The investigator-in-charge, role or profession?

Qualifications of the person who is responsible for the organisation, conduct and control of an investigation

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Preface

This thesis is the final project of the Delft TopTech postgraduate Management of Safety, Health & Environment course.

The research has been team-work of Thom Koning and Maurice Peters. We both work for the Dutch Safety Board (DSB). Thom as a senior investigator with a maritime background and Maurice as an investigator with an aviation background. The allocation of tasks during the research is depicted in section 2.6.

The audience for this thesis is anyone who is involved or interested in the field of accident investigation and especially those with a special interest in the field of multi-modal Boards. No prior knowledge of the subject is required.

We would like to thank the people who directly contributed support to the realisation of this thesis. Our coach John Kingston for his close support, with great devotion and enthusiasm, during the whole research process. Our supervisor Louis Goosens for the discussions we had together. Colleagues who were always willing to take part in discussions, interviews and meetings. Herry Klumper, Head Investigation and Analysis of the DSB, who made it possible for us to attend the course and write this thesis partly during office hours. Iep Visser, the managing director of the DSB, who made it possible for us to organise an international meeting with experts in the field at the head office of the DSB in The Hague. The experts, who participated in this meeting, and provided useful input for this thesis.

Special thanks as well to our families. Without the support of our partners Annemieke and Nicole, we were not able to complete the thesis in the way we did.

Table of contents

List of figures

Abbreviation list

AAIB	Air Accidents Investigation Branch
CCOHS	Canadian Centre for Occupational Health & Safety
DORI	defining operational readiness to investigate
DSB	Dutch Safety Board
DTSB	Dutch Transport Safety Board
EC	European Community
ESReDA	European Safety, Reliability & Data Association
ICAO	International Civil Aviation Organisation
IIC	investigator-in-charge
IMO	International Maritime Organisation
INERIS	L'Institut National de l'Environnement Industriel et des Risques
ITSA	International Transport Safety Association
KEI	knowledge, expertise and interests
KLM	Koninklijke Luchtvaart Maatschappij
MAIB	Marine Accident Investigation Branch
MAIIF	Maritime Accident Investigation International Forum
NND	norms, novelties and deviations
NRI	Noordwijk Risk Initiative Foundation
NTSB	National Transportation Safety Board
OECD	Organisation for Economical and Cultural Development
RAIB	Rail Accident Investigation Branch
RASCI	responsible, accountable, supportive, to be consulted and to be informed
SME	subject matter expert
STEP	Social, Technological, Economical and Political Assessment

Summary

A current discussion within multi-modal Boards concerns the qualifications of the person who is responsible for the organisation, conduct and control of an investigation. In the field of accident investigation this person is called the investigator-in-charge, abbreviated to IIC. As accident investigation has been growing from technical issues to include complex systems in society, the tasks of an IIC are not comparable with the early days of investigation.
In a multi-modal Board, management has the responsibility to provide the Board with investigation results obtained with state-of-the-art tools. To satisfy the Board, and in fact society, with accident investigation reports, management is facilitating the work of IICs. These IICs are preferably tasked to investigations in any domain, as this will enhance the operational readiness of the Board.

The central question of our research is to identify if the IIC is playing a focal role[1] or performing a profession[2] in accident investigation. For this research several methodologies were used; experience diaries, semi-structured interviews, mind mapping exercises, research of literature and a focus group meeting. The converging results of the respective methods were combined, which resulted in four high level themes for IICs:

- the IIC as the Board's means of meeting corporate-level requirements;
- the IIC as team leader;
- the IIC role in establishing/maintaining confidence and trust;
- the IIC as the administrator of the investigation process lifecycle.

It should be noted that the investigative tasks vary during the lifecycle of the investigation, making different demands on the IIC and the team. The scale of investigations also needs to be considered. In small scale investigations (with a team that does not include more than three members) the IIC needs to be a domain expert who has knowledge of and experience with the investigation life cycle. In the case of large scale investigations the focus on the required investigation skills of an IIC is more on controlling, conducting and organising different aspects, irrespective of the phase of the investigation cycle. Domain knowledge of the IIC is less required.

[1] A role is mostly defined as an expected behaviour in a given individual social status and social position. The functionalist approach, which is largely borrowed from anthropology, sees a role as the set of expectations that society places on an individual (Wikimedia Foundation, 2006).
[2] A profession is an occupation that requires extensive training and the study and mastery of specialized knowledge, and usually has a professional association, ethical code and process of certification or licensing. Examples are accounting, law, nursing, medicine, finance, the military, the clergy and engineering (Wikimedia Foundation, 2006).

In our research it became clear that the IIC presently plays a focal role in the accident investigation. Accidents will be more and more complex due to the interconnection of systems. These developments have an impact on the requirements of the IIC. The IICs will be charged with complex accident investigations.
According to our opinion the approach to complex system accident investigation indicates that the function of IIC is not just a focal role to be fulfilled but is developing into a profession. Within the Dutch Safety Board (DSB) so far the function of IIC has been considered more as a role instead of a profession.

By defining it as a profession people can grow to become managers for complex investigations if they are given the right challenges, study and mastery of specialized knowledge, extensive training and development into specialised skills dedicated to professional accident investigation.
This thesis ends with five recommendations for the international community of multimodal Boards, organised in the International Transport Safety Association (ITSA) and its individual member, the DSB:

- As a multi-modal Board, the DSB should focus on the five specific domains health services, transport, energy, food and water supplies, information and telecommunications as mentioned by the Organisation for Economical and Cultural Development (OECD) report for preparing IICs for the accident investigation in complex systems.
- In realising the complexity of the various domains a multi-modal Board, and the DSB in particular, should establish investigators as focal point for one or maximum two specific domains to establish confidence, trust and ongoing accident investigation(s) in the particular domain.
- The International Transport Safety Association (ITSA) should initiate the development of an international recognised training program in which investigators can professionalize their skills. This will need to develop criteria around which to organise the training. Some of the required competencies are known, others are more subtle and harder to analyse and further research may be needed to elaborate criteria for these.
- It is recommended that the training programme should recognise subsequent grades of investigator, starting with grade 1 'developing investigator' and leading to a, for example, grade 5 'senior investigator' with the competency to lead and manage a major investigation.
- The DSB is recommended to invest further in the development of criteria and training of investigators tasked to be IIC in order to achieve and maintain operational readiness.

The contents of this thesis reflect our thoughts and although similarities might arise between the DSB and this thesis they do not necessarily reflect the opinion of the Board or the individual members.

This chapter starts with a description of the motive for research. Next the objective will be given, including the thesis question and the limiting conditions and starting-points. The chapter will be concluded with a description of the structure of the thesis.

1. Introduction

1.1. Research motive

In February 2005 the transformation from the Dutch Transport Safety Board[3] (DTSB) to the Dutch Safety Board[4] (DSB) took place. This implied a change of law, but also another structure for the bureau. The DTSB, which had existed for seven years, was divided in five sectors ('chambers'), each working with their own investigators, with respective domain expertise.

The new DSB enlarged to ten sectors. The Board did not receive funds to double the number of investigators and during the development of the DSB, management made the decision that investigations in the new domains have to be executed by either domain experts from the pre-existing transport sectors with limited knowledge of the new domains or newly hired 'generalists' with no special accident investigation skills. As they all have to investigate in unknown environments, methods are needed to guarantee the progress and quality of the investigation process. These elements, such as project management and investigation techniques, are continuously reviewed and further developed to enhance the quality of investigations.

As part of the process to set-up the DSB, research was conducted to describe the basic principles for a multi-modal Board[5]. This research of the E.M. Meijers Institute (Leiden, the Netherlands) has been published as 'Beginselen van behoorlijk rampenonderzoek', (Principles of reasonable disaster investigation). Although biased by a jurisdictional viewpoint, this work has served as one of the guiding principles for our thesis. The following fundamental principles are stated as 'principles for reasonable disaster investigation' (Hallers, e.a., 2002, 237-238):

- Independence;
- The separation between the question of guilt and the question of cause;
- Public;

[3] Chambers (5): rail, shipping, aviation, road transport and pipelines.
[4] Sectors (10): rail, shipping (inland and marine), aviation, road transport, industry, pipelines and energy net, construction and services, defence, health care, water (environment) and crisis control.
[5] Multi-modal Board: a board established by law, executing accident investigations in more than one sector.

- Hear both sides;
- Careful;
- Expert knowledge;
- Proportionality and subsidiarity;
- Fair treatment of witnesses and parties involved;
- Motivation;
- Completed within a reasonable time.

Those fundamental principles will be explained in appendix A.

These 'principles for reasonable disaster investigation' are based on research into several Boards and interviews with many key figures in the field of accident investigation. These principles do reflect the goals and working of the Board as a whole. Like other studies we looked at, COT (2004), Bos (2001) and RAND Europe – Leiden (1997), these principles do not describe the actual process of investigation or the necessary skills and tools for the investigators to fulfil their tasks.

To have a closer look at these tasks, we used the investigation process of the DSB to describe the ideal situation regarding a multi-modal Board where the most important resource, the existing workforce, can be used as flexibly as possible, subject to people's qualifications and individual experience.
Our research on this part of the investigation, did not focus on the Board as a whole but on the investigators working for the Board. It brought us to another guiding principle for our thesis, the 'Operational Readiness to Investigate'. In the DORI[6] white paper, published by the Noordwijk Risk Initiative Foundation, readiness to investigate requires that people work with equipment and procedures within an environment that is conducive to good performance (NRI Foundation, 2005, 5).

Another identifiable element in accident investigation is the development from 'classical' technical accident investigations to investigations into complex systems. The changing context of accident investigation will need to be reflected in the skills required of an investigator-in-charge (abbreviated to IIC[7]), the individual responsible for the organisation, conduct and control of an investigation.

The new fields of activities for the multi-modal accident investigation Board coupled with the requirement to investigate in this context of complex systems, challenged us to search for the set of identifiable necessary elements to qualify the IIC.

In parallel with this thesis, we were charged with developing a conceptual design for an investigation manual for the DSB. This internal manual is intended as a document for IICs and will give an outline of the processes, the roles and possible fact finding and analytical methods which can be used during the investigation life

[6] DORI = Defining Operational Readiness to Investigate.
[7] In this thesis the definition according to the 94/56/EC (Council Directive) is used. The IIC is a person charged, on the basis of his qualifications, with responsibility for the organisation, conduct and control of an investigation.

cycle. The development of this manual and the research for this thesis had various links which were useful to focus on.

1.2. Objective of the investigation

On the basis of a general look at the founding and establishment of a safety Board, the accident investigation life cycle, aspects as culture and organisational learning and the different types (referring to experience and education) of an IIC, we analysed which factors determine the qualifications of the person who is responsible for the organisation, conduct and control of an investigation.

The research started as an investigation into the question 'should an IIC be a domain expert, a generalist or an investigation manager?' During our research we considered this 'concept' thesis question and our research results. The research is a reflection of the question, 'The investigator-in-charge, role or profession?'.

First we will define role and profession:

A role is the expected behaviour attached to that position. It is mostly defined as an expected behaviour in a given individual social status and social position. The functionalist approach, which is largely borrowed from anthropology, sees a role as the set of expectations that society places on an individual (Wikimedia Foundation, 2006).

A profession is an occupation that requires extensive training and the study and mastery of specialized knowledge, and usually has a professional association, ethical code and process of certification or licensing. Examples are accounting, law, nursing, medicine, finance, the military, the clergy and engineering.

In modern usage, professions tend to have certain qualities in common. A profession is always held by a person, and it is generally that person's way of generating income. Membership in the profession is usually restricted and regulated by a professional association. Hence, professions also typically have a great deal of autonomy, setting rules and enforcing discipline themselves. Professions are also generally exclusive and require rigorous training and schooling beyond a basic college degree. Lastly, because entrance into professions is so competitive, their members typically have above average mental skills (Wikimedia Foundation, 2006).

The general guiding principle of the E.M. Meijers Institute (Hallers, e.a., 2002) and the 'Operational Readiness to Investigate' (NRI Foundation, 2005) principle were combined. As is common in working environments, people are supplied with necessary procedures (tasks) and tools to get the job done in a certain context. This threesome has to match; otherwise the results will not be the maximum possible. This means that;

- the right people

- are in the right place
- at the right time
- working with the right hardware
- according to the right procedures and management controls.

The operational readiness of the organisation is vital when we look at organisations as (transport) safety Boards, as they are in the spotlight when accidents occur. If we consider this vital, the work processes, the investigation tools, the people and the working environment within accident investigation should be properly described. In describing the various elements management obtains valuable information for controlling the phases of the accident investigation life cycle.

The methodological knowledge developed through decades of investigation has not produced a 'one-almighty-tool' to solve all kinds of investigations. Depending on the size of the accident, the 'client' (justice, civil court, internal organisation, society as a whole, etc.) and the sector (i.e. the users of the results), all kinds of tools and skills are available, but not always applicable. As seen in figure 1, the skills and tools map (Kingston, 2005, 9) shows a variety of possibilities. The mastery over all of the skills and tools forms the basis of being able to rise above limited sector-specific knowledge and skills.

In establishing the skills and tools map, the investigation life cycle and secondary processes for the working environment (funds, safety, health, environment, business control, etc.), procedures and hardware are considered. To get the right people at the right time during the investigation life cycle is a responsible task for management as well as the people involved in an investigation. This thesis seeks to identify those elements which constitute the right people in the right place at the right time.

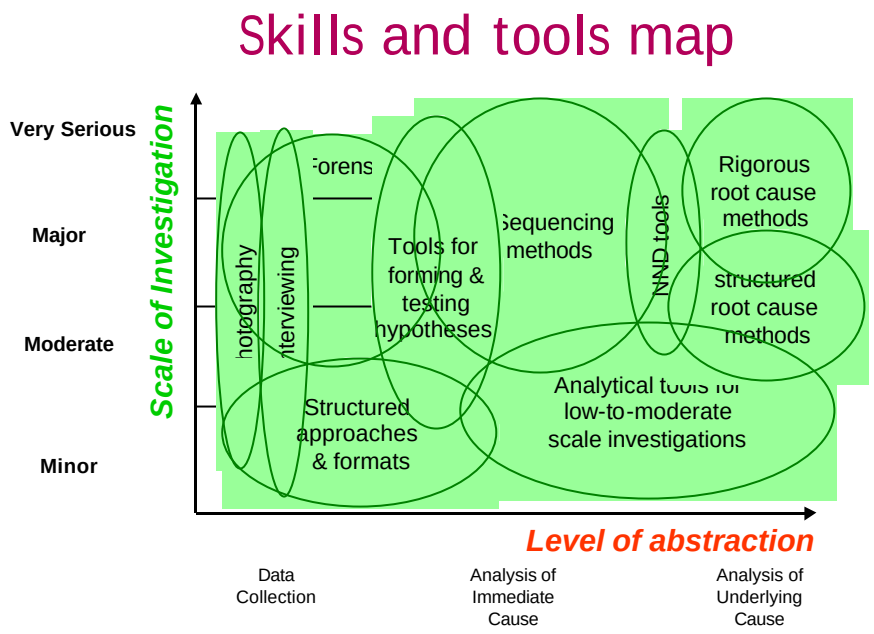


Figure 1: Skills and tools map.

1.3. Structure of the thesis

The research methodology will be described in chapter 2. Chapter 3, entitled 'Developments', starts with a view of the establishment of a Board considering uni and multi-modality. The chapter continues with a description of the investigation life cycle, the history of accident investigation and the subjects culture and organisational learning. Chapter 4 focuses on the focal role of the IIC in investigations. Four themes for IICs will be defined and the differences and similarities between a uni-modal versus a multi-modal Board, regarding those themes, will be discussed. Next the IIC profile will be discussed and assessable criteria for IICs will be determined. In the concluding chapter 5 an answer will be given to the thesis question and in chapter 6 recommendations will be made.

This chapter gives an overview of the methods of research used. By choosing five separate approaches we have as much as possible created an objective view of the thesis question.

2. Research methodology

Part of our research was to establish the right methodology to get an answer to the thesis question. The thesis is part of a study for a masters' degree, in which aspects of safety, health and environment and the impact on organisations are considered. These aspects reflect on strategy, culture, organisational learning, but also on personal skills and motivation, investigation into accidents, management skills and system approach.

Our research methodology is based on these aspects, and divided in several subsets to consider the various factors and to obtain an objective view.
Part of the research is depending on experience in the field of accident investigation. As there are various circumstances in which Boards are established and demands can vary, we obtained information by interviews and expert views. Multi-modal Boards, especially those which cover a variety of sectors, have a tendency to regard themselves as unique, regarding the processes and their role in society as a whole. To maintain objectivity it is necessary to have a look at other organisations. For the investigation processes we looked at other governmental bodies, especially the National Audit Office.
The literature search was based on the direction of the masters' study and on key words obtained during the interviews.
Finally we established a focus group to provide us with possible missing links in our research.

2.1. Review of own experience

As researchers we are biased by our own experience. This will influence the objectivity if it is not properly dealt with. We envisaged our own view, biased as it is, emerging from more than 10 years experience in respectively air accident investigation and maritime accident investigation in different settings and functions. Our accident investigation experience is based on working in various environments. Maurice Peters worked as an investigator for KLM Royal Dutch Airlines before joining the DTSB. Thom Koning worked as an investigator for the Dutch Shipping Inspectorate and the Dutch Maritime Board of Inquiry before joining the DTSB. Our own experience diaries and an example of the KEI-matrix[8] are depicted in appendix

[8] KEI- matrix, an Excel-sheet with the available knowledge, expertise and interests (KEI) of employees of the DSB.

B. From these diaries we considered the main aspects and compared them, via the actual KEI-matrix of the DSB, with the experiences of our colleagues. The results of this comparison were used for the semi-structured interviews and mind mapping exercises.
We preferred to use the experience diary as it is easy to learn from each others background and to combine main issues.

2.2. Semi-structured interviews

Semi-structured interviews were held with several colleagues in different positions and at all levels within the DSB. We interviewed investigators, IICs, secretary-writers[9], management and members of the Board.
During the interviews we had a list of themes and questions (see appendix C) to be covered, although these varied from interview to interview, depending partly on the answers and partly on the position of the interviewee. They varied as well during the investigation, because the thesis question was refined during the process of research. The order of questions varied per interview depending on the direction of the conversation. Data was recorded by note-taking.
The interview results were used for three mind mapping exercises, to focus on the following subjects:

- the main issues of an accident investigation;
- the role of the IIC;
- the risks an IIC might encounter during the execution of an investigation.

2.3. Mind mapping

We used mind mapping exercises to establish the focus on the issues to be considered. Each mind map represents words and ideas which could be linked to the key word. In the first and second exercise, *quality of investigation* and *the role of the IIC* were the key words used. The third mind mapping was centred around the *risks* an IIC might encounter during the execution of the investigation life cycle. See appendix D.

The results of the mind mapping exercise regarding the *quality of investigation* have been used for a graphical depiction of the investigation life cycle (see figure 3 on page 22) and a description of it (see appendix E). The results of the exercise on *the role of the IIC* have been used in chapter 4 to determine the IIC profile. The results of the third mind-mapping exercise have been used in paragraph 4.5.2, 'The IIC as team leader'.
We chose the mind mapping method in order to get a clear connection between the various items arising the thesis question. Especially in the early stage of our research it was useful for structuring our work.

[9] A secretary-writer is responsible for communication, reporting and advice within a specific sector.

2.4. Literature

For this thesis a search was performed into literature.
During the postgraduate Safety, Health & Environment course we were introduced to several items as strategy, culture and organisational learning. These introductions were accompanied by lists of literature of the most relevant authors, and directed us to several other researchers on the issues related to this research. The focus group meeting (see section 2.5), the interviews we held during the investigation and the libraries of the Technical University Delft and the DSB provided us with relevant literature as well.
The literature search resulted in a list of useful literature which is depicted in the reading list.

2.5. Focus group

Because insufficient literature was found to provide context to answer the thesis question, a special focus group[10] was established. We assembled an international panel of eight leading experts in the field of accident investigation. The focus group of leading experts consisted of:

- Carolyn Griffiths (Head of UK Railway Accident Investigation Branch, UK);
- Graham Braithwaite (Director of the Safety and Accident Investigation Centre, Cranfield University, UK);
- Henk Zieverink (Senior secretary writer, Dutch Safety Board, The Netherlands);
- Jean-Christophe Le Coze (INERIS, L'Institut National de l'Environnement Industriel et des Risques, France);
- John Kingston (The Noordwijk Risk Initiative Foundation, The Netherlands);
- John Stoop (Safety Consultancy KINDUNOS, The Netherlands);

[10] A focus group is a form of qualitative research in which a group of people are asked about their attitude towards a product, concept, advertisement, idea, or packaging. Questions are asked in an interactive group setting where participants are free to talk with other group members (Gibbs, 1997). Focus groups are an important tool for acquiring feedback regarding various topics. Focus groups have a high apparent validity, since the idea is easy to understand, the results are believable. One can get results relatively quickly, and they can increase the sample size of a report by talking with several folks at once (Marshall and Rossman, 1999, 115).

However, focus groups also have disadvantages: The researcher has less control over a group than at a one-on-one interview, and thus time can be lost on issues irrelevant to the topic; the data are tough to analyse because the talking is in reaction to the comments of other group members (Gibbs, 1997); observers and moderators need to be aware of this.

- Martti Heikkila (Vice President, Maritime Accident Investigation International Forum, investigator-in-charge, Accident Investigation Board Finland (Onnettomuustutkinta), Finland);
- Sidney Dekker (Professor of Human Factors and System Safety, Director of Research, Lund University School of Aviation, Sweden).

First we sent the experts a tentative draft of our thesis, accompanied by a list of propositions (see appendix F), made after our first findings and related to the chapters in the draft. We requested comments on the draft and to offer their opinion on the propositions during a meeting, which was organised by us at the office of the DSB in The Hague at May 15th 2006. Based on the written comments we received, the thesis question was refined and the structure of the draft was reorganised. The number of propositions was reduced to three (see appendix F). The aim of the propositions was to provide a focus for discussion. During the focus group meeting the IICs (project leaders) of the DSB were invited for a part of the programme to participate in group discussions. The experts and the IICs were split up in three groups; each group discussed all of the three propositions. These discussions were finished with short presentations for the whole group.

During the meeting we arranged the qualitative research with the experts with us as dual moderators. One moderator to ensure the session progressed smoothly, while the other ensured that the main topics were covered. This was done to limit the disadvantages of the focus group. When the group was split up in three groups for discussions, a colleague analyst moderated one of the groups.

To find connections between the data which was derived from the focus group meeting we clustered the data. This was done by two members of the focus group and the present authors. First a list was made of subjects that emerged from the several discussions. Next, each subject was linked to one or more themes and we put all this data in a matrix. This matrix was subsequently converted into a graphical display to get a picture of the connections between the different themes. Next the themes were clustered in four groups. The matrix with the results of the clustering and a radial tree with the four theme groups are depicted in appendix G.

Finally conclusions were drawn, based on the converging research results of the different resources.

2.6. Allocation of tasks

This research has been team-work of Thom Koning and Maurice Peters. For the different chapters of this thesis the responsibility has been set up as follows:

Chapter		Responsible
1.	Introduction	Together
2.	Research methodology	
2.1	Review of own experience	Together
2.2	Semi-structured interviews	Maurice

2.3	Mind mapping	Thom
2.4	Literature	Together
2.5	Focus group	Together
3.	Developments	
3.1	Uni-modal Board versus multi-modal Board	Maurice
3.2	Life cycle of accident investigation	Thom
3.3	From classic to state-of-the-art accident investigation	Maurice
3.4	Culture	Thom
3.5	Learning organisation	Thom
4.	The IIC as the focal role in investigations	Together
5.	Conclusions	Together
6.	Recommendations	Together
Appendix A		Maurice
Appendix B, C, D		Together
Appendix E		Maurice
Appendix F		Thom
Appendix G		Together
Appendix H, I		Thom

This chapter is focussing on the perspective of investigation. This perspective is influenced by political choices and international obligations. A Board will develop strategies for accident investigations given the context of its environment.
Attention is given to the life cycle of accident investigation and to aspects of investigation, culture and learning organisation as strategic choices of the Board. The management has to translate these strategic choices to goals, scenarios and measurable results. All these aspects eventually have an impact on the qualifications of an IIC

3. Developments

3.1. Uni-modal Board versus multi-modal Board

Establishing a Board is determined by the outcome of several political strategies. Major disasters can cause a movement to an overall Board. The diversity of the domains can also lead to an uni-modal Board[11] or Boards investigating transport accidents only.
Depending on these political strategies, each strategy being part of a political movement in a specific country, they can be translated to constraints, directives but also to choices based on democracy.
An accident investigation Board, established by law, will develop strategies depending on these choices, influenced by constraints such as available funds and personnel.

A closer look will be taken at the factors that influenced the establishment of a uni-modal Board, the Rail Accident Investigation Branch (RAIB) in the United Kingdom, versus a multi-modal Board, the DSB in the Netherlands. The consequences of making the choice for one or the other, particularly for the role of the IIC, will be discussed as well.
In establishing the RAIB (equivalent to the AAIB[12] for air transport and MAIB[13] for maritime transport) a thorough mapping was made of possible accident investigations and the respective required investigators. To carry out its investigations the RAIB has appointed and trained inspectors recruited from the railway industry and other investigating bodies. They are experienced, have a broad mixture of skills across the railway industry and have been trained in investigation techniques.

[11] Uni- modal Board: a board established by law, executing accident investigations in one sector.
[12] Air Accidents Investigation Branch.
[13] Marine Accident Investigation Branch.

The DSB, although doubling the number of sectors, but limited by her funds, more or less has to rely on the existing experience in the transport sectors. A mapping was made of possible accident investigations in the new sectors. As a result eight new collegues with experience as project managers, experience in certain sectors and academic research experience were added as coming IICs. The new collegues did not have particular expertise in accident investigation.

These developments reveal several important issues. Due to political context choices are different. Also budget claims vary and as a result the RAIB can invest more into training investigation skills and preparing the bureau. On the other hand the DSB is relying on third parties for the technical part of investigations. This will reflect the training and background of the workforce, as the emphasis for the IIC in the DSB context will be focussing on the process and organisation of the investigation, not the technical skills of the particular domain.

Both Boards however will have a strategy aiming to reach state-of-the-art safety investigations. Both Boards also will have to cope with EC directives. The RAIB has the advantage to deal with the rail aspects only. The diversity of a multi-modal Board needs clear and precise descriptions of tasks, responsibilities and accountabilities as it has to deal with several different EC directives and supra-national established resolutions (f.e. ICAO[14], Annex 13 and IMO[15], Res. 849).

The RAIB and the DSB have two things in common. They are established by law and they investigate to find causes of serious incidents and accidents and issue safety recommendations aimed at improving public safety to responsible organisations. The accident investigation life cycle for this process can be regarded as a common feature as will be explained in the next paragraph.

3.2. Life cycle of accident investigation

Understanding failure requires several steps, starting with establishing the precise sequence of events (expressed in specific accident scenario descriptions), identification of specific failure mechanisms and the development of scientific evidence in the explanation of the failure mechanisms. Understanding failure provides a basis for intervention in the characteristics and conditions, eliminating deficiencies in the system design and operation. Accident investigation is a critical instrument in this concept, dealing with a fact-finding phase before analysis, drawing up of recommendations and implementation of systemic changes may take place (ESReDA, 2005, 12).

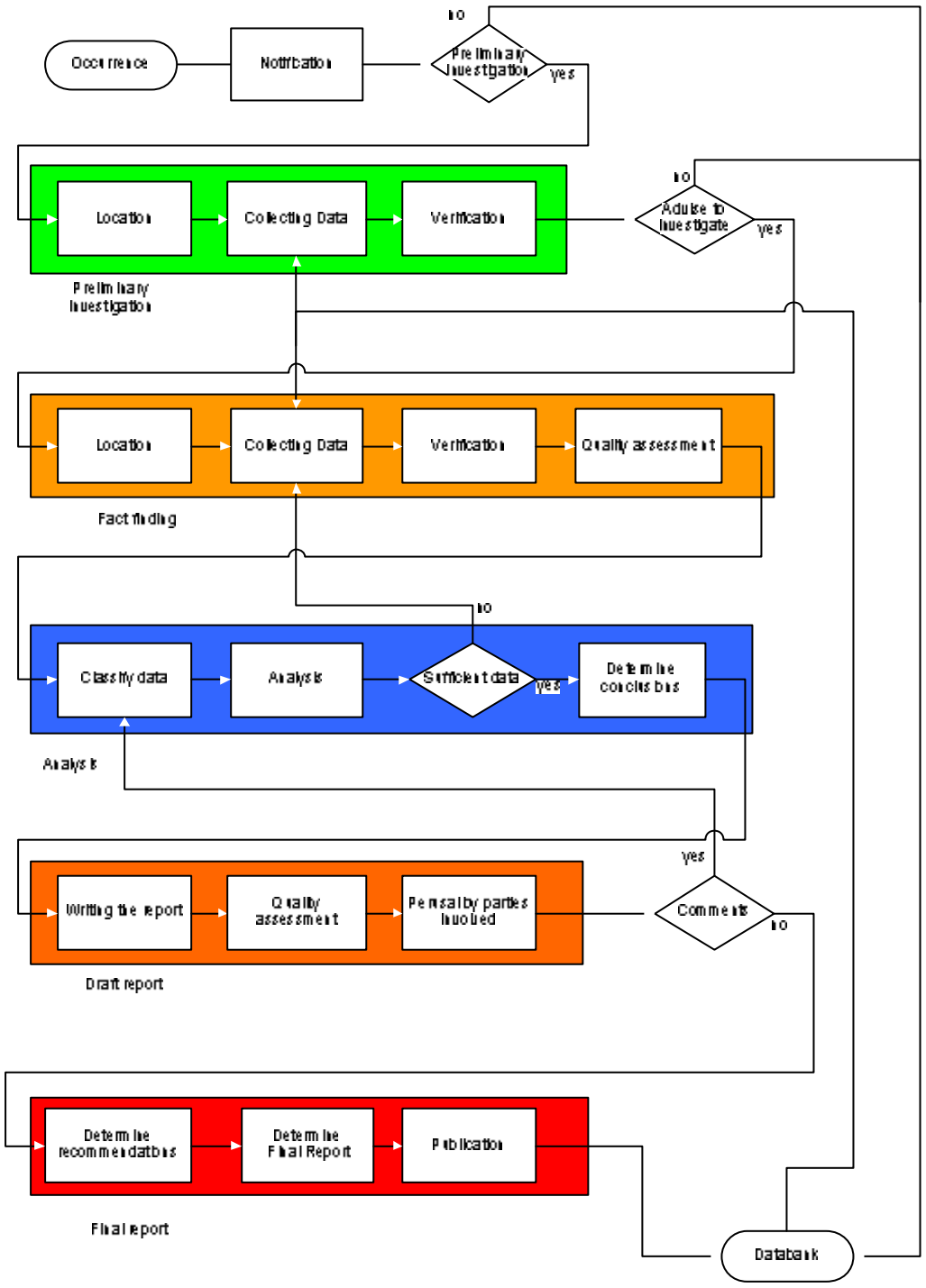
[14] International Civil Aviation Organisation.
[15] International Maritime Organisation.

In general (and simplified) the process of an accident investigation (see figure 2) consists of the following steps[16]:

- initiation;
- fact finding;
- analysis;
- reporting;
- follow-up.

There are different ways to map the investigation life cycle. Because investigations normally are carried out in a limited time frame and most Boards aim to finish investigation reports within one year, it is relatively easy to translate the investigation life cycles to investigation projects. In several Boards these projects will be part of a programme, based on the strategy the Board has developed. The programme management is tasked to management. Every individual investigation into an accident and also thematic safety studies will be part of the established programme, managed by a project leader responsible for the investigation life cycle, the earlier mentioned IIC. When the process is mapped as presented in figure 3 it is necessary to be clear about the responsibilities in the investigation. By using the RASCI chart[17] (Nieuwenhuis, 2003) it is relative easy to map the parties involved (see example appendix H).

[17] RASCI = abbreviation for Responsible, Accountable, Supportive, to be Consulted and to be Informed.


Occurrence
Notification
Preliminary Investigation
no
yes
Location
Collecting Data
Verification
Preliminary Investigation
Advise to Investigate
no
yes
Location
Collecting Data
Verification
Quality assessment
Fact finding
Classify data
Analysis
Sufficient data
no
yes
Determine conclusions
Analysis
yes
Writing the report
Quality assessment
Perusal by parties involved
Draft report
Comments
no
Determine recommendations
Determine Final Report
Publication
Final report
Databank

3.3. From classic to state-of–the-art accident investigation

Over time the transport and all other possible areas of accident investigation have seen an extensive development in techniques. The aviation industry with dependable systems expanded in only decades. If we focus on health care, the most sophisticated instruments and computer aided surgery are used.
In this world of ever improving and therefore specialist techniques, the attention will be drawn to the increasing interconnections of systems. The Organisation for Economical and Cultural Development (OECD, 2003) in their 2003 report "Emerging Systemic Risks in the 21st Century: an agenda for action", highlighted the interdependence of systems and the increasing potential for disasters. These disasters can cause big commotion and even damage the trust[18] in the Government, the entity primarily responsible for social security. To cope with the social commotion and reduce the chance of repetition, independent[19] accident investigations into the causes of disaster are a necessity.

The accident investigation can be limited to the sole area of technique, or the company in which it is operated, but this leaves several topics (such as human factors, rules and regulations and change management) unaddressed. Accident investigation will be more and more the quest for answers about accidents in a complex environment with many actors.

Rather than an increased focus on failure, the challenge may lie in clarifying the systems mode of operation for operators, managers, regulators and designers during regular operations as well as during emergency and crisis situations.
This evolution of accident investigation can be identified in the Netherlands if we look at the investigation into the Bijlmermeer disaster (Netherlands Aviation Safety Board, 1994) which focussed on technical issues compared with the investigations into the Enschede firework disaster (Commissie onderzoek vuurwerkramp, 2001) and the Volendam pub fire (Commissie onderzoek cafébrand nieuwjaarsnacht 2001, 2001). Within ten years the focus of investigations in the Netherlands had broadened to include organisational issues and system characteristics.

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[18] Trust in sociology and psychology refers to an open, positive relationship between people, or between people and social institutions such as a corporation or government. More specifically, trust is the belief by one person that another's motivations towards them are benevolent and honest (Wikimedia Foundation, 2006).

Dr. Duane C. Tway, Jr. in his 1993 dissertation, *A Construct of Trust*, defines trust as, "the state of readiness for unguarded interaction with someone or something." He developed a model of trust that includes three components. He calls trust a construct because it is "constructed" of these three components: "the capacity for trusting, the perception of competence, and the perception of intentions."

[19] Independent in this context means not dependent on another institution, government or equivalent, expressed in formal law (Hallers e.a., 2002).

The 'classic accident investigation' mainly focussed on technical failure. This 'classic' approach revealed many technical failures unaddressed. But the more technical issues are accounted for and improving techniques and design and research deal with 'problematic' items such as aging of material, the less accidents should happen. As practice made clear, and research learned that investigation could consider more than technical issues, a focus on human factors was established. This established other latent failures, and accident investigation focussed on items such as training, resource management and situational awareness. Alongside these developing techniques the technical part of investigation remained, leading to a more holistic approach, in the sense that (*ESReDA, 2005, 19*):

- Safety is growing into an umbrella concept; it covers a wide variety of aspects, like technical-, external- and social safety, rescue and emergency and working conditions. It is considered as a concept of 'integral' safety;
- Safety is considered a systems characteristic and a system performance indicator. A shift in focus is occurring from the accident as a unique phenomenon to a managerial systems characteristic;
- A shift in performance indicators (from quantifiable and detailed standards into functional demands), which requires a change in (safety) management strategies from all stakeholders towards control over their primary processes, taking safety into account as a decision making aspect at strategic, tactical and operational levels.

This holistic approach to safety investigations will have a direct effect on the strategy, mission and vision of the DSB. The strategy will be translated to goals, scenarios and measurable results using critical succesfactors[20].

The Treaty of Chicago, Annex 13 and the EC-directive[21] offer a basic framework in which investigation of disasters should take place. Due to the direct applicability of those international legal and supra-national obligations, safety investigation of accidents has to comply with the elements outlined in this Treaty and the directive. On the basis of this Treaty the relevance of certain principles can be verified (Hallers e.a., 2002, 28):

- Description of the situations for which the accident investigation is applicable;
- Requirement to investigate (according EC-directive);

[20] Critical succesfactors: essential factors for surviving and success (Nieuwenhuis, 2003, 24).

[21] The Council Directive 94/56/EC of 21st November 1994 contains the legal requirements for investigating air accidents in the Member states. The directive requires as a mandatory prerequisite for an investigation executed by a body, which is independent of the regulatory body for aviation. Apart from this principle, the different requirements follow the rules set out by the Chicago Convention on Civil Aviation, Annex 13, which is regularly reviewed by the ICAO.
In the period of writing this thesis the EC is drawing up directives for rail accident and maritime accident investigation, based on the EC directive for air accident investigation and other applicable obligations.

- Independence;
- Public;
- Separated from other investigations.

In this context there are some differences between a uni-modal Board and a multi-modal Board in their approach to the accident investigation.
The main difference between a uni-modal and a multi-modal Board is the scope of activities concerning the domains. As the multi-modal Board will be active in a variety of sectors such as defence, health care, inquiries into major disasters and all transport sectors the learning curve will be more explicit at Board level and/or IIC level. By investigating accidents in this range of sectors the multi-modal Board has the possibility to focus more on comparable factors between sectors.

In a uni-modal Board the focus will be on technical and organisational matters within the sector.
However in the United Kingdom the different transport accident investigation branches agreed on the following joint initiatives to take advantage of synergies between them (MAIB, 2006, 7):
- Developing common processes and practices for accident investigation;
- Sharing technical facilities, equipment and expertise where appropriate;
- Use and continue to develop joint accident investigation training for new and established Inspectors;
- Developing common competencies for operational and performance management purposes;
- Share resources and expertise in staff recruitment;
- The Board of Transport Accident Investigators will continue to meet regularly to identify opportunities to share best practice and develop efficient use of resources between the three branches.

Following the example of the UK branches it is possible as a uni-modal Board to gain the same advantages and opportunities as in a multi-modal Board. But these advantages are limited due to geographical separation of the branches and the limited amount of sectors to be investigated.

3.4. Culture

Culture can be described as something shared between people or the collective programming of the mind, which distinguishes the members of one group or category of people from another (Hofstede, 1991).
Because multi-modal Boards have a wide variety of domain experts and discipline expertise it is essential to develop a ‘common language’, such as by means of an Investigator’s Handbook. Investigation skills and state-of-the-art safety investigation are the binding factor and can be a foundation of the Board’s culture. Different definitions of culture reflect different theoretical bases for understanding, or criteria for evaluating, human activity.

Culture is a social phenomenon; people are working together and learning together. This means that people 'make' culture. Culture is an evolutionary system in which people know how to act and work with each other. It can be seen in everyday life. Working in an aviation environment has different norms and artefacts than working in a hospital, in merchant shipping or at a chemical plant.
An accident investigation Board will have its own culture. Within multi-modal Boards, culture is emerging from the various domains and related to the common goal of improving safety. This is called organisational culture, defined as a pattern of shared basic assumptions that a group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems (Schein, 1992).

3.5. Learning organisation

Part of the developing culture of the Board will be shaped by the processes through which the Board, management and the investigators understand and manage their experiences. The investigation experiences in the various domains will be shared especially when problematic situations arise.
Organisational learning occurs when individuals within an organisation experience a problematic situation (a surprise) and inquire into it on the organisation's behalf (Argyris & Schön, 1996).

Individual learning, if it is to become organisational or even collective, needs to be shared. And knowledge sharing requires the institutionalisation of certain structures. The effective promotion of organisational learning will, therefore, depend on factors as (Wilpert, 2004):

- Development and use of a common language among organisation members;
- Mutual trust among members in the organisation;
- An adequate error culture (no blame culture);
- Willingness to challenge old practices at all levels;
- A thorough and shared understanding of the needs of the company and industry;
- Analytical skills to predict how challenges will influence the organisation;
- Identifying and removing existing blocks and hindrances to learning and the sharing of knowledge.

Organisational learning will take place during the investigation life cycle if it is arranged and accessible. The IIC must be able to translate the aspects of organisational learning to and from his or her investigation project.
The databank, as depicted in figure 3, is used as a memory, fed by individuals, maintained by the responsible analist(s). In figure 4 the learning agency is shown as part of an organisation, after Argyris.

The databank[22] in the investigation life cycle is seen as the principal tool of the learning agency within the Board.

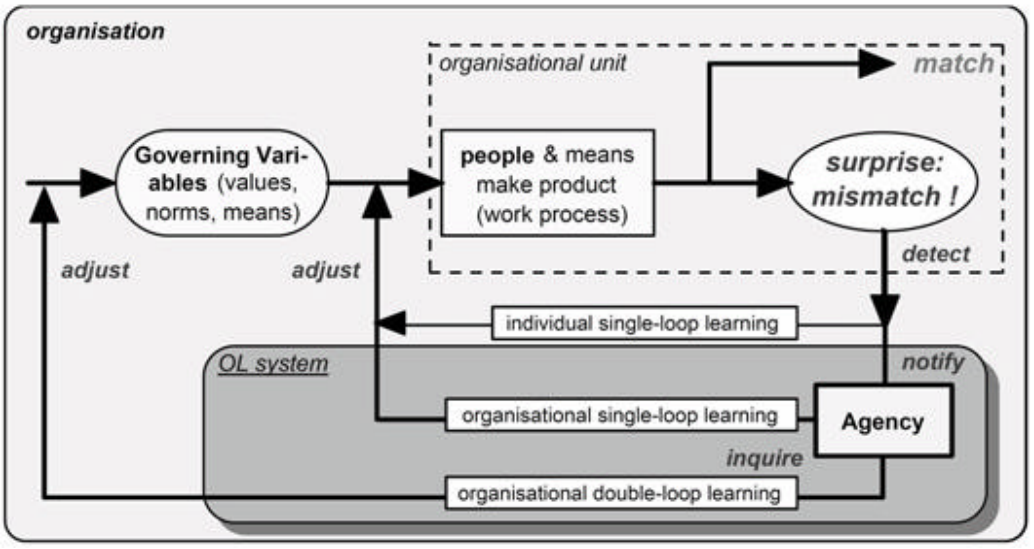

Figure 4: Organisational learning modified after Argyris (Koornneef e.a., 2005).

According to our opinion investigation process management can be seen as the general management of IIC decision-making. Each part of the investigative process should be visible to a management system but the monitoring and control options need to be sensitive to the special characteristics of each. Management intervention in IIC freedom needs to be more reliant on real-time feedback approaches than feed forward, rule-based procedural control. All IIC decisions should take place within a system of managerial control. However, a well-designed, well-operated system is likely to be perceived by IICs as enabling rather than disabling (Kingston, 2006).

[22] The databank is not an agent in itself. The organisation defined responsibilities for ensuring that it is not only filled, but also used, and took into account the problems, resource implications, training needs and culture change issues of introducing such a databank and getting it actively used.

In this chapter the IIC will be defined and a closer look will be taken at the IIC requirements for conducting an investigation. The clustering of the results of the focus group meeting, resulted in four high level themes for IICs. The themes will be discussed as well as the differences between a uni-modal versus a multi-modal Board regarding those themes.

4. The IIC as the focal role in investigations

4.1. Definition IIC

There are various definitions for the investigator-in-charge. The EC Council Directive (94/56/EC) establishing the fundamental principles governing the investigation of civil aviation accidents and incidents defines the IIC as a person charged, on the basis of his qualifications, with responsibility for the organisation, conduct and control of an investigation[23] (Council of the European Union, 1994, 2). This definition is used in this thesis.

The Railway Safety Directive (2004/49/EC) uses almost the same definition. Only in this definition the line, "on the basis of his qualifications" is not mentioned (European Parliament and the Council, 2004, 2).

It is open to discussion whether the IIC is the person charged with responsibility for the organisation, conduct and control of an investigation at the accident site (for one or several days) or the person working at the office of a Board, or the person working at both locations. In general the IIC is defined as the person who is responsible for the whole investigation life cycle as depicted in figure 3 on page 22. At the DSB in several cases another strategy is followed, where as described in chapter 3, the domain expert is in charge at the preliminary investigation, to be succeeded by an IIC nominated by management (regardless of his domain or discipline). This 'second phase' IIC should have specific organisational skills to fulfil the tasks required to project management, of which in the DSB managing the variety of opinions of Commission, Board, management and the parties involved is his major concern. The domain knowledge will be part of the team doing the investigative tasks.
When an IIC is working in his own sector, he usually is called a domain expert. Definitions and descriptions of the subject expert, offered by the literature are

[23] The International Civil Aviation Organization (ICAO) notes to this definition: Nothing in the above definition is intended to preclude the functions of an investigator-in-charge being assigned to a commission or other body (ICAO, 2001).

numerous and varied. There is a notion in some industries that the expert is someone who has done the job for a considerable period of time, knows well the rules and procedures and the range of routines required, but also knows how and when to sidestep these and to intervene and apply strategies of their own (Farrington-Darby and Wilson, 2006, 18). Expertise is domain specific (Chi et al., 1988). The increased exposure of experts will enlarge their domain knowledge and improve their ability to recognize situations and variations in these. Closely linked with both experience and position is the position of specialist. Because of the way organisations are organised (departmentally and hierarchically) the acquisitions of skills and knowledge through experience over time often runs in parallel with increasing specialisation. Experts hold knowledge of who has information, how to obtain it from them, knowing individual capabilities as well as the technical systems capabilities, and have skills in how to manage situations where people are working towards different goals (Farrington-Darby and Wilson, 2006, 25, 26, 28).

A domain expert or subject matter expert (SME) is a person with special knowledge or skills in a particular area. The term can also refer to someone particularly familiar with a group or its work habits. (Hjørland and Albrechtsen, 1995, 400).

4.2. Requirements for conducting an investigation

Each body investigating accidents, has its own view on the requirements of an IIC. Each body is using its own cultural environment to establish certain detailed domain expertise. The common requirements are the investigating skills, conduct, control and organisation of an accident investigation. They will reflect the settings of the body and influence the tasks for the investigator. We introduce three more or less random examples of requirements. The examples start with the Canadian Centre for Occupational Health & Safety (CCOHS) noting the following (CCOHS, 2006, 1-2):

"*ideally, an investigation would be conducted by someone experienced in accident causation, experienced in investigative techniques, fully knowledgeable of the work processes, procedures, persons, and industrial relations environment of a particular situation.*

Some jurisdictions provide guidance such as requiring that it must be conducted jointly, with both management and labour represented, or that the investigators must be knowledgeable about the work processes involved.

In most cases, the supervisor should help investigate the event. Other members of the team can include:

- *employees with knowledge of the work*
- *safety officer*
- *health and safety committee*
- *union representative, if applicable*
- *employees with experience in investigations*

- *"outside" expert*
- *representative from local government*".

This example can be matched with the requirements mentioned in Nemeth et al, 2004. In their discussion of the quality of medical accident investigations and analysis they state that:

"*healthcare accidents have features that make post-event investigations particularly difficult. [..] Healthcare accident examination requires detailed domain knowledge and the use of diverse investigation methods.*

Without an impartial panel of qualified professionals, healthcare accident investigation and analysis can fall prey to the influence of the hospital organisation, turf conflicts, legal concerns, and limited investigator expertise.

The underlying complexity of the medical domain is substantially higher than other domains in which accident investigation is conducted. This makes the assembly and validation of the precise sequence of the accident and its surrounding context more difficult than in other fields. The variety of technical knowledge in this domain is exceptionally high. The creation of a cadre of investigators who have the necessary technical knowledge could result in a very large group of professionals. During a recent investigation planning phase, for example, it became clear that investigating the particular incident would involve epidemiologists, infectious disease specialist, and medical device materials technologists, among others. Creating teams of such investigators that could mobilize quickly to an accident site would require "up front" work."

The Maritime Accident Investigation International Forum (MAIIF) investigation handbook on marine accident investigation (MAIIF, 2006) states:

"The investigator, the investigative team and teamwork"; marine accident investigation is a highly specialized task which should <u>ideally</u> only be undertaken by highly trained personnel possessing many qualities, not the least important of which are an inquisitive nature, dedication to this kind of work, diligence and patience. The investigator must have a good sound working knowledge of ship operations. Technical skills, perseverance and logic are the tools of the profession; humility, integrity and respect for human dignity, his guiding rules.

<u>Ideally</u>, it is not sufficient to nominate, as the occasion arises, a person with specialist marine knowledge to be the investigator, however, many administrations are unable to maintain a large staff of trained investigators so they must depend on contracted investigators. [...] Wherever possible, at least one experienced investigator should be assigned to each inquiry so that a continuing thread of experience may maintain the standards of accident investigation and reporting.

It is desirable that an accident investigator has, as a foundation on which to develop his skills, a professional mariner's background, either as a deck officer or as an engineering officer. Depending upon the particulars of the accident and the needs of

the investigation, it may also be important to employ specific subject matter experts in the investigation, such as human performance specialists, metallurgists, naval architects, etc."

A common feature in these three extracts is the claim that sector expertise is highly recommended, to prevent being disconnected from the sector. Furthermore it is stated that specific subject matter experts are a necessity due to the variety of technical knowledge needed in the specific domain.

4.3. General aspects of uni-modal and multimodal Boards

In general an investigation will be executed for approximately six months to one year (which is the average period), sometimes extending to two years or more, depending on the available funds and the scope of the accident investigation. The investigation team may consist of people with different cultural backgrounds as we have seen in the various domains described in the previous paragraph.

In both uni-modal and multi-modal Boards the progress of investigation is a main issue. The investigation life cycle should be as short as possible. Under accountability of the Board the IIC is the 'instrument' (tool) used by the Board. The IIC is responsible for proper management of his investigation in order to get the best results in the limiting conditions set out by the Board. The Board will show its accountability by expressing corporate ownership of each investigation.

At the beginning of the investigation life cycle, when evidence is collected, speed is an issue; domain knowledge is critical at this stage (Griffiths, 2006b). The IIC takes command of the site activities and liaises with investigating parties. A main role is to integrate all the collected facts. The IIC has to manage specialists in different areas in his team, integrate the different views and maintain a helicopter view. To maintain this helicopter view, the IIC should be aware of details as well as the main aspects of the operational investigation. He is creating the means for managing the direction of the different views within the team. The IIC needs a broad appreciation of the different disciplines and sciences that may have value in the investigation. The multi-modal and uni-modal Board use the same objective, the right people at the right place. At on-site accident investigation the right people are the ones knowing the domain and its specific 'language'. This means also that if domain expertise might not be available the Board should use contractors as experts (Zieverink, 2006), representing the investigative aims of the Board.

Efficient investigation of accidents and incidents however requires certain preconditions, which have to be created by the Board and its management. According to our opinion the principles for reasonable disaster investigation, as published by the E.M. Meijers Institute and mentioned in chapter 1 can be regarded as a set of preconditions which have to be fulfilled within a Board.

If the preconditions are satisfied it is of importance that the necessary tools and skills are available for the IIC to enable him to perform investigations in all kind of domains. As mentioned before there is not 'one-almighty-tool' available to solve all kinds of investigations. Depending on the context the necessary kinds of tools and skills should be facilitated by senior management, as part of the operational readiness philosophy. To produce descriptions of operational readiness for each investigative context, the management responsible for developing readiness should follow the four paths of decision-making that are described below (NRI Foundation, 2005, 2):

- Determine the range of incidents that need to be catered for as part of a planned approach to investigation (strategy plan);
- Determine the tasks to be done in the course of investigating incidents (main issues, criteria for investigation);
- Determine the criteria for how the tasks should be performed (standards);
- Determine the resources and arrangements (organisation, supervisory, managerial) required to perform the tasks.

If the principles and operational readiness are accounted for, these do not automatically make the investigation life cycle to proceed smoothly. There are still many factors that can and will affect the investigation life cycle. Due to the unique characteristics of each investigation, IICs require special skills to stay and remain in control. In the next paragraphs we will focus on four themes, in which the context of these special skills is explored.

These high level themes were derived from the clustering we performed on the data obtained from the focus group meeting. For the description of the various steps to arrive at the themes, see appendix G. Each high level theme contains various low level themes.
The four high level themes are:

- the IIC as the Board's means of meeting corporate-level requirements;
- the IIC as team leader;
- the IIC role in establishing/maintaining confidence and trust;
- the IIC as the administrator of the investigation process lifecycle.

Regarding these four high level themes there are major and minor differences between uni-modal and multi-modal Boards. Therefore we will first look at these themes in a uni-modal Board, followed by the same themes for a multi-modal Board.

For the context of the role of the IIC the present authors make a distinction between small and large scale (accident) investigations. When the investigation team includes not more than three members (specified as internal or external expertise) we define the investigation as small scale. In the case of more than three members we call it a large scale investigation; in those cases the investigation is usually divided over different subjects to be handled. An example is the NTSB's

party system; under this system, qualified technical representatives of organisations with a specialized knowledge are invited to join in the field, in the fact-finding portion of the investigation. The party participants – being air carriers, manufacturers, pilots organisations, emergency response providers, suppliers, or maintenance providers – all provide the Safety Board with the technical depth of knowledge that is needed (Hall, 1998).

In this section we mentioned that the IIC needs special skills; the special focus group was the means by which we explored this aspect.

4.4. The four high level themes for IICs related to the uni-modal Board

4.4.1. The IIC as the Board's means of meeting corporate-level requirements

The uni-modal Boards are known as bodies with specific knowledge on investigation and a workforce related to the specific sector the Board is acting in. The life cycle of an investigation is regarded as a product of the accident investigators within the Board. The director of the Board with the investigation team decides which recommendations to be made. The advantage of this is the focus on the subject by a group of experts in the field. This advantage can become a risk if the group is not able to have a helicopter view over the subject.

4.4.2. The IIC as team leader

The uni-modal Boards have several teams available to execute investigations, usually headed by a team leader with additional management skills. As they act in a uni-modal environment they will not be distracted by, or charged to, other investigations outside their specific domain. Within the domain, specific tasks can be assigned to the expert investigators.

4.4.3. The IIC role in establishing / maintaining confidence and trust

Uni-modal Boards have the advantage that they can build on trust by investigating and reporting at a steady rate. In the specific domain these reports will contribute to improvement of safety.

4.4.4. The IIC as the administrator of the investigation process life cycle

In a uni-modal Board the administrator aspects might be considered less needed as the structure of such an organisation is usually less complex and there are less different roles which have to be described. The uni-modal Board is focussing on different aspects (such as engineering, human factors) within the domain and will search for expertise with affinity to the specific domain. This will expedite the

process of the life cycle but introduces the risk of group think (see appendix I: Voskhod investigation).

4.5. The four high level themes for IICs related to multi-modal Boards

4.5.1. The IIC as the Board's means of meeting corporate-level requirements

The multi-modal Board is assuring competence in the investigation life cycle from a different perspective. As the investigation is transferring from accident-site to office activities the progress of investigation might be critical on other aspects. Political interests, Boards' objectives, facilitation of resources are aspects the IIC has to cope with in this phase of the investigation life cycle. As these aspects differ from the operational issues, opportunities arise to charge IICs with characteristics not specified by their domain knowledge, but on issues such as project management, ability to cope with complex systems, political sensitivity or specific discipline expertise. These issues are more important when the investigation is into complex systems as mentioned by the OECD report and executed in a multi modal Board as the DSB.
The IIC in the multi-modal Board will be required to put much effort into building a team with specified expertise to meet with the correct profile for the investigation (see paragraph 4.7) and making a proposal on the context of the investigation in a project plan.

4.5.2. The IIC as team leader

A sceptical inquiry is the preferred philosophy for the investigation and/or IIC (Braithwaite, 2006). The IIC manages aspects such as priorities, quality and independence. This is applicable as well when reliant on an external investigation (outsourcing). The IIC is the person who should encourage and challenge the team members and has a role in ensuring discipline of the investigation life cycle as it unfolds. These aspects differ greatly from the early or 'classic' investigation environment. In the early days of investigation the IIC was on 'speaking terms' as he knew the technical language of the colleagues surrounding him. With complexity and a variable set of team members with various expertise, and reporting to Board and management, the IIC will have other challenges at hand, and these will make demands on his person skills.

The IIC, in creating the means for managing the different world views within the team (Le Coze, 2006), will have to use an independent approach to the occurrence that has to be investigated, by (Dekker, 2002):

- Laying out the sequence of events in context specific language;
- Dividing the sequence of events in episodes;
- Finding out how the world looked or changed during each episode;
- Identifying people's goals, focus of attention and knowledge active at the time;
- Stepping up to a conceptual description.

With the above steps it is possible for IICs and their teams to reconstruct the (human) contribution to accidents and avoid biases, especially of hindsight.
This will add to a change of culture within the investigators' field, transferring from technical experts to investigation managers. The IIC must be vigilant regarding risks (see appendix D) that can be encountered during the investigation life cycle. His role is to create an environment in which team members are encouraged to notify the operational surprises they encounter during the investigation, so things can be learned from. Individual learning within the team has to be transformed into organisational learning for the Board. He is the challenger on initial causal analysis and of draft recommendations and has to assure the quality of the final report.

Culture is an important factor for an IIC to consider when the investigation takes place in an unknown environment with assumptions and espoused values which are taken for granted. It is also possible in a multi-modal Board that the members of an investigation team will have backgrounds in different organisations with own patterns of shared basic assumptions. The IIC should also be able to operate in different sectoral cultures or bring together people with different cultures within a team. We conclude that the IIC should be a people manager and be sensitive to cultural aspects.

Accident investigation can have elements that under certain circumstances lead to higher risks of misjudgment. We will explain this as follows.
First, circumstances can lead to operant conditioning. The behaviour satisfied will be encouraged. Behaviour which will be questioned will be turned down over time.
Second, shared delusion, evidence kept away from the investigation because it will be against the formed hypothesis of the team. No attempts to be made to falsify the own conclusions, only verifying the given evidence (Crombag e.a., 1992). An example of groupthink is described in appendix I. It is a task of the IIC to avoid those processes of misjudgement in his team.

The investigative tasks of the IIC and his team vary during the investigation life cycle. There is no doubt that the strength of the results of the investigation depends on the thorough collection of available data. All analysis, for immediate or underlying causes, depends on the forensic investigation, the interviewing and the photography together with structured approaches and formats.

During the investigation the IIC of a multi-modal Board is acting as project manager and informing the Board and management, extracting information from a commission, the sector and other relevant parties with the aid of his team. The IIC is the key co-ordinator and liaison manager with the external parties and the communication link between the team and the members of the Board. He has to be politically sensitive. For example, the IIC of the investigation by the Accident Investigation Board of Finland on the natural disaster (tsunami) in Asia on December 26th 2004 was the former prime minister of Finland. He was chosen by virtue of his expert knowledge of the political system (Heikkila, 2006).

The IIC as liaison manager and co-ordinator might lead to a new cultural environment in which IICs deal with each other on the basis of managing projects, instead of expertise in a particular field. Regarding the above mentioned subjects we state that the role of the IIC can be a very complex one. The IIC in these examples is operating more distant from operations, which may be demotivating in the long run (Griffiths, 2006b). This means that in order to keep the balance right, senior management *and* IICs should be explicit about their expectations regarding their role in accident investigation.

In this paragraph items for managing a team and risks of operant conditioning or groupthink are applicable for uni-modal and multi-modal Boards. The risks of groupthink however might be higher in a uni-modal Board as the team will be more homogeneous. The cultural and organisational learning aspects however are not as diffuse as in the multi-modal Board serving ten sectors.

4.5.3. The IIC role in establishing / maintaining confidence and trust

Next to their 'own' sector the IICs of multi sectoral Boards may have to work in other sectors with which they are unfamiliar. This requires a different approach from them and their team members. To maintain credibility the IICs have to stay up-to-date with developments within the domain(s) in which the investigation is executed. If credibility is lost the investigating body will lose trust from society.
In a multi-modal Board with a diversity of possibilities to investigate in a variety of sectors, domains will not be fed continuously by new reports. A multi-modal Board will focus on complex issues in a specific domain in a specific period in time. After the report the Board may shift its focus on another domain. Each domain therefore will get short attention instead of a steady focus during a longer period of time. Therefore the challenge exists about how to support IICs, who carry much of the responsibility to manage the perceptions of external stakeholders, to ensure credibility across a range of sectors.

4.5.4. The IIC as the administrator of the investigation process life cycle

An important task in accident investigation is maintaining progress in the investigation process life cycle. With unlimited funds many accident investigations could be conducted for several years as each specific issue might be interesting enough for further investigation. However Boards will try to finish the process within one year. The IIC will be tasked to administer the investigation process and he should be aware of the various phases in the process, know when to apply stop rules (i.e. no further inquiry in a specific issue) and he will be responsible for delivering intermediate products to senior management and Board.

As mentioned in chapter 3 in mapping the process of investigation it is necessary, especially in multi-modal Boards, to define the different roles in the process, for example by using the RASCI chart.

The DSB is a multi-modal Board consisting of five members, domain commissions and 35 investigators and secretary-writers managed by a managing director. In these circumstances it is needed to describe thoroughly the accountabilities, responsibilities, consultative and supportive tasks within the investigation life cycle. Especially the role of the IIC will be very specific towards the various internal entities (Board, management, domain commission).
IICs must satisfy all of these internal stakeholders; this can be done by demonstrating compliance with the corporate investigation process. However, the demonstration of compliance is a complex matter: it has to accommodate the uniqueness of each investigation and the diverse needs of internal stakeholders. The IIC needs to be able to manage this complexity throughout the whole investigation life cycle.

4.6. Scale of investigation

For small scale investigations, the role of collecting, integrating and assessing all available data will be fulfilled personally by the IIC. The IIC plays an active role in the execution of the investigation. This requires domain knowledge, because he has to be familiar with the latest developments, the network, the culture and the jargon in the domain. Consequently he will be taken seriously as an interlocutor. The IIC has to be careful that he is not biased by his own experience – not just to the extent expected of a domain expert – but in keeping with the IIC's role in assuring the quality (including objectivity) of the investigation.

In the case of large scale investigations the focus on the required investigation skills of an IIC is more on controlling, conducting and organising aspects, irrespective of the phase of the investigation life cycle.
Integration of all the collected facts, maintaining a global helicopter view, independence, encouragement of the team members and adherence to the time planning regarding the investigation life cycle are the main issues the IIC has to deal with. Domain knowledge of the IIC can be advantageous in large scale investigations, but it is less required. If it is not present, the IIC has to rely more on the team members with knowledge of the domain. In this case the IIC should be an investigation manager[24]. The investigation manager has general management skills,

[24] Management (from Old French *ménagement* "the art of conducting, directing", from Latin *manu agere* "to lead by the hand") characterises the process of leading and directing all or part of an organisation, often a business, through the deployment and manipulation of resources (human, financial, material, intellectual or intangible).
Early twentieth-century management writer Mary Parker Follett defined management as "the art of getting things done through people."
One can also think of management functionally, as the action of measuring a quantity on a regular basis and of adjusting some initial plan, and as the actions taken to reach one's intended goal. This applies even in situations where planning does not take place. From this perspective, there are five management functions: Planning, Organizing, Leading, Co-ordinating and Controlling. (Wikimedia Foundation, 2006). According to Nieuwenhuis (2003)

project management skills and has experience and knowledge of the investigation process (Griffiths, 2006a).

4.7. Profile of investigation

In accordance with the varying investigative tasks of the IIC and his team during the investigation life cycle, the required investigation skills and domain and discipline knowledge vary as well. Figure 5[25] shows by means of three axes the type and amount of required investigation skills and domain and discipline knowledge of the IIC and his team, depending on the moment of time during the investigation life cycle. The figure presents an accident investigation in which several issues are to be accounted for. The speed and thoroughness of the investigation is requiring several disciplines and domain expertise. These profile settings differ with each investigation, due to the context of the operational surprise or thematic study.

It is the task of the IIC to define after the preliminary investigation in which areas expertise is required. The Board will give specific tasks (research questions) to be investigated and the first analysis of the sequence of events will indicate the necessary performance of the investigation. In setting up his plan of approach with the relevant entities in the Board (secretary-writer, investigator(s), Board-member(s), domain commission, management) the IIC can outline the profiles needed for the specific investigation.
To fulfil this project management task the IIC can use the KEI-matrix.

The depiction (in figure 5) indicates the required team composition in time for a certain investigation. Depending on the nature and context of an investigation, the focus can be on certain disciplines, like for example engineering, human factors or dangerous goods. Within the team, expertise regarding those disciplines has to be present, when applicable. Domain knowledge is always required in the team for the investigated domain (like aviation, health care, industry).

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there are six valuable management functions: strategy, structure, culture, people, resources and results.

[25] Figure 5 and 6 are both pseudographs; the x-axis are in nominal and the y and z axes are ordinal.

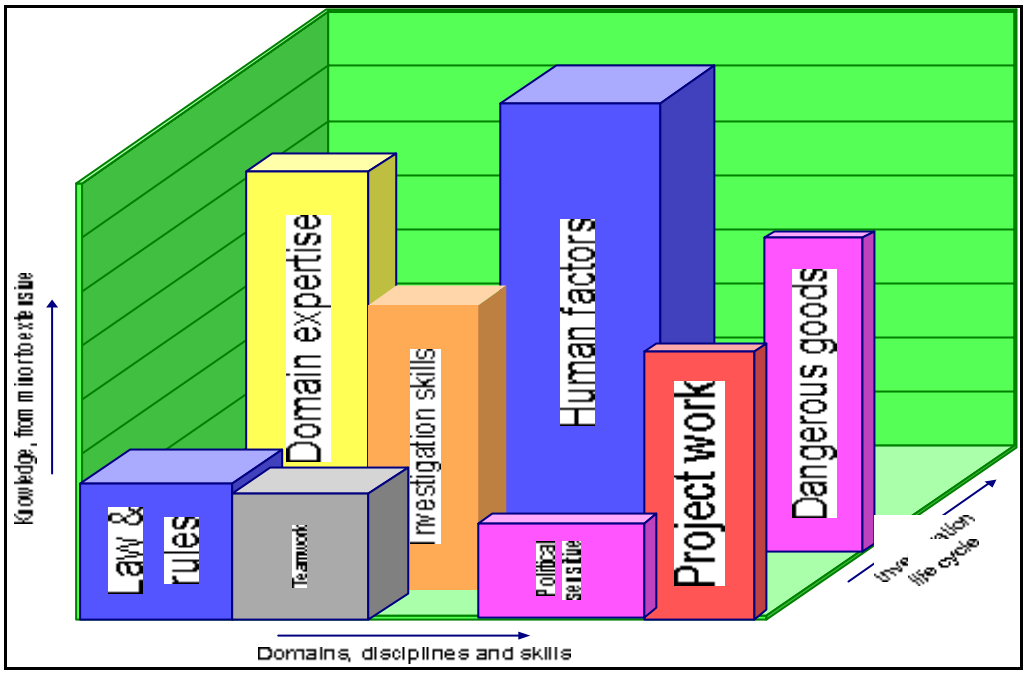


Figure 5:Requirements during investigation life cycle.

In figure 6 a similar depiction is presented for the career life cycle of an investigator. In time his domain and discipline knowledge and skills vary.
After the notification of an occurrence and when the decision has been made by the Board to initiate an investigation the management will assign an investigator to become the IIC. If the knowledge, experience and skills of an investigator at that moment fit the (expected) requirements of a new investigation he should be charged to the investigation. This corresponds with the operational readiness philosophy, which implies that the right people are working in the right place at the right moment.

After the assignment, a task of the IIC is to assure that his team is composed of members with the necessary knowledge and skills in time.

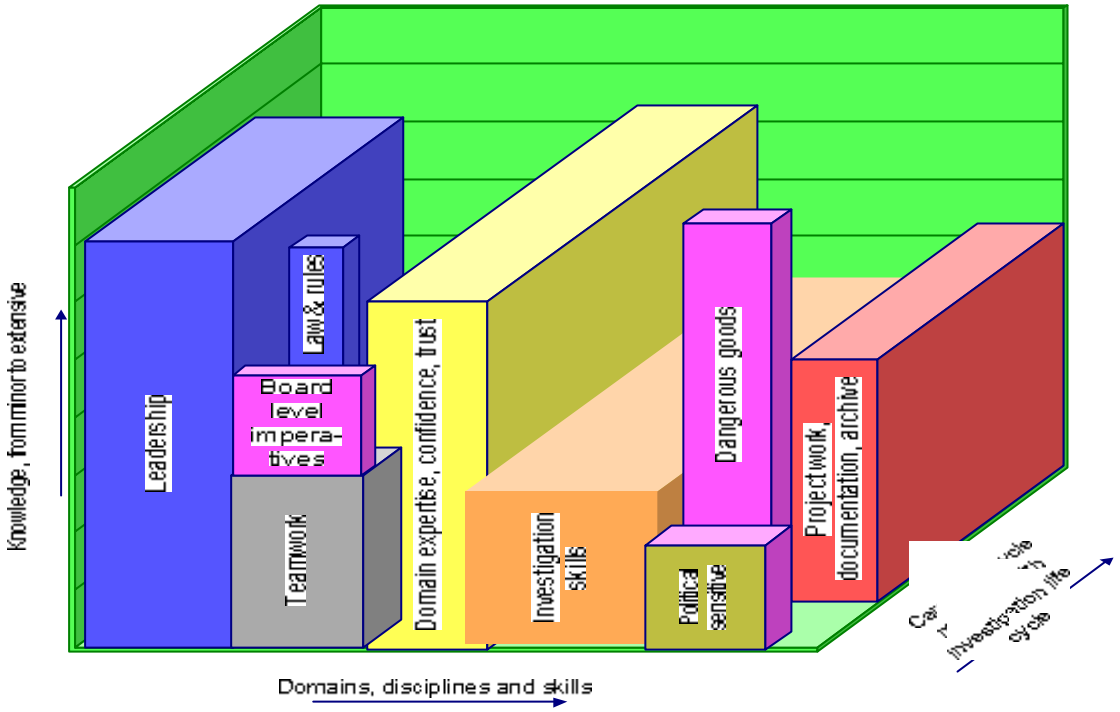


Figure 6:Knowledge and skills of an IIC during his career life cycle.

4.8. IIC profile

An investigator who is motivated to become an IIC will negotiate with senior management to develop and maintain his knowledge and skills, by adequate or specialised training, as required by the Board. As every individual will work on his career, the match between an investigation life cycle and the career life cycle can differ over time. An IIC should be aware of the fact that each investigation is unique and therefore it might be possible he will not be the right person in the right place at the right moment.

The IIC profile requirements depend on the investigative context. Depending on the training, development and seniority, an IIC, who is in the beginning of his career life cycle, will be assigned to small or large scale investigations primarily in his own domain. Generally large scale investigations will be marked by their complexity. Complexity meaning the organisational complexity of the investigation and not the technical complexity of the accident (Griffiths, 2006b).
After gaining experience as IIC in his own domain, the IIC can be charged to investigations in other domains as an investigator, before acting as IIC in these new domains.

Besides being a domain expert or an investigation manager the IIC, as team leader, should possess personal characteristics to manage a complex investigation and face the challenges he will encounter.

4.9. Assessable criteria for IICs

The investigators of the Board are required to have the necessary knowledge and skills based on the rules of accident investigation (DSB law and other (inter)national obligations) to execute the investigative demands of the Board.
The elements knowledge, skills and rules are based on the fundamentals mentioned in chapter 1. The rules, the investigators have to comply with, and conduct an investigation with, are set up in the law of the DSB and translated to procedures and instructions (Investigators' Handbook).

To gain knowledge and/or skills of accident investigations the personal background is influencing the needs of additional training (see appendix B, Experience diary and KEI-matrix). The training is based on the common principles of investigation as laid down by various universities (such as Cranfield University, UK) or developed from years of experience within the Board or its predecessor. Most of the training is still on the job. To support this, several Boards developed systems and/or manuals to assure the training is directed to a, for the organisation, common language of accident investigation. These on the job trainings mixed with theoretical approaches to specific subjects will ensure that investigators and IICs gain the required expertise.

To keep up with the developments to a more holistic approach to accident investigation and the various domains seen (by OECD) as potential risk environments, the Board will have to establish continuous development of training and education in the specific fields. Training and education will have to concentrate on managerial aspects of investigations if the IIC is charged to complex investigations.

The organisation needs to professionalize these training and education. It is necessary to assign several levels of investigation from simple to complex and subsequently different grades with core competencies for investigators.
The main grades, derived from interviews and information of Accident Investigation Boards (Australian Transport Safety Bureau, Transportation Safety Board of Canada, Accident Investigation Board Finland) contain different themes in which investigators are challenged to gain a higher level during their career. The four high level themes for IICs are part of the main grades domain knowledge, project management and law and regulations.

The main grades are;

1. Law and regulation (corporate level requirements, domains, regulating bodies)
2. Inquiries (types, participation, limitation)
3. System thinking
4. Safety management sytems

5. Safety investigation methods (chain of events, models) and analysis (STEP, Tripod, Track, etc.)
6. Human factors (stress, fatigue, memory, attention, etc.)
7. Interviewing (preparation, role, traps and skills, interpreter)
8. Evidence (recording, sampling, documents, wrecking)
9. Occupational Health and Safety (personal protection, site discipline)
10. Responding to a casualty (equipment, other parties)
11. Effective us of communication and reporting (writing)
12. Project management (team leader, organisational/administrator skills)
13. Knowledge management
14. Domain knowledge and network (confidence and trust)
15. Quality control
16. Professional development

1. Law and regulation

Different countries often categorise and name legal subjects in different ways. Sometimes people distinguish public law subjects, which relate closely to the state (including constitutional, administrative and criminal law), from private law subjects (including contract, property). In civil law systems contracts fall under a general law of obligations and trusts law is dealt with under statutory regimes or international conventions. All legal systems deal with the same issues, because the same questions are raised in every society.

Regulation mandated by the government or state attempts to produce outcomes which might not otherwise occur, produce or prevent outcomes in different places to what might otherwise occur, or produce or prevent outcomes in different timescales than would otherwise occur. Common examples of regulation include attempts to control market entries, certain industries, standards of production for certain goods and services, like inspections.

Each investigation has to establish the influence of law and regulation on the incident investigated, especially to check whether law and regulation were adequate enough to deal with the situation.

2. Inquiries

In rough terms, abduction is what we use to generate a likely hypothesis or an initial diagnosis in response to a phenomenon of interest or a problem of concern, while deduction is used to clarify, to derive, and to explicate the relevant consequences of the selected hypothesis, and induction is used to test the sum of the predictions against the sum of the data. It needs to be observed that the classical and pragmatic treatments of the types of reasoning, dividing the generic territory of inference as they do into three special parts, arrive at a different

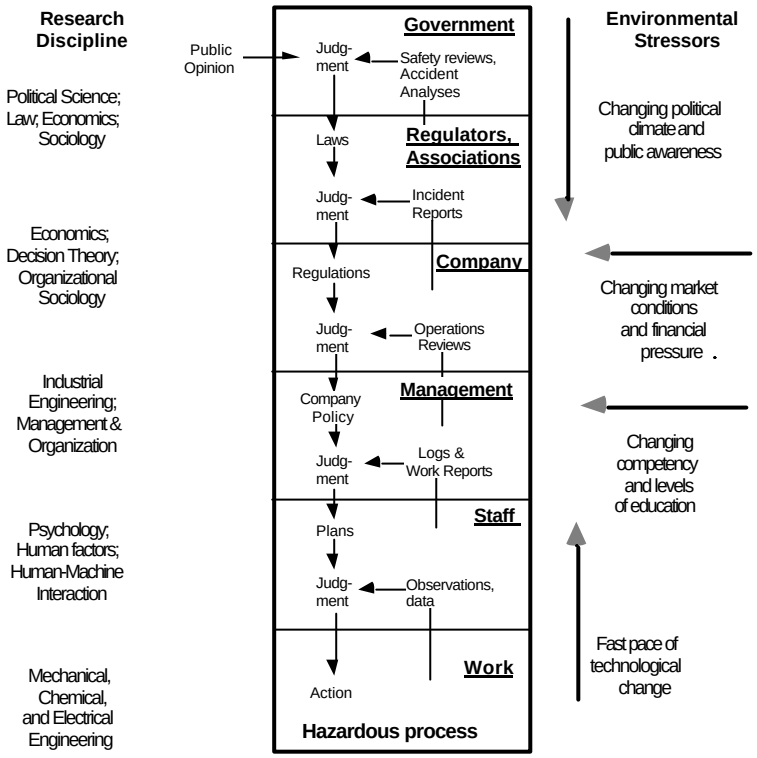
characterization of the environs of reason than do those accounts that count only two.

These three processes typically operate in a cyclic fashion, systematically operating to reduce the uncertainties and the difficulties that initiated the inquiry in question, and in this way, to the extent that inquiry is successful, leading to an increase in knowledge or in skills.

In the pragmatic way of thinking everything has a purpose, and the purpose of each thing is the first thing we should try to note about it. The purpose of inquiry is to reduce doubt and lead to a state of belief, which a person in that state will usually call knowledge or certainty. As they contribute to the end of inquiry, we should appreciate that the three kinds of inference describe a cycle that can be understood only as a whole, and none of the three makes complete sense in isolation from the others. For instance, the purpose of abduction is to generate guesses of a kind that deduction can explicate and that induction can evaluate. This places a mild but meaningful constraint on the production of hypotheses, since it is not just any wild guess at explanation that submits itself to reason and bows out when defeated in a match with reality. In a similar fashion, each of the other types of inference realizes its purpose only in accord with its proper role in the whole cycle of inquiry. No matter how much it may be necessary to study these processes in abstraction from each other, the integrity of inquiry places strong limitations on the effective modularity of its principal components.

3. System thinking

This enables the investigator to look at complex structures, installations and organisations in a logical way and to describe and draw these systems. Without system modelling it is virtually impossible for an investigator to oversee the complexity.
It is possible to analyse step by step and synthesize the different components. An investigator is confronted regularly with complex dependences and influences of different parameters. System modelling is very suitable for a quantitative approach. The ultimate goal is to communicate in a uniform language about the various entities; from people to organisations, to governmental bodies, and from components to machines to complex industries and factories.
Using the same terms will able us to communicate about the relationships between these different entities. System modelling can be seen as a basic reference for communication about problems and solutions. During accident investigation, when unintended actions take place between system boundaries and/or with the outside world, a system will not be looked at at one particular moment in time, but the total lifecycle will be looked after. The type of incident will regulate the accent of the investigation to one or more elements of the total life cycle. (specifications, design, development, operation, ‘onderhoud’, changemanagement, aging and replacement). An investigator has to be knowledgeable about the typical lifecycle and be attentative during the investigation.



There are different methods possible to describe the elements in a system in a methodological way. Investigators should be able to use these kind of methods as for example the SADT method. (Structured Analysis and Design Technigue)

Figure 7:Rasmussen, social technical system.

4. Safety management systems

Safety management is the total amount of activities that are carried out by an organisation to control the dangers within its own used technology and organisation. These dangers can damage property, employees, customers or people living in the area. To have a functioning safety management system it is necessary to know and control the possible risks. A risk analysis. With barriers scenario's ending in loss of control can be avoided or the effects can be minimised. The Bow-tie is an example of how to show this in a simple figure. The loss of control is in the middle. The hazards on the left side the consequences on the right hand side.
In case of an incident it appears that the responsible management was not able to control the various hazards. Thee investigator shall have to look into the safety management system in order to find out why barriers failed or were not recognised.

5. Safety investigation methods (chain of events, models) and analysis (STEP, Tripod, Track, etc.)

Careful and complete analysis of the data collected following an accident is critical to the accurate determination of an accident's causal factors. The results of comprehensive analyses provide the basis for corrective and preventive measures. The analysis portion of the accident investigation is not a single, distinct part of the investigation. Instead, it is the central part of the iterative process that includes collecting facts and determining causal factors. Well chosen and carefully performed analytical methods are important for providing results that can aid investigators in developing an investigation report that has sound judgments of need.
Caution must be taken in applying analytic methods. First, no single method will provide all the analyses required to completely determine the multiple causal factors of art accident. Several techniques that can complement and cross-validate one another should be used to yield optimal results. Second, analytic techniques cannot be used mechanically and without thought. The best analytic tools can become cumbersome and ineffective if they are not applied to an accident's specific circumstances and adapted accordingly (Chapter 7 MAIIF Investigators' Manual).

Accident investigation teams commonly use four techniques to analyze the factual information they have collected, to identify conditions and events that occurred before and immediately following an accident, and to determine an accident's causal factors.
Four core analytic technigues exist in accident investigation;

- Events and causal factors charting and analysis
- Barrier analysis
- Change analysis
- Root cause analysis.

6. Human factors (stress, fatigue, memory, attention, etc.)

Areas of interest for human factors practitioners may include the following: workload, fatigue, situational awareness, usability, user interface, learnability, attention, vigilance, human performance, human reliability, human-computer interaction, control and display design, stress, visualization of data, individual differences, aging, accessibility, safety, shift work, work in extreme environments including virtual environments, human error, and decision making.

Simply put, human factors involves working to make the environment function in a way that seems natural to people. Although the terms "human factors" and "ergonomics" have only been widely known in recent times, the field's origin is in the design and use of aircraft to improve aviation safety.

7. Interviewing (preparation, role, traps and skills, interpreter)

The class of interviews we are seeking are meant to gather information about an incident. These interviews are central to the practices of accident investigation and can be an important source for the investigator. In general the quotes and information gathered in the interviews are used in the analysis of the incident.

8. Evidence (recording, sampling, documents, wrecking)

The investigative team proceeds in gathering, cataloging, and storing physical evidence from all sources as soon as it becomes available. The procedures for access to, and the controlling of, evidence maybe subject to national legal requirements which vary from country to country. The most obvious physical evidence related to an accident or accident scene often includes solids such as:

- Equipment
- Tools
- Materials
- Hardware
- Pre- and post-accident positions of accident-related elements
- Scattered debris
- Patterns, parts, and properties of physical items associated with the accident.

Less obvious but potentially important physical evidence includes fluids (liquids and gases). Analyzing such evidence can reveal much about the operability of equipment and other potentially relevant conditions or causal factors. Care should be taken if there is pathogenic contamination of physical evidence (e.g., blood); such material may require autoclaving or other sterilization. If required, expert analysts should be requested to perform tests on the fluids and report results to the team.

9. Occupational Health and Safety (personal protection, site discipline)
Accidents create unpredictable working conditions for personnel conducting on-scene investigations. Investigators must be prepared to immediately switch from a sedentary office environment to strenuous labour under trying circumstances, in all extremes of climate and conditions prevailing at various facilities.
Although the hazards inherent in this type of work are self evident to experienced investigators, it is beneficial to summarize what past experience has taught with respect to personal safety in accident investigations. The desire to get the job done expeditiously, thoroughly, and economically can easily lead to disregard for personal risks. Perseverance, dedication, and initiative are the trademarks of Safety Board investigators. These are precious commodities that have to be preserved by the judicious application of risk controls.

10. Responding to a casualty (equipment, other parties)
In order to have an efficient investigation, the IIC should be knowledgeable about the necessities for responding to a casualty. In a Safety Board these facilitating equipment should be available at first hand and is stretching from personal equipment to the means of transportation to the accident site. It is not the responsibility of the IIC to keep this up-to-date, but he is responsible to organise the necessary equipment at the accident site. Also will he be up-to-date of the parties involved nationally and internationally, to assure every party joining the investigation is linked to his team.

11. Effective use of communication and reporting (writing)
How to relay the message to the outside world will be the main issue when reporting about the results of an investigation. In order to reach the right people and organisations and gain confidence from the public the report should be clear in its message. There are several ways to inform the public, each investigation requires a different approach and subsequently the report will be part of the communication strategy. Every safety board will develop its ways to communicate with regards to culture and strategy.

12. Project management (team leader, organisational/administrator skills)
Project management is the discipline of organising and managing resources in such a way that these resources deliver all the work required to complete a project within defined scope, time, and cost constraints. A project is a temporary and one-time endeavor undertaken to create a unique product or service, that brings about beneficial change or added value. This property of being a temporary and a one-time undertaking contrasts with processes, or operations, which are permanent or semi-permanent ongoing functional work to create the same product or service over and over again. The management of these two systems is often very different and requires varying technical

skills and philosophy, hence requiring the development of project management.

13. Knowledge management

Knowledge management refers to a range of practices used by organisations to identify, create, represent, and distribute knowledge for reuse, awareness, and learning across the organisations.

Knowledge management programs are typically tied to organisational objectives and are intended to lead to the achievement of specific outcomes, such as shared intelligence, improved performance, competitive advantage, or higher levels of innovation.

Knowledge transfer (one aspect of knowledge management) has always existed in one form or another. Examples include on-the-job peer discussions, formal apprenticeship, corporate libraries, professional training, and mentoring programs. However, since the late twentieth century, additional technology has been applied to this task, such as knowledge bases, expert systems, and knowledge repositories.

14. Domain knowledge and network (confidence and trust)

An investigator is required to have knowledge of the domain he is investigating. This will provide him and the parties involved the confidence of knowing what are the do's and don'ts in this particular environment. Independent investigators should allow the parties involved to have trust in the expertise of the Safety Board. This can be established by learning more of the cultural environment and its particular beliefs. As these elements cannot be learned in a classroom only time and patience are necessary elements to gain the required trust.

15. Quality control

The company-wide quality approach places an emphasis on three aspects:

- Elements as controls, job management, adequate processes, performance and integrity criteria and identification of records,
- Competence such as knowledge, skills, experience, qualifications
- Soft elements, such as personnel integrity, confidence, organisational culture, motivation, team spirit and quality relationships.

The quality of the outputs is at risk if any of these three aspects are deficient in any way.

The approach to quality management given here can be applied to accident investigation activities. It comprises a quality improvement process, which is generic in the sense it can be applied to any of the activities and it establishes a behaviour pattern, which supports the achievement of quality.

16. Professional development

Themes (core competencies) for each grade can be described and assigned to a specific level for the developing investigator as well as the more experienced investigator[26].

We state that the main grades are a necessity for an investigator acting as the IIC for complex investigations. This means that the IIC has to develop various skills, partly as investigator, as team leader and project manager and developing (political) sensitivity for aspects related to the Board and its reports.

With the main grades and different themes the Board creates assessable criteria for IICs. This means that the expected behaviour, related to the role investigators execute in the various projects, should be translated to the criteria mentioned as main grades and themes. Each individual investigator can develop into an IIC but has to pass several training moments before acting as one.

Investigators are expected to develop their skills and knowledge. This will be combined by theoretical training and experiences in the field. The core business of investigators is not managing accident investigations but to perform investigations. Process management elements as Money, Organisation, Quality, Information and Time, are not the main goal but are there to facilitate the investigation. Not all investigators will become investigator in charge. They orientate and develop mainly in a profile as investigator. A few are able to perform at the higher level as team manager with its own aspects as process management and communication. From this group it is logical to understand that several will develop to managers handling complex investigations as major disasters will be.

[26] Each theme within the main grade and corresponding level for the investigator requires further study. Due to the limited timeframe for this study, we do not have detailed information regarding these grades and subsequent themes.

In this chapter conclusions will be drawn and an answer will be given to the thesis question. The chapter is finalised with recommendations for the DSB.

5. Conclusions

5.1. General

A multi-modal Board must be able to accommodate the diversity of contexts in which it undertakes investigations. It can do this in two ways: being selective about which investigations to initiate (e.g. through management of Board's strategic programme) and by flexible deployment of its workforce.

In the ideal situation of a multi-modal Board, the most important resource, the actual workforce, can be used as flexibly as possible, considering people's individual qualifications and experience. This means that all investigators can be assigned as an IIC of investigations in all possible domains. For these reasons it is the IIC cohort who have to meet the challenge of accommodating the investigative diversity of the multi-modal Board.

As well as the diversity of the multi-modal context, there are various other dimensions to the complexity faced by individuals serving as IICs. If we look at the different elements, as discussed in this thesis, the IIC is facing various challenges and has to cope with investigations into systems which are themselves complex.
The IIC does not and should not act in isolation; he plays a variety of roles each reflecting a different web of relationships, tasks and goals; again, complexity. These roles depend among others on the nature of the accident, the phase of the investigation life cycle, the location where the investigation takes place (on/off site), the influences from various parties involved, the particulars of the Board, political sensitiveness, cultural aspects and the size and composition of the investigation team.

5.2. The IIC, role or profession?

For IICs four high level themes were identified;
- the IIC as the Board's means of meeting corporate-level requirements;
- the IIC as team leader;
- the IIC role in establishing/maintaining confidence and trust;
- the IIC as the administrator of the investigation process lifecycle.

These themes define the context of operation of the IIC.

The uni-modal Board as well as the multi-modal Board are assuring competence in the investigation life cycle from different perspectives. The cultural and organisational learning aspects which have to be managed by the IICs in a uni-modal Board are not as diffuse as in the multi-modal Board.

To maintain credibility the IIC in a multi-modal Board is faced with the challenge to stay (or rapidly come) up-to-date with developments within the domain(s) in which the investigation(s) is (are) executed. The role of the IIC will be very specific towards the various internal entities (Board, management, (domain) commission).
In a uni-modal Board these aspects might be considered less needed as the structure of such an organisation is usually less complex and there are less different roles (responsibilities, accountabilities) which have to be described.

In our research it became clear that the IIC plays a focal role in the accident investigation. As mentioned in the OECD report, accidents will be more and more complex due to the interconnection of systems. The EC or its individual countries might be confronted in the near future with large scale disasters requiring a holistic approach to in-depth independent investigations, not limited by boundaries of individual countries. There are specific domains with vital systems the OECD report (2003) is warning for;
“Health services, transport, energy, food and water supplies, information and telecommunications are all examples of sectors with vital systems that can be severely damaged by a single catastrophic event or chain of events.”

The EC but indeed its individual countries should be aware and prepared for such events. For the DSB the operational readiness philosophy should be at least executed in the domains specified by the OECD. These developments have an impact on the requirements of the IIC. The IICs will be charged to complex accident investigations and required to have a holistic approach. To comply with the operational readiness philosophy the focus for training and (gaining) expertise should be on the five large risk clusters, leading to IICs prepared for and knowledgeable within the specific domains.

To reach the state of operational readiness, the DSB is executing projects to develop and enhance project management, program management, competence management and supporting the operations by creating an investigators’ manual as part of an overall manual for the organisation.
In this operational readiness philosophy the Board will further;

- Determine the range of incidents that need to be catered for as part of a planned approach to investigation (strategy plan);
- Determine the tasks to be done in the course of investigating incidents (main issues, criteria for investigation);
- Determine the criteria for how the tasks should be performed (standards);
- Determine the resources and arrangements (organisation, supervisory, managerial) required to perform the tasks.

The mentioned steps are leading to an arrangement where the IICs will be required to develop their skills and knowledge to the expected tasks. Not every investigator will be capable to perform at high level. Therefore different levels of core competencies will be required. With these developments around the holistic approach to complex system accident investigation the IIC is not just a focal role to be fulfilled. Being an IIC embraces much more than showing the expected behaviour that is attached to the position. Investigators can grow to managers for complex investigations if they are given the right challenges, study and mastery of specialized knowledge, extensive training and development into specialised skills dedicated to the professional accident investigation. Only then they can gain the grades required to become an IIC. So it can be concluded that the IIC can be seen as a profession.

Within the DSB so far the IIC has been considered more as a role instead of a profession. The investigators are trying to fulfil the expectations of the Board and management without precise knowing the requirements of their expected behaviour as project manager for an investigation. By means of creating standards the investigators can professionalize to become IICs with the four high level themes in focus.

6. Recommendations

- As a multi-modal Board, the DSB should focus on the five specific domains health services, transport, energy, food and water supplies, information and telecommunications as mentioned by the Organisation for Economical and Cultural Development (OECD) report for preparing IICs for the accident investigation in complex systems.

- In realising the complexity of the various domains a multi-modal Board, and the DSB in particular, should establish investigators as focal point for one or maximum two specific domains to establish confidence, trust and ongoing accident investigation(s) in the particular domain.

- The International Transport Safety Association (ITSA) should initiate the development of an international recognised training program in which investigators can professionalize their skills. This will need to develop criteria around which to organise the training. Some of the required competencies are known, others are more subtle and harder to analyse and further research may be needed to elaborate criteria for these.

- It is recommended that the training programme should recognise subsequent grades of investigator, starting with grade 1 ‘developing investigator’ and leading to a, for example, grade 5 ‘senior investigator’ with the competency to lead and manage a major investigation.

- The DSB is recommended to invest further in the development of criteria and training of investigators tasked to be IIC in order to achieve and maintain operational readiness.

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Appendix A: Explanation of principles for disaster investigation

The following fundamental principles are stated as 'principles for reasonable disaster investigation' (Hallers, e.a., 2002, 237-238):

Independence
Disaster investigation has to take place in an independent way. Independence is related to different parts. The investigation has to be done by independent people, who don't have any involvement or interest in the disaster, the people involved and the government. The appointment and discharge of the members of the Board takes place independently for a limited period. The Board determines independently if an investigation has to be performed and which methods will be applied. It can independently design its intern organisation, including personnel and finances. The independency should be guaranteed in a formal law.

The separation between the question of guilt and the question of cause
A formal separation between the investigation into the question of guilt and the question of cause has to take place. If there would be no separation, witnesses would not like to speak to the Board about the true causes. It is necessarily to make formal agreements between the Board and other bodies about the different forms of disaster investigation, as convergence of different investigations and procedures will take place. Those agreements have to be recorded in a public document. Cooperation and exchange of information with other bodies shall only concern logistic parts of the investigation process.

Public
The disaster investigation has a public nature. The results of the investigation will be represented in a public report. The methods will be made public.

Hear both sides
A public procedure has to be developed which designs the principle of hearing both sides. People involved get the opportunity to give an opinion on concept texts of the Board within sufficient time. The Board determines independently to what extent the comments of the people involved will be processed in the final report. The Board has to motivate when those comments are not processed.

Careful
The disaster investigation has to take place carefully. A public document should exist in which the investigation method is described. The Board should apply a quality system to safeguard the carefulness of the investigation.

Expert knowledge
The Board disposes of great expertise to perform the disaster investigation. This expertise is permanently available to the Board. External experts can only participate in the investigation if they can be considered as independent

and operate within the area of responsibility of the Board. The quality of the expertise can be supervised externally. Cooperation with safety boards in other countries takes place.

Proportionality and subsidiarity

The investigation methods that are applied have to be proportional in relation to the interest of investigation. A public document should describe which investigation methods are applied in which cases and under which conditions. The competences of the Board may not be used for other purposes than what they are meant for.

Fair treatment of witnesses and parties involved

Witnesses and parties involved have to be treated in a fair way. This fair treatment has different aspects:

- It should be clear which investigation methods can be applied by the Board towards parties and witnesses;
- The rights and duties of the parties and witnesses have to be made explicit;
- It should be made clear in which way findings and conclusions were drawn.

Motivation

The disaster investigation has to be justified. The conclusions of the Board have to be well-founded. The Board has to indicate in which way evidence has been obtained for specific conclusions and recommendations. It should be possible to verify the grounds stated.

Completed within a reasonable time

The disaster investigation has to take place energetically. The Board has to indicate within which term findings and conclusions will be drawn.

Appendix B: Experience diaries

Experience diary Thom Koning

Higher professional education; maritime nautical education.
After study: working in the maritime field in several functions as (Chief) mate and captain, practical trainer/teacher, inspector ship building projects and port state control, crewing, auditing and formal safety assessments, investigation on site and off site, acting as prosecutor for the Maritime Board of Inquiry, independent investigation, advisory for international safety management code, organisational development (project management, competence management, strategy, mission).

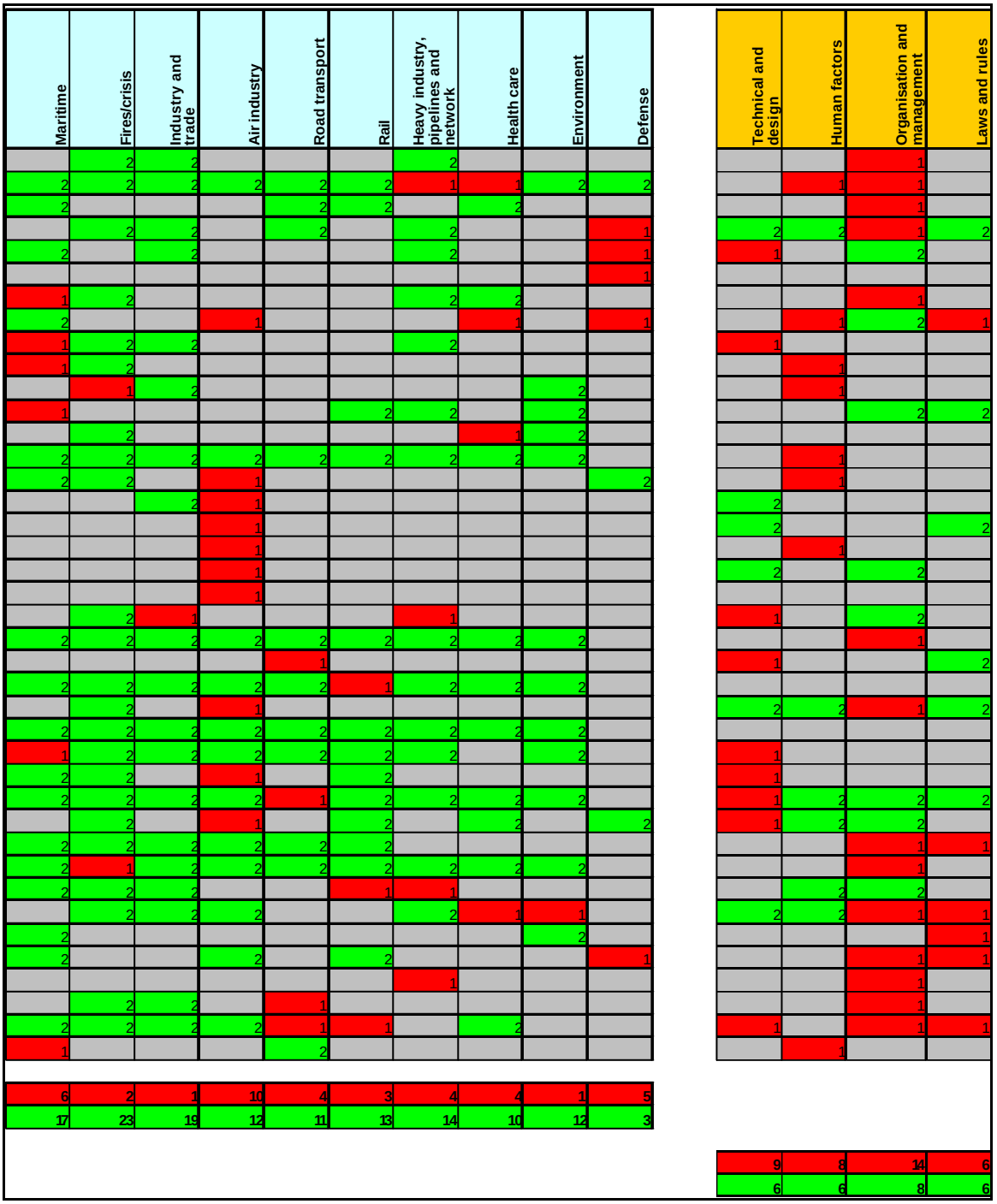
Experience diary Maurice Peters

Higher professional education; electrical engineering/electronics, specialisation industrial automation.
After study: military service (air reconnaissance liaison officer) and working in aviation in several functions as student air traffic controller, flight operations officer, consultant flight safety, air safety investigator (on/off site), auditor.
Holder of a private pilot licence for single engine piston aircraft and glider instructor/examiner.

Experience diary in a KEI-matrix

The experiences of the workforce available to the Board can be translated to a matrix displaying knowledge, expertise and interests. Each individual is asked to give his specific skills and background. Together this will give a list of individuals with professional skills, expertise and interests translated to preferences (first, second, third, etc.). This will enable management to identify the needs on specific sectors for additional training, development or even new employment to satisfy the needs for the investigation process.

The KEI-matrix is to be used as a first selection for identifying possible IICs as well as investigators for specific investigations. After this selection a more precise profile should be established together with the proposed IIC.


Maritime
Fires/crisis
Industry and trade
Air industry
Road transport
Rail
Heavy industry, pipelines and network
Health care
Environment
Defense
Technical and design
Human factors
Organisation and management
Laws and rules

KEI-matrix

Appendix C: Semi-structured interviews

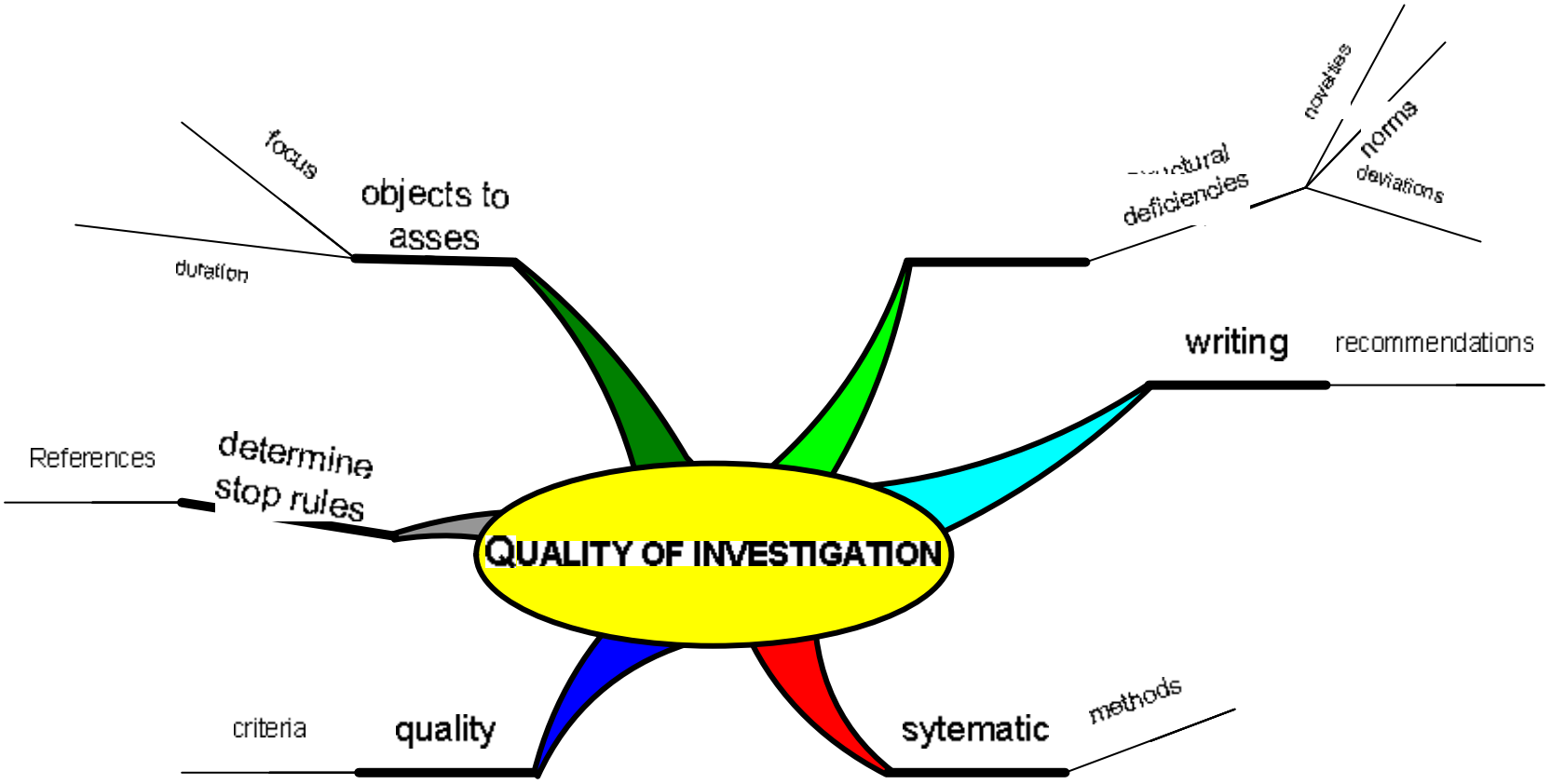
List of themes and questions which were covered during the semi-structured interviews:

Developments investigations in general
Developments DTSB/DSB
What kind of occurrences should be investigated by the DSB
Accident investigation life cycle
How to improve the investigation process
What is a good/qualitative investigation/report
Composition of investigation team
Characteristics of an investigator
Requirements of an IIC
Should an IIC be a generalist or a specialist
...

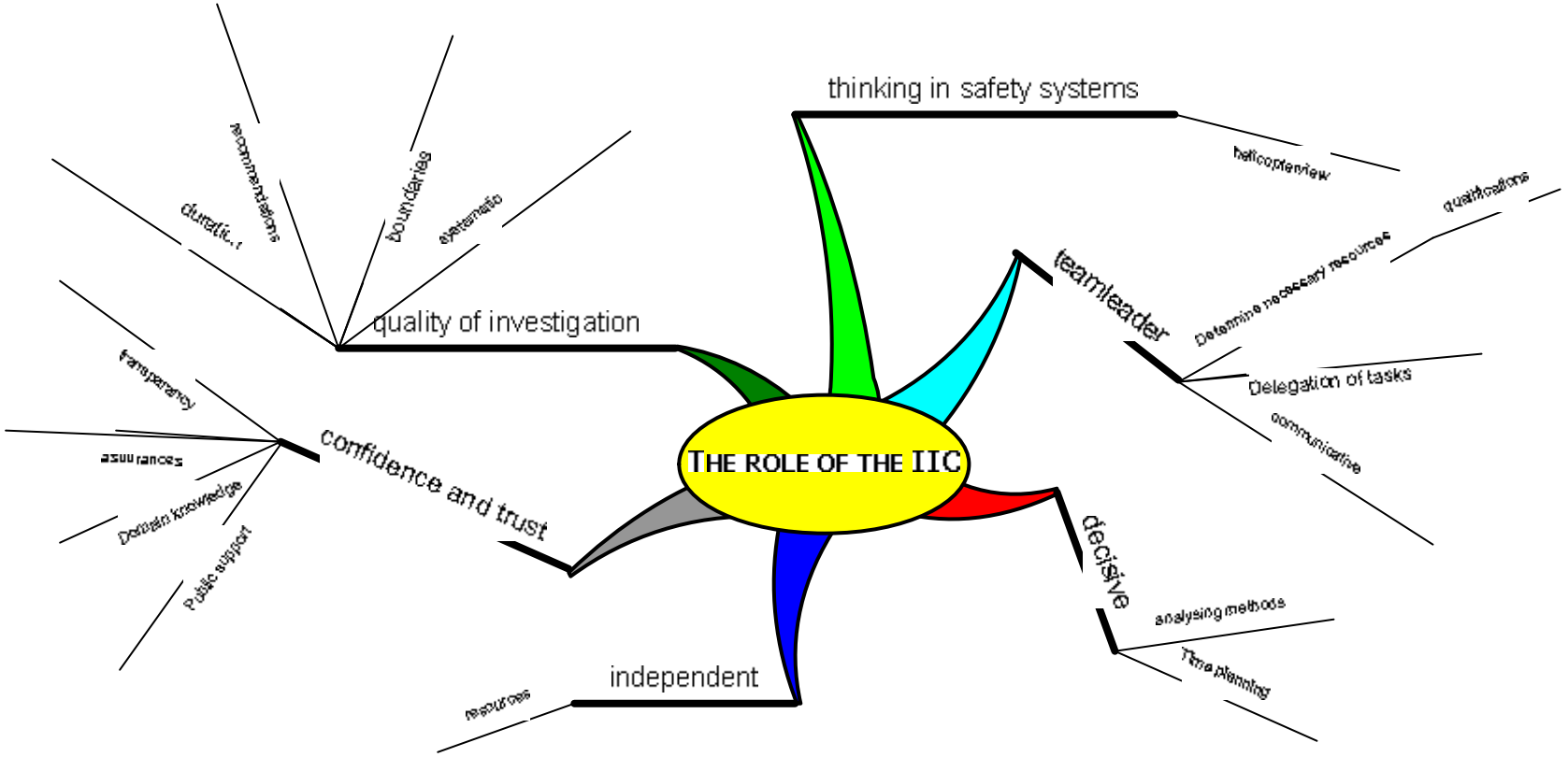
Appendix D: Results mind mapping exercises

Mind mapping exercises:

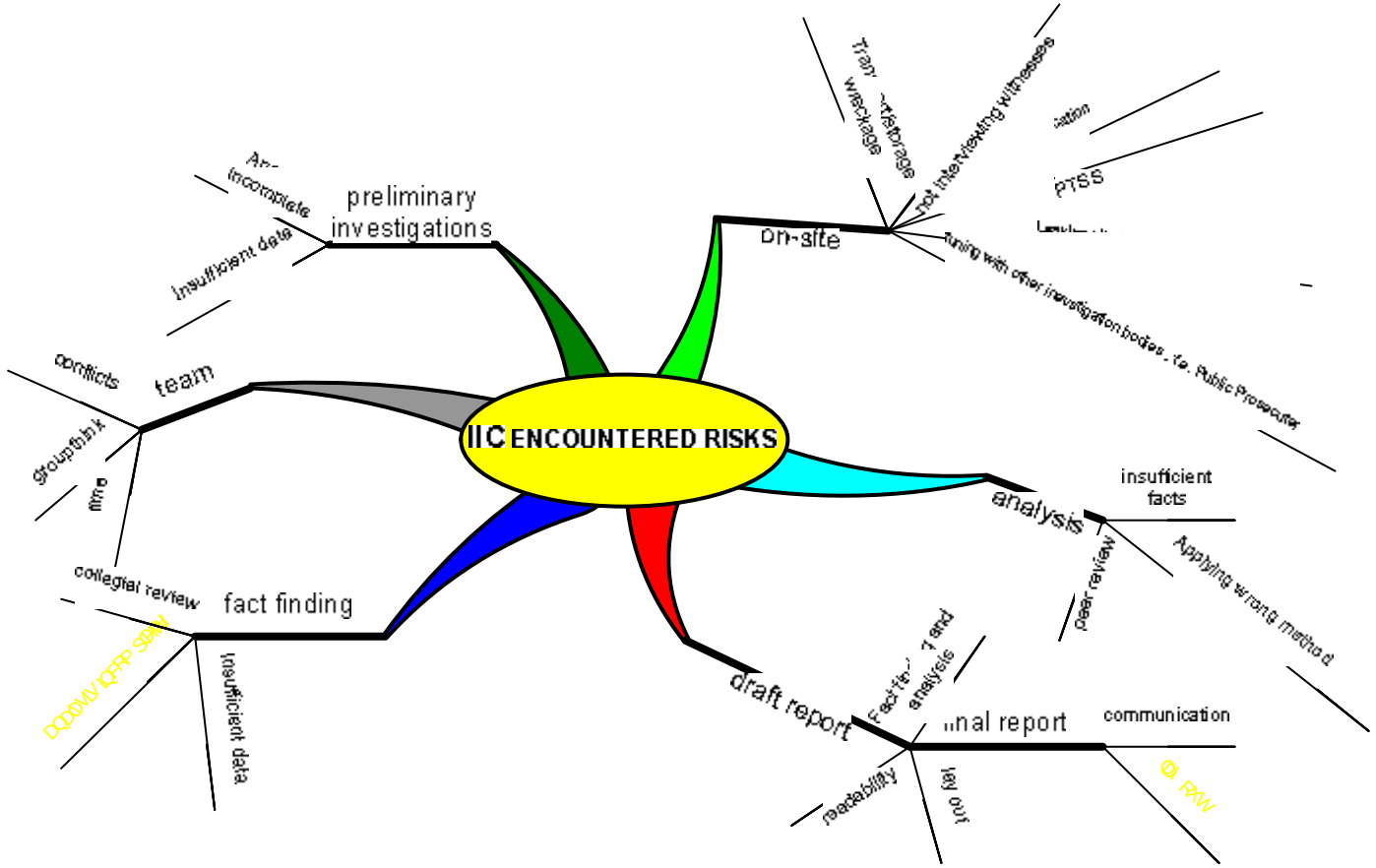
#1 Quality of investigation
#2 The role of the IIC
#3 IIC encountered risks



Mind mapping exercise #1: Quality of investigation.



Mind mapping exercise #2: The role of the IIC.



Mind mapping exercise # 3: IIC encountered risks.

Appendix E: Description of investigation life cycle

The different steps of the investigation life cycle of any given Board:

Preliminary investigation
The decision is made by means of mapped decision matrices if a team of investigators will travel to the occurrence site. Then, among other things the site will be secured and examined, the equipment, vehicle or wreckage will be examined, traces will be investigated, witnesses will be interviewed, pertinent information will be collected and specific wreckage items will be selected and removed for further examination. To check whether a similar occurrence has taken place before the databank can be used. Within a legal term of five days an advice to investigate has to be written, based on the collected data which has been verified. Subsequently this advice will be presented to the Board members who will decide if the occurrence will be investigated by the Board. If no further investigation takes place the collected data will be stored in the databank.

Fact finding
If an investigation will take place, further collection of all relevant data concerning the occurrence and underlying factors takes place. Again data out of the databank can be used. If all data has been collected it will be verified and an assessment takes place regarding the quality of the data.

Analysis
Then all data will be classified after which it will be analysed and structural safety deficiencies will be traced. For those processes several methods, like Tripod Beta, are available.
During this phase the Board may:

- Examine all pertinent company, vehicle, government, and other records;
- Examine selected wreckage in the laboratory and test selected components and systems;
- Read and analyse recorders and other data;
- Create simulations and reconstruct events;
- Review autopsy and toxicology report.

Then it will be checked if sufficient data has been collected. If the data is complete, conclusions will be determined which are based on the analysis. If not sufficient data is available, more data will be collected
When safety deficiencies are confirmed or suspected, the Board will advise the appropriate person or authority as soon as possible –without waiting until publication of the final report- so the problem can be corrected.

Draft report
The report will be written. When a draft version is ready a quality assessment will take place by colleagues. Next the Board reviews the draft report, which may be approved, amended, or returned for further staff work. Once the

draft report is approved, a copy of the confidential draft report will be sent to designated reviewers for review and comment. Those reviewers have the opportunity to dispute, correct, or contradict that which they believe is incorrect and prejudicial to their interests. This review process ensures procedural fairness and the accuracy of the report. The Board considers all comments. It is possible that the analysis phase will be entered again. Depending on the comments it can be possible that more data has to be collected. Next the report will be amended where required.

Final report

The Board members will determine the recommendations after which the final report will be approved. Then it is prepared for release to the public. The Board aims to release final reports within one year of the occurrence date. However, investigation reports for major, very complex, or unusual investigations may take longer. The relevant data of the investigation will be stored in the databank.

Appendix F: List of propositions

List of propositions

This is the list of propositions we sent initially, together with the tentative draft of our thesis, to the experts. The propositions were linked to the chapters of that version of the draft.

Chapter 4, proposition
The primary process resembles 'the PDCA/Shewhart Cycle'. After each set of information is received successively the investigator in charge and the Board decide whether to investigate further or not. A negative decision leads to unrevealed structural deficiencies.

Chapter 5, proposition
The IIC should act as a learning agent, but he/she should have the 'guts' by giving the relevant parties the time and space to learn.

If the DSB acts as a learning agency, by investigating accidents, no adequate learning takes place at the responsible organisational levels of the parties involved. The DSB is problem solver and messenger.

Chapter 6, proposition
To be taken seriously in society the DSB should always take into account the relevant culture of the sectors investigated. This should be done by adding key figures from the sector to the investigating team.

Chapter 7, proposition
Although safeguards are used, every investigation is biased by it's investigation team.

Chapter 8, proposition
In order to achieve maximum results in the investigation the IIC should be able to use maximum creativity not limited by a safety management system.

Chapter 9, proposition
The investigator in charge should be a manager not a technical expert.

During the focus group meeting the following propositions were discussed:

Proposition #1
The investigator in charge (IIC) should be an investigation manager and a domain expert, not a generalist.

Proposition #2
To be respected in society the IIC should always include key figures from the sector in the investigation team.

Proposition #3
The IIC should act as a representative for the learning agent, but he/she should have the ‘guts’ by giving the relevant parties the time and space to learn.

Appendix G: Results of clustering of data

During the focus group meeting notes were made of the statements being made during the discussions in response to our three propositions. Those notes were made by a colleague, two focus group members and us. The next day we performed a 'thematic analysis' with two focus group members. This analysis provided a basis for exploring the relationships between the statements. Because most statements were quite rich and complex, they often spoke to more than one theme. Through review and discussion of each statement, we identified 19 themes. By identifying these themes we could (i) group statements together; (ii) group themes together; (iii) explore conceptual relationships at the statement or thematic level. Exploration is the key word, we weren't testing hypotheses, but just looking for patterns to help organise the concepts that arose from the discussions.

The propositions that we produced for the panel, can be seen as inputs to the models of the 'investigative context' represented in the minds of the experts. By the same token, the responses of the experts can be seen as outputs. Our analysis, as well as aiming to reduce the mass of output to something more manageable, can also be seen as an attempt to deduce the structure of these expert models. An assumption here is that there is a high degree of correspondence between the models in the heads of the experts, high enough to allow us to treat these models as minor variations of a single coherent whole [model]. We think this is probably fair enough, the experts are all working with the same sorts of issues in very similar contexts with highly comparable norms and their differences were corrected-for by us.

Our thematic analysis is represented by: (a) a matrix showing the correspondence between statements and themes and (b) a thematic network diagram showing each theme as a node, and the relationship between the nodes as lines, each line representing a statement.

When we drew the thematic network diagram on a flip chart paper, the positioning of the nodes (i.e. the themes) was arbitrary; the only constraint being that we tried to achieve the fewest overlaps of lines. However, the relationships between themes should <u>not</u> be arbitrary, there will be some structure to it. The basic sign of structure will be that some themes are more closely interrelated than others and most of the variations in closeness will be not be random. The question then is how to measure this closeness of relationship. This is where cluster analysis, also called cladistic analysis, comes into play.

Using cluster analysis on this sort of data is pretty unusual: normally, cluster analysis uses frequencies of objective phenomena. Our data was subjective (the themes we identified). We produced a semantic system with which to structure the expert panel results in a meaningful and convenient way.

The matrix was analysed by a focus group member using a suite of software (Winclada, NONA and TNT; see "www.cladistics.com"). Within this software, a variety of heuristics are used to assess the degree of relationship between the themes on the basis of the expert panel statements common to each. Hundreds of patterns are tested and only the more reliable ones are retained. This software is usually used for creating classification systems from observations of plants and animals. So the use we made of it is a bit unusual. According a focus group member these results are expected to be reliable for this set of data (if we analysed it with different software and assumptions, the outcomes would be comparable). But, with different propositions, or different experts, or different analysts identifying themes, the outcomes would be different. As for validity - meaning, the extent to which the results reflect true relationships, we think the resulting groupings of themes make sense, so we can at least claim 'face validity'. Because we are not hypothesis-testing, face-validity is an adequate standard; but if we wanted to use the cluster model for some predictive or normative purpose, we couldn't claim empirical validity on this basis.

Returning to the analysis itself, the degree of relationship between themes can be seen hierarchically. For example, the themes 'Investigation process' and 'lifecycle' are more closely related to each other than either is to 'mapping'. But all three themes are more closely interrelated than any of them to the theme of 'motivation'. However all four of these themes are more closely related to each other than any of them is to the theme of 'competence assurance'. We tried various different ways of doing the analysis, with very similar results. The hierarchic aspect was important, in our view. We took a network of relationships (which is good for exploring the interconnection of ideas) but really very unhelpful as a guide for writing-up (Where to start? Where to finish? How to account for the virtual infinity of ways through the network?). This is why we produced a hierarchical analysis, an account of the relationships which lends itself to being converted into headings and paragraphs.

Lastly, the various aspects of the cluster analysis, both our manual efforts and the computer-based efforts, did cast a new light on the ideas. It made us see the IIC as an instrument through which the Board controls the production of knowledge. It also allowed us to arrive at four "meta-themes":
(1) Board level imperatives,
(2) Team roles follow the pattern of the investigation process lifecycle,
(3) IIC as team leader,
(4) Confidence and trust.

In the rows of the matrix (on the next page) the subjects are listed that emerged from the several discussions during the focus group meeting. The abbreviations CG, GB, HZ, JC, JK, JS, MH and SD in the different rows stand for the initials of the focus group member, who made a statement about the specific subject.

Next those subjects were linked to one or more themes, which are listed on top of the columns.

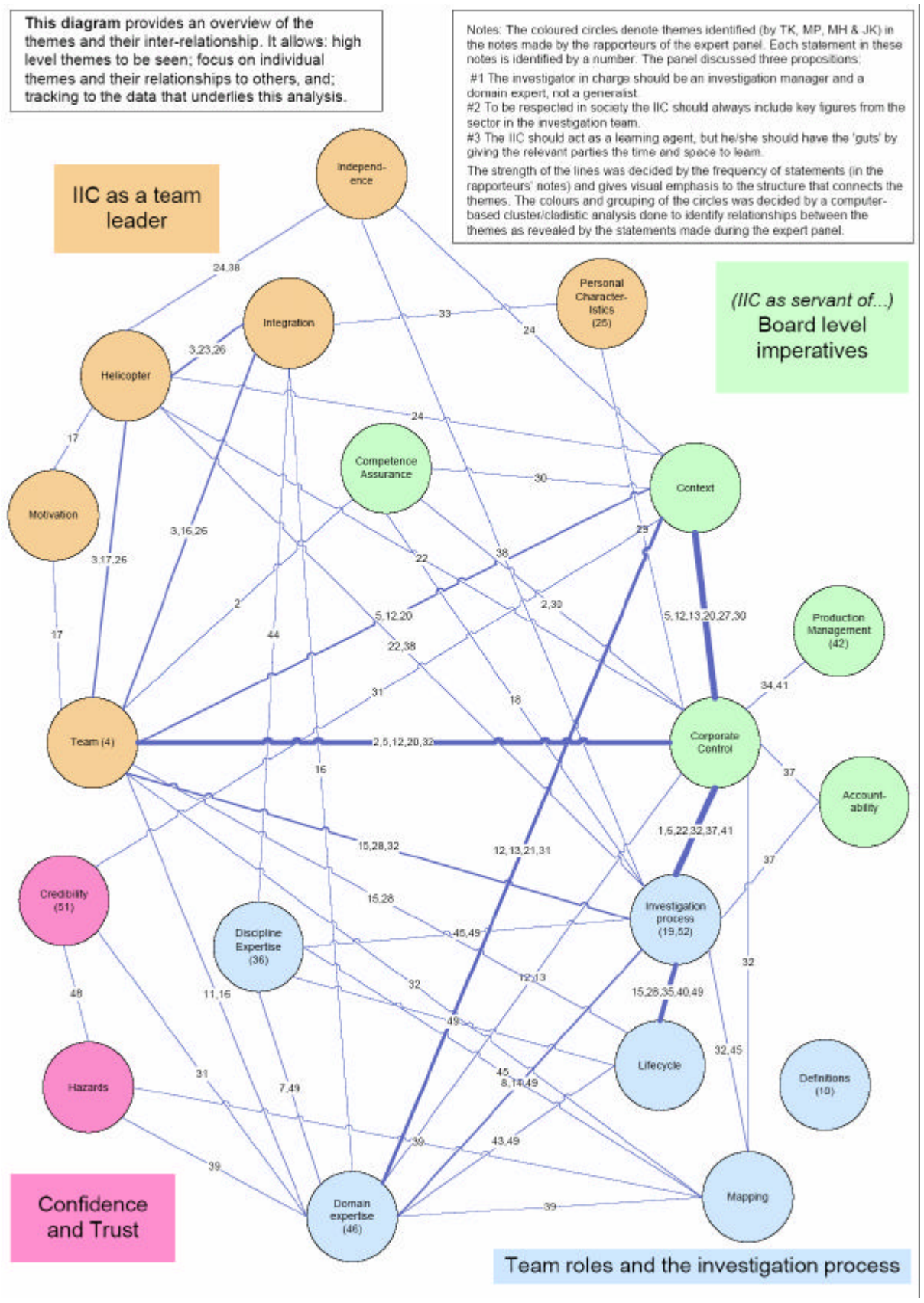
Points emerging	Corporate control	Investigation process	Competence assurance	Team	Helicopter view	Integration	Context	Domain expertise	Discipline expertise	Credibility	Definitions	Life cycle	Motivation	Personal characteristic	Mapping	Hazards	Independence	Accountability	Production management
1. IIC staff member (HZ)	X	X																	
2. Experts as contractors (HZ)	X		X	X															
3. IIC managing specialists in different areas (JC)				X	X	X													
4. IIC must be embody people-manager specialist and generalist (SD)				X															
5. IIC profile depends on investigative context (JK)	X			X			X												
6. Have qualities of importance been lost during evolution in investigation Board? (JS)	X	X																	
7. Properly account the role of technology (JS)								X	X										
8. On site special requirements of PIC(Sleets) (JS)		X						X											
9. Credibility to the sector depends on credibility of IIC (JS)								X		X									
10. Definitions of domain expert, investigation manager see slide (CG)											X								
11. Investigation manager limited knowledge of sector, have to rely on expert team -members (CG)				X				X											
12. Key figures only providing input to the team if they provide necessary knowledge (CG)	X			X			X	X											
13. Best person as IIC, f.e. former prime minister in Tsunami investigation FAIB, by virtue of his expert knowledge of the political system (MH)	X						X	X											
14. IIC should have through knowledge of the investigation process, domain knowledge a surplus but not necessary (MH)		X						X											
15. IIC role in ensuring discipline of investigation process particularly in development of findings, conclusions		X		X								X							

Points emerging	Corporate control	Investigation process	Competence assurance	Team	Helicopter view	Integration	Context	Domain expertise	Discipline expertise	Credibility	Definitions	Life cycle	Motivation	Personal characteristic	Mapping	Hazards	Independence	Accountability	Production management
and recommendations (MH)																			
16. IIC are specialist generalists (GB) (CG remarks are all orange)				X		X		X											
17. IIC more distant from operational investigation, necessary to maintain distance, but maybe demotivating in the long run (CG)				X	X								X						
18. IIC investigative skills needs to be maintained through ongoing operational experience (MH)		X	X																
19. IIC should require peer reviews on the progress and process of investigation and reporting (GB)		X																	
20. Complexity of investigation determines the seniority of the IIC (GB)	X			X			X												
21. Organisational complexity of the investigation not technical complexity of the accident! (CG)							X	X											
22. IIC is manager first and foremost (JK)	X	X			X														
23. IIC is able to maintain a global view (many dimensions) (JC)					X	X													
24. Danger/fear of regulatory capture (any of the teammembers too close to the sector) IIC must be vigilant (GB)					X		X										X		
25. Sceptical inquiry is the preferred philosophy for the investigation/IIC (GB)														X					
26. IIC creating the means for managing the direction of the different world views within the team (JC)				X	X	X													
27. Some aspects of IIC requirements depend on the particulars of the Board (multi, transport, single and	X						X												

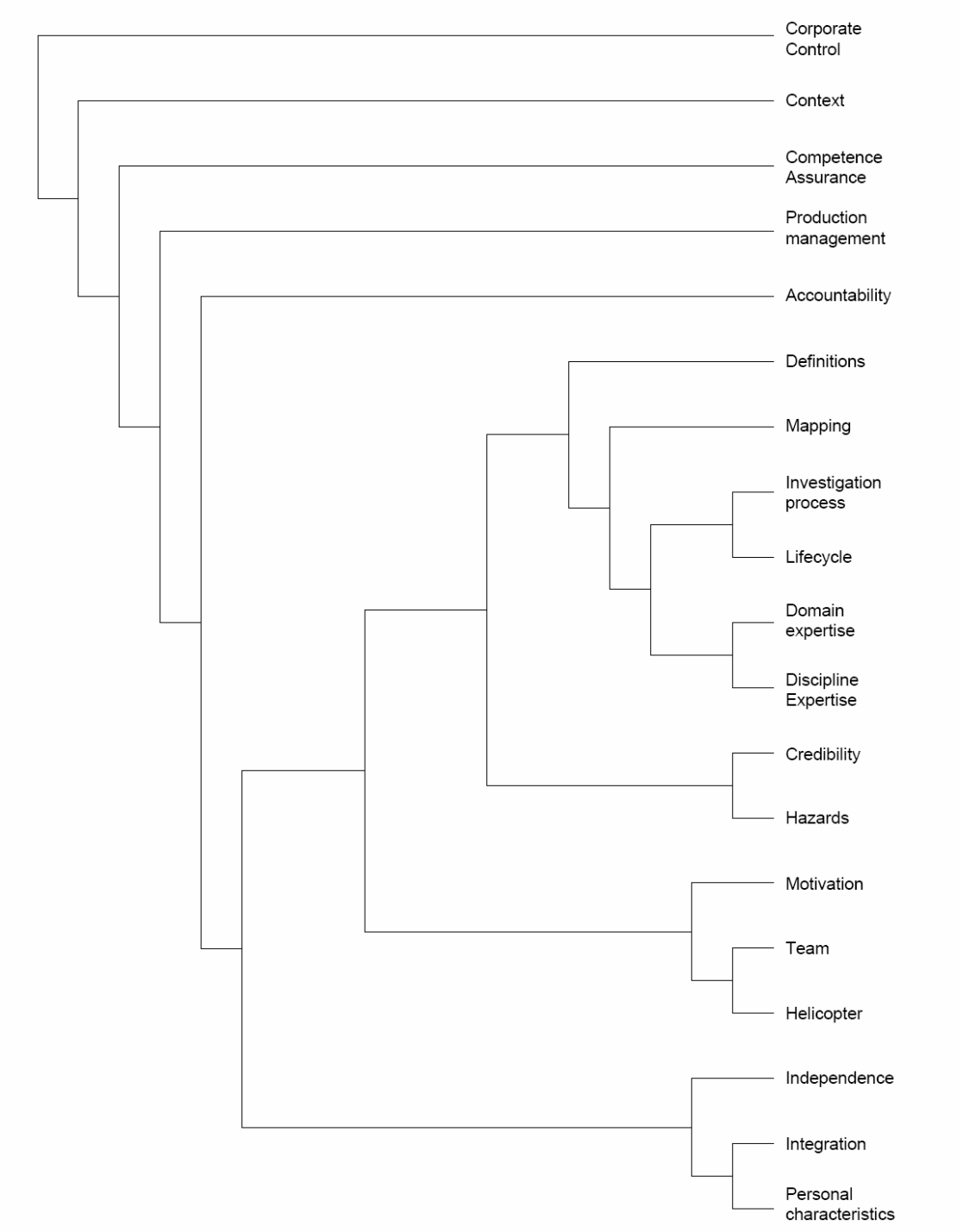
Points emerging	Corporate control	Investigation process	Competence assurance	Team	Helicopter view	Integration	Context	Domain expertise	Discipline expertise	Credibility	Definitions	Life cycle	Motivation	Personal characteristic	Mapping	Hazards	Independence	Accountability	Production management
also how it is organised) (HZ)																			
28. Investigative tasks will vary during the lifecycle of investigation, make different demands on the IIC and the team (JC)		X		X								X							
29. Investigative process must be mapped (procedures developed) (map is not the territory) (CG and MH)	X														X				
30. Need diversity in the population of IICs to match with the diversity of investigative context (Matthijs)	X		X				X												
31. International investigations may need a higher degree of domain expert involvement in order to ensure common language and mutual respect							X	X		X									
32. Kick-off meeting, opportunity for briefing senior person receiving their endorsement. They produce a mindmap as a way of supporting the process (CG).This will be turned into a plan of approach (MP) (Terms of reference, JK). The bigger the investigation the more critical this stage is (MH). Spot the specific areas of unknowns (CG), can be addressed by experts.	X	X		X											X				
33. IIC needs broad appreciation of the different disciplines/sciences that may have value in the investigation, e.g. prejudices may exclude use of external expertise.						X								X					
34. Informative relationship between Board and IIC (Matthijs, neck turnes the head)	X																		X
35. IIC approach to thematic studies? (Arlette)		X										X							

Points emerging	Corporate control	Investigation process	Competence assurance	Team	Helicopter view	Integration	Context	Domain expertise	Discipline expertise	Credibility	Definitions	Life cycle	Motivation	Personal characteristic	Mapping	Hazards	Independence	Accountability	Production management
36. IIC acting as an expert generalist, this case applying scientific method rather then serving as a biologist (Arlette).									X										
37. Corporate ownership of each investigation (CG)	X	X																X	
38. IIC manages when reliant on external investigation (outsourcing) (CG) (priority, quality and independency)		X			X												X		
39. Efficiency and naïve stand points, apparently incompatible goals (Hans vR), Person from another domain asking the naïve questions ex. danger of thinking what the answer is before having the data or thinking to know what the questions are before knowing the context (JK)								X							X	X			
40. Long process to deliver		X										X							
41. IIC has a role in delivering intermediate products (JS)	X	X																	X
42. The IIC manages the information flows in the investigation (JS) (inside and outside)																			X
43. At the beginning (collecting evidence) speed is an issue, domain knowledge is critical at this stage (CG)								X				X							
44. Generalists are a different kind of experts, not just the application of common sense (Matthijs) (JK). Generalist is asking the meta level questions (SD)						X			X										
45. Picture of process of investigation, because there are different opportunities for involving generalist (discipline experts) and not leaving the matter to the experts (CG)		X							X						X				

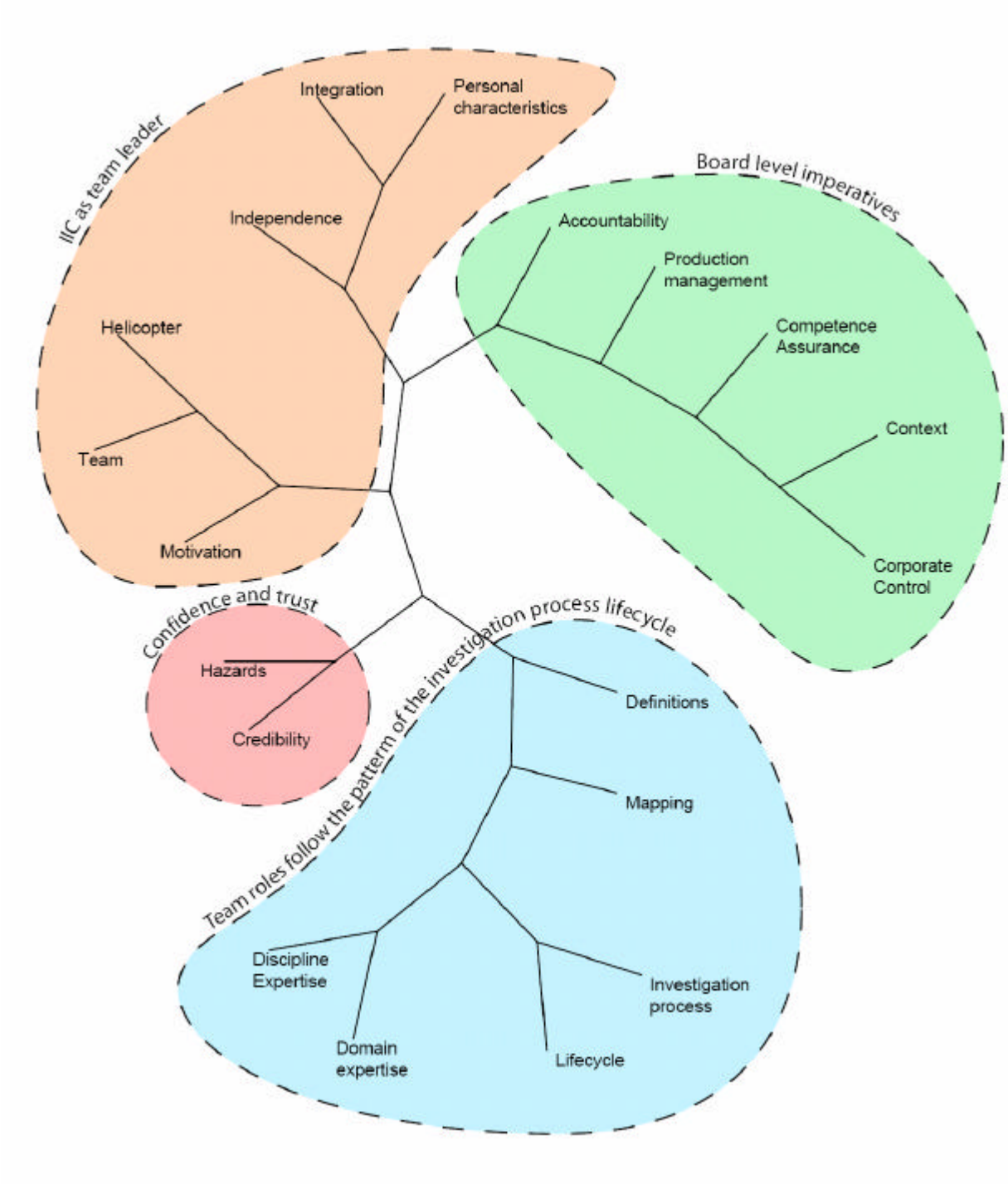
Points emerging	Corporate control	Investigation process	Competence assurance	Team	Helicopter view	Integration	Context	Domain expertise	Discipline expertise	Credibility	Definitions	Life cycle	Motivation	Personal characteristic	Mapping	Hazards	Independence	Accountability	Production management
46. Domain has a specific culture, IIC should be knowledgeable about the domain (Guy)								X											
47. See the dimensional model (JC)	X	x						x	x										
48. Dangers of losing credibility (JC)										x						x			
49. Distinction between factfinding (experts), analyses (other knowledges), conclusions (commission, Board) (JC)		x						x	x			x							
50. Respected no, credibility yes (JC)										x						x			
51. Constraints and strategies available, allocating resources (JC)	x																		
52. Process management tasks (JC)		x																	


This diagram provides an overview of the themes and their inter-relationship. It allows: high level themes to be seen; focus on individual themes and their relationships to others, and; tracking to the data that underlies this analysis.
Notes: The coloured circles denote themes identified (by TK, MP, MH & JK) in the notes made by the rapporteurs of the expert panel. Each statement in these notes is identified by a number. The panel discussed three propositions:
#1 The investigator in charge should be an investigation manager and a domain expert, not a generalist.
#2 To be respected in society the IIC should always include key figures from the sector in the investigation team.
#3 The IIC should act as a learning agent, but he/she should have the 'guts' by giving the relevant parties the time and space to learn.
The strength of the lines was decided by the frequency of statements (in the rapporteurs' notes) and gives visual emphasis to the structure that connects the themes. The colours and grouping of the circles was decided by a computer-based cluster/cladistic analysis done to identify relationships between the themes as revealed by the statements made during the expert panel.
IIC as a team leader
(IIC as servant of...) Board level imperatives
Confidence and Trust
Team roles and the investigation process
Independ-ence
Personal Character-istics (25)
Integration
Helicopter
Competence Assurance
Context
Motivation
Production Management (42)
Team (4)
Corporate Control
Account-ability
Credibility (51)
Discipline Expertise (36)
Investigation process (19,52)
Lifecycle
Definitions (10)
Hazards
Domain expertise (46)
Mapping
24,38
33
24
3,23,26
24
17
30
3,16,26
3,17,26
22
38
29
2
2,30
5,12,20
5,12,13,20,27,30
17
44
22,38
34,41
31
18
2,5,12,20,32
16
37
15,28,32
12,13,21,31
1,5,22,32,37,41
37
15,28
45,49
32
12,13
48
11,16
32
15,28,35,40,49
49
32,45
31
7,49
45
8,14,49
39
43,49
39
39

This picture represents the connections between the themes:



Radial tree with the four theme groups, which correspond with the paragraphs 4.3 up to and inlcuding 4.6. The names of the groups in the depiction below have been renamed for the paragraph indications.



Appendix H: RASCI chart

Mapping of Investigation Life Cycle, RASCI.

The investigation life cycle has to be translated to tasks, responsibilities and authorisations. As we define investigations as projects we use some accepted methods used in project environments.

The investigation life cycle is a process which is to be managed for results. During this process it is necessary to know exactly who is responsible for the different steps and results of those steps and who is doing the activities necessary to accomplish the task(s) and using the various outcome.
For describing these tasks, responsibilities and authorisations the RASCI method can be used.

RASCI meaning;

Responsible – The person responsible for the process and the results (process owner, project leader)
Accountable – The person(s) authorised to decide about, approve the results (Board, mnaging director)
Supportive – The person(s) producing, to gain results in the project (project assistants, external expertise for the project)
Consulted – Person(s) providing information to complete the work (Board, Commission)
Informed – Person(s) informed after completion of the results:, not able to influence the results (external parties)

A typical arrangement could be as in the diagram below;

	PL	BM	B	C	MD	PA	EE
Life cycle							
Preliminary	R	A/C	A	C	C	S	S/I
Fact finding	R	A/C		C	C	S	S/I
Analysis	R	A/C		C	C	S	S/I
Draft report	R	A/C	A/C	C	A/C	S	S/I
Final report	R		A/C		A/C	S	S/I

PL - Project leader
BM - Board member
B - Board
C - Commission (persons with domain knowledge and/or expertise)
MD - Managing director
PA - Project assistent(s)
EE - External expertise (persons hired for specialist tasks)

Appendix I: Voskhod investigation

Review of the investigation into the accident of the fast flying ferry Voskhod 605, sailing from Velsen to Amsterdam[27].

G.Th. (Thom) Koning, senior investigator, Dutch Safety Board, The Hague, Netherlands

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Review and its goal

This review is made for dual purpose. At first it is meant to be a study for the writer in exploring the use of various tools and models for the purpose of investigation. At second, as it is handling a real case scenario which happened recently during an investigation at the Dutch Transport Safety Board, it will be used to enhance the quality of investigations within the newly formed Dutch Safety Board. To fulfil the latter purpose it will be placed on the intranet of the Board and be part of the continuous improvements in quality of the investigation needed within the Bureau.

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[27] This review might be suggesting that several mishaps found during the investigation were not important enough. This not the case. The investigation was set up from a system thinking setting (Rasmussen). The system failures found during the investigation of the Voskhod incident were serious enough to warn the organisation Connexxion. Most important mishaps or system failures;

- Demands on design (shipbuilding and machinery)
- Rules for navigating at high speed passenger ships
- Training of personnel
- Safety culture of the organisation as a whole and with a focus to this subdivision.
-

Introduction

At 18 October 2003 at 12.50 p.m. the fast ferry Voskhod 605 collided at full speed with a quay at the starboard side of the North Sea Canal, on her routine trip between Velsen and Amsterdam Central Station. The crash resulted in a badly damaged ship with several injured passengers and crew. Luckily the ship stayed on the quay and did not sink. Everybody was able to leave the ship, some with help of the ambulance services, police and harbour officials. At prime time the crash was mentioned at all the Dutch TV networks with pictures of the accident site.

Figure 1, Voskhod 605 at cruising speed

From July 1999 the Dutch Transport Safety Board (DTSB), in accordance with the subsequent law acted as the independent investigating body. In the four years of existence the DTSB had already built up a large amount of facts and figures registered with inland vessels subject to accidents and incidents. At the moment of the Voskhod crash a thematic study was still going on about ships not responding to the wheel (about 15 % of all incidents/accidents registered within 4 years).
This thematic study was well known within the inland vessels community and people were expecting a lot from the conclusions and recommendations of the Board.
At first sight the Voskhod crash had one or maybe more common causes related to the causes found in the thematic study. In this paper we look with hindsight at what the effects of the above were on the investigation team when investigating the Voskhod crash.

Theory of investigation of accidents

Before looking at the daily operations of the DTSB we have to explore the more theoretical part of the art of investigation. As is common in business environments people are supplied with necessary procedures (and/or tasks) and tools to get the business done in a certain context. It

does not matter what business you are in, there will always be the foursome people: tools and procedures (tasks), and the context in which this will take place. The foursome has to interact with each individual item, otherwise the outcome will not be at the maximum possible.

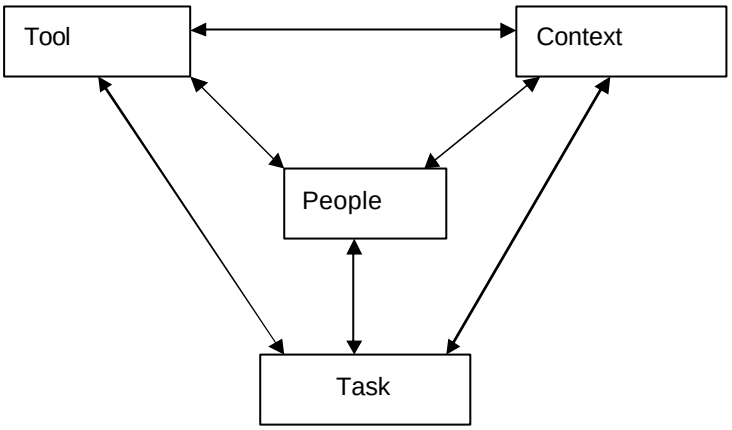

Figure 2, Factors relevant to the selection of an investigation tool (Kingston, 2004)

This means that;

- the right people
- in the right place
- at the right time
- working with right hardware
- according to the right procedures and management controls

The operational readiness of the organisation is the most important, especially when we look at organisations as (Transport) Safety Boards, as they are in the spotlights when accidents occur.

Based on the knowledge developed in decades of investigation, there is not one almighty tool available to solve all kinds of investigation. Depending on the size of the accident, the 'client' (justice, civil court, internal organisation, society as a whole, etc.) the sector, i.e. the users of the outcome, all kinds of tools and skills are available, but not always applicable. As seen in the figure on the next page, the skills and tools map shows a variety of possibilities.

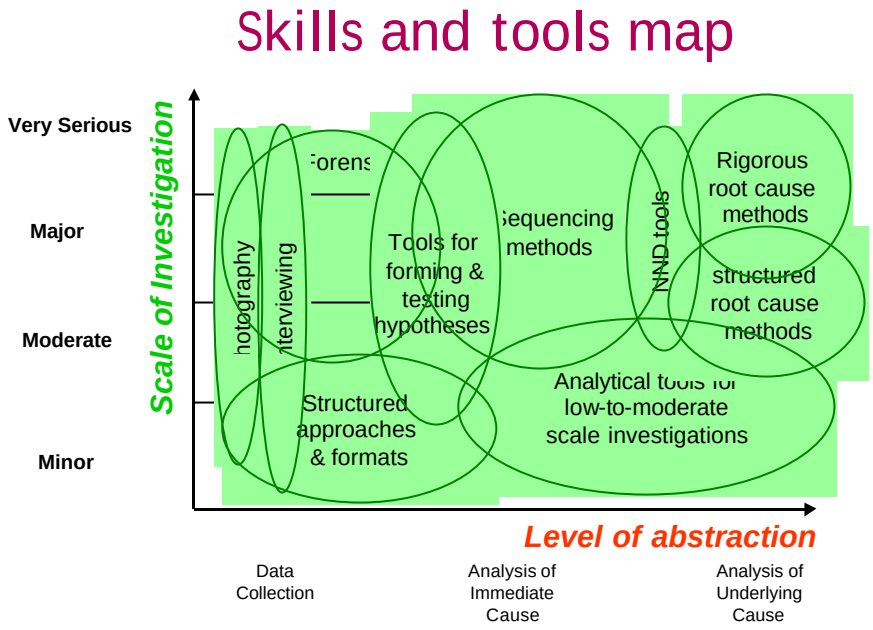

Figure 3, skills and tools map

In this review it is not possible to check all available possibilities usable for the Voskhod investigation. It is not the intention to qualify each skill and tool. For the sake of this report we will look at the question with which skills and tools the accident was investigated. Next to that it will be checked if these were sufficient enough for the quality of the investigation report, looking at the team and time available.

The framework of the actual investigation of the accident.

Facts and figures

One of the investigators of the DTSB shipping sector was routed to the site of the accident and immediately started the investigation. As was the policy within the DTSB the first hours he used mainly for making the necessary contacts with local authorities, taking photographs of the situation outside and inside of the vessel and making sure the names were at hand of the crew and vital passengers. The latter were needed and would be used in the following weeks to establish interviews with the key persons on board at the moment of the crash. In the first two weeks several meetings were held at the office of the Board and the investigation team with several tasks was formed. All the members of the team consisted of experienced investigators with thorough knowledge of shipping. One exception was made. One of the two investigators planned for the interviews had knowledge of investigations in the rail sector and thorough knowledge of interviewing techniques. In total the team consisted of 5 Transport Safety Board investigators who used external contractors for identifying probable causes related to technical matters. The team was backed up by experienced members of the Board itself, who had in the first months briefings on the investigation on a regular basis.

Analysis

About six weeks after the accident, the investigators had found several technical failures on board the ship. They also revealed that technical management was not at expected standards, but more or less depending on hobbyism and enthusiastic people within the public transport company.
Based on these results in the investigation the DTSB could not wait for the overall investigation report, which would certainly take ten more months. Therefore the DTSB issued an official letter to the director of the public transport company expressing the Board's concern about the technical status of the vessel investigated and the equally low standard of the other two vessels in exploitation.
From the investigative interviews no explicit explanation could be found for the last 15 to 20 seconds before the crash. Combining the technical evidence with the interviews held, the most likely outcome would be one or more technical failures leading to the crash. Just before making up the report a Tripod-ß analysis was made with the help of a facilitator.
Not earlier then the moment the report had to be made, the investigator in charge (IIC) ran into difficulties matching the technical failures with each other and with the final outcome. A thorough re-investigation of the available evidence seemed necessary as the IIC was unable to finish the report.
During one week the total investigation team was called together and technical support was added to the team by using an external technical investigator who had not been involved in the investigation before. By systematically scanning the available material it was finally concluded that technical mishap could not be the cause of the crash. But still this conclusion did not match with the interviews. A final interview (the fourth) was held with the captain of the vessel in which he explained the cause of the accident.
Again a Tripod-ß analysis was made, to no surprise a different one than two months earlier.

Conclusions

For a long time the investigation team and the controlling experts were striving for the same wrong goal. The interviews of those involved (direct or indirect) were more or less ´blaming` technology as cause of the crash. The factual information supported this at first glance. Although not convinced totally the investigation team was at the moment not able to discover new or other possibilities as causes for the crash.
It was only at the moment the report had to be made, that the IIC raised questions about the factual information. He was not able to connect the evidence to a logical sequence of events causing the crash. Through discussions with colleagues it appeared to be that the whole team had been investigating in the wrong direction. Question now raised is could this be prevented or is this just part of the process of investigation.

The 'had-to-do' framework for investigating the accident.

In this paragraph we shall look at the factors contributing to the investigation. Looking first at the investigation team with all the necessary skills, checking the fact-finding and analysis, and last but not least, the Board members responsible for the final report.

As soon as the accident happened an experienced investigator from the shipping sector went to the accident site. For the purpose of good and severe investigation and as reminder for the different aspects to be investigated the investigator was able to use the manual especially developed for shipping. The manual was based on the extensive search and development of the Investigation Hand Book by the *Maritime Accident Investigation International Forum (www.maiif.net),* the recommendations made by *IMO (IMO Res. 849)* and the Basic Risk Factors (BRF) known from the *TRIPOD theory*. The manual actually consists of several checklists and questions to be answered in different chapters referring to specific categories (related to BRF). As it turned out several months later, in the first months after the crash the manual was not used by any member of the team.

The factual information on the accident was overwhelming in the sense that new techniques were used for exploring some of the data recovered, especially from the GPS. Also a lot of effort had been put into the testing of the rudder equipment on Board and ashore under different circumstances. All resulted in new data which more or less confirmed the team in its first analysis, based on the technical failures.

The first report to the Board (6 weeks after the accident) mentioned that the immediate cause of the accident should be found within the technical matters. As underlying causes, also permits for sailing and technical inspections were in doubt. For the Board this was reason enough to give the investigators further advice to search for mishap in the management of the company. The Board also edited a letter to the company to warn its management of the technical failures and lack of maintenance management.

The IIC made up a project plan in which the advice of the Board and further necessary steps for fact-finding and analysis were mentioned. Only one tool was mentioned to support the investigation, the TRIPOD-ß analysis.

All the necessary ingredients were there to have an investigation of the type 'quick and clean´, as the Board and the investigation team were convinced they knew the cause of the accident. We could not get closer than the above as to *Jens Rasmussens' informal stop rule for investigators: Keep investigating until you find a familiar problem to which you know the cure*. And so we did!

What went wrong and how did we identify it.

As the investigation continued, further back-up was gained from technical evidence. It confirmed the theory of technical problems within the company, and even more important the GPS data confirmed the starboard turn of the vessel. In summer 2004 almost all analysis had been done and the first start-up could be made for the report. The TRIPOD-ß analysis backed up the theory of the happenings. As we understood later we had garbage getting in the analysis and not much more out of it!
After the 2004 summer holidays the IIC run into difficulties as the facts could not be structured to a congruent chain of events.
As Chris Argyris mentioned; "Trying to learn from `threatening problems´ is even more difficult when information is `vague, unclear, inconsistent, incongruent and/or, scattered´.

And that actually was the case. Inconsistency of facts and not clear where to find the data to support the theory.
The situation at that moment even related to the so called *ladder of abstraction (Kingston, 2004)*. Team members standing on different ladders, or at different levels on the same ladder and the IIC calling from the other side of the room he could not find a ladder at all. All with their own theoretical view of the events.

Only one solution remained to solve all the problems encountered. All the members of the investigation team were called to join a full re-investigation of all the available material. At the same moment the (lack of) use of the investigator manual was reviewed in order to know if it could have prevented the way things had happened.
After a full week of exploring all the options with the help of a newly introduced technical expert, checking all the hard evidence (f.e. photographs taken at the accident site), the team was convinced that technical failure could not have been the cause of the accident. It was concluded that the captain, after being distracted, in an ultimate attempt to avoid the quay was hampered by the slow turning response of the vessel when sailing at high speed.
A sequence of events was made up and the aim of the team was to confront the captain of the ship with the factual sequence. As it turned out, the captain himself came with the same story even before the latest findings of the investigation team were showed to the captain and his lawyer.

After all, the team found the true cause before the report was brought to the Board. But the Board was not convinced at first hand. With the available evidence, the latest interview with the captain responsible, and an analysis of the company and all related parties (for inspection, certification, permits, etc.), the resulting report complied with the qualitative requirements and standards used by the shipping department within the Board. A new TRIPOD-ß analysis, complying with the new data, was made.

Conclusions

The structuring of facts, collation of diverse evidence, revealing uncertainties, ensuring a broad scope of explanation, presenting information in an accessible form, were all aspects which were not or only partly done by the team in the first instance. Only 9 (nine!) months later, when the sequence of events could not be explained by the factual evidence, did the investigators became more critical to themselves.

Instead of using one or more tools *rigorously* from the first moment of investigation, like *STEP or ECFA +* , to reveal the more *unfamiliar issues,* the team trusted itself to collect all data and not make any sequence of events or time table with the available data (except for the GPS data). Further more the TRIPOD-ß method was more or less abused by forcing it to produce a preconceived outcome. It showed again that the TRIPOD-ß method is only useful for structuring data, not for discovering the cause(s) or a new cause of accidents.

The investigation manual had not been used in the way it should have been. The investigators more or less felt at ease with the familiarity of the accident!

But the most important issue is the way we look at investigating accidents, especially when regarding the necessary skills and tools to help the investigators find the cause(s).
There is no doubt that the strength of the results of the investigation depends on the thorough collecting of available data. All analysis, for immediate or underlying causes, depends on the forensic investigation, the interviewing and the photography together with a structured approach and format. The skills and tools map as shown in figure 2 at page 2 therefore might even be on its side, showing the forensic investigation, the interviewing and the photography together with a structured approach and format as fundamentals for the total building of what we might call *thorough investigation*.

Appendix J: List of competences

There is a difference between the (project)manager of accidents and the professional working in relevant sector. We arranged a shortlist of competencies for each level of investigator;
Level 1 starting investigator
Level 2 developing investigator
Level 3 experienced investigator
Level 4 project manager
Level 5 project manager for major disasters

Within the board an extensive training programme should be available to train and qualify investigators for each level. In the table shown below the competencies are shown and further divided in subcompetencies Each mark indicates the level of training for the different types of investigators. Each starting investigator will be trained in one or two sectors. An experienced investigator and/or projectmanager can be used in any kind of sector.

LAW AND RULES	*level*				
	1	2	3	4	5
Law of the Board	X	X	X	X	X
Related to the sector	X	X	X	X	X
Procedures of the investigating body	X	X	X	X	X
Others than the own sector			X	X	X

TYPES OF INVESTIGATION	*Level*				
	1	2	3	4	5
Minor investigation own sector[28] (max. 3 pers.)	X	X	X		
Minor investigation other than own sector			X		
Major investigation own sector (min. 4 pers.)		X	X	X	X
Major investigation other than own sector			X	X	X
Thematic investigation studies		X	X	X	X
Major disasters			X	X[29]	X

METHODS OF INVESTIGATION	*Level*				
	1	2	3	4	5
Risks of the method(s)		X	X	X	X
Reason, Rasmussen etc. theories	X	X	X	X	X
STEP, Tripod-ß, Track, MORT, ECFA+ etc.		X	X	X	X

HUMAN FACTORS	*Level*				
	1	2	3	4	5
SHEL (Software, Hardware, Liveware, Environment)	X	X	X	X	X

[28] At small investigations there is no dedicated projectmanager. These tasks are divided within the team, which has a maximum of 3 persons.
[29] Only as projectmanager of a part-project.

model					
Stress, fatiguee, memory, alertness		X	X	X	X
Perception		X	X	X	X
Skills, knowledge, rules and cert. of competence	X	X	X	X	X

INTERVIEWS	*Level*				
	1	2	3	4	5
Prepare and doing interviews	X	X	X		
Judging the results of interviews		X	X	X	X
Interviewtechnigues (roles, "valstrikken", competences)	X	X	X	X	X
Use of a translator at interviews		X	X		

EVIDENCE	*Level*				
	1	2	3	4	5
What is evidence	X	X	X	X	X
Registration	X	X	X		
Sources of evidence	X	X	X	X	X
Documents		X	X	X	X
Photographs (digital)	X	X	X		
Interdependence of facts		X	X	X	X
Samples	X	X	X		
Wreckage and apparatus		X	X		
General principles and judging the location of the accident		X	X	X	X

SAFETY, HEALTH AND ENVIRONMENT	*Level*				
	1	2	3	4	5
Personal protection	X	X	X	X	X
Discipline at location	X	X	X	X	X
Care to collegues		X	X	X	X
Multi-modal conscious at the location		X	X	X	X

THE ACCIDENT SITE	*Level*				
	1	2	3	4	5
Relations with other parties involvded (goverment, industry, local authorities, media, etc.) own sector		X	X	X	X
Relations with other parties involvded (goverment, industry, local authorities, media, etc.) other than own sector			X	X	X
Selection and organisation of A.I. team			X	X	X
First evidence and briefing investigation team			X	X	X

Field equipment		X	X	X	X
Assistence of professionals			X	X	X
Briefing Board				X	X
Basic management technigues			X	X	X
Budget control			X	X	X
Media technigues			X	X	X

REPORTS	*Level*				
	1	2	3	4	5
Lay-out of the report (message)		X	X	X	X
Writing the report		X	X	X	X

PROJECTMANAGEMENT	*Level*				
	1	2	3	4	5
Working in projects		X	X	X	X
Projectleader				X	X
Projectleader parts of the project			X	X	
Projectassistence	X	X	X		
Organisation/management skills				X	X

MANAGEMENT OF KNOWLEDGE	*Level*				
	1	2	3	4	5
Use of data (in - en external)		X	X	X	X

SECTOR KNOWLEDGE AND NETWORK	*Level*				
	1	2	3	4	5
Latest developments	X	X	X	X	X
Sector news	X	X	X	X	X
Networking		X	X	X	X
Joining symposia, congresses		X	X	X	X

SYSTEEMMODELLING	*Level*				
	1	2	3	4	5
'Systeem thinking'		X	X	X	X
Able to use technigues for describing systems			X	X	X

KNOWLEDGE OF SAFETY MANAGEMENT SYSTEMS	*Level*				
	1	2	3	4	5
General knowledge		X	X	X	X

KNOWLEDGE OF REGULATORS	*Level*				
	1	2	3	4	5

Art of work/inspections		X	X	X	X
Responsiblities		X	X	X	X

COMMUNICATION SKILLS	*Level*				
	1	2	3	4	5
Next of kin			X	X	X
Eye witnesses		X	X	X	X
Speaking in public			X	X	X
Media training			X	X	X
Parties involved		X	X	X	X
Post traumatic stress syndrom			X	X	X

CAREER DEVELOPMENT	*Level*				
	1	2	3	4	5
Keeping up-to-date		X	X	X	X
Interogation skills			X	X	X

QUALITY CONTROL	*Level*				
	1	2	3	4	5
Check on collegues			X	X	X
Check own reports		X	X	X	X

IT-APPLICATIONS	*Level*				
	1	2	3	4	5
Database applications		X	X	X	X
General a pplications (Word, Excel, Powerpoint etc.)	X	X	X	X	X