call-outs
- Checklists

Mistakes

A mistake refers to a situation where a person successfully performs a task, but the outcome of the task is different from the person's expectations. Underlying the mistake, there is often a misconception of the situation at hand, which can be based on insufficient information or a false interpretation. Mistakes may also occur because the consequences of the chosen action are assessed incorrectly or all affecting factors are not taken into account.

On the bridge, mistakes may occur, for example, when setting the radar scale or interpreting the lights on safety devices. In the example accident discussed under Risk Management Procedures (Example accident 1, p.6), the immediate cause of the accident was a mistake concerning the lights marking the fairway.

As mistakes are usually related to an incorrect assessment of the situation or erroneous decision making, they should primarily be avoided by using all available information in ensuring good situation awareness and decision making. This requires effective communication and co-operation among the crew. The follow up of decisions and actions that have been made is also a fundamental part of mistake management. In practice, avoiding mistakes is primarily based on good planning and the briefing of the personnel as well as active checking of activities and assertive intervention if a plan or a decision is not deemed to be safe or their outcomes are not as expected.

Violations

This error type refers to the intentional noncompliance with orders or regulations. What is essential when it comes to violations is that the actions are undertaken knowingly and purposefully. There may be different motives and reasons underlying a violation that can be related either to the individual or to the organisation. The person committing the violation may think, for example, that the regulation that is broken is not relevant for the particular situation, or they may commit the violation because it is necessary for the task at hand. The person committing the violation may also think that it provides them with a possibility to perform the task better and faster, or that the organisation expects that violations are committed in order to secure smooth operations. Although violations should not be accepted at the organisational level, it is however important to understand why violations do occur in certain situations in order to prevent them.

The number and properties of violations serve as an indicator of the prevailing working culture. Certain orders may be ignored routinely, and in such cases the question is not about a deviation caused by an individual person or situation, but rather a structural problem in the operational system. The safety issues caused by violations usually include the fact that the significance of the ignored order is not understood or the consequences of noncompliance are not considered. Effective co-operation and open communication have a central role in managing violations. It is more likely that through co-operation and communication others that have noticed the situation will intervene in the violations and raise questions about the reasons behind the deviant activity.

Error Management Practices

"Master shall establish specific preventive measures to guard against external and internal errors." (IMO, Model course 1.22)

Human errors can never be avoided in operations, but they can be managed so that there will be no hazardous situations or accidents.

The first phase of human error management is to reduce their number. Here, the relevant issue is to predict the risks that affect operations. If the potential risk and the criticality of a certain task can be identified beforehand, the error can probably be avoided. This can be accomplished, for example, by focusing on a task where errors are especially common and minimising all distractions while performing the task.

The second phase of error management is to ensure that the error will be detected when it occurs, or at least before the possible consequences of the error start affecting the safety of the operations. Typical methods used in error identification include the monitoring and checking of operations, which in team work includes communication during the tasks. For example, the people involved in the steering of the vessel should be notified of a change in course. In this way, another person can confirm whether the action was appropriate or not (detecting a possible mistake), and the correct selection of the new course can be verified from the vessel's equipment (detecting a possible slip). In order to detect errors it is important to have a clear task sharing about who is in charge of executing an action and who of their verification.

In the third phase, the focus is on the identification and correction of the error induced situation. If the error is not identified early enough, it will usually lead into the deviation from expectations (the vessel will not have the expected course, for example). In these cases the situation may have reached a point where the error cannot be repaired using normal procedures; abnormal procedures, such as using alternative steering systems, must be used instead. From the point of view of identification and management of error critical situations it is important to be well aware of the threshold requiring the use of abnormal procedures as well as the actions that these procedures comprise. For example, in a turning situation in a narrow passage, everyone involved in steering should know what the safe tolerance for staying on the route line is and the amount of deviation that should be reported clearly, as well as the alternative actions that must be applied if the vessel cannot be kept inside the safe area by normal procedures.

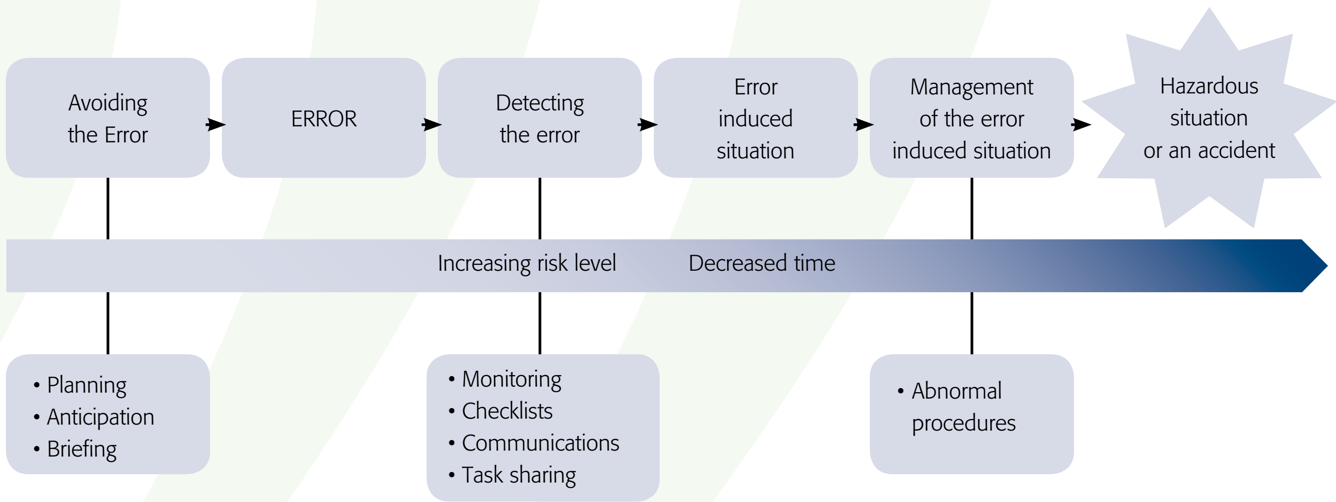


Figure 4. Phases of error management

Activities on these three levels may be based on documented working methods, procedures, or undocumented working methods used by the personnel and developed through training and experience (Figure 4). The following sections describe the most typical methods of error management as well as practices in abnormal situations.

Monitoring

"All essential information should be collected, processed and interpreted, and made conveniently available to those who require it for the performance of their duties."
(STCW Section B-VIII/2, Part 3–1, 5.12)

By monitoring is generally understood an activity that is especially related to the monitoring of the location of the vessel and the execution of the voyage plan. Indeed, from the perspective of maritime safety, monitoring and checking related to navigation are central tasks on the bridge. 80% of the accidents related to navigation are caused by human errors. In many cases, the information that could have prevented the accident would have been available, but for some reason it was not used. Therefore, IMO recommends that all decisions are cross-checked so that potential errors could be detected and corrected as early as possible. Moreover, deck officers should ensure that all available information is used in a systematic way.

"Masters, skippers and watchkeepers should ensure that optimum and systematic use is made of all appropriate information that becomes available to the navigational staff."
(STCW Section B-VIII/2, Part 3–1, 5.12)

However, monitoring is not only limited to following the planned route; it is rather applied to the verification and follow-up of all critical tasks. The aim of monitoring is to provide the relevant information to all who need it.

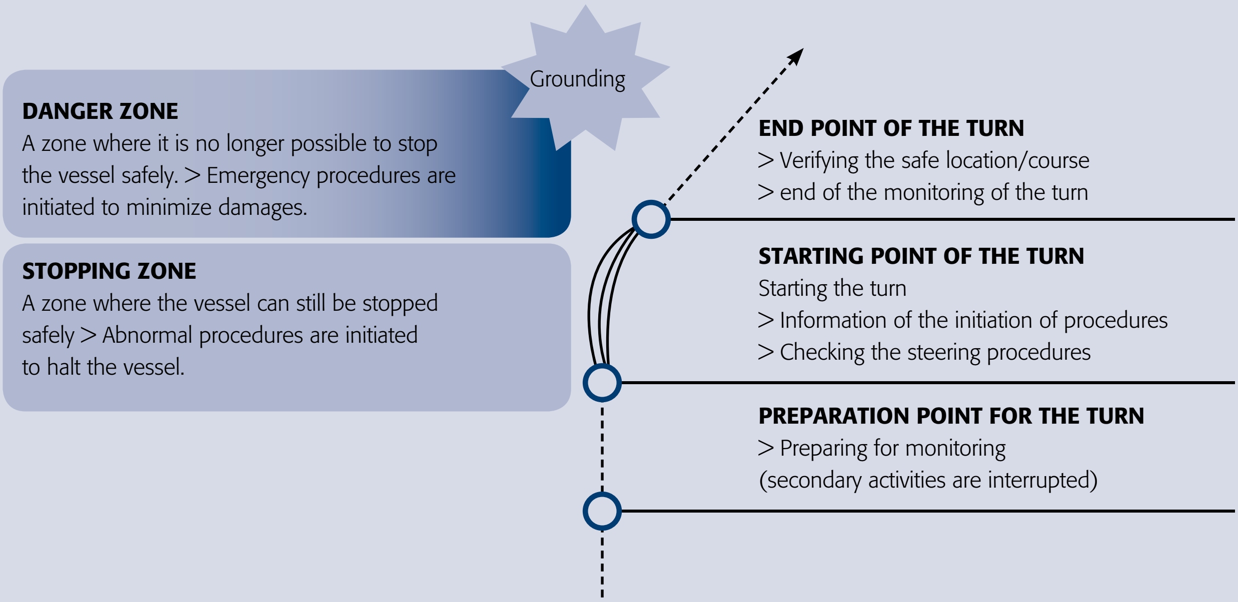
For monitoring to be successful, the following issues should be considered:

- Which functions should be monitored at the given moment?
- Who is responsible for the monitoring of these functions?
- Which observations should be communicated to other personnel?

PRACTICAL EXAMPLE 2.

Efficient monitoring while proceeding in a narrow passage

It is extremely critical for the vessel to stay on the planned route line when proceeding in a narrow passage because straying from the line may quickly lead into a situation where grounding cannot be avoided. Therefore, the monitoring of the turns is a relevant part of safe navigation in narrow passages. The targets of monitoring in turning situations include the location of the vessel in relation to the route line, direction of steering, course, speed and the correct functioning of the devices and steering systems used in the turn. Below you will find an example that is based on the monitoring of a critical turn. The example includes three phases, which are used to ensure that all the aforementioned factors are monitored until the critical turning phase is completed.



The three phases to the right of the picture ensure the monitoring during the turn. Preparations for monitoring can be initiated by using a standard call-out (e.g. "Approaching"), which directs the attention to the most significant monitoring targets of the turn. As the turn begins, it is important to communicate clearly the choices and procedures related to steering; their validity should be confirmed by other personnel. The final phase is the conclusion of monitoring where it is ensured that the vessel has obtained the desired course and location, and that the turning phase is completed. Attention can now be shifted to other operations on the bridge.

On the left side of the picture, there are two zones that are related to the vessel drifting away from the safe route line during the turn. The first of these is the "stopping zone", which starts from the point where the vessel can no longer be kept within the desired route. In this case the only way to prevent grounding is to stop the vessel either by using the main or alternative steering systems. If the vessel cannot be stopped, the vessel enters the "danger zone" where the collision cannot be avoided; it is only possible to minimise the damages caused by the collision by slowing down the vessel's speed as much as possible and/or steering the vessel to a direction that best helps it to withstand the collision.

The aim of monitoring and the related exchange of information is to maintain the shared situation awareness of the personnel. If the available information is not used to maintain the situation awareness, as has been the case in several accidents, the following three questions can be used to approach the problem:

- Did someone detect the issue in question?
- Was the issue considered to be important enough to be presented?
- Was the issue communicated in a way that resulted in a shared situation awareness?

Good monitoring practice will ensure that the confusions described above will not prevent information exchange to those who need it. Hence, the basic prerequisite for successful monitoring can be considered to be a task sharing that clearly defines whose current responsibility it is to monitor the function in question, which observations are relevant to the operations and how they should be reported.

Monitoring can be divided into passive (i.e. reactive) and active (i.e. anticipatory) monitoring. The difference between passive and active monitoring methods is whether monitoring is general monitoring of the activities or conscious checking of specific functions.

Passive monitoring refers to the monitoring of the general level of activities. General level monitoring is based on the presence of the monitoring officer and on stimulus-based reactions in situations where a deviation from the normal situation or another corresponding event causes the monitoring officer to take notice of the situation. A stimulus of this kind may be a system warning, for example. The weaknesses of passive monitoring include the incapability to detect small and slowly occurring deviations, the inability to react early to quickly evolving situations and the decrease of vigilance in a monotonous environment that includes only few stimuli.

Active monitoring refers to activities where a member of the bridge personnel knowingly pays attention to predetermined targets, whose expected status or functions he attempts to follow or ensure at a certain moment. When the person monitors several things, he will change the target of monitoring regularly.

Active monitoring requires that the targets requiring attention are known in advance and that the responsibility for their monitoring is clearly determined. The personnel should therefore know where to pay attention in different situations or during different procedures, and which changes are included in the plan and which are not. The following phases, which will result in communication, are included in several monitoring principles:

1. Preparing for monitoring (the situation requiring monitoring is approaching)
2. Initiation of activities (the monitored phase begins),
3. Checking of activities (changes according to plan) and
4. Ending the monitoring (attention can be shifted to other matters).

Communication is a central part of monitoring. It is not possible to maintain shared situation awareness and to ensure that attention is paid to the correct matters in co-operative monitoring if communication among personnel does not work.

Moreover, a protocol for reporting deviations needs to be defined in order to ensure that reactions to the observed deviations from the plan are sufficiently fast. Example 3 depicts how the different monitoring phases are shown during a turn in a narrow passage.

Procedures for active monitoring and communicating of deviations need to be in place for all situations where the detection of error is critical in terms of time, as in:

- Turn situations
- Port areas
- Archipelagos
- Narrow places (e.g. shallows and nearby areas, straits, rivers, locks etc.)
- Streaming water
- Conditions where the vessel is subject to pull (squat, bank effect)
- Busy regions
- Demanding conditions
- Other special situations, such as ice conditions, with a tugboat, abnormal and emergency situations etc.

To summarise, general observations (passive monitoring) do not necessarily guide the attention to the issues that are important for operations. Therefore, monitoring practices should be developed in such a way that focus will be on ensuring the matters relevant to the situation. This requires that the issues that are monitored are known by the personnel, the task sharing is clear concerning monitoring responsibilities, and the way the observations and deviations are communicated is agreed upon.

Task sharing

"Duties should be clearly and unambiguously assigned to specific individuals, who should confirm that they understand their responsibilities." (STCW Section B-VIII/2, Part 3–1, 5.3)

Excessive workload and unclear task sharing have often been discussed with reference to accidents. Any confusions regarding the task sharing will easily lead to memory errors caused by the workload, misunderstanding in co-operation based on assumptions, insufficient checking of critical procedures and poor utilisation of resources. These problems can be avoided by clear task sharing.

The starting point for functional co-operation should be a clear division of responsibilities, roles and tasks among all the operators in the group at all times. In this case, roles refer to predefined basic activities that include many responsibilities concerning procedures and their checking. Roles can be assigned and changed depending on the situation.

The manning of the bridge may vary for several reasons. In the offing, the bridge may be manned by one person only, whereas when proceeding in a fairway in poor weather conditions, the helm may be occupied by a helmsman, a lookout, the first mate, the master and a pilot. Many vessels have regulations for the minimum manning of the bridge for different stages of the voyage or different conditions. However, the mere presence of these people is not enough; rather, the task sharing in different manning conditions should be clear as well. For example, a situation where the master is called to the bridge should not automatically result in a change in the current task sharing. The change in the task sharing should be communicated clearly when the change is deemed necessary and the task sharing is altered. Manning changes will pose a challenge for the definition of standardised task sharing. Usually, tasks cannot be preassigned to certain people; instead, the task sharing must be defined individually for each manning situation according to the "working roles". Because of this, the most important starting point is to identify which tasks should be assigned and which person is the best choice for each task in each manning situation from the perspective of efficient use of resources. The most important questions from the point of view of efficient resource management include:

1. Who has the best qualifications to carry out the task?
2. How can it be ensured that the task sharing is clear for everyone?

In functional task sharing models, the activities and responsibilities are clearly coordinated at least for the following operations:

- Steering and control of the manouevring area
- Positioning and choosing the course
- Confirming the positioning (monitoring)
- Monitoring of the traffic situation
- Planning for meeting with other vessels
- Lookout
- Communication with people outside the bridge (bow, aft, engine room, tugboats etc.)
- Communication with other vessels and the VTS centre

In other words, the task sharing is not only about the division of the tasks to be performed, but also about the monitoring activities. The task sharing for both the monitoring of the external operating environment and the checking of performed activities should be clear. In connection with task sharing, it is possible to define the ways that the group members can take part in the tasks and responsibilities of another group member. The monitoring of activities should be based on clear communication about the planned procedures and a clear way of expressing the occurrence of deviations if the procedures are not completed according to plan.

EXAMPLE ACCIDENT 3.

A vessel was on its way to port in hard wind conditions. Two tugboats were assisting the vessel. There were five people on the bridge: the master, the pilot, the staff captain, the chief mate and the helmsman. The master was steering the ship, while the pilot was taking care of communications with the tugboats, and the chief mate was observing the distance between the vessel and buoys from the other wing. The staff captain did not have a specific task. The master and the pilot had jointly agreed on the way to enter port.

They had decided to drive the vessel to port backwards. This failed, however, as the wind pushed the vessel off the passage. The people on the bridge did not detect the drifting of the ship, even though the electronic nautical chart would have shown it. In the dark, perceiving distances is optically difficult.

The investigation reported that the unclear task sharing on the bridge contributed to the accident. Although the bridge was sufficiently manned, the drifting of the vessel was not detected because the monitoring of positioning and wind direction from different devices was not clearly agreed upon, and the relevant information about the drifting of the vessel that was observable from the electronic nautical chart was not used.

In order to avoid unclear situations, changes in the task sharing should always be performed using a procedure based on standardised routines. Especially the responsibilities concerning the steering of the vessel should be confirmed by standardised call-outs. For example, the shift of steering from the wing to midship can be confirmed by using standardised call-outs: "steering to midship" (call-out by the person on the wing) and "steering at midship" (confirmation by the person at midship).

Workload Management

"Non-essential activity and distractions should be avoided, suppressed or removed."

"Tasks should be performed according to a clear order of priority."

"No member of the navigational watch should be assigned more duties or more difficult tasks than can be performed effectively." (STCW Section B-VIII/2, Part 3–1; 5.4, 5.5 ja 5.10)

Workload management is based on sufficient anticipatory measures, task-specific task sharing, the management of available time, the prioritisation of relevant activities and the effective resource management.

The amount of workload will differ during the operation depending on conditions. By anticipatory measures and planning it is often possible to shift part of the workload-increasing tasks from a recognisable heavy workload situation to be performed before the highest workload peak. In this way, the workload can be kept reasonable for human performance during the entire operation.

The pressure caused by high workload may often result in a person trying to perform several tasks at once. This will often, however, slow down the overall performance, as shifting one's focus and orientation between tasks takes time. Moreover, the number of errors will increase, as performing one task will have a negative impact on performing another. Because of this, it is important to structure the work in high workload situations in a way that the performance and the disturbances caused by simultaneous tasks are minimised. This requires active decision making concerning the order of performing the tasks and guiding the activities so that the tasks or their parts are performed one at a time.

The management of available time is a crucial part of workload management. Under time pressure, it may go unnoticed that it would be possible to gain more time to perform the task by suitable solutions, such as slowing down the speed, changing the route, or other solutions that are feasible in the situation. As the workload increases to a high level, the ways to gain more time to perform the tasks should become the focus of active consideration.

If no extra time can be gained to perform the tasks in the situation and the workload increases to a level that is too high for the situation, activities will need to be prioritised. This refers to active decision making about which tasks are the most important ones in the situation and which tasks can be disregarded. The collapse in performance caused by high workload and stress can be avoided by efficient prioritisation. Efficient resource management is the most central part of workload management in a teamwork situation. This includes the utilization of the personnel, equipment and the available information when handling the situation. Resource management is discussed in more detail in a separate chapter.

Checklists

"Companies should issue guidance on proper bridge procedures, and promote the use of checklists appropriate to each ship taking into account national and international guidance." (STCW Section B-VIII/2, Part 3–1, 4)

"The Company should establish procedures for the preparation of plans and instructions, including checklists as appropriate, for key shipboard operations concerning the safety of the ship and the prevention of pollution." (ISM Code Part A, 7)

"A description of the checklists and purpose of the specific items should be included in the Vessel Operation Manual." (MSC/Circ. 1061)

Checklists are used to ensure that the most important tasks in a situation are performed, thus minimising the risks caused by memory errors. Checklists are typically used after the preparation phase to ensure that all relevant tasks have been performed before the critical working phases. There are two kinds of checklists: a work list (so called read-and-do list) and a confirmation list (the so-called do-and-verify list). A work list refers to a list that guides the work and that is designed to be used as a memory aid as the work proceeds. Here, the worker will carry out the tasks while reading the list. Confirmation lists are used after certain working phases to ensure that the tasks that are the most critical and the most difficult to detect have been performed. Both kinds of checklists can be used either individually or in a team.

When using checklists, it should be defined who will request the list and when this will be done. Typically, the person requesting for the list as well as the person reading the list are defined, and the list will then be performed jointly.

A practice concerning work lists and confirmation lists for pre-departure procedures on the ship is described below. The operating model is based on the idea that each person has a work list guiding the procedures of his own area of responsibility, according to which the preparatory activities are performed. When the preparations are finished, the personnel will use the confirmation list to check the most central procedures. The articles in the confirmation list can be used to verify whether the activities based on the task lists have been accomplished.

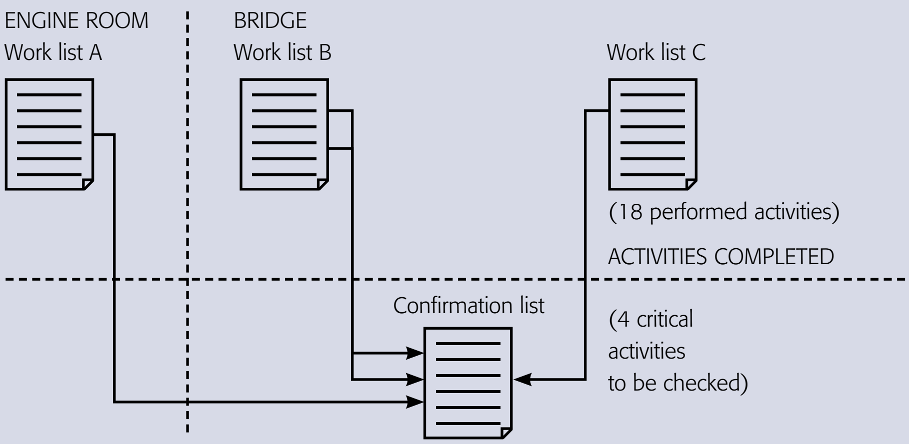
In terms of usability, the confirmation list should be short and concise so that it can be gone through at a single time without interruptions. The activities included in the work list may take a significant amount of time, but operations can be made flexible by a good task sharing and timing of the separate tasks, as the activities included in the different work lists are independent of each other.

PRACTICAL EXAMPLE 3.

Pre-departure checklists

In the example below, the vessel's pre-departure preparations include altogether 18 preparatory activities or checks that are performed in the engine room or on the bridge. These procedures are managed by work lists that can be reviewed by different persons. When the preparatory tasks have been completed, a confirmation type checklist will be read just before departure.

The confirmation list will then be used to check the most critical preparatory activities. This will be performed quickly; for example, the master will read aloud each item that needs to be checked according to the list, and the person who carried out the task will then confirm that the task has indeed been completed.



By using the described practice, it is possible to carry out the activities efficiently and with a clear task sharing. Moreover, the most important activities are checked twice.

Checklists can be applied to many different situations. ICS's Bridge Procedures manual includes examples of checklists and their contents. The manual provides examples of the checking of the following situations, for example:

- Preparing for departure
- Departure and arrival situations
- Initiation of piloting
- Moving from one navigation area to another, e.g. from the high sea to the archipelago, or from the archipelago to port area
- Special situations, such as anchoring, passing through ice, or towing
- Changing the lookout
- Abnormal and emergency situations

Using a checklist to support memory is an excellent way to avoid human memory errors, but its usability should be considered carefully when planning the list. List structures that are too heavy or impractical will easily lead to people ignoring the list. Moreover, the longer the list, the more likely it is to overlook an item included in it. The division to work lists which guide different activities, and to short and concise confirmation lists helps to avoid this problem. Work lists may be long if needed, and they also include activities that are not relevant for safety. Confirmation lists, on the other hand, only include issues that are critical for safety, and they are short enough to guarantee easy use.

Communications Practices

"Communications among members of the navigational watch should be clear, immediate, reliable, and relevant to the business at hand." (STCW section B-VIII/2, Part 3–1, 5.9)

"Terminology for standard Call-Outs should be developed by the Company and presented in the Vessel Operation Manual." (MSC/Circ. 1061)

Communications practices are standardised ways that are intended to convey information that is critical for safety among the personnel so that the risk of misunderstandings in communication has been minimised. Call-outs (short standardised words or word pairs) and standard phraseology (standardised ways of expressing critical messages) are the most common ways to avoid misunderstandings. Moreover, in a safety critical environment it is important that the sender of the message ensures that the receiver of the message has indeed received the message and understood it correctly. This is verified by a practice where the receiver indicates that he has received the message, and shows that he has understood it correctly by repeating the central contents of the message. In this way the sender may be assured that the communication was successful. This practice is referred to as closed loop communication (Figure 5).

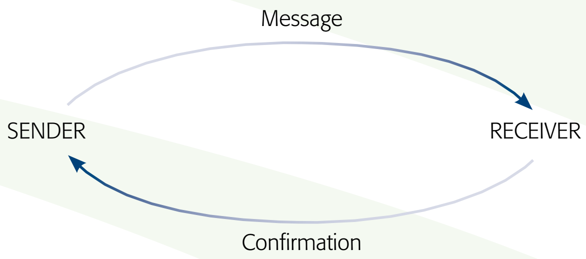


Figure 5. The closed loop communication principle

The need for standardised communication practices as well as suitable means of communication need to be defined separately in each operating environment and situation. Nevertheless, standardised communication practices should be utilised at least in the following situations:

- Situations that immediately affect the steering and the navigation of the vessel, such as
- Changes in the steering orders
- Speed changes
- Steering changes
- Changes in the level of automation
- Turning situations
- Yield situations
- Changes in roles and responsibilities, e.g. changing the officer of the watch, changing the lookout etc.
- When reporting sightings, e.g. of another vessel, a sea mark (especially on fast vessels)
- VHF traffic, e.g. VTS communications or arranging a meeting with another vessel (SMCP Standard Marine Communication Phrases)
- Certain communications with other groups on the vessel, such as deck groups (e.g. mooring and unmooring commands) and the engine room, and
- Other special situations, such as starting and ending pilotage, towing, assistance in ice conditions etc.

The starting point of a standardised message is to define the message and the following answer in a way that minimises the risk of misunderstanding. In practice, the most usual way is to repeat the entire message, which ensures that the receiver heard the message exactly as it was sent. Repetition is especially used in conveying messages that concern steering. These messages often include numerical values, the correct hearing and understanding of which can only be confirmed by repeating the contents of the message. On the other hand, standardised call-outs should not be too rigid, as this will increase the risk of not using them. Repeating the entire message is certainly not necessary in all situations. In situations where there is no risk of misunderstanding the action related to the request or a command, the form of communication can be a general acknowledgement like “ok” or “roger”, which will only confirm that the message has been received. Often, the communication chain also contains “two phases”. In the first phase, the command is conveyed and its reception is confirmed. In the second phase, the completion of the requested activity is reported and the reception of this information is confirmed, as in the example below (Figure 6).

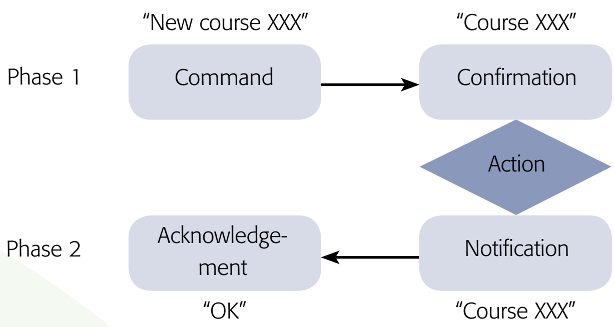


Figure 6. Communicating a helm order

Table 1 includes examples of the standardised call-outs used on the bridge.

The examples are not necessarily in use everywhere in the same form; there are many variations. Standardised call-outs are usually used in connection to the steering of the vessel, engine orders and VHF traffic.

”Steady as she goes”	Helm order ; directs the course at the time of command
”Full ahead”	Engine order; full speed
”Stand by bow and aft”	Message to the deck groups to start preparations for mooring or unmooring the vessel
”Untie the aft spring”	Command to untie the aft spring
”Steering to midship”	Notification of changing the vessel’s steering to midship
”Autopilot track mode”	Notification of setting the autopilot to track mode
”A vessel 10 to the right”	Notification of a detected ship 10 degrees right of the bow
”Port area”	Notification of moving into port area. This means that bridge operations are changed to correspond to a critical port area (manning, tasks, device and engine settings etc.)
”How do you read me”	A question in VHF traffic to find out about the coverage of the radio communication
”Steer ... degrees to make a lee”	The pilot is asking the vessel to make a lee
”Passing buoy number one”	VTS announcement of a required passing point (in this case buoy 1)

Table 1. Examples of call-outs in use

IMO's Standard Marine Communication Phrases is a good guideline for unifying communication in English.

Practices in abnormal situations

"The Company should establish procedures to identify, describe and respond to potential emergency shipboard situations."
(ISM Code, Part A, 8.1)

An abnormal situation may occur on the bridge for several different reasons. The reason may be an unexpected change in the vessel's course caused by the conditions, a mistake, and a malfunction in the bridge systems or, for example, an emergency on the ship caused by a fire. Clear procedural guidelines that include directions for the personnel's actions should be in place for the foreseeable abnormal situations.

In an abnormal situation, the workload usually increases temporarily to a high level, and there may not be much time to perform the tasks. For this reason, the procedures related to the management of abnormal situations should be especially clear and well rehearsed. This emphasises the need to define the operating procedures related to foreseeable abnormal situations, and furthermore, maintain the preparedness through training (see the section "Maintaining Preparedness for Abnormal Situations").

Procedures for abnormal situations can be divided into abnormal procedures and emergency procedures. An abnormal situation requires attention either immediately or soon, but it does not necessarily cause an immediate danger for safety. An emergency situation, on the other hand, demands immediate attention and immediate action to avoid damages. This distinction is important for the correct prioritisation of activities. If the operations are in a critical phase when the abnormal situation emerges (e.g. a device warning signal during a turn in a narrow passage), the activities related to the turn should be completed before attention is shifted to, say, a small device malfunction that has no effect on the vessel's steering and navigation capabilities. However, if the malfunction leads to a loss of steering in a corresponding situation, the actions leading to restoring the vessel's steering should of course be prioritised, and hence avoid drifting away from the passage.

Examples of abnormal situations include:
- Malfunction in the communications system
- Malfunction in a single navigation device
- Bout of illness (for someone who does not take part in the vessel's steering)

Examples of emergency situations include:
- Loss of steering capability
- Grounding
- Blackout

Procedures used in abnormal and emergency situations can be described in procedures whose form and structure should be as clear as possible for optimum usability. Similarly to checklists used in normal operations, the procedures for abnormal and emergency procedures can be documented in loose-leaf books or a laminated guideline kept in the working area (if the instructions cover only a situation related to a particular working area). The instructions can be encoded by a colour and content scheme to facilitate its usability (e.g. abnormal procedures can be kept separate from emergency procedures), and the contents can be classified by different situations and devices, which will help in finding the correct procedure.

Equally important to the availability and usability of the procedures is the principle underlying their application. Workload will increase in critical situations, and therefore the task sharing must be as efficient as possible in order to ensure sufficient resources both for the accomplishment of the procedures and their checking. Moreover, when the procedures are being defined, the persons responsible for the continuation of normal operations (e.g. steering, navigation) should also be defined along with those responsible for the initiation, performing and checking of abnormal procedures. It can be considered a general practice that the person in charge of the operations will give the order to initiate the procedures, after which one person will read the procedure from the abnormal (work list type of) checklist while another person performs the tasks. Going through the procedures in a coordinated way is ensured by using standardised communication related to the performance of the activities.

As mentioned before, the initiation of the procedures may require quick reactions to avoid grounding, especially in emergencies related to the steering of the vessel. In these situations there may not be time even to consult an abnormal checklist that is easily available; instead the procedures need to be initiated immediately. For these situations, the so-called "by-heart procedures" should be defined. There procedures are performed from memory immediately when the situation is noticed, and verified from the relevant procedure after their execution. These kinds of situations are not common, and they are usually related to the vessel's steering and navigation ability. The example below shows how the procedure would work in a situation where the vessel does not turn to the expected course due to a failure in the steering system.

PRACTICAL EXAMPLE 4.

Failure in the steering system

STEERING CONTROL FAILURE
MANUAL CONTROL..APPLY*

ENGINE EMERGENCY STEERING ....ENGAGE*
ANCHORING (if shallow water) ....PREPARE

If unsuccessful to gain steering control:
ANCHORING ....APPLY

In case of grounding, see TAB 5: "GROUNDING"

(Adapted from ICS Bridge Procedures Guide, 1998)

The first items in the procedure are marked with an asterisk (*), which means that they must be performed immediately by memory. After this, they are checked using the emergency checklist. Only those activities that are critical for time should be performed by memory. In practice, the above activities should be performed so that the person who is in charge of steering and who noticed the problem would report "steering control failure", after which he would perform or give orders to perform the immediate activities. After this, he would give the order "emergency checklist". At this point another person should take the emergency checklist and read aloud the tasks included in it step by step. While going through the first two tasks that have already been performed, the person responsible for these tasks would confirm the tasks to be completed ("applied", "engaged"). Following tasks would then be continued in accordance with the procedure. The procedure will also guide the user ahead depending on whether the situation can be managed by determined procedures or if it leads to a subsequent emergency (grounding).

When it comes to the procedures, the example is not perfect for the situation in question, and cannot be directly adapted to the bridge. Nevertheless, it can be used to show the form of the lists of emergency procedures and their central principles of use.

Maintaining Preparedness for abnormal situations

The ability to act in accordance with the procedures in abnormal and emergency situations requires that the situations in question are practiced regularly. In training, special attention should be paid to the use of the procedures and co-operation in abnormal and emergency situations, and not only to the technical understanding of the consequences of the procedures.

In addition to regular repetitive training, especially the knowledge of the most critical activities performed by memory should be ensured before each voyage. In practice, this will be accomplished so that one phase of the normal departure preparations should consist of going through the critical procedures in accordance with the corresponding task sharing. The procedures are not actually performed, but the necessary procedures are practiced, for example, by placing a hand on an emergency switch etc.

Summary

Error management is based on the detection of potential errors and the application of the procedures related to their management. The most important starting point for successful error management is to understand the critical phases in the operations, the potential errors related to them as well as their consequences. In this way, it is possible to develop procedures for checking the tasks relevant for safety and for avoiding errors. As human memory errors and slips can never be completely avoided, the routines on the bridge should be developed so that all errors are detected early enough. Different checking procedures are the most important part of the activities related to the detection of errors. As it is very unlikely that the same mistake is made at exactly the same time by several persons, the cross-checking of the critical activities is a central part of error management.

Co-operation and Resource Management

"Companies should also issue guidance to masters and officers in charge of the navigational watch on each ship concerning the need for continuously reassessing how bridge-watch resources are being allocated and used, based on bridge resource management principles such as the following." (STCW Section B-VIII/2, Part 3–1)

Resource management training was initiated in commercial maritime in the 1980's as Bridge Resource Management (BRM) training, which was based on Cockpit Resource Management (CRM) training developed in aviation. The training takes into account the fact that insufficient technical knowhow was not the problem underlying the accidents that were caused by a human error, but rather problems related to co-operation, decision making or leadership. Recent developments have expanded the point of view to also include co-operation between people outside the bridge. The aim of Maritime Resource Management training is to develop resource management for the entire operational system.

BRM training covers the limitations of human performance, the mechanisms behind human errors and the procedures for co-operation and resource management. An example of the topics included in the course is given below (Figure 7).

Content of the BRM course

The BRM course covers the following topics:

- Human Performance & limitations
- Attitudes
- Situational Awareness
- Cultural Awareness
- Communications and Briefings
- Authority & Assertiveness
- Challenge & Response
- Short Term Strategy
- Workload
- Humans and Automation
- Team State
- Error Management
- Leadership Styles
- Decision Making
- Crisis Management
- Crowd Management
- Critical Incident Debriefing

Figure 7. An example of the contents of a BRM course

Resource Management as Practical Activity

Resource management refers to the maximally efficient use of all human and technical resources in order to ensure safe and efficient operations. In practice, these resources refer to the skills and knowledge of the personnel, third party assistance, and technical devices, such as automation, that can be used both in workload management and as a source of information.

The management of these resources is an active process that is manifested primarily as communication between the personnel. In other words, communication is not only a part of resource management, but rather a tool for all sorts of resource management. In decision making situations, all available information cannot be used without interpersonal communication. Moreover, it is not possible to anticipate risks or maintain situation awareness if related information, observations or plans are not communicated among the personnel.

The aim of this application handbook is to describe how co-operation and resource management are manifested in operations. Resource management can be divided into different parts that each has their own co-operative goals. There are also clearly identifiable working methods in the personnel's operations that are aimed at achieving a certain goal. The four most important parts of resource management are described below (Figure 8).

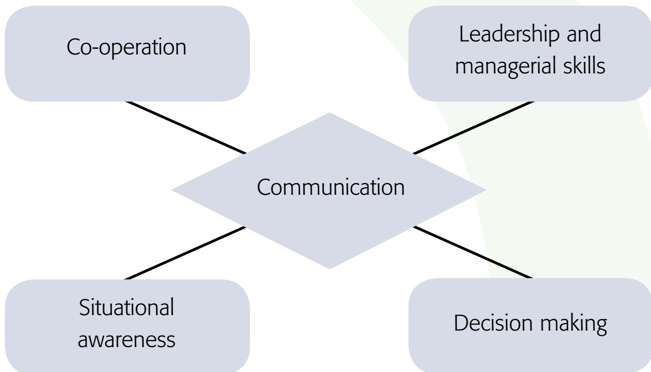


Figure 8. Parts of co-operation on the bridge

"Master should establish an open, interactive and closed loop communication style." (IMO, Model Course 1.22)

The first part of successful resource management is to support active co-operation, whose aim is to create an open climate for communication and a motivation to work towards a common goal. As a result, people will be more active in exchanging information, voicing their interpretations of different situations and potential deviations.

Another important part of co-operation is leading of a situation and a task. Efficient leadership is based on sufficient planning and anticipation, an effective task sharing and active direction of operations. For co-operation to be successful, all activities that are related to leadership should include active communication, which helps to ensure that everyone has a shared situational awareness of the planned activity and their roles in it.

The third part of co-operation, maintaining situational awareness, has often been mentioned in the investigations of hazardous situations in maritime. Situational awareness is mainly related to the positioning of the vessel, the conditions affecting operations and the status of devices and systems. From the point of view of resource management, the maintaining of situational awareness refers to an effective process of acquiring information from several sources in order to combine and analyse it to construct and maintain a realistic view of the situation.

The third part of co-operation is decision making. In decision making, resource management aims to produce the best prerequisites possible for making a safe decision by offering enough information, alternatives and risk assessment to support decision making. The decision making process will be manifested as communication during the different phases of decision making.

Several different practices that can be related to the aspects of co-operation mentioned above can be identified in the actions of different bridge staffs. These practices may also be grouped more specifically for each sub-part according to different aims. These practices are described for each sub-part in the following:

Supporting Co-operation

Co-operation is understood broadly as referring to all co-operative interpersonal activities on the bridge. Co-operative practices, however, refer here to the measures that are taken to encourage the personnel to report more actively about deviations and their observations, to be involved in other people's activities and to express their personal interpretations of situations. The following table includes examples of this (Table 2).

Practices related to the creation of a co-operative climate	**Examples of communication between members of the personnel**
Encourages to participate	"Let's look at it together."
Encourages to express one's opinion	"What do you think?" "Please tell me if you disagree."
Takes other people's comments into account	"Thank you for pointing that out."
Emphasises the group, not the individual	"So, have we done everything now?"
Takes other people's knowhow into account before taking action	"How would you feel if I handled this?"
Avoids personalisation of conflicts	"Let's focus on this problem here..."
Has a problem-solving mentality	"I think that these are the alternatives we have..."

Table 2. How a co-operative climate is reflected in communication

Leadership

"The crew are allocated duties and informed of expected standards of work and behaviour in a manner appropriate to the individuals concerned." (STCW Table A II/2 Organize and manage the crew, Criteria for evaluating competence)

Leading a task is one of the key parts of co-operation as far as operational safety is concerned. The significance of leadership is especially emphasised in situations where the workload on the bridge is increased along with the probability for errors on the personnel's part. Workload management is based on sufficient anticipatory measures, a task-specific task sharing, management of the available time and prioritisation of relevant tasks as well as correct allocation of resources. For example, by proper anticipatory measures and methodical re-assignment of workload it is possible to perform some of the workload-increasing tasks already before the workload peaks, and thus keep the workload reasonable for human performance during the entire operation. In high workload situations, the working situation is made more transparent by structuring the work carefully, minimising the number of unnecessary interruptions and making sure that there is enough time to perform the task without interference.

From the point of view of risk management, it is possible to take into account the potential risk factors affecting the operations early enough by using efficient anticipatory measures, and create a plan which the personnel can use to minimise the risks related to these factors or their effects. The following table (Table 3) includes leadership practices that describe how a member of personnel works.

Practices related to the leadership of a situation and a task	Examples of communication between members of the personnel
Discusses the upcoming situations	"We need to start preparing in a minute…"
Brings out factors affecting the operations	"At least those vessel's seem to become relevant in a moment"
Communicates plans and intentions clearly	"I thought that I'd slow down a little so that the vessel beside us can overtake us well before that turn"
Prepares for alternative methods of action	"If that vessel won't turn to the right before we get there, let's take…"
Uses all resources effectively	"Could you please use the VTS to ask if they know…"
Ensures a clear task sharing	"Confirm steering at midship?", "steering at midship"
Prioritises the issues that are operationally the most important ones	"Let's first put some distance between us and this place, and after that we can…"

Table 3. Practices related to management of personnel

Maintaining Situational Awareness

Situational awareness can be approached by considering which operative functions of the personnel it concerns. These functions are the positioning of the vessel, the conditions affecting the operations and the status of the devices and systems on the vessel or the bridge. As these three functions are different from each other, the procedures that are used to maintain situational awareness also fall naturally into three parts, as can be seen in the following table (Table 4). The situational awareness of the personnel, i.e. the forming of a realistic view of the situation, should not be seen only as a process taking place in the individual's mind, but rather as a product of communication between the members of the personnel. Even if everyone shares a common view of the situation, this will not be obvious before this common view is ensured via communication. The following includes a description of the practices related to the maintaining of situational awareness, including examples of the ways in which a member of personnel may act.

Practices related to the maintaining of situational awareness	Examples of communication between members of personnel
Anticipates the signs for positioning the vessel (Awareness of the vessel's position)	"Next we should see a buoy to the right."
Confirms the position of the vessel (Awareness of the vessel's position)	"We just passed..."
Confirms the position from several sources (Awareness of the vessel's position)	"We are now on this position according to the radar. Can you see..."
Introduces the threats to the operations in advance (Awareness of the conditions affecting the operations)	"Visibility is becoming worse." "The traffic on that part of the passage seems to be exceptionally heavy."
Collects information about the factors affecting the operations (Awareness of the conditions affecting the operations)	"Can you see anything on the radar that we should take into account?"
Communicates the choices concerning the use of devices (Awareness of the vessel's devices and systems)	"Changing to manual steering" – "You have manual steering."
Communicates the perceived changes in the status of the systems (Awareness of the vessel's devices and systems)	"Changing speed to seventeen." (Automatic activation of a pre-programmed change)

Table 4. Maintaining situational awareness and related communication

The role of the practices related to maintaining situational awareness is naturally emphasised in conditions that are the most challenging for navigation as well as other critical stages of the voyage, such as mooring or port operations. Therefore, there should be a clear change in the activity of maintaining and communicating situational awareness when a more challenging phase is entered. Likewise, as the margins for positioning are increased, it is natural that communication related to position will decrease, at least as far as active monitoring of position is concerned. It is difficult to define a critical minimum level for safety, but a starting point could be that all navigational procedures should always be communicated on the bridge to ensure that all members of the personnel maintain a shared view of the vessel's current movement.

When it comes to devices and systems, communication should primarily be concerned with the actions and choices that have an immediate impact on the reliability and safety of the operations. One can wonder why not communicate every action and choice that takes place on the bridge. While this approach is basically positive, it is not recommended because it includes the risk that when everything is verbalized the line between extremely significant and less significant information becomes blurred. As the members of the personnel limit the communication to the issues they personally deem relevant in any case, it is a challenge to achieve a unified communicational policy.

Decision Making

For decision making, the key question concerning co-operation is to use all available information for defining the problem, assessing alternatives and executing the decision, so that all the people involved in the operations remain aware of what is going on and for what reason. The co-operative principles related to decision making describe a process which is consistently used to achieve the best possible outcome for the situation with those resources that are available for decision making. From the co-operative point of view, decision making cannot be evaluated only with reference to the outcome, i.e. the safety and validity of the chosen course of action. The quality of the decision will naturally depend on the personnel's experience and knowhow to operate in the given situation. Co-operation and the decision making process itself may be apparently successful; however, a decision that is made based on insufficient experience and knowhow is not the best possible decision in terms of the requirements for the situation. A good decision making process is a means to ensure that the personnel is able to make sustained decisions that are the best ones possible considering the circumstances and their knowhow. The following table (Table 5) describes practices related to decision making, showing how a member of personnel works.

Practices related to decision making	**Examples of communication between members of personnel**
Defines the problem clearly	”The vessel isn't reacting to manual steering.”
Collects information to double-check the situation	”Could you also check..?”
Discusses alternative modes of action	”We can move straight ahead a little further, or slow down and...”
Encourages people to participate in decision making	”Can you think of other alternatives?”
Evaluates the risks included in the alternatives	”If we continue this way, we will come quite close to the shallows over there.”
Confirms the chosen course of action	”Okay, we will do so that...”
Assesses the effects of the decision and, if necessary, changes the plan by a new decision	”It seems that we may not be able to turn before that, so we can either...”

Table 5. Decision making and communication

Summary

Co-operation on the bridge is a central part of risk and error management. Efficient resource management is based on open communication, explicit leadership and coordination, active maintaining of the situational awareness and the use of all available information when making decisions.

Interpersonal communication is a prerequisite for efficient co-operation, and therefore all parts of co-operation, from planning to problem-solving, should result in communication between people. The amount and quality of communication is a good predictor of human error management on the bridge. Groups that communicate only little about the factors affecting operations will usually regard as surprising the factors that could be anticipated, which means that they end up making the decisions in these situations quickly and without proper consideration. This will increase the workload, complicate the maintaining of the situational awareness and increase the risk of errors.

Resource management is basically about the efficient use of the available information and workforce. In additions to the people present in the situation, information can be obtained by following the system displays or from external sources. Workload can be divided among the personnel, but it can also be assigned to the systems on the bridge by the proper use of automation, for example. Traditionally, the manning of the bridge is strengthened when the conditions become more challenging, but having more people on the bridge does not automatically result in improved safety. The task sharing should also be defined efficiently and clearly.

The group can function more efficiently and safely than an individual only when its resources are used efficiently. The aim of the practices described above is to ensure that this goal can be achieved.

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