CRANFIELD UNIVERSITY

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Developing Capability for Air Accident Investigation

School of Aerospace, Transport and Manufacturing

PhD - Full Time
Academic Year: 2018 - 2019

Supervisor: Professor Graham Braithwaite

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“Submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy.”

ABSTRACT

The Member States of the International Civil Aviation Organisation (ICAO) are facing an increased challenge to improve their aircraft accident investigation capability. This area is the least compliant, according to the ICAO Universal Safety Oversight Audit Programme (USOAP). While existing literature covers many topics of relevance to transport accident investigation, there is a paucity of research that tackles the challenge of how to improve capability in States that have limited resources or absence of a functional Accident Investigation Authority (AIA). Understanding the many aspects of what may be described as 'capability' represents an important step towards identifying a roadmap for the less-developed States.

This study explores the concept of capability in the context of a 'not-for-blame' State-level aircraft accident investigation function. It achieves this through a systematic literature review, followed by interviews and a survey with experienced investigators. The output is a proposed eight-dimension framework to guide less-developed States to establish their AIA and develop its capability.

The results of the study demonstrate that investigation is a cooperative activity depending on multi-scale collaboration by all involved States. In turn, this requires international assistance to obtain appropriate expertise and achieve the required level of quality. Emphasising the independence of the AIA in local legislation and regulations and ensuring effective separation of the investigation process from any administration and/or judicial proceedings were the most notable factors apart from the organisation model. The study provides insights by generating guidance to develop the capability of the AIA. The achievement includes a maturity model to show the evolution of the AIA over three different stages, defined as initial, established and optimised, to help prioritise actions.

Keywords: ICAO USOAP, Capability, Developing Framework, Accident Investigation Authority,

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LIST OF ABBREVIATIONS

ADREP	Accident/Incident Data Reporting
AAIB	Air Accidents Investigation Branch (UK)
AIA	Accident Investigation Authority (As defined in Annex 13) – known in the distributed survey as State Accident Investigation Authority (SAIA)
AIB	Accident Investigation Branch
AIG	Accident Investigation Group
ATC	Air Traffic Controller
CAA	Civil Aviation Authority
CC	Chicago Convention
CMA	Continuous Monitoring Approach
CURES	Cranfield University Research Ethics System
CVR	Cockpit Voice Recorder
DSB	Dutch Safety Board
EI	Effective Implementation
EU	European Union
FDR	Flight Data Recorder
GACA	The General Authority of Civil Aviation
ICAO	International Civil Aviation Organisation
IIC	Investigator In Charge
MoU	Memorandum of Understanding
NTSB	National Transportation Safety Board
OJT	On-the-job Training
PQ	Protocol Question
RAIO	Regional Accident Investigation Organisation
RII	Relative Importance Index
SARPs	Standards and Recommended Practices
SLR	Systematic Literature Review
SMS	Safety Management System
STAMP	Systems-Theoretic Accident Model and Processes
USOAP	Universal Safety Oversight Audit Programme

1 INTRODUCTION

1.1 Research Background

The Convention on International Civil Aviation, which was signed by 54 States on 7 December 1944, at the conference held in Chicago, continues to influence the modern civil aviation system significantly. The Chicago Convention (CC) and its Annexes remain the authoritative reference of all the International Civil Aviation Organisation (ICAO) Member States. ICAO was established primarily to strengthen international co-operation in the field of civil aviation. It marked an important step towards unifying the systems and procedures established in this area (Smart, 2004). The responsibilities of the State of Occurrence were determined in Article 26 of the CC (ICAO, 1944), and are to;

> "…*institute an inquiry into the circumstances of the accident, in accordance, so far as its laws permit, with the procedure which may be recommended by the International Civil Aviation Organisation.*"

Following the 1944 Convention, ICAO issued Standards and Recommended Practices (SARPs) through what are currently 19 Annexes, with the procedures for the investigation of aviation accidents being documented within Annex 13. The Annex, which was first adopted in 1951, provides an international framework that clarifies States' responsibilities when investigating aviation accidents and subsequently disseminating the lessons learned (Smart, 2004).

The investigation philosophy is to follow the ICAO guidelines (Annex 13 SARPs) to raise various questions regarding what happened, why and how such a mishap could have been avoided. The primary focus of accident investigation in aviation is not-for-blame (ICAO, 2016), and to learn from the investigation process to prevent recurrence (Cedergren and Petersen, 2011; Fajer and Fischer, 2012). Roed-Larsen et al. (2004, p.7) observe,

> "*Accident investigation is the most widely used method to clarify the basic, contributing and immediate causes to such accidents as well as identifying*

the appropriate measures to prevent the occurrence of similar events in the future"

In 1999, ICAO established the Universal Safety Oversight Audit Programme (USOAP) through its Assembly Resolution A32-11 which recommended the implementation of regular, mandatory, systematic, and harmonised safety audits (Huang, 2009; Skybrary, 2017). The audit programme went through different phases and was upgraded periodically to reflect ICAO's desire to implement SARPs in different areas, including air accident investigation. The most recent phase of USOAP, Continuous Monitoring Approach (CMA), identified 'Accident Investigation' as the lowest Effective Implementation (EI) score by ICAO Member States, as shown in Figure 1-1 (ICAO, 2018). In other words, this is the area of lowest compliance by Member States.

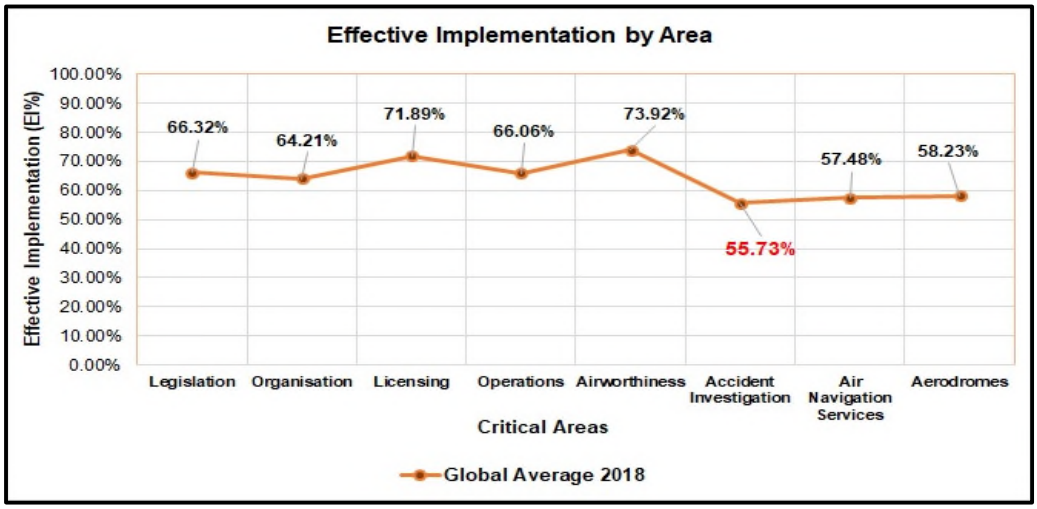

Figure 1-1 Effective Implementation by Area - Source: (ICAO, 2018)

1.2 The Deficiencies Identified by ICAO-USOAP

The USOAP audit has been seen as a measure of compliance with ICAO SARPs, rather than a measure of accident investigation effectiveness (Alsrisari, 2013).

In many cases, these audit programmes measure something theoretical, i.e. whether a State *could* investigate an accident, rather than whether it *does* or *has* – as an accident may not have occurred for many years. From this audit, Member States were categorised as follows:

- States that have already established a permanent investigation authority separate from the regulatory body.
- States that have established a permanent investigation office under the umbrella of the regulatory body.
- States that have not yet established any permanent body or office in charge of accident and incident investigations within or outside of the regulatory body.

Critically, this categorisation identified not only States with investigation authorities at low levels of independence, but also States with no such bodies, which are together referred to in this thesis as the "*less-developed States"*. The USOAP audit revealed that many of these States either lack the ability to conduct an investigation or to co-operate with other States whom they may delegate such an investigation to. Furthermore, many other deficiencies affecting the credibility of accident investigations were also discovered via the audit. For example, legislation and regulations in several Member States were found insufficient to assist with the effective implementation of ICAO Annex 13 SARPs such as absent provisions to properly handle serious incident investigations. (AIG Secretariat, 2008). In addition, in relation to the training of investigators, some States have not yet established formal training systems.

Moreover, guidance materials on accident investigation matters such as procedures, policies, guidelines, processes, and checklists were also missing. While in some cases, procedures were established, they were not consistently implemented. Other areas found not to comply with ICAO provisions were final reports, safety recommendations, and ADREP reports. The final reports in some cases were found either not completed or published (AIG Secretariat, 2008).

In combination, the discovered deficiencies negatively affect the ability of States to execute their obligations under ICAO Annex 13. However, as Blumenkron (2009) highlighted, many States are unable to improve SARPs implementation due to limited technical, financial, or human resources.

1.3 Research Problem and Significance

Over nearly two decades, ICAO audits have emerged as powerful platforms for aviation safety oversight (Huang, 2009; Weber, 2012). However, the results show that many States continue to lag behind because of their inability to address the shortcomings expressed in these findings (ICAO, 2017a). ICAO has stressed many times that audits were performed to determine States' capability in terms of safety oversight, and hence to promote global aviation safety (ICAO, 2006).

Of particular relevance to this study is the ICAO's identification of the problem that many States lack the appropriate capability and/or the means to establish an accident investigation system (AIG Secretariat, 2008). That said, a review of the audit process reveals this so-called 'capability', which ICAO Member States are required to demonstrate, as not being clearly described. Specifically, while a State is assessed as capable based on its audit results; there is no clarification of what 'capability' embraces. Indeed, more generally, the nature of capability appears to be unclear in the context of air accident investigation. As such, it is challenging for less-capable States to know how to improve other than by being 'compliant' with the Annex 13 SARPS.

Following the initial USOAP results, many States have improved their SARPs EI score. However, the latest USOAP results (Figure 1-2) reveal wide variation in levels of compliance. Anecdotal evidence suggests two extremes – more capable States with the resources to improve and greater ability to address specific deficiencies; and less capable States which struggle to understand how to begin to build up their capability.

The researcher experienced this problem first hand as an investigator for the State of Libya. Although the country has been an ICAO Member State since 1953, it was not until 2012 that a bureau was established under the umbrella of the national regulator that would be responsible for the investigation of air accidents and serious incidents. This was in response to deficiencies identified by the USOAP audit, which took place in 2007, but even now, the State remains non-compliant.

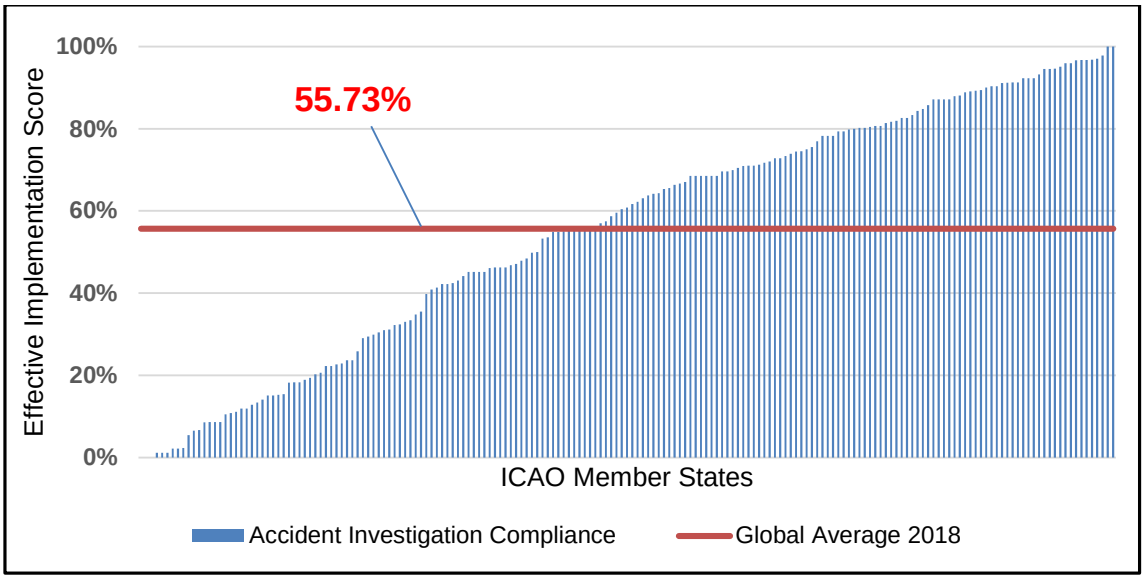

Figure 1-2 States' Effective Implementation Score with SARPs - (ICAO, 2018)

Establishing a system required to be capable of conducting an effective accident investigation has been extremely difficult. This was mainly because although the ICAO SARPs describe what a State must comply with, there is a lack of guidance as to how to build the broader capability, especially in a State which has limited resources or experience.

This challenge provides a practical basis for this research study – to better understand how to build that capability from either zero or a minimal baseline.

1.4 The Rationale for the Study

To demonstrate the rationale of this research and position the field of inquiry for this study, two essential aspects have to be covered. The first is to review the academic literature for material, which may provide a theoretical underpinning for the discipline of investigating aircraft accidents as a starting point. The second is to ensure that the scope of the study remains rooted in the practical side. That means to consider the real situation of the studied area and what is being applied currently in the field of air accident investigation. As the preliminary research problem seems to be very much centred on a specific, practical problem, the optimal plan, should consider linking both perspectives – those found within the academic literature and those identified by industry.

1.4.1 The Research Perspective

A preliminary search of the literature aimed to achieve two goals:

- To familiarise the researcher with the breadth and scope of the research literature to help set the boundaries of this study;
- To justify the subsequent steps, including identifying keywords for a systematic review of the literature.

The initial keywords that were used in this preliminary search were:

(*"Air Accident*[1] Investigation" OR "Aircraft Accident* Investigation" OR "Air Safety Investigation" OR "Aviation Safety Investigation") AND (Capabilit*)*

The selected search field type was **(**Article title, Abstract, Keywords), and three different search databases (Scopus, ProQuest, Ebsco) were used. This search revealed a minimal set of relevant publications and demonstrated the need to conduct a deeper systematic literature review, which is detailed in Chapter Two.

1.4.2 The Industry Perspective

The foundation of aviation safety worldwide could be characterised as being based on compliance with the ICAO's published SARPs in different aviation fields, including accident investigation. For States to execute their obligation effectively, they need an accident investigation system that can respond to an infrequent, complex, but a potentially catastrophic event. The aviation sector is an excellent example of where accident investigation has brought tremendous benefits to safety performance by providing deep learning about accident causation. The not-for-blame approach allows safety recommendations to be made to improve all aspects of the safety system, from technical design and airworthiness issues to the performance of individuals and organisations.

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[1] * is used by many database as a truncation command. Truncation instructs the database to search for the root of the word and retrieve any alternate endings.

However, according to ICAO (2010a), not all States have the desired capability to investigate accidents. Figure 1-3 shows the current situation amongst 185 ICAO Member States which were audited as part of USOAP (ICAO, 2018) in terms of their effective implementation (EI) score of SARPs in the area of air accident investigation. Eighty five countries scored below the global average with EI scores ranging from zero to 55.7%. Appendix A provides details of these States with their scores.

Also, as shown in Figure 1-3, 60% of these countries are located in Africa and Asia, whereas only 20% are located in Europe. These are areas of the world with a greater proportion of less-developed countries. One explanation may be that resources are limited and therefore full compliance with ICAO SARPs may be challenging financially.

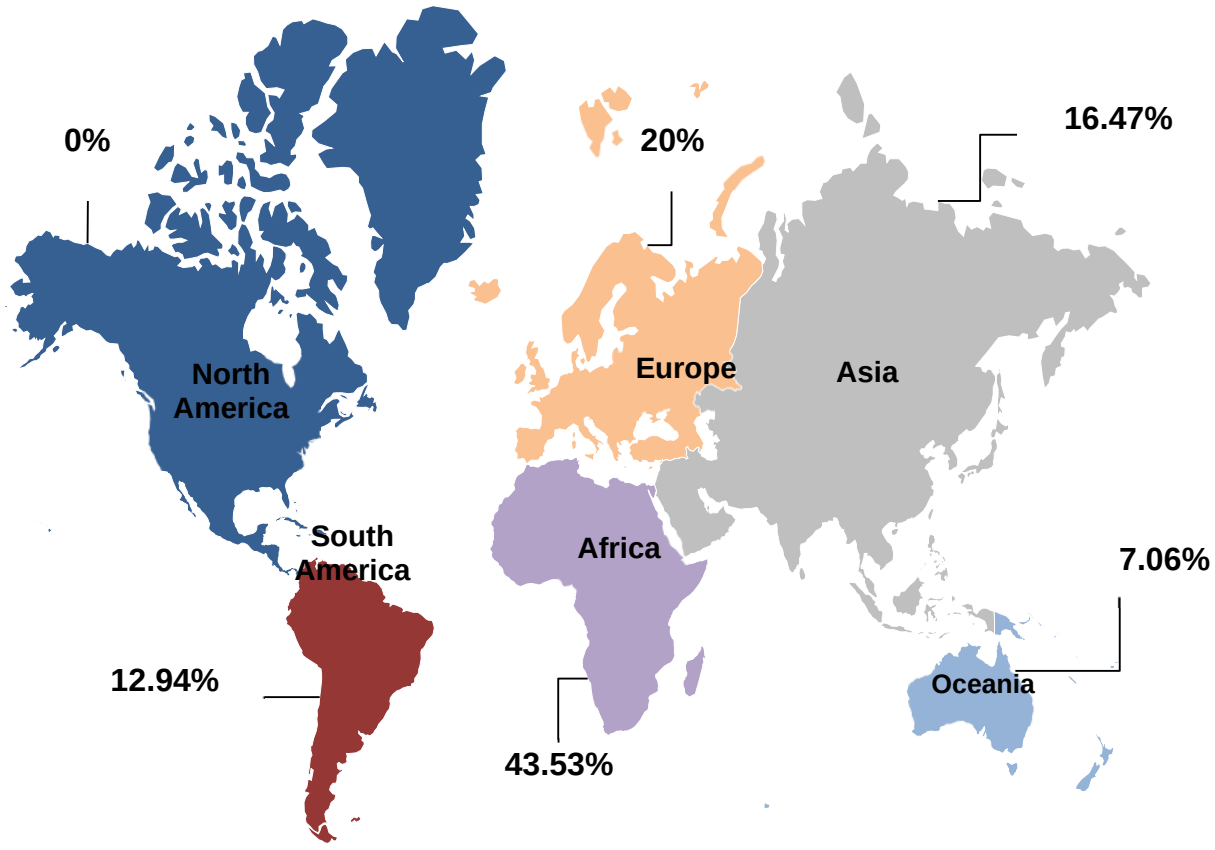

Figure 1-3 Worldwide States Accident Investigation - EI Score below the Global Average – Source (ICAO, 2018)

1.5 Research Question, Aim and Objectives

Considering the previous discussion, the question, which this research aims to answer, is:

How air accident investigation capability can be developed?

The research aim is to identify the best processes and practices to develop the capability of air accident investigation in less developed States, and thus, understand what is required to build and maintain such capability to assist in conducting an accident investigation.

Four objectives flow from the aim, these being to:

- Identify the elements that are required to establish and develop an accident investigation capability in less-developed States; and thus, investigate the meaning of ‘capability’ within aviation and surrounding disciplines, in respect of how it relates to air accident investigation.
- Contribute to identifying how less-developed States can establish and develop their accident investigation capability by suggesting a framework.
- Test and refine the developed framework based on a collection of evidence from the practitioner community to assist in the identification of best processes and practices.
- Propose recommendations for the most appropriate ways to establish and develop the capability of air accident investigation in less-developed States based on the results obtained.

1.6 The Structure of the Thesis

This thesis consists of seven chapters.

Chapter One describes the background to, and motivation for, the research. This starts from the industry perspective that when measured in terms of compliance with ICAO SARPs, the area of accident investigation is the least compliant category. This is at odds with a sector that places occurrence investigation as a key pillar of its safety management approach. The importance of linking both

research and industry perspectives is stressed to develop a research study that is both academically and industry-relevant. The research aim and objectives are introduced.

Chapter Two presents an overview of the concept of capability as it relates to accident investigation in the transport sector, its motives, approaches and challenges in developing this area. It presents a critical review of the literature in the field of accident investigation. It provides a foundation, as one source to identify the main components and features which capability in the context of air accident investigation can be understood. This review develops an appreciation of the evolution of the accident investigation models and allows for the identification of the research gap.

Chapter Three presents the adopted methodology in light of the scarcity of information revealed by the literature. It clarifies the research activities undertaken and provides a narrative to show how the study unfolded. This includes an explanation of the research design and the research paradigm that was constructed, the activities it comprised, and how the data was collected. It shows the research strategy and highlights the use of triangulation to enhance research validity. Additionally, ethical issues and the integrity of the research are considered.

Chapter Four discusses the interview process undertaken with Subject Matter Experts (SMEs) from the area of air accident investigation. It explains the approach to conducting these interviews, which was built on how less-developed States can establish their AIA, and thus develop and maintain their capability. The target is to explore what can assist the less-developed States in establishing and developing their accident investigation capability. Thus, thematic analysis was employed to analyse the data gathered via this research phase.

Chapter Five presents the questionnaire information, which covers its design, structure, and information about the selected samples and population. It provides a descriptive analysis of the gathered data. The results are offered in respect of each of the discovered areas from the interviews process, which are interpreted

and discussed. Where possible, additional statistical analyses were performed to confirm the integrity of the data, and details of these are reported. Furthermore, where findings coincided or varied with the literature or the SMEs results, these are discussed.

Additionally, the chapter presents factors analysis using the relative importance index (RII) method. The significance of these factors in different situations is established to promote an overall understanding of their importance among the proposed model areas, and different organisational models. Then, the proposed framework is introduced.

Chapter Six provides rationality by analysing the qualitative data obtained from the survey. This analysis is provided to facilitate the emergence of important insights into the quantitative data. The validation of the framework is explained, which was performed by both a case study and evaluation of two AIA's.

Chapter Seven consists of a short discussion and presentation of the research findings. Additionally, it identifies the contribution of the study and acknowledges its limitations, which serve as the foundations for suggestions for future research.

2 LITERATURE REVIEW

2.1 Introduction

The specific challenges of either establishing a new air accident investigation body or enhancing a deficient body in less-developed States deserve consideration from different perspectives. The ultimate goal of the literature review is to satisfy the first research objective, by identifying the required elements to establish and develop accident investigation capability and investigate the meaning of ‘capability’ within aviation and surrounding disciplines, in respect of how it relates to air accident investigation. The purpose is threefold, firstly, to review the specific requirements for air accident investigation, an activity which is governed by national and international rules. Secondly, to scope the elements, which are necessary to achieve the intent successfully; and thirdly to identify what exists within the scientific literature, which may assist in the development of accident investigation.

To achieve the first aim, it is vital to start with the technical requirements of the aviation industry. At the international level, this begins with the requirements of ICAO. The USOAP results show low levels of effective implementation (0-55.7%) of SARPs for 85 States in the area of air accident investigation (see Chapter One). Indeed, to assume that a specific State is ‘capable’ simply because it is ‘compliant’ with SARPs is arguable. It may meet assessed criteria about what it has (compliance) without necessarily being able to perform (capability). A parallel may be drawn with operators where compliance is increasingly seen as ‘bare minimum’ whereas those with a healthy safety culture aspire to exceed regulatory minima to achieve superior performance.

In practical terms, even ‘more compliant’ States may not be able to achieve the highest standard of accident investigation. For instance, challenges include maintaining the proficiency of investigators in countries, which have a low rate of accidents and serious incidents (see Stoop and Roed-Larsen, 2009). Additionally, even those investigation reports which are produced may lack important details that preclude lessons being learned from conducting such

investigations (see Braut, Solberg and Njå, 2014) (refer to section 2.4.5). This may suggest that compliance with SARPs is not necessarily a guarantee of a State's capability (refer to sections 1.2, 1.3).

On the basis that ICAO is looking for an outcome rather than regulatory compliance *per se*, and as ICAO notes that the results of USOAP provide only a "*snapshot*" of the safety oversight system rather than performance monitoring on a continuous basis (ICAO, 2010b, p.2), there is a question over how Member States ensure that they possess the right capability to execute their obligations under Annex 13, and thereby achieve the goal of accident prevention. Other than the published SARPs, what guidance is provided to States to assist their compliance, and most importantly, to improve their performance, especially from zero or limited capability level? Is capability adequately described such that States can monitor it? What exactly does capability include? A broader assessment of capability is required to assess how well an authority might manage future incidents and accidents. In addition, can less-developed States correctly establish their AIA's and develop and maintain its capability in this area?

Acknowledging that regulatory compliance *per se* is not the overall aim for air accident investigation, the next question to answer is what would collectively achieve the desired objective, which ICAO clearly state as;

> "*The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability*" (ICAO, 2016) (also see Vuorio et al., 2014).

Therefore, the second aim of the literature review is to scope the elements, which are necessary to achieve this objective.

2.2 Systematic Literature Review as an Approach

To achieve appropriate and balanced coverage of the academic literature, it is important to adopt a structured approach. The 'Systematic Literature Review' (SLR) as a methodology emerged as a result of an effort to establish "*agreed and formalized procedures for systematic review to synthesize and disseminate evidence*" across different healthcare areas. This methodology includes research

area identification, selection of studies, quality assessment, data extraction, and data analysis and synthesis. It reports the evidence to reach explicit assumptions about what is and not known (Denyer and Tranfield, 2009; Tranfield, Denyer and Smart, 2003). This allows for transparent and reproducible inclusion and exclusion approach to articles selection and analysis (Bergström, Van Winsen and Henriqson, 2015).

An SLR is distinguished from the traditional literature review by its rigorous and transparent process in conducting an unbiased review, inclusive of relevant studies, and indicative outputs that in turn, lead to the next phase of research (Denyer and Tranfield, 2009).

2.3 Systematic Literature Review Search Criteria

To successfully execute an SLR, suitable search criteria must be identified and then refined to generate appropriate and relevant publications. For the current SLR, the final selection of keywords resulted from extensive searching using different keywords. An iterative process used several synonyms also associated with other safety-critical sectors such as those represented by words like nuclear, rig*, pipeline and petroleum. This approach generated a slightly higher number of titles, but introduced the risk of moving away from the study area, and therefore, losing relevance. In particular, the philosophy of investigation applied in some of these fields may be more aligned to apportioning blame or liability. For example, in a road traffic collision in the UK, there is a baseline assumption that someone is to blame. Therefore, after consulting a reference panel (three academic staff and one information specialist) who assisted in the process of the SLR, the keywords were limited to only cover the '***not-for-blame***' elements of the transport sector, specifically rail, marine and aviation. Hence, the search included keywords with a configuration of mainly article titles, abstracts and keywords as follows:

((accident* OR incident* OR crash* OR safety OR disaster*) w/3 investigat*) AND

(air OR aircraft OR aviation OR airline* OR rail* OR train OR trains OR marine OR maritime OR transport*) AND

(capabilit* OR performance OR effective* OR efficacy OR competenc* OR framework*)

where w/3 means *within three words.*

Figure 2-1 shows the process of the SLR, including the screening stages.

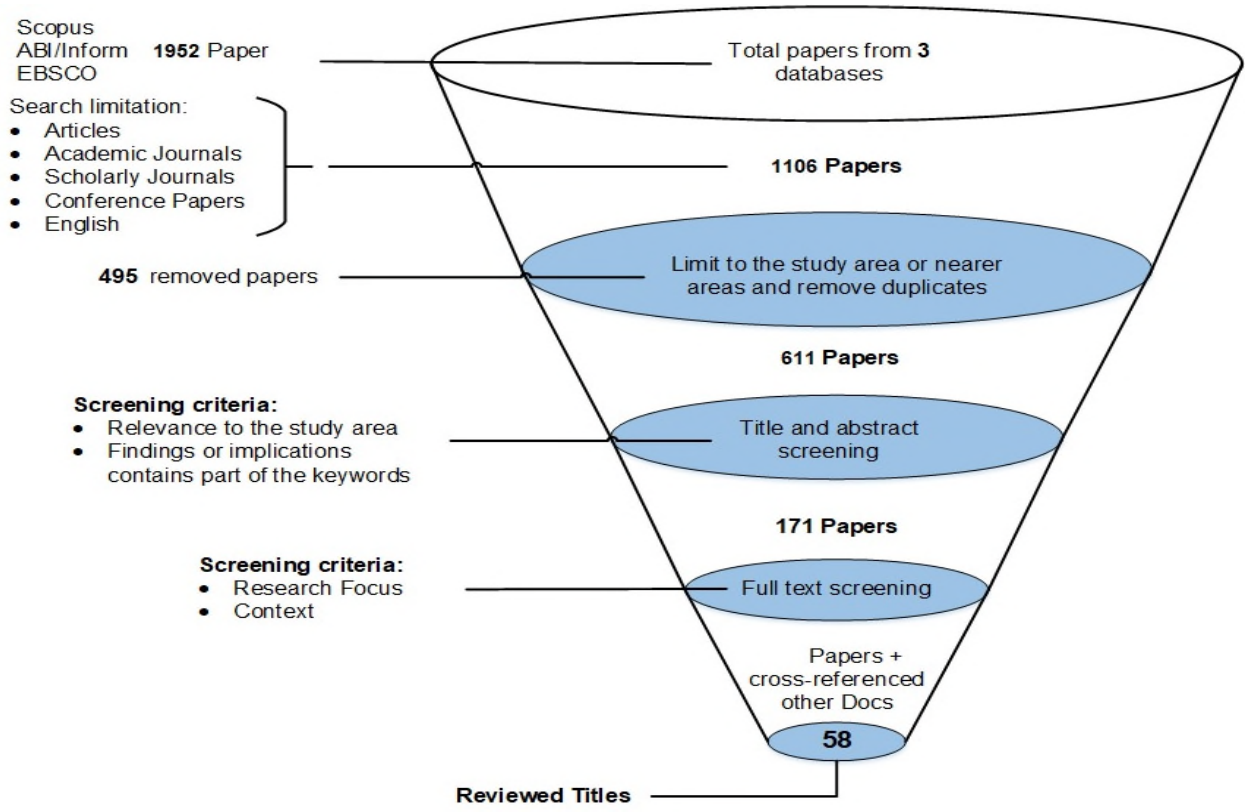

Figure 2-1 Methodology of the Deployed Systematic Literature Review

At the final search stage, other cross-referenced titles were identified and evaluated before being added to the existing number as follows:

- Some ICAO publications (which undergo an extensive editorial process) were included to articulate the perspective of the aviation industry. In particular, the Safety Management Manual (SMM), which describes the high-level guidance, provided to States for the implementation of a Safety Management System (SMS).
- Another area that was considered is the conference proceedings of the International Society of Air Safety Investigators (ISASI) where three relevant titles were selected, in addition to five related books and book

chapters. Moreover, one relevant thesis was included in the cross-referencing.

- While the word ‘capability’ was included in the search keywords (along with other synonyms) for the current SLR, titles covering the broader concept of capability were not included in this count. A specific approach to define the capability as a concept can be viewed in Section 2.7.

Accordingly, this brought the final total number of titles included in this SLR to 58 titles.

2.4 The Philosophy behind Investigating Accidents

Accident investigation has played a fundamental role in improving aviation safety. The United Kingdom, for example, first established the role of Chief Inspector of Accidents in 1915. The concept of learning from failure is not unique to aviation and is arguably a basic animal instinct. However, the formal investigation of an accident is a process that can be approached from several different stakeholder perspectives (Michaelides-Mateou and Mateou, 2010).

The achieved enhancement in safety relies not only on technology development but also on “*incremental design improvements triggered by accidents*” as suggested by Waycaster et al. (2018, p.1086). Generally, in the transport sector, the most important motivation behind the development of accident investigations has been to maintain public confidence that the appropriate levels of safety were being achieved, as highlighted by Stoop and Roed-Larsen (2009).

Nonetheless, the expectations of the investigation process are now increasing. The goal is not only to prevent future accidents but also to achieve the broader aim of strengthening safety in general, to arrive at a more “*resilient system*” (Cedergren and Petersen, 2011; Stoop and Dekker, 2012).

2.4.1 The Investigation Concept

The SLR revealed that ‘Investigation’ was identified as a very commonly-advocated approach and “*consequently is becoming an umbrella concept*” (Stoop, 2011, p.1392). In general, ‘investigation’ incorporates numerous

approaches on distinctive system levels, including transport accidents, crime scenes and natural disasters. To maintain credibility in the eyes of expert legislators and the public, accident investigations should preserve their distinctive role, purposes and operational circumstances.

> "*Accident investigations have come under public and political scrutiny and have raised scientific interest in their models, methods and practices*" (Stoop, 2011, p.1392).

There are four key challenges to the external circumstances in which these investigations must be conducted in terms of actual behaviour, skills and competencies required: independence, scope, the methodology of investigations, and safety training and competence (Stoop, 2011). Not-for-blame accident investigations have been recognised as an effective tool – initially within aviation and subsequently in marine, rail and, in some countries (e.g. Norway, USA), road transport. A separate investigation authority has been established by many countries to deal with one or more of these transport sectors, depending on international rules, as is the case in aviation (Stoop, 2004). The importance of accident investigations in these areas lies in their design, technological development, and contribution to the maintenance of adequate safe performance levels and public confidence (Stoop and Roed-Larsen, 2009). In more recent decades, the attribution of accident causes has evolved. Technological factors have decreased while human factors have increased, and organisational factors have emerged and increased substantially (Hollnagel, 2009).

Dechy et al. (2012) and Rasmussen and Svedung (2000) emphasise that the frequency and severity of accidents play an essential role in the decision to launch an accident investigation. Generally, investigations can be classified into three main categories: internal investigations for recurrent events with small scale value, technical or safety investigations for medium non-recurrent events, and finally public accident investigation for occasional large scale events.

From a general perspective, it is possible to allocate safety investigation to different schools of thinking, as specified by McIntyre (2000) and Stoop and Roed-Larsen (2009):

- **A Tort Law school:** this originated in the 19th century based on the railways and transport industries. It looks into the causes of accidents and features a deterministic approach.
- **Reliability Engineering:** this examines risk in terms of probabilities as well as using normal accident theory, the effects of human actions and organisations that are reliable. Its roots are in the commercial industry, and it relies on the quantification and probability of risk.
- **System Safety Engineering:** this came out of space technology and examines life cycles, management of emergencies, certification, governance, disaster, and impact assessment. This school is most concerned with integrated system safety and risk as a social construct created by perception and awareness.

However, the need to emphasise investigation independence has been recognised by many States as well as ICAO. It can be seen as the first requirement in initiating a reliable accident investigation organisation.

2.4.2 Different Aims of Accident Investigation

In some cases, several organisations want to perform investigations of the same accident, potentially prompting clashes, such as access to the accident scene and interviewing witnesses, safeguarding of evidence, and the gathering of facts. Moreover, the result of each investigation might be influenced by the varying objectives and goals of each stakeholder. Hence, some States have attempted to establish collaboration standards between safety and judicial authorities to control the relationship between the different organisations that have an interest in the investigation (Dechy et al., 2012; Marinho De Bastos, 2004). However, proof of accountability, particularly from a legal or commercial view, remains a target of many accident investigations, as highlighted by Reiman and Rollenhagen (2011). Therefore, a clear distinction in the accident investigation

objectives is made between those whose aim is not to apportion blame or liability but to search only for reasons and preventive measures and those whose target is to settle legal cases for negligent or criminal performance (Stoop, 2011).

2.4.3 Accident Investigation Methodology

The SLR suggests that the decision to investigate occurrences varies, as each reported event requires some assessment before deciding to investigate it. Usually, the scale of the event plays an integral part in such a decision. Occurrences classified as minor incidents are referred to another body such as the operator, local regulator or the manufacturer. In contrast, serious incidents and accidents resulting in severe damage or serious injuries or death are investigated by the responsible investigation authority in the State concerned. The traditional investigation methodology, which comprises the investigations of technical and human errors, is still widely practised in many States. Relatively few States use approaches and methods that include social, technical and organisational factors (Dechy et al., 2012; Underwood and Waterson, 2013).

To elaborate, there is a difference between the contemporary approaches proposed by the research community and those utilised by investigators or practitioners who usually conduct the investigation. For instance, Underwood and Waterson (2012) argued that older analysis tools such as Fault Tree Analysis are still widely used in the investigation process (see Reuss, 2015), which has led to the results of many investigations omitting important factors related to the organisational level. In spite of the evolution of systemic analysis tools such as the (STAMP) (Leveson, 2004), and the Functional Resonance Analysis Method (Hollnagel, 2012) which are used for accident analysis and risk assessment (Furniss, Curzon and Blandford, 2016), many investigators were found to be unaware of such tools and consequently, do not use them in their investigation analysis. Factors such as reluctance of investigators to change their investigation approach, lack of learning opportunities due to workload demands, and obstacles related to accessing and utilising the relevant research information to facilitate the use of a systemic analysis technique, were among the direct obstacles

preventing investigators from changing their investigation approach (Underwood and Waterson, 2013).

From another perspective, Lundberg, Rollenhagen and Hollnagel (2009) identified some factors, such as time and personnel, which affect the normal activities of the investigation process. However, five essential phases of a non-specific nature, containing essential characteristics of the investigation methodology have been identified (Kahan, 1998; Stoop and Roed-Larsen, 2009); these are:

- **The initiation of the investigation** – which is frequently generated based on the requirements of international or national rules or regulations, such as ICAO Annex 13 and EU Regulation 996/2016.
- **The fact-finding phase** – to identify the accident HOW and WHAT questions by the collection of facts at the accident investigation site. It is a comprehensive phase involving investigators from different areas of expertise to clarify the accident scenario and results in moving from facts to causal factors.
- **The analysis phase** – to achieve a clear and adequate clarification concerning the WHY of an accident to outline the nature of accident causation such as system deviation or knowledge deficiencies.
- **The recommendation phase** – this deals with the draft preparation of recommendations for WHO has to do WHAT to prevent the future occurrence of similar accidents and incidents. This phase defines the transition from explanatory variables to the change of variables in socio-technical systems.
- **The monitoring phase** – this follows up the proposed recommendations and their implementation by all the parties involved. This phase primarily deals with risk assessment plus communication to stakeholders and public responsibilities.

However, the way an accident investigation organisation is established, and whether it is single mode or multimodal, should be explored to facilitate the understanding of the different models for those organisations.

2.4.4 The Difference in Structure of Accident Investigation Organisations; Single Mode or Multimodal

The literature suggests that in many cases, the establishment of a permanent accident investigation body has often been a response to a major accident with serious outcomes (Stoop and Roed-Larsen, 2009). In this vein, Stoop and Kahan (2005) note that the establishment of multimodal boards often occurs after major events outside of the transportation field, which motivate the need for independent investigations in the public eye.

According to Baxter (1995), establishing one organisation with responsibility for investigating all transport accident modes will guarantee the conduct of independent investigations. It is suggested by Smart (2004) that the practices and procedures associated with aviation accident investigation are acknowledged as generally offering a sound framework for the investigation of accidents in other forms of transportation. The value of organisations entrusted with such investigation lies in their ability to provide safety standards and make recommendations as to how these should be met. Indeed, Stoop and Roed-Larsen (2009) note that the professionalism and independence of these organisations boost public confidence and that in particular, aviation and shipping, representing high tech sectors, benefit greatly from them.

Stoop, and Roed-Larsen (2009) highlighted the efforts of the European Commission to establish models which, in their view, are more organised and achieve specific standards for accident investigation. However, these models were likely to be limited to the sectorial tradition (chemical sector, air, sea, rail, etc.). The main cited advantage in favour of the multimodal organisation is the possibility of using the same basic methodologies of investigation across other modes (Flaherty, 2008; Kahan, 1998). In this respect, it is noted by Flaherty (2008) that the training of investigators, the use of some investigative and

recording tools, and approaches to forensics, public relations and legalities are shared across this type of organisation. In Stoop's (2004) opinion, the establishment of multimodal boards will increase as the harmonisation of investigative methodologies increases. Certainly, advocates of the multimodal option consider the test of time to prove its credibility (Dechy et al., 2012), and Vollenhoven (2002), former Chair of the Dutch Safety Board (DSB), highlighted the reluctance of the multimodal organisation to return to being a single mode organisation.

2.4.5 Learning from Accident Investigations

The literature shows that a major objective of accident investigation is to learn from the experience gained and that this involves different targets, both individuals and organisations (Hovden, Størseth and Tinmannsvik, 2011; Njå and Braut, 2010). For instance, the lessons learned from investigating aviation accidents have assisted in establishing training requirements, such as simulator training scenarios for flight crews (Crider, 2017). Additionally, the lessons learned from investigating the "*Tenerife*" accident assisted in establishing human failure research and crew resource management (Stoop and Dekker, 2012). A closer look at the transport sector reveals a growing willingness to conduct investigations into accidents and incidents for learning and recommend corrective actions, as highlighted by Stoop (2004).

However, many accidents and even disasters still occur in every industrial sector worldwide. This situation reflects the multiple failures of the risk management process, and to learn from the experience (Cook and Rohleder, 2006; Dechy et al., 2012; Dien, Llory and Montmayeul, 2004; Stemn et al., 2018). The recurrence of accidents provides evidence of the failure of people and organisations to learn from previous events (Leveson, 2004). It is, therefore, necessary to continually re-evaluate the quality of accident investigation to maximise the learning process (Dechy et al., 2012). However, the question of whether accident investigation authorities in the transport sector follow a learning model when investigating accidents is raised by Braut, Solberg and Njå (2014). Thus, it is important for

accident investigation authorities to ensure that the investigation process embodies learning methods on different levels to fulfil this target. However, it might still be challenging to assess the learning value before the deployment of the investigation or collection of evidence, as argued by Nixon and Braithwaite (2018).

It is suggested by Jakobsson (2011) that while some authorities specify learning as the most important target and outcome of their investigation, they do not clarify the means of achieving this target. Likewise, and from a broader perspective, accident investigations in the aviation sector are criticised for the amount of learning they provide. For instance, in a study performed in Europe, a limitation of using formal methods in most of the investigations undertaken was discovered as having led to weakness in the investigation analysis. This was attributed to the investigators' general training and insufficient experience of systematised and organisational approaches to documenting learning, which contributed towards the repeated failure to learn from experience (Dechy et al., 2012; Dien, Dechy and Guillaume, 2012) (Also see Ferjencik, 2010).

Factors such as poor feedback from experience, the political context of organisational learning and the fear of blame and liability represent barriers to the learning to be gained from investigating accidents (Perrow, 1984, cited in Hovden, Størseth and Tinmannsvik, 2011). However, there is no actual consensus on the concept of 'learning' and all of its various aspects, as highlighted by Njå and Braut (2010). One definition suggested by Størseth and Tinmannsvik (2012) is that learning is a skill that demands effort for it to be sustained. From another perspective, learning after an event is considered by Braut and Njå (2010) to require the prompt handling of the data and information relating to that event. To transfer this logic to accident investigation in the aviation sector, the credibility of such investigation can be seen to depend upon the prompt response of the investigators to the accident site and their preservation of evidence. Such preservation is not always easy, as highlighted by Nixon and Braithwaite (2018) who note the risks associated with perishable or vulnerable evidence.

2.4.5.1 Individual Influence in Learning

Considering individual learning from accidents, the concept of learning should not be approached from a single perspective. However, it is assumed by Njå and Braut (2010) that the investigator as a single individual within the overall investigation system is the most vital unit, even when studying the concept of learning on a large scale such as in organisations and societies. The learning at the organisational level is assumed to be "*oriented towards individuals*" (Njå and Braut, 2010, p.3); hence, individuals feed their knowledge into the organisation via the stipulated hierarchy.

One of the most important components of the information produced by individuals is the investigation report itself (Njå and Braut, 2010), in which respect Cedergren and Petersen (2011) stress that the investigator's competence and experience are key factors as these determine the focus of the report. However, in some cases and during the investigation process, investigators may omit the learning aspect, as is evident in some published final reports, as argued by Braut, Solberg and Njå (2014).

2.4.5.2 The Organisational Influence in Learning

The learning gained from experience comes from effective and thorough involvement in the investigation process (Hollnagel, 2016). Still, that investigation is in itself based on certain assumptions, and these will colour the lessons learned. Hence, the selection of specific events to investigate by the organisation might compromise the learning process due to that choice narrowing the scope of learning by excluding events that might have generated valuable lessons; indeed, the selection process may point to bias within the organisation in respect of the selection criteria (Hollnagel, 2008). Størseth and Tinmannsvik (2012) also acknowledge this possibility, concluding that the learning focus should not be directed only to the study of accidents, but rather extend to cover frequently-occurring incidents. In general, by considering where the learning can take place in the organisation, three different levels have been identified as possible targets for learning from accidents: the microlevel, mesolevel and macrolevel (Cedergren

and Petersen, 2011). However, the important lessons to be derived from investigating accidents are those that occur at higher levels in the organisation hierarchy, as they provide explanations of the factors limiting the actions of individual operators (Cedergren and Petersen, 2011).

It is important to highlight that continuous learning can come from all accidents irrespective of their gravity or the scope of the investigations undertaken. It is, however, frequently the case that the more serious the consequences of the accident, the greater the complexity of conducting a formal investigation since many factors (such as the ability to maintain the required evidence) contribute to expanding the opportunity for learning (Soma and Rafin, 2006). Moreover, such learning may be seen as influenced by both the individuals involved and/or the organisation. Authorities wanting to learn from accident investigation might want to follow the suggestion of Rosness (2009, cited in Braut, Solberg and Njå, 2014) to clearly show in their findings how the organisation's normal process contributed to the event.

2.5 Further Results from the SLR

Developing the capability of air accident investigation in less-developed States is essential for all ICAO Member States since this contributes to the aviation sector by improving and maintaining higher safety levels. Such development enhances a State's ability to use its resources appropriately and organise its work based on the importance of each task or target. Hence, the aim is to identify what exists within the scientific literature, in how best to establish accident investigation authorities in less-developed countries, and to sustain its capability so the State can comply with its international and national obligations. Section 2.7 explores the meaning of capability in this respect.

However, the SLR demonstrates a focus on WHY States must conduct accident investigations, WHAT process should be followed, and WHEN such investigations must be performed. Moreover, while the HOW to establish an investigation authority does feature in the literature, the emphasis is on the process after initiating the accident investigation following an occurrence. Most

of the literature reviewed discusses the evolution of the accident investigation as a system, the consequences, and some perspectives on how such a process may be improved in the future. For instance, the need to implement a system that focuses on safety deficiency and system change by identifying its existing deficits is identified. This system should emphasise the requirement to make safety reforms that undergo regular monitoring to ensure that they are enduring over time (Rasmussen and Svedung, 2000; Stoop and Dekker, 2012; Stoop, 2004). There is also a need in the current accident investigation system to change the focus towards prevention to reduce accident rates. This can only be achieved with a thorough understanding of the typical performance indicators and identification of weaknesses in the system, independent from operational and maintenance functions. Thus, operators are becoming more attracted by the independent investigation of safety (Aziz, 2000, cited in Stoop, 2004).

Moreover, despite the vast improvement in accident investigation methodology, criticism does exist of the system currently applied. Considering the global situation of air accident investigation, States classified as non-capable vary in their capacity to handle severe mishaps due to different factors, such as the readiness of investigators and their training, but there is only brief discussion of these in the literature.

Furthermore, the reviewed literature identified many contributory factors to the investigation process, which aims to gain public trust, but four general principles are suggested for a transport accident investigation to be seen as reliable. These are:

1. Independence from any other parties in the State, such as local regulators
2. Transparency of its work
3. Credibility by maintaining a close understanding of technology
4. Influence in its investigation results, including the most important outcome of the investigation; safety recommendations

Summarised from Marinho De Bastos (2004).

According to Guo Fu (2010), the objectivity of an investigation depends on certain factors, such as the law, the organisation, the investigator's qualities, and the level of independence of the investigation. In this respect, he stressed the need for a respectable level of quality and credibility. Roed-Larsen and Stoop (2011, p.1395) have also identified the challenges facing modern safety investigations which they describe as "'*very fragmented*", and have suggested improving four areas within the investigation community, these being: independence, scope, methodology, and training and competence. However, it seems that there are additional factors to consider in the case of less-developed States wanting to establish their national authorities, and develop and maintain their capability.

Former Chief Inspector of the UK Air Accidents Investigation Branch, Ken Smart (2004) described the factors which contribute to establishing people's trust in accident investigations in the aviation field. Such factors include: (a) the actual form of the investigation structure (framework), (b) its relevance to the safety culture in the aviation industry, (c) the independence of the investigating authority and finally the skills of the investigators and their efforts to maintain contact with the families and accident victims.

2.5.1 Challenges of Less-developed States

As already mentioned, the focus of much of the literature relates to the process after deploying the accident investigation, such as the analysis phase and learning from accident investigation. Even when the discussion covers the period before initiating the investigation, it is to pave the way to debate the current investigation process. Additionally, it was found that the broader discussion targets States that already have accident investigation authorities in place where the debate focuses on enhancing the current accident investigation process. In the situation of a less-developed State, with no capable body or investigation system, and a low score in ICAO audits, important questions are not clearly addressed in the literature, and these need to be further clarified in this research. These include:

- What is a less-developed country required to do to establish and develop the capability of its air accident investigation authority?
- With limited resources available, what are the most important aspects to prioritise?
- What elements must come first to ensure maximum effectiveness?

Moreover, questions of how independence can be accomplished, and how recommendations and learning can be mediated are also important (Jakobsson, 2011). Generally, in the transport sector, the results show that in many countries, the establishment of a separate body within the aviation sector is based on international standards, as highlighted by Roed-Larsen and Stoop (2011) and Stoop (2004). The initiation of an investigation is usually conducted based on international criteria and requirements such as stipulated in aviation (ICAO Annex 13), and the Shipping Code for the Investigation of Maritime Casualties (Stoop and Roed-Larsen, 2009). The investigation, in general, requires new expertise and much more resourcing than previously. This trend presents a challenge in investigating accidents in that States must continually improve and adopt new approaches to prevent further accidents. However, several important aspects to be considered within accident investigation in the transport sector in general, and aviation specifically, are identified within the literature.

The first aspect is independence. There is a high agreement within the literature that independence is essential and must be guaranteed in accident investigations in the transport sector (Arnaldo Valdés and Comendador, 2011; Dempsey, 2010; Jakobsson, 2011; Reuss, 2015; Smart, 2004; Stoop and Dekker, 2012; Sweedler, 1995; Trogeler, 2010). Indeed, many other sectors are adopting this maxim to ensure their investigations are credible and sound. The ongoing discussion requires the conduct of the investigation to be independent of the influence of other parties in the State, such as the judicial authority. However, independence in the investigation process should assist in identifying the causes of an accident and provide an answer to important questions, "*what happened?*" and "*why it did happen?*" (Arnaldo Valdés and Gómez Comendador, 2011; Baxter, 1995; Dien, Llory and Montmayeul, 2004; Stoop and Roed-Larsen, 2009). To avoid any

conflict of interest within the other State bodies such as regulators, independence of accident investigations is assumed as a Citizens' Right and Society's Duty (Stoop and Kahan, 2005; Vollenhoven, 2002). Realistically, independence from the politico-cultural system does not exist; hence, this is considered to be a relative concept, which is highlighted by Dechy et al. (2012) as the evaluation and assessment of the investigation findings and facts apart from the influence of other agencies in the State so the final report and safety recommendations can be finalised accordingly. This may indicate that the State should ensure a certain level of independence, which allows investigations to be conducted from which the findings cannot be used for legal prosecution.

The second aspect of consideration is the State internal legislation system. Legislative efforts concerning overall safety in the transport sector are seen in product safety, the environment, and other activities classified as hazardous. The SLR suggests that the aim of initiating laws and regulations in the transport sector is to improve safety since organisations will be better motivated to enhance their safety record (Waycaster et al., 2018). Additionally, the establishment of relevant rules within those laws and/regulations can ensure the investigations are performed independently (Fu, 2010). Moreover, to ensure the identified SARPs and guidance materials are followed and implemented, Member States should develop their national legislation and regulations to reflect such international rules (Dechy et al., 2012). The best example of the contribution made by legislation and regulation to the enhancement and strengthening of the accident investigation system is seen in the European Union (EU), via Regulation 996/2010. This Regulation addresses many aspects, including organisational changes that require a clear separation between the roles of the accident investigation authorities and the EASA (Arnaldo Valdés and Gómez Comendador, 2011).

The third aspect of interest is the organisation, alternatively referred to as the agency, authority or safety board in those States adopting a multimodal approach to accident investigation (Kahan, 1998; Stoop, 2003). As noted already, two types of model are currently in use, the single mode and the multimodal; and this poses

the question of which type should be selected by a State attempting to establish its accident investigation organisation from scratch or limited resources? No certain factors contribute to this selection, and the situation varies one State to another. However, the literature is not very informative in this respect, no general guidance has been found, and clearly, there are pros and cons of each model. According to Kahan (1998), critical mass in investigative resources, and arguments about economies of scale and organisational efficiency are important factors in recommending the adoption of a multimodal approach, especially in small countries. From another perspective, Stoop (2004) suggested two strategies that can be followed by States to establish their accident investigation organisations; these being: by combining several sectors within one agency on a national basis or developing multinational boards within a single mode of transportation. Jakobsson (2011) has, however, questioned why one organisational model is preferred to other possible models.

The fourth aspect is the investigators. Accident investigation as a task can be unlimited in scope, which requires qualified personnel who can perform the necessary investigation of different tasks.

> "*What is clear is that a good investigator does not come about by chance or simply the ownership of a fluorescent jacket*" (Braithwaite, 2002, p.1).

The availability of capable investigators with the requisite expertise allowing them to participate effectively in the investigation process was identified in the literature as an important feature of modern accident investigations (Stoop, 2011). Among the tasks facing investigators are the need to maintain control of the management of the investigation process, and to communicate and co-operate with other involved parties. The baseline in respect of investigative skills and competence must be established as requirements for all investigators, whether they are participating in accident investigations or serving as members of accident investigation committees or organisations (Stoop, 2011). Dechy et al. (2012) consider that the quality of any accident investigation depends upon the level of competence and performance of the investigators, and on the resources made available to them.

2.6 Safety Management Theory and Approach

It is argued that the adoption of safety management has improved gradually in the past years in different areas (Moorkamp et al., 2014). The Safety Management System (SMS) is a system for managing safety. From a theoretical perspective, SMS is considered to be more explicitly arranged around the organisation's management and control processes, as highlighted by Moorkamp et al. (2014) also see Hale et al. (1997).

Within aviation, and according to ICAO definition, SMS as an organised approach to safety management comprises organisational structures, accountabilities, policies and procedures (Li and Guldenmund, 2018). From the company viewpoint, safety in its abstract perspective implies that no accidents can occur in any of its facilities since the main task of safety management is to prevent accidents, which cause, in addition to financial losses, reputation damage, and loss of life and goods. The implementation of SMS includes the reporting and investigation of accidents and incidents to ensure learning and continuous improvement (Grote, 2012). The learning and improvement imply the introduction of safety defences such as safety equipment, devices and specific behaviour patterns. These defences have been elaborated in many theories and paradigms (such as the Hazard-Barrier-Target model and Reason's Organisational Accident model) and were used and developed in companies prior to the advent of the SMS, as argued by Li and Guldenmund (2018).

As the primary rationale for using an SMS is to prevent accidents by applying measures to control risks, the concept has claimed a position as a proactive approach, among others such as quality assurance. However, Stoop and Dekker (2012) have observed that such a claim might be questioned since regardless of the follow-up rate of recommendations, no principles are guiding the measurement of accident investigation success. Others, such as Swuste (2008) have also pointed to the lack within SMS of any records based on principles that would facilitate their comparison with other safety improvement methods. It is suggested that the SMS should include a focus on the management of

knowledge, aimed at developing organisational learning instead of addressing private companies on a rule-based level (Johnson, 2007, cited in Stoop and Dekker, 2012). Nonetheless, it is still anticipated that the adoption of the SMS among the State service providers such as aviation companies and maintenance organisations will bring safety enhancement and increase safety awareness.

By recalling the aim of this research, the literature suggests that the deployment of SMS would help to develop aviation safety and enhance the exchange of safety information between the regulatory and the Accident Investigation Authority (AIA) which should be kept independent. The rationale for the independence of the State AIA from those of other organisations is that accident causation could be linked to other organisation factors such as the regulator. It is therefore assumed that while adopting a safety management approach would contribute to the development of the AIA's capability, the process of establishing and developing such authority would focus on more important aspects such as ensuring its independence based on international and national rules.

The third part of the literature review aims to identify what exists within it that may assist in the development of accident investigation. To some degree, the literature directly addressing this issue was highlighted through the first SLR, but much of this identified individual elements of a larger whole without necessarily considering how those elements interact. The challenge was to identify additional literature, which encompassed the various elements and their interaction. Having considered a number of terms (included in SLR1), the term 'capability' seemed best placed to describe all of the physical, procedural and human elements of accident investigation including preparedness. Therefore, to further explore the Capability concept, a second SLR was conducted to establish the academic meaning of 'capability' as a concept, and whether it was indeed the most appropriate term.

2.7 An Exploration of Capability as a Concept

The literature has provided insight into the prerequisites for effective accident investigation. These include the legislation and regulations that need to be in

place; an appropriate independent body or agency; skilled, experienced and current investigators; the investigation philosophy and methodology and so on. What has to be established is more than an entity; it is something that must be *capable* of achieving the intent of Annex 13. Whether 'capability' is the correct word is debatable, so a second structured literature review was conducted to determine whether a better understanding of the topic would assist in the development of accident investigation.

As previously demonstrated, Annex 13 requires that Member States establish an entity to handle the responsibility of air accident investigation (ICAO, 2016). Such entities or organisations are comprised of individuals, roles and functions, which in turn contribute to the success of an investigation. Indeed, as Zehir, Acar and Tanriverdi (2006) note, both *personal* and *organisational* capabilities influence organisational success.

2.7.1 Definition of Capability in the Literature

Commencing an SLR with as broad, a term as 'capability' was challenging. Even acknowledging the view of Saint-Amant and Renard (2004) that capability is the result of active learning, both at individual and organisational levels, a search for '*capability*', '*individual capability*' and '*organisational capability*' using the same database search in SLR1 generated over 1,000 titles (articles and scholarly journals). Given the focus on developing a general understanding of the concept, rather than its use in a specific field (*the search of different capability keywords revealed no results related to the specific area of the study – refer to SLR1*), the results were sorted according to the most-cited titles (*importance*) and then purposive selection was made (see Table 2-1). The selection criteria for the final papers involved excluding specific technical papers, or those focused on a precise aspect far from the area of study. Such judgment was validated with the assistance of the reference panel (three academic staff and one information specialist), although it is acknowledged that this is a subjective view. In addition, three related books were included, which brought the number of titles included in SLR2 to 33.

Table 2-1 Sample of some cited Papers

Paper or Article Title	Cited By
Firm resources and sustained competitive advantage	18681
Strategic assets and organizational rent	3523
The dynamic resource-based view: capability lifecycles	1384
Toward a synthesis of the resource based and dynamic capability views of rent creation	956
Competencies and imitability in the pharmaceutical industry : An Analysis of their relationship with firm performance'	143
Capital investment as investing in organizational capabilities : An empirically grounded process model	112

Various attempts to define the concept of capability and clarify its meaning have covered a range of disciplines, although some definitions only serve specific situations or areas such as industrial, economic, social and managerial research (see Collis, 1994; Gong, Baker and Miner, 2006; Grant, 1996; Shekarriz and Mousavi, 2009; Winter, 2003). Some researchers seem to use words 'ability', 'competence' and 'capability' interchangeably (Ulrich and Smallwood, 2004), which suggests confusion about the use of these concepts, as highlighted by Zehir, Acar and Tanriverdi (2006). Tables 2-2 and 2-3 reflect these varieties.

Some definitions highlight 'reliable or predictable' outcomes, using, for instance, phrases like "… *with results above a threshold level and can sustain that performance level*" (Gong, Baker and Miner, 2006, p.3), and "… *achieving a particular end result*" (Helfat and Peteraf, 2003, p.999). Therefore, it appears that consistent results are one of the primary features of many capability definitions.

Additionally, Shekarriz and Mousavi (2009) observe that, due to the various perspectives on the nature of the capability concept, different categories of capabilities have arisen. Many authors have considered capability based on its type (physical, human or organisational) (Barney, 1991), level (individual or organisational) (Ethiraj et al., 2005) and originality (generic or unique) (O'Regan and Ghobadian, 2004). Collis (1994) sees capability as the product of the

organisation's entire system, including the accumulation of skills, routines, and processes.

Table 2-2 Sample of Capability Definitions

Definition	Source
"A capability is a set of business processes strategically understood."	Stalk, Evans and Shulman (1992)
"Capabilities, refer to a firm's capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end."	Amlt and Schoemaker (1993, p.35)
"Capability is the way with which tools and methods are blended, coordinated and used in a company".	Cantamessa (1999)
"To be capable of something is to have a generally reliable capacity to bring that thing about as a result of intended action. The dynamic property of this capacity is its development and continuity."	Dosi, Nelson and Winter (2001)
"A capability is defined as a special type of resource – specifically, an organizationally embedded non-transferable firm-specific resource whose purpose is to improve the productivity of the other resources possessed by the firm."	Makadok (2001, p.389)
"Capabilities come from exploration and exploitation of risks, which moves the firm from current to critical positions. Capabilities are always associated with strategies to decide on options."	Kogut and Kulatilaka (2001)
"A capability is defined as a firm's capacity to deploy its assets, tangible or intangible, to perform a task or activity to improve performance."	Maritan (2001)
"Capabilities are unique and idiosyncratic processes that emerge from unique and path dependent histories of individual firms"	Pandža et al. (2003)
"Capability is a concept, which covers competence, strategy, ability and resources and is shown in technical and social issues of an organisation."	Zehir, Acar and Tanriverdi (2006)

Table 2-3 Sample of Organisational Capability Definitions

Definition	Source
"A holistic concept that describes how an individual or organization applies their ability in a confident manner to problems in new and unfamiliar circumstances as well as in familiar situations."	Cairns (1997)
"An organizational capability refers to an organizational ability to perform a co-ordinated task, utilizing organisational resources, for the purpose of achieving a particular result."	Helfat and Peteraf (2003)
"Organisational capability relates to the use of the resources in the attainment of the firm's strategic goals and objective"	O'Regan and Ghobadian (2004)
"Organizational capabilities: the socially complex routines that determine the efficiency with which firms physically transform inputs into outputs"	Collis (1994)
"Organizational capability: a firm's ability to perform repeatedly a productive task, which relates either directly or indirectly to a firm's capacity for creating value through affecting the transformation of inputs into outputs."	Grant (1996, p.137)
"Organizational capability as best practice. Practice refers to the organization's routine use of knowledge and often has a tacit component, embedded partly in individual skills and partly in collaborative social arrangements."	Szulanski (1996)
"A know how to act, a potential of action which results from the combination and the coordination of resources, knowledge and competencies of organization through the value flow, to fulfil strategic objectives."	Saint-Amant and Renard (2004) (cited in Rauffet, Cunha and Bernard, 2016)
"An organization has a capability when it can execute a specific activity with results above a threshold level and can sustain that performance level."	Gong, Baker and Miner (2006, p.3)
"An organizational capability is a high-level routine (or collections of routine) that, together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type."	Winter (2000, p.983)

Acknowledging the diversity of organisations, Ulrich and Smallwood (2004) argue that there is no universal list of capabilities. In fact, some authors argue that there is no accepted definition of organisational capability and even that it is not possible to obtain a definitive listing of it (see O'Regan and Ghobadian, 2004). What organisational capability can comprise is based on different objectives and

reveals how the same concept is viewed and used in different forms. For instance, organisational capability represents the capacity of the organisation itself to change and adapt to financial, strategic and technologic transformations (Ulrich, 1987). Furthermore, Wang and Zeng (2017) describe organisational capability as a function related to working in an organisation in terms of '*uncertainty*' to perform the required work which they classified in three categories:- routine; solving problems; and strategic decision-making. In the view of Ulrich and Smallwood (2004), organisational capability emerges when an institution delivers the competencies and common abilities of its members. However, the individual attributes such as being technically sophisticated or demonstrating leadership skills, may or may not be reflected in the organisation's outcomes as a whole.

2.7.2 Capabilities versus Performance

The literature confirms a strong link between capabilities and performance, with such relationships being evident in the particular literature relating to dynamic capabilities, organisational learning theories, the Resource-Based View, and knowledge-based models (De Carolis, 2003, pp.33–34). Wang and Zeng (2017) argue that organisational performance is collectively determined by the performance of individuals in the organisation, while the view is expressed by O'Regan and Ghobadian (2004) that most organisations possess capabilities that are positively linked with their strategies and performance.

It is observed by Schreyögg and Kliesch-Eberl (2007) that capability is generally conceived as not consisting of just one particular resource, but rather as the skill of combining a variety of resources (e.g. financial, technological, human) to use them to good effect, such that an organisation appears to be able to perform outstandingly. Collis (1994) suggests that the capability concept is often left vague in the literature, with some authors considering it as an understood colloquial expression, and others emphasising its particular dimensions. For instance, in their attempt to define individuals' capability, Stephenson and Weil (1992, p.2) suggest that capable people have confidence in their ability to take

the proper and effective action, live and work effectively with others, explain what they are about, and continuously learn from their experiences.

These skills and abilities seem to be required by the leading players in accident investigation since the way they work and engage with each other is fundamental to a good outcome. Such investigators have to consider and appreciate teamwork, share their experience and values, and maintain their proficiency at the highest possible level by active learning from investigations that demonstrate their strong ability to tackle diverse investigation cases.

2.7.3 Capabilities versus Competencies

A closer examination of the literature reveals that interchangeable terms are employed for the two concepts of capabilities and competencies. Sheard, Kakabadse and Kakabadse (2009) best describe the distinguishing features of both concepts, asserting competencies to be a collection of skills and behaviours required to perform the job, and capabilities as to how those skills and behaviours are applied. Townsend and Cairns (2003, p.318) offer a compatible view by highlighting that competence as a concept is more regularly defined and theorised to cover "*observable current skills based on current knowledge*". They continue to clarify that competence derivatives such as competencies and competency are based on demonstrable performance or actions and are "*behaviourist concepts*". Table 2-4 compares the two concepts.

Table 2-4 Capability versus Competency (Pryor, 2015)

Competency	Capability
Knowledge related to the workplace	Theoretical knowledge related to the profession
Skills related to the workplace	Skills supported by theoretical knowledge
Application is usually limited to defining a set of circumstances although there may be some scope for new situations	Can be applied in complex and changing circumstances
Standard set for performance	May not have a defined standard
Standard set by regulatory process/workplace	Standard may be set by profession or external body

Capability can thus be seen to be an all-encompassing concept that addresses issues relating to values and self-efficacy that would seem to be at the heart of the concept. In contrast, competence focuses on performance in a specific situation; it is a narrower concept (Townsend and Cairns, 2003). This may suggest that accident investigators need to be capable of handling different levels of a complex process such as accident investigation (which is more than competence). However, they need to demonstrate competency as part of their overall portfolio that makes them capable.

To summarise, the many definitions for both capability and organisational capability suggest neither concept have universally accepted meaning. Definitions can be implemented in different contexts and to differing levels of abstraction. While these concepts have been widely studied in different fields, the unique situation of the field of this study requires attention to ensure their meaning encapsulates the reality. As SLR1 demonstrated, there is a lack of academic literature regarding capability and its nature, features or components in the area of air accident investigation. De Pablos and Lytras (2008) emphasise the necessity of developing individual competencies by utilising effective human resources practices. However, it must be made clear that trying to define capability as it relates to the field of this study should not drive it away from its primary aim.

2.7.4 The adopted definition of 'Capability'

According to USOAP results, ICAO identified many States as not having the capability or means to establish their investigation system. This may suggest that the required capability is more than simply checking boxes for compliance with SARPs and that States need to possess the ability to perform effectively in the case of an accident. This requirement may create *uncertainty* within those States about where to start or what to prioritise in developing their capability in this field.

Hence, in accident investigation, where accidents and serious incidents may occur without warning, the responsible investigation authority must be prepared to deal with such events. Dechy et al. (2012) address this, noting that

organisations should formulate their accident investigation protocols and provide appropriate training to their investigators to ensure their effectiveness when an accident occurs.

Therefore, in accident investigation terms where the organisation's success largely depends on individual and organisational efforts and as there is no single agreed definition of capability, then considering what has been reviewed, a definition was adopted for the purpose of this research. Capability in an accident investigation context may be defined as *developing and maintaining the ability to perform the required investigative tasks, which includes the availability and readiness of several essential components to handle accidents and incidents to particular acceptable standards*.

2.8 Research Gap

This SLR has revealed three important research gaps related to the context of this study, these being:

- There is no clear identification or clarification in the literature of what constitutes 'capability' in relation to air accident investigation.
- Limited attention has been paid in the literature as to how less-developed States develop their accident investigation capability: much of the research focused on how to improve the process of investigation in already more-developed States further.
- It is not clear how a less-developed State would develop the capability of its air accident investigation authority due to the lack of guidance as to the establishment of such authority and which elements are more important than others are to start with, which may point to uncertainty in this matter.

2.9 Literature Review Summary

The literature does not adequately address how a State establishes or demonstrates its capability in terms of air accident investigation. Even ICAO USOAP focuses on assessing a State's compliance with SARPs rather than considering its actual performance in discharging its responsibilities

(effectiveness). Additionally, the experience of developed States in the investigation of aviation accidents varies from one country to another, a situation explained by the variation in investigation models adopted by these countries.

Potential elements that may contribute to capability (such as the State legislative system, independence, organisation, and personnel) were identified initially through a systematic literature review. However, it is essential to explore further what information or insights might support a specific State to develop its accident investigation authority capability. The relative lack of literature redirects the focus of the research to gather the experience of more-developed accident investigators and their organisations.

While the research and technical literature contain much information about specific elements and techniques relevant to accident investigation, relatively little is known about how to build or maintain the required level of organisational capability to do the job effectively. The challenge is exemplified when a specific State with limited resources wants to develop its accident investigation system and comply with standards like Annex 13. Simply explained, there is a clear view of what accident investigation *is*, but there is not enough information about how to establish and maintain capability at the State level.

The following chapter discusses what best can be selected and applied from the available various research methodologies to answer the research question so that the objectives of this research can be accomplished.

3 METHODOLOGY

3.1 Introduction

This chapter introduces the methodology adopted to conduct the empirical work. It begins with a discussion of the research design and proceeds to consider the different research paradigms available. Discussions of the research approach and strategy follow. The importance of theory and the role this plays in giving a study a deductive or an inductive underpinning is then considered before the selection of research methodology is explained. Then the matter of data collection sources is introduced. After that, comments about the ethical considerations are made in the research, before a clear description of the data cleaning, preparation and analysis techniques is given.

3.2 Research Design

According to Crotty (1998), the research design addresses five parts; the research paradigm, approach, group, strategy and finally, methods for gathering the data. Marshall and Rossman (2006) and Robson (2002) suggest four types of research purpose as follows: exploratory, descriptive, explanatory and emancipatory. While a study may have more than one purpose, generally, one will outweigh the others, and possibly be changed or modified as the research progresses. Figure 3-1 illustrates the flow chart of the research methodology.

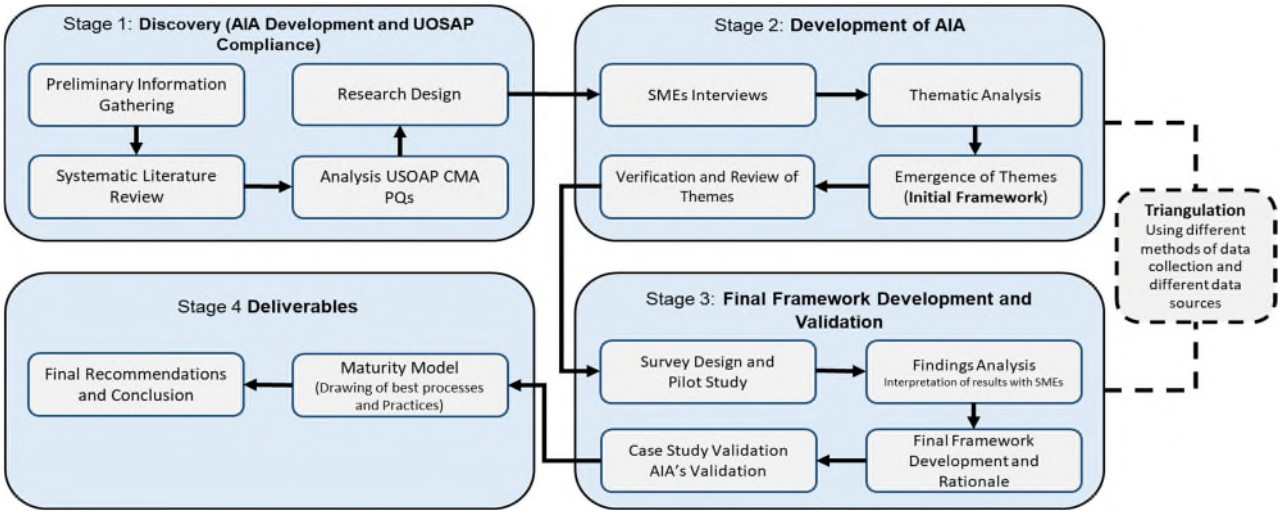

Figure 3-1 Research Methodology Flow Chart

3.3 Research Paradigm

Reliable information can be secured from different approaches to research based on different philosophies. The paradigm, which is also known as the researcher's *worldview*, according to Creswell (2013), is defined as "*a basic set of beliefs that guide action*" (Guba, 1990, p.18). Such beliefs form a research philosophy or paradigm, through which the surrounding reality can be explained (Guba and Lincoln, 1994). The paradigm is presented in terms of ontology, epistemology, and methodology, which respectively concern the nature of the knowledge, how such knowledge is acquired, and the techniques used to secure it (Creswell, 2013; Healy and Perry, 2000). However, the lack of consensus regarding what counts as knowledge and how to obtain it has prompted the creation of several traditional research schools. These include those subscribing to Positivism, Interpretivism (Creswell and Clark, 2007), and Critical Realism - which is proposed as an alternative to these two paradigms, as highlighted by Wynn and Williams (2012).

Positivism concerns itself with the careful monitoring and measuring of objective reality through the collection of quantitative information that is subsequently analysed in a deductive fashion to produce 'knowledge'. It assumes that to obtain accurate conclusions about reality, there is a need to identify and evaluate the relationships between cause and effect in an objective way, meaning that the researcher searches for the objective truth (Creswell, 2013; Creswell and Clark, 2007).

Interpretivism (or Constructivism) is concerned with securing the views of research subjects in a qualitative way, and then constructing an understanding of the world in which they live and work (Creswell, 2013). Using this paradigm enables a researcher to appreciate his/her relationship with the investigation, and to realise the role played by researchers in constructing their own reality.

Critical realism, as the third paradigm, is characterised by pragmatism. In this approach, the researcher usually employs all available methods to accommodate the dimensions of the problem, thus implicitly focusing on its importance, rather

than on how to explore it (Creswell, 2013). This paradigm is not bound by any system of philosophy and reality. The researcher is free to choose the methods, techniques, and procedures that best facilitate the research. For example, the reality of the research is seen as a single entity, but the acquisition of knowledge comes through an in-depth analysis of specific cases related to the study, and their objective verification (Wynn and Williams, 2012).

3.4 Research Approach

Just as the purpose of a study dictates the nature of the research questions posed (Gray et al., 2007; Marshall and Rossman, 2006), so too, the research questions have a bearing on the approach to a study. Besides, where there is any vagueness surrounding the concept for investigation, careful consideration is required in this respect. ‘Capability’ as a concept in the context of air accident investigation tends to be fuzzy, it is not well defined in the literature, and in particular, the best way for less-developed States to establish their accident investigation authorities, develop and maintain their capability is not clear. Hence, accepting the vagueness and subjectivity of the research question, and that it could be answered by exploring experts’ actual experience, the present study was initially identified as exploratory, and therefore, one that would benefit from employing a qualitative approach as a start.

Case studies are often used in exploratory research, but for this study, such a strategy was inappropriate for several reasons. Firstly, case studies require the investigator to be involved in attending meetings and obtaining sensitive data, such as copies of letters, communications, and information, which may require having access to specific data sets, and in general, this was difficult to achieve (this issue is further discussed in Section 3.7). Secondly, it is not possible to use experiments in this field because of the lack of studies in the area, and the nature of the study.

3.5 Research Strategy

As already noted, the purpose of the study and the type of research will guide what follows, and this includes the selection of the research strategy and the methods to be used (Cavana, Delahaye and Sekaran, 2001). Given the fact that little information or knowledge is documented regarding the variables affecting the research problem being investigated, consequently, several different methods, collecting both quantitative and qualitative data, are employed to achieve the study aim and objectives. Therefore, following this pragmatic approach, the study adopts the strategy of reviewing secondary data (literature review), and gathering primary data via empirical research (interviews and survey), in the belief that through these means, an excellent opportunity for collecting valid and reliable data would be available (see Creswell, 2013; Johnson and Onwuegbuzie, 2004; Johnson, Onwuegbuzie and Turner, 2007).

3.5.1 Triangulation

In social research, the term triangulation is a process that improves accuracy by looking at something, such as research question, from various points of view to enhance the study findings (Neuman, 2014). It is recognised in the literature that the validity of research findings can be jeopardised by the effect of different issues such as participants' and researchers' bias (Lincoln and Guba, 1985). Therefore, the use of triangulation can strengthen the research further by improving its validity and eliminating any biases by handling the research questions using different approaches (Richards, 2015). According to Bryman (2012), triangulation involves the use of multiple investigation methods and data sources. Triangulation may emerge because of a planned strategy that aims to collect data using two methods to use the findings from each method to corroborate the findings from the other. Equally, it may arise unexpectedly in an unplanned way by comparing the findings once the data have been collected (Neuman, 2014).

The literature identifies four types of triangulation (Neuman, 2014; Robson, 2002):

1) Triangulation of methods, by using a mix of qualitative and quantitative approaches to collect data.
2) Triangulation of observers, by the engagement of more than one investigator in the study.
3) Triangulation of theory, by using different theoretical perspectives in the conduct of the study.
4) Triangulation of data, by using different data sources.

As already indicated, this study adopted both a qualitative and quantitative strategies, thus allowing for triangulation of empirical data sources, and greater confidence in the findings since the limitations of using only one data collection method or source was reduced. Therefore, the results that are presented from the statistical analysis of the questionnaire in chapters 5 and 6 are assumed as further support to clarify the findings of the interviews presented in chapter 4, thus, reducing the impact of any possible subjectivity that may have arisen during the research process.

3.6 Theory

The definition of a theory which was introduced by Kerlinger (1979) still seems valid, as asserted by Creswell (2013). Theory can be defined as (Kerlinger, 1979, p.9)*;*

> "*a set of interrelated constructs (variables), definitions, and propositions that presents a systematic view of phenomena by specifying relations among variables, with the purpose of explaining natural phenomena".*

Creswell (2013, p.110) stated that "*Theory has a place in quantitative, qualitative, and mixed methods research"*. While it clarifies the relationship between the variables studied by the researcher in the quantitative study, the clarity and evolution of its dimensions are also noticeable in the development of the stages followed in the qualitative research, whereas it is employed by the researcher in mixed methods in several aspects, including those related to quantitative and qualitative studies (Creswell, 2013). For instance, most quantitative research

starts from a pre-existing theory and adopts a Positivist philosophy. Specifically, the researcher tests that theory by proposing some hypotheses and then collecting data to assess their validity (Phillips and Burbules, 2000). This approach differs from the Constructivist paradigm, in which the development of theory or a pattern of meaning occurs by looking at the evidence presented by the case being investigated (Creswell, 2013).

Where the researcher starts with a specific theory and then subjects it to observation, the mode of inquiry is described as deductive. The theory is known in advance of the data collection and is applied in the interpretation of the findings from the analysis of the data obtained. Where the opposite process is employed, and the theory is built as the data is being processed, the research is considered to be inductive, i.e., from the evidence obtained, a theory is induced.

> "*The research cycle is begun with observation. From the data collected, a generalised understanding of behaviour is gradually induced*" (Gray et al., 2007, p.24) (also see Liehr and Smith, 1999; Sitwala, 2014).

Given the aim of this study and the fact that some of the research activity involved includes USOAP results, which has been implemented worldwide by ICAO for less than two decades, it is theory *generation*, as opposed to theory *testing* that forms the focus of the study. Indeed, the performed literature review revealed no previous studies on this subject, and no existing theory to be followed or tested. Consequently, the study concentrates on building a theory rather than testing or adopting established ones.

3.7 The Selection of the Research Methodology

The applied research methodology was decided because of the review of the common research methodologies, which were guided by the research aim and objectives. The limited information about the concept of capability in the field of air accident investigation made it difficult to have a fixed research design (see Anastas and MacDonald, 1994; Robson, 2002).

While considering whether performance-based approach (by conducting several case studies to examine how developed States are keeping fit in this field or by exploring the deficiencies of less-developed States individually as identified by USOAP), would best suit this research, several challenges were faced which led to change in the selected methods. For instance, because of sensitive information, all requests made by the researcher to gain access to USOAP findings of Member States were rejected; the explanation provided by the USOAP administration was that access to the online framework audit site could not be granted to individuals. The entrance to USOAP findings would have contributed significantly to the research by offering the opportunity to study the common outcomes, differences and similarities and the subsequent detailed assessment for Member States that would be covered by the current study. Hence, limited available choices were left for the researcher who decided to adopt an inductive approach, which involves a qualitative method, as the first phase of data collection, following the conduct of the SLR. Also, choosing to start with a qualitative approach may be justified by its power and flexibility in collecting data by interacting with experts from the field of air accident investigation.

Later, adapting the research strategy by generating a questionnaire to be distributed to a sample of experts in the field to collect the desired data was under consideration. The majority of the collected data were in nominal and ordinal scales, which can be analysed descriptively. It provides "…. *a powerful summary that may enable comparisons across people or other units*" (Trochim, 2006).

3.8 Data Collection Methods

3.8.1 Conducting a Literature Review

To explore and understand how less-developed States can develop the capability of their air accident investigation authority, the current literature was consulted searching for any relevant published findings. Creswell (2013) highlights the importance of conducting a literature review as this facilitates the understanding of the research problem, avoids the duplication of work, and contributes to the identification of those research approaches and methods that can produce the

best outcome. A thorough examination of the literature enables clear identification of the research gap. Hence, the literature reviewed was broad in nature, including journal articles, conference proceedings, books, previous theses relating to the topic area, and other resources related to the industry. The review of the literature provided little clarity on the steps a less-developed country should take to build the capability of its national authority. Consequently, the researcher recognised the need to follow other sources of information and to continue to explore the situation by considering industry perspectives through empirical work.

3.8.2 Consulting ICAO

Considering the importance of maintaining close contact with the real world in which the research topic resides, arrangements were made to interview an ICAO expert, to build a better understanding of the roles played by ICAO as the lead organisation, in mapping the system of air accident investigation among its Member States. It was also the intention to gain a general view of 'capability' as a concept from the perspective of ICAO and to understand how it judges a specific State as being capable in this area. The overall discussion produced general information concerning *Annex 13* and the strengthening of independence within air accident investigation. ICAO does not precisely dictate what States must do. Rather, its role is limited to publishing SARPs in the expectation that States organise their response according to their individual circumstances. To assist, ICAO publishes a range of guidance materials. ICAO also suggest that less-developed States share their resources and collaborate through the establishment of Regional Accident Investigation Organisations (RAIO). The initiation of such an organisation is to enable a mechanism to facilitate the co-operation between different States when there is a need as is often the case in the field of air accident investigation.

While the discussion provided useful context; it yielded little information about how a less-developed Member State could build capability in the broadest sense. In the expert's view, the presence of RAIO was seen to be the mechanism

through which each State would demonstrate the ability to conduct an investigation with the support of other RAIO States.

3.8.3 Documents Review

The main aim of establishing ICAO USOAP was to check the compliance of each State with SARPs – using compliance as a measure of capability (see Section 1.2). The last phase of the audit involved a 110 question survey based on a common protocol. Each State is requested to conform to this protocol as a measuring tool for its ability in air accident investigation according to ICAO perspective. Therefore, as a part of the research process, the researcher analysed the USOAP CMA Protocol Questions (PQs). This analysis identified the USOAP's target elements in respect of its audits. Also, different ICAO manuals and documents, including working papers and reports were studied, and where appropriate, these are referred to in this research.

3.8.4 Interviews with Subject Matter Experts

Interviewing is a tool used widely in research to identify people's experiences, attitudes or concepts in a particular field (Robson, 2002). The choice of interviews rather than other approaches, such as observation, is usually made based on a need to approach a problem by talking to experts with a range of experiences and backgrounds (Suddaby, 2006). This was the rationale in this study; the expectation is that greater in-depth insights related to the research and access to various aspects of accident investigation would be gained. In general, interviews can be categorised into three types, which vary in both the standardisation level and structure. These are structured; semi-structured; and unstructured interviews (Fontana and Frey, 2005; Hayes, 2000; Robson, 2002).

By referring to the context of the current research, unstructured interviews were prioritised to be undertaken for many reasons. When investigating the concept of capability, the discussion requires questions to be as open as could reasonably be achieved. This type of conversation takes into consideration spontaneity and the opportunity for new questions to be asked, depending on the interviewees' reactions (Bailey, 2008). Indeed, Fife (2005, p.103) makes the point that where

the researcher does impose such restrictions by using a more directed form of unstructured interviewing, there is a *"loss of spontaneous information that might have come the researcher's way if s/he had not directed so much of the conversation".*

Accordingly, such interviews can lend legitimacy and depth to interviewees' answers (David and Sutton, 2004), and in the case of this study, were believed to achieve multiple and different views about developing the capability of less-developed States. What made unstructured interviews suitable for this research came from their wide flexibility to pursue information depending on what emerges during the discussion (Patton, 2002). Also, they can enable contextual issues to emerge by reducing many preconceived ideas (Becker, Bryman and Ferguson, 2012) which may have taken root because of the scarcity of information about the topic. Unstructured interviews also aim to focus on the interviewees' thoughts about a specific topic or phenomena.

Zhang and Wildemuth (2014) observe that unstructured interviews are particularly beneficial when deep insight is wanted into a specific phenomenon that is occurring against a certain cultural backdrop. Additionally, while the method for unstructured interviews varies widely, its central element, as emphasised by Bowling (2014), is to gain information from the respondent in a more impartial environment with less attached bias from the interviewer. The conducted interviews were analysed using thematic analysis. Further information is presented in Chapter 4.

3.8.5 Questionnaire Distribution

The importance of the data collected from the distribution of a questionnaire as a data collection tool lies in that some participants are responding on behalf of a group or organisation. Therefore, questionnaires are commonly used in social science research as they can collect large amounts of data (Saunders, Lewis and Thornhill, 2009), and indeed possess several other advantages. At the same time, there are certain disadvantages, for example, participants may not answer the questions thoughtfully, and the investigator may not be aware of this (Robson,

2002) (see Table 3-1). Therefore, it is recommended that the questionnaire method be combined with the interview method, as the benefits of one method tend to outweigh the disadvantages of the other and vice versa.

Table 3-1: Advantages and Disadvantages of Questionnaires

Source: (Cavana, Delahaye and Sekaran, 2001; Sekaran and Bougis, 2016)

Data Collection Mode	Advantages	Disadvantages
Mail Questionnaire	High Anonymity	Response rate is mostly low
	Can reach a wide geographic area	Cannot clarify questions
	Respondents can respond at their convenience	Follow-up procedures for non-responses are required
	Can include some incentives to encourage responding	
	Can be distributed online if needed	
Electronic Questionnaire	Easy to administer	Requires computer literacy
	Can easily be distributed globally	Respondents must have access to the computer
	Inexpensive	Respondents are committed to finishing the survey
	Fast Delivery	
	It can be answered at respondents' convenience	

Several reasons support the selection of a questionnaire designed as an online tool for this study. Firstly, it is easier to distribute. Secondly, online distribution means it can reach a large geographically dispersed sample with full confidentiality. Thirdly, an online questionnaire can be completed and returned faster leading to a high response rate in a short period compared to other formats, meaning that the analysis of results comes earlier. Fourthly, the method is low cost (Sheehan and McMillan, 1999).

Moreover, it is good at providing a significant amount of data (Robson, 2002). However, when deciding to use an online questionnaire, it is essential to minimise its complexity by undertaking a pilot study. In general, two types of questions form

most of the questionnaires: open-ended and closed-ended questions. Further explanation is presented in chapter 5.

3.9 Research Ethics and Integrity Approval

All research activity should conform to ethical principles and standards, which include the need for informed consent to be obtained from participants before any part of the study commences. In the case of this study, the required approval was obtained from Cranfield University Research Ethics System (CURES) under reference CURES/925/2016. Regarding the protocol applied in this study, participants' names were kept confidential, and during the interviews, the discussion of sensitive information was largely avoided. Great attention was given to the need to safeguard participants, not to affect their position or relation to their organisation, and they were made aware of their right to withdraw from the study at any time (See Ethical Approval at Appendix B).

3.10 Cleaning and Preparing Data for Analysis

The choice of an online questionnaire eliminated many of the problems that can occur by distributing a survey in paper format (Denscombe, 2003). Using the "Qualtrics" software meant that during the process of downloading the data for use by the SPSS software, there were no missing data or unclear inputs as the whole process from data collection to analysis and data coding was done electronically, with minimal manual input (Denscombe, 2003).

In addition, some respondents used the option '*other'* that was provided in many questions to express their opinions in more depth and offer more information. These particular contributions were reviewed and matched with the other given answers when possible. In this process, the assistance of other researchers was enlisted to ensure the accuracy of the result. By considering the different opinions of many people, such contributions were appropriately classified, and the validity of the data set was ensured.

3.10.1 Data Quality

The reliability and validity of any instrument (in this case, the questionnaire) should be identified before being used to collect data as the credibility of the entire study is dependent upon the particular constructs being accurately measured (McMillan, 2004). Table 3-2 shows the type of tests employed to ensure the reliability and validity of the questionnaire. Construct reliability was examined via Cronbach's alpha, which should reach a value equal to or more than 0.7 (see DeVellis, 2003; Kline, 2005; Nunnally, 1978). As illustrated in Table 3-2, all of the constructs have Cronbach values of more than 0.7, which may indicate a high level of internal consistency in the obtained responses.

In addition, the external validity, which is related to objectivity and generalisability, was covered by distributing a self-administered questionnaire to many experts from different accident investigation authorities worldwide.

Table 3-2 Validity and Reliability Tests

Measure	Test Type	Ideal Result
Face Validity	Pilot Study Phase 2	Good
Content Validity	Pilot Study Phase 1	Acceptable
Construct's Reliability	Cronbach's Alpha	More than 0.7

3.10.2 Is the Collected Data Normally Distributed?

Scientific literature has many common statistical errors where at least one error could be found in about 50% of the published articles, as highlighted by Curran-Everett and Benos (2004). There are some conditions, which cannot be ignored for different statistical procedures related to parametric tests and variance analysis to assume the data follows a normal distribution or a '*Gaussian'* distribution (Driscoll, Lecky and Crosby, 2000; Field, 2013). This indicates that the populations from which the samples were taken are normally distributed (Ghasemi and Zahediasl, 2012). It is expected that no precise and reliable results concerning the reality can be obtained if the process includes no respect for the normality assumption (Field, 2013; Öztuna, Elhan and Tuccar, 2006).

Research and studies which deal with large enough sample sizes (> 30 or 40), should have no significant problems regarding the violation of the normality assumption, as highlighted by Pallant (2016). The use of parametric procedures, in this case, is permitted, even when the data are not normally distributed (Elliott and Woodward, 2007). Regardless of the shape of the data, the sampling distribution tends to be normal as the normality test is only recommended when the sample size of the data is less than 50 (Elliott and Woodward, 2007, p.25; Field, 2013). The samples obtained for this research are 86**,** which means that the normality of the distribution is not a matter of concern.

3.11 Application of Results and Research Recommendations

Recognising that AIA capability-building for less-developed States is likely to be incremental, the final stage of the methodology is to develop a tool whereby States may assess progress. The proposed tool would assist a State by providing a detailed description of what “good, better and best” may look like in terms of implementation, based on the developed framework. The proposed tool will likely follow the form of an adapted ‘maturity model’ as described below.

3.11.1 Maturity Model

Strutt et al (2006) stated that Capability Maturity Models (CMMs) are tools used to assess the capability of an organisation to perform the key processes required to deliver a product or a service. Significantly, they can be used, both as assessment tools and as a product improvement tool. The process comprises a set of management tasks and practices that are necessary for an organisation to meet strategic obligations and goals such as operational safety or environmental risk targets (Strutt et al., 2006).

The Capability Maturity Model (CMM) was first developed by the Software Engineering Institute (SEI) (Paulk et al., 1993 cited in Poeppelbuss and Roeglinger, 2011) and, since then, the use of maturity models across multiple domains has become popular. They usually establish a systematic basis of measurement for describing the “*as is*” state of a process and provide

improvement options to satisfy the intended objectives of a process over time (Rose, 2013).

The primary purpose of using maturity models "*consists in describing stages and maturation paths*" (Poeppelbuss and Roeglinger, 2011). Hence, the characteristics of each phase, including the logical relationship between the successive stages, require clarification (Kuznets, 1966). In practice, maturity models aim to show current and future maturity levels and, in doing so, to identify weaker areas so that they can be developed. This approach appears to suit the nature of the problem being considered within this thesis.

3.11.2 Understanding Maturity Levels

Each maturity level describes specific and general practices against which a particular organisation can be graded or compared. This also provides a way to characterise its performance. Evidence shows that the greatest improvements occur when an organisation focuses its efforts on a manageable number of processes at any one time. Experience also shows that, as the organisation improves, those processes need to become more sophisticated (SEI, 2010).

Each level of maturity is a defined plateau in the evolution of an organisation's improvement in its processes and achieving each one then allows it to move up to the next level. All maturity models also reflect capability levels in both design and content (Paulk et al., 1993; SEI, 2010). A tailored model will be developed based on the results of this study containing the three levels typically found in such models, which can be described as follows:

- Maturity Level: **Initial**. At this level, processes are generally *ad hoc* and incomplete. The AIA does not exist; hence, there is no stable environment in which processes can be carried out as so few are defined. Therefore success depends on the efforts of individuals.
- Maturity Level: **Defined**. At this level, the AIA still not fully formulated; hence, the organisation's set of standard processes are still being established.

- Maturity Level: **Optimizing**, the highest level is the one in which the AIA continually improves its processes based on a quantitative understanding of its objectives and performance needs.

The resulting maturity model is presented in chapter six

4 DEVELOPMENT OF ACCIDENT INVESTIGATION AUTHORITY

4.1 Introduction

The preliminary review of the industry's perspective (Chapter 1) and the literature review (Chapter 2) revealed two main issues. First, there is a lack of a definition of the concept of capability as it relates to the area of air accident investigation. Second, there is a gap in the literature in relation to the specific situation of assisting less-developed States in developing and maintaining the capability of their Accident Investigation Authority (AIA).

Moreover, the literature review demonstrated that the preliminary research problem seems to be centred on a specific practical problem. The optimal plan should link the perspective of the industry with that of academic research. Accordingly, this chapter aims to satisfy the research second objective and present the findings from interviews with Subject Matter Experts (SMEs).

4.2 Formulating the Interviews Guide

As already stated in chapter 3, unstructured interviews, which are also known as an in-depth investigation or informal interviews (Denscombe, 2003), were chosen as the mechanism for the interviews with the SMEs. The role of the researcher is to be as "*un-intrusive as possible*", thereby allowing ample space for the interviewees to develop and express their thoughts on the topic (Denscombe, 2003). However, while unstructured interviews do not use pre-defined questions, they are neither random nor non-directive, as noted by Patton (2002, p.343) in his observation that "*Being unstructured doesn't mean that conversational interviews are unfocused*".

To gain the most from the interviews and to ensure that the interviewees were approached comprehensively (Patton, 2002), the researcher developed a short interview guide. This "*aide memoire*" or "*agenda*", as McCann and Clark (2005) called it, contained the topics to be covered during the discussion. However, no detailed questions in a specific order were prepared in advance, as in

unstructured interviews the questions are normally generated by the interviewee's narrations (Kvale and Brinkmann, 2009; Zhang and Wildemuth, 2014). The prepared agenda comprised the study purpose and general scope of the investigation authority establishment and development.

4.3 Data Gathering Process

The interviews conducted were mostly in the form of a conversation (Hayes, 2000). The flexibility enabled the interviewees to introduce their thoughts and share their experience on the topic discussed. Preparation for the interviews followed a procedure adapted from Robson (2002). Preliminary contact was made with participants (Denscombe, 2003), where the researcher explained the purpose and nature of the study and that the interviewee had been selected based on their experience. The interviewees were assured of their anonymity within the thesis and the confidentiality of their responses. They were informed that no (real) boundaries had been set for the intended interview except that it would remain within the discussed topic. They were also told that their contribution would be to express opinions and share a personal experience, and they could withdraw from the interview at any point. A consent form (signed and received by email for those who were interviewed by telephone) and permission for recording the interview was obtained.

The interviewer introduced himself to the participants as a researcher interested in the topic as his country of citizenship is a less-developed State whose AIA lacks capability in this field. This introduction assisted in engaging with the participants and building rapport, which is essential for gaining the required information (Bryman, 2012). The participants were very cooperative, reflected in their desire to assist less-developed States in developing their AIA's' capability. As the collection of good quality data depends on the commitment of the researcher to remain focused on the topic discussed (Parikh, 2002), most of the conducted interviews stuck closely to the area of research interest. All interviews were conducted in English, which is the international language of aviation. Depending on the location of the interviewee (see Section 4.4), interviews were

undertaken either face-to-face or over the telephone. Robson (2002) highlighted that telephone interviews share many advantages of face-to-face interviews, such as high response rates. According to Bryman (2012), they are cheaper and quicker to administer. In addition, the remoteness of the interviewer in telephone interviewing removes the potential bias of respondents stemming from characteristics of the interviewer, such as ethnicity.

Among the drawbacks of telephone interviews are that the interviewer would miss important visual cues and the body language of participants, such as signs of puzzlement or unease on the faces of participants when they are asked a question (Bryman, 2012). On one occasion, an application called "*GoToMeeting"* was used to enable the exchange of some files and to review some documents related to the study. All the interviews were audio-recorded, and note-taking was undertaken during and after interviews. Two interviews had to be resumed due to time constraints or technical problems. The focus of the researcher was to ensure that all interviewees were comfortable and willing to participate in the interview, which helped in acquiring rich information.

4.4 The Interview Sample

Qualitative study samples usually are lower than those in quantitative studies (Denscombe, 2003). However, considering the study scope and the information required at this phase, the selected sample is likely to be based on non-probability sampling. The ideal population for sampling would be key players and experienced air accident investigators which is a small community of highly specialised individuals. For instance, in their study, Nixon and Braithwaite (2018) argued that,

> "*The modest sample size is warranted by the highly specialised nature of the industry which in the UK has a population of fewer than twenty-five full-time investigators*".

In total, eleven interviews were conducted with SMEs from the field of air accident investigation. The sample covered five countries, which adopt either single-mode

or multimodal approaches and have higher SARPs EI in USOAP (See Figure 4-1).

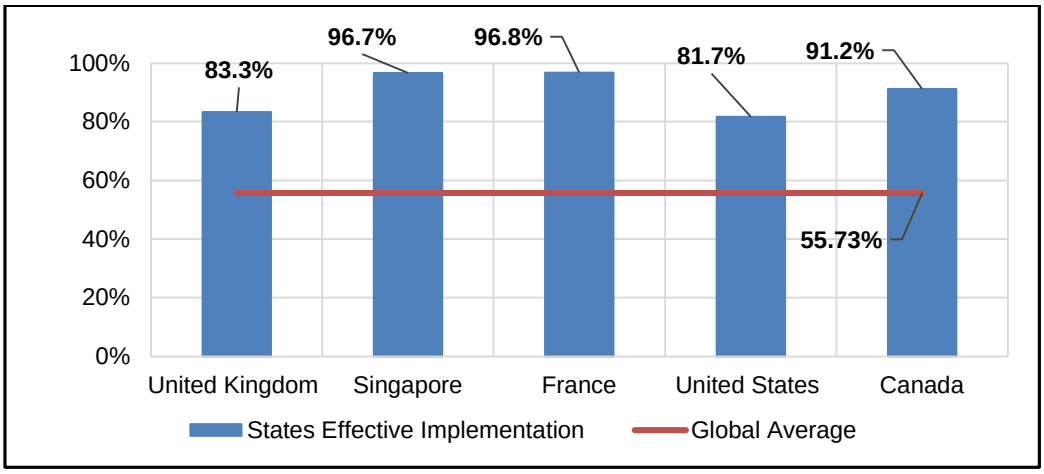

Figure 4-1 SMEs States USOAP Scores for AI Area – Source (ICAO, 2018)

Table 4-1 Experts Interviewed

No of Interviewees	Type of Organisation	Interviewee Role	State	Interview Type	Organisation Mode
1	AIA	Senior Management Position	United States	Telephone	Multimodal
1	AIA	Senior Management Position	Singapore*	Telephone	Single Mode
1	AIA	Senior Management Position	France	Telephone	Single Mode
1	AIA	Management Position	Singapore*	Face to Face	Single Mode
1	AIA	Management Position	France	Telephone	Single Mode
1	AIA	Retired	Canada	Telephone	Multimodal
1	AIA	Experienced Investigator	United Kingdom	Telephone	Single Mode
1	AIA	Experienced Investigator	Canada	Face to Face	Multimodal
2	Education Organisation	Academic Staff	United Kingdom	Face to Face	-
1	ICAO	Senior Management	Canada	GoToMeeting	-

* Singapore restructured its authority to multimodal on August 2016.

In addition, an ICAO expert based in Montreal, Canada (See Table 4-1) was interviewed. The selection of participants was purposely based on their experience; three of them were working in a senior management position in their organisation; five were either working for or had retired from, accident investigation authorities; all of them had a high level of expertise and experience in accident investigation. Two academic staff who specialize in the field of accident investigation were also interviewed. The calculated mean value for the level of experience of participants is 12.3 years.

4.5 Analysis and Coding Process

In general, qualitative analysis procedures need to be approached flexibly to fit the research questions and the data collected (Patton, 1990). An approach called "*interpretive thematic analysis*" (see Liamputtong, 2009; Markovic, 2006), also known as thematic analysis, was thought to be the most appropriate method to analyse the interviews conducted. This was due to its flexible approach, the accessibility of its results to educate the general public and its ability to highlight similarity and differences within the dataset (see full advantages of thematic analysis in Braun and Clarke, 2006).

Thematic analysis at its simplest is a method by which to analyse and report patterns (themes) in the data by organising and describing it in more detail (Boyatzis, 1998; Braun and Clarke, 2006; Gioia, Corley and Hamilton, 2013; Hannah and Robertson, 2015; Hayes, 2000). In addition, Braun and Clarke (2006, p.78) highlight that thematic analysis "*provides a flexible and useful research tool"* so the emerging template or themes can be developed along with the progress of the analysis. In this vein, key codes, which is a feature of this method, can be determined ahead of the analysis phase based on the research question or existing theory. This is known as a deductive approach or theory-led thematic analysis (Hayes, 2000). An alternative is an inductive approach where the codes emerge from the collected data (Boyatzis, 1998; Braun and Clarke, 2006; Robson, 2002) (also refer to section 3.6). According to Boyatzis (1998), thematic analysis as a process can be used with most, if not all, qualitative

methods, whereas Braun and Clarke (2006) advocated thematic analysis as a foundational method for qualitative analysis, and therefore, it is seen as a stand-alone method.

A theme can be explained as a category identified through the data, which mostly relates to the research focus or the research question (Bryman, 2012). Braun and Clarke (2006, p.82) define a theme as;

> "*Something important within the data which has a relation to the research question, and represents meaning within the data set*"

However, according to Braun and Clarke (2006), the researcher's judgment and his flexible approach in handling the data are essential to determine what a theme is. Also, Denscombe (2003) highlights that the recurrence of ideas or issues may indicate their importance by being highlighted by many individuals. Identifying themes can be primarily linked to the entire set of data and not necessarily to each interview,

> "*The 'keyness' of a theme is not necessarily dependent on quantifiable measures - but rather on whether it captures something important in relation to the overall research question*" (Braun and Clarke, 2006, p.82).

The analysis process followed was conducted based on the phases highlighted by Braun and Clarke (2006). The researcher chose to approach the final themes by reviewing the coding process used by other researchers (Boyatzis, 1998). Also, by considering Ryan and Bernard's (2003) recommendations in identifying themes by looking for repetitions of topics and unfamiliar local expressions (categories) which were used among the data. A reflection on the use of some words, which point to a causal link in the minds of participants, along with questioning what is missing from the data was also considered (Ryan and Bernard, 2003). It should be clarified that the thematic analysis was driven by the study's focus on exploring how best to establish the AIA aiming to develop its capability.

Considering the analysis process, after transcribing the recorded interviews, it was important not to add any information or to interfere with the respondents'

feedback, as recommended by Bartunek and Seo (2002) before importing them into NVivo. A thorough reading of all available data was conducted many times, in connection with the notes that were taken during interviews. Initial ideas were highlighted in the process of establishing the AIA. Coordination and reorganisation of the data into "*analyzable units*" (Coffey and Atkinson, 1996) by noting down initial ideas (codes) was fundamental as the first step for the analysis. The initial codes were combined to form more holistic ones, which are known as "*proto-themes"* according to Hayes (2000). The appearance of the latter codes facilitated the amalgamation of different codes together into broader potential themes where all relevant data was connected to each theme. This process was achieved by moving back and forth as needed throughout the phases. By checking the link of the themes and their connection to the first codes and the entire set of data many times, a developed thematic map of the analysis result was generated (see Figure 4-2) where clear names were specified for each theme to emphasise their connection, together with the requirements of establishing the AIA**.** Some themes were merged at the last stage to minimise the number of existing themes by considering their "*internal homogeneity*" (Patton, 1990) and also as recommended by Braun and Clarke (2006). The final thematic map showing main and sub-themes is shown in Figure 4-3.

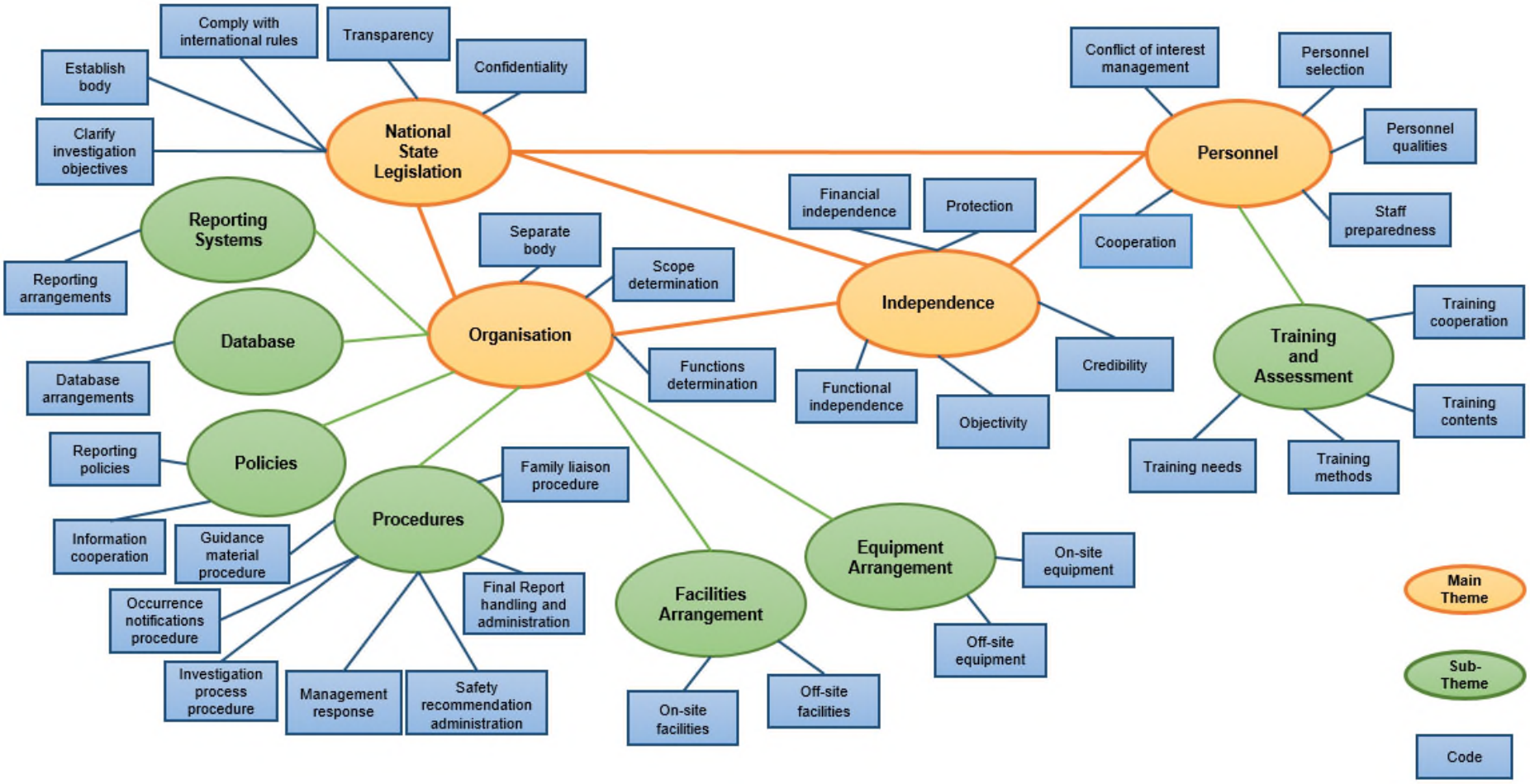

Figure 4-2 Developed Thematic Map – showing themes and their later codes

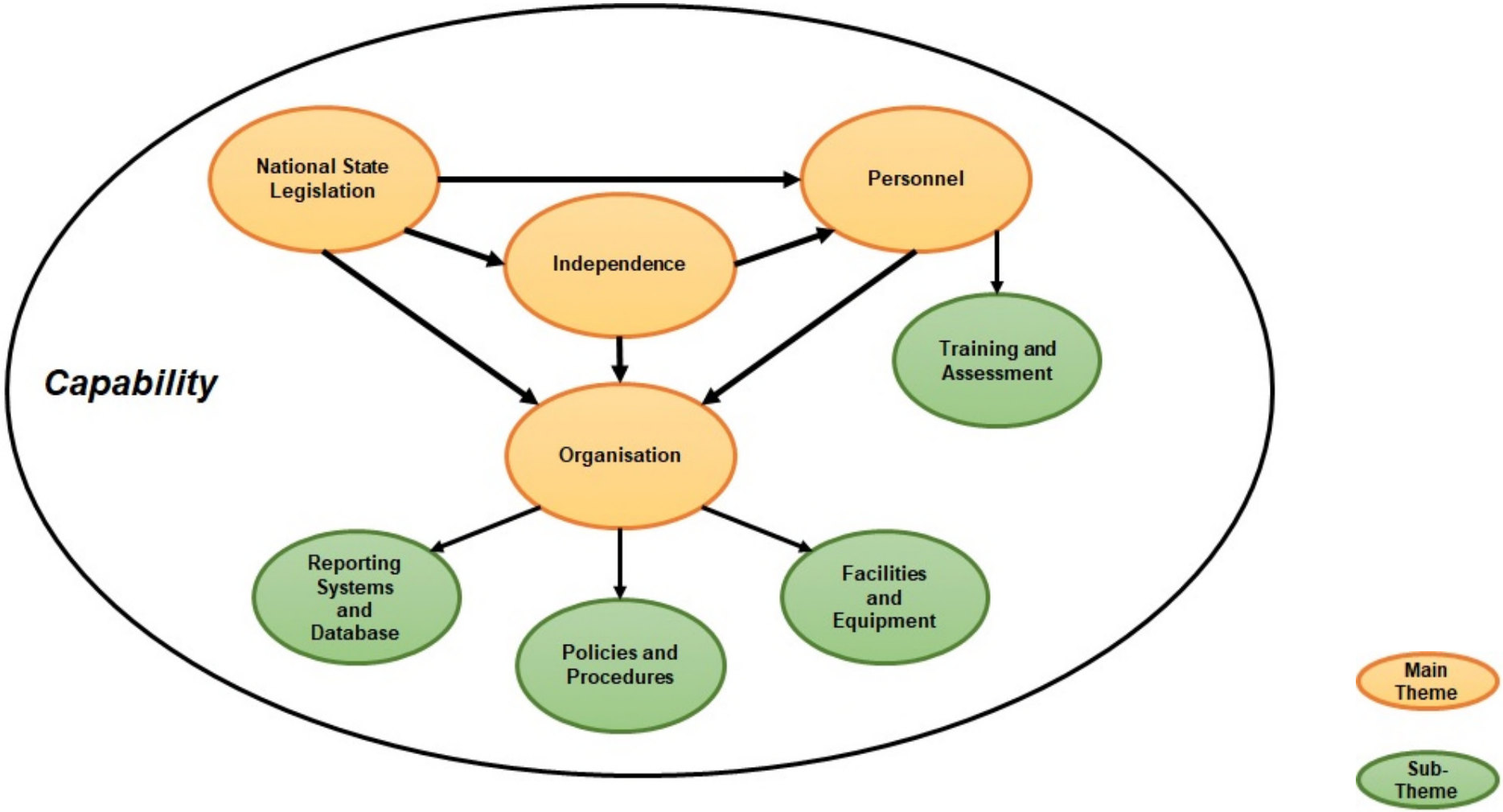

Figure 4-3 Final Thematic Map (Initial Framework)

4.6 Analysis Findings

The interviews were interpreted using thematic analysis at the semantic level (explained in 4.7) which resulted in identifying many themes based on what interviewees felt was of greatest importance in establishing an AIA or in terms of what is needed for an AIA to develop its capability in less-developed States. Four main themes were identified as follows:

1. National State Legislation
2. Personnel (Investigators)
3. Independence
4. Organisation

First, interviewees explicitly cited the main themes on different occasions during the interview process. Second, the main themes were identified based on many factors and categories related to them in the early stage of the coding process. In addition, another four sub-themes were defined as follows:

1. Facilities and Equipment
2. Policies and Procedures
3. Training and Assessment
4. Reporting Systems and Database

The classification of the emerged areas as themes and sub-themes was mainly to clarify their connection and relationship with each other (refer to Figure 4-3). Therefore, it is not the intention at this stage to grade the importance of main themes in favour of the sub-themes; thus, they are treated with equal importance. The findings are presented below, supported with some interviewees quotes, which are presented in *italics*.

4.6.1 Independence

The most frequently identified theme is **Independence**. All interviewees on several occasions, emphasised it as essential when establishing the AIA. This was expressed in a number of different approaches, including its active link with

maintaining the credibility of the investigation through independence, objectivity and transparency.

> "…*maintain full independence and international credibility*",
>
> "…*ensure the accident investigation is factual and objective*"
>
> "…*eliminating all conflict of interests in the state*".

> *"Accident investigations must examine the role of the regulator or other authorities. The investigation must […] free of any influence from those other organisations being investigated."*

The independence theme has an active link with the other three themes: the national State legislation, organisation and personnel. Interviewees highlighted the importance of regulating independence in the State legislation to ensure the credibility of the investigation process and afford reasonable protection to the authority and the dedicated staff. Independence also has an impact on the organisation theme due to its connection with structural independence. The requirement for functional independence is based on the proposition that any event being investigated may have arisen from the actions or omissions of other parties in the State. For instance, the regulator may be found to be one of the causes or contributing factors that led to an accident or serious incident due to deficiencies in its safety oversight performance.

> "*The investigation must be separated to remove any suggestion/suspicion that a regulator/other authority might have influenced the conduct of the investigation*"
>
> *"The regulator will be seen to have an inherent vested interest if it owns the investigative body."*
>
> *"The investigation body should have no relationship with anybody that finds fault relating to law."*
>
> *"The regulator lack of oversight of an operator or a manufacturer could be a contributing factor finding after an accident has occurred."*

In other words, independence from any party, which may have influenced the outcome of an accident or serious incident is essential to the credibility of an investigation. From another angle, the need for independence is crucial to eliminate any accusation of political influence or commercial pressure where investigators must be able to make conclusions and findings.

> "*Political or other external influences may trump sound independent investigations."*
>
> "*The formation of an independent investigative branch would help ensure that an independent and unbiased investigation is conducted."*
>
> *"Independence is important to provide thorough and unhampered investigations, no conflict of interest."*

In addition, independence helps to ensure the sole objective for the investigation is to prevent further accidents and/or incidents and not to apportion blame or liability by being separate from the pressure of other organisations in the State. Investigators benefit from gaining reasonable protection and privileges to conduct their investigation by having access to the desired information during the investigation process as required.

> *"…so as to be impartial and to conduct investigation without any pressure from others."*

However, the variation in States' situations (such as resources) may make independence difficult, as highlighted by some participants.

> "*This should be achievable in most States; but, it must be recognised that extremely small States with little aviation activity may not be able to justify the administrative resources necessary to be 100% independent*".

This issue highlighted different opinions among interviewees as to what was classified as two different types of independence: structural and financial. Whereas almost all participants agreed it is important to ensure functional independence, which was explained by an interviewee as:

"..the investigation body can take a decision in initiating an investigation and claim control over its process."

4.6.2 National State Legislation

The **National State Legislation** was often spoken of alongside the independence theme, from the perspective of providing a legal framework to ensure the conduct of independent investigations. The impact of national legislation was also found to affect the organisation theme. Interviewees highlighted that the national legislation and regulations should include the required provisions to ensure the establishment of the AIA. For example, to provide powers to protect the accident site from interference by other State agencies or interested parties such as judicial authorities and the media.

"Free of influence by other authorities, the accident investigation authority should report by the law to board member of ministers' council or general attorney."

"Legal protection of safety information and data and enablement of investigators have to be in state law and regulations."

"We live in an ever changing legal world. Local national legislation ensures protection of the investigative body beyond what is provided by Annex 13."

Such national legislation clarifies the roles and responsibilities of the AIA to have a top to bottom effect, which can "*mitigate the repercussions of conflicting goals with other parties in the State*" as stated by an interviewee. The credibility of the authority and its capacity to advance aviation safety relies on its ability with all of its management and employees to remain free of any actual or perceived conflicts of interest, which should be made clear in the State national legislation.

"…because to avoid the conflict of interest during the investigation."

"*The relationship between AIB and Justice can be conflicting especially for the site… sharing of any information regarding the safety investigation*"

It was highlighted during many interviews that while every State is expected to comply with ICAO SARPs, the internal system of States may vary, and this

requires formally notifying differences to ICAO. The expectation on States to comply with SARPs was highlighted in the literature, and this can only be assured through national legislation. A strong agreement among interviewees was observed to make the "*investigation objectives*" clear in the national legislation, so the principle of not-for-blame is in place legally.

> *"Local rules are needed to assure that the objective of investigation is achieved"*

As a response to the question "*what can assist the State in developing its national legislation?*", the suggestions among interviewees included Annex 13 and legislation and regulations of other States.

> *"State laws of the land are an important factor when developing an accident investigation authority and subsequent legislation and regulations. Annex 13, is a great foundation for which the State laws may be compared and contrasted."*

In addition, some interviewees discussed the need for the investigation authority to demonstrate transparency by enforcing through its local legislation the publication of the investigation reports to the public. Some restrictions may be applied to the use of any obtained data during the investigation process. Therefore, to maintain confidentiality, certain information may be protected from disclosure by local regulations.

4.6.3 Organisation

As stated earlier, the **Organisation** theme was linked to the independence theme from the perspective of a need to have a separate body that can tolerate any political or other conflict situation.

> *"….Separate body, avoid political pressure, avoid commercial pressure."*

While most of the interviewees agreed that, the established body has to be separate and report to a higher government level, others explained that the lack of resources (financial and human) might stand against the wishes of States to have this implemented.

“In ideal situation, yes it should be separate so that it is fully independent and able to investigative even aspects of the regulator that may be involved.”

“*….extremely small States with little aviation activity may not be able to justify the administrative resources necessary to be 100% independent*”.

It was highlighted that the authority functions and responsibility should be made clear where plans of how to handle the events that occurred have to be established. In this vein, it is deemed important to evaluate the extent of the investigation tasks and scope at the beginning in order to assign the proper investigation team; hence, the required resources can be arranged appropriately.

“In normal circumstance, authority functions and responsibilities should be well-drafted to promote funds allocation and improve scope evaluation.”

There was a variety of views among interviewees regarding the preferred mode for the investigation authority: single mode or multimodal. Many investigators defended their own State’s approach as the best to implement, which may point to an existing bias from participants. However, it has been found that no particular requirements can regulate this selection other than some possible factors that were mentioned by some interviewees in favour of a specific mode, which was captured for further data collection.

“*The country size would stand against implementing a single mode body due to the difficulty of covering wide land area*”

“*…I have found most of the time extensive flying operations would normally contribute to initiating a single mode organisation*”

4.6.4 Personnel

The **Personnel** (Investigators) theme, appeared as essential in the investigation process as highlighted by most interviewees. It is influenced by the other two main themes, the national State legislation and independence. The rights to investigate accidents and incidents should be guaranteed for investigators in the national legislation to minimise the conflict with other agencies. Investigators shall

have an acceptable level of independence to perform their tasks without political influence or pressure.

> *"…their decisions and findings should be made without fear or favour."*

Additionally, this theme has a direct impact on the sub-theme Training and Assessment of investigators. The presence of qualified staff who have a collection of expertise and appropriate skills to handle different mishaps is critical for the success of the investigation authority. The authority may consider having a selection process for its staff.

> "*….. there should be a process of staff recruitment according to specific criteria applied ahead by the agency."*
>
> *"I suspect the success or failure to get qualified investigators largely depends on how best the recruitment drive targets the specific skills required for the team.*"

Different qualities such as objectivity and integrity for the investigators as well as a curiosity (their ability to keep asking questions) and analysing the obtained findings in the investigation were among the required characteristics that were deemed essential by interviewees. Readiness and preparedness of staff to perform their tasks were also discussed topics related to this theme. In countries which have a low rate of accidents and incidents, it was suggested that recurrent training has to be in place for investigators.

There were different opinions related to the availability and ability of investigators, which covered the need for the State under some circumstances to obtain support and greater cooperation from other States, especially for a newly established authority. Such cooperation could be secured by having different arrangements, and Memoranda of Understanding (MoU) signed with other States and internal agencies in the State itself.

4.6.5 Training and Assessment

The emerging of the **Training and Assessment** sub-theme to the Personnel theme was based on the principles of training contents, training methods, training

delivery, training measurements and cooperation. It appears concerning the authority that a training plan should be developed to train investigators. Detailed training requirements for investigators have to be established along with plans to conduct such training.

> *"…agree on a training plan and schedule the training accordingly"*
>
> *"….establish standards to support the desired level of training then enforce them."*
>
> *"Describe training process and have someone in charge of the training."*
>
> *"…by a well established, and regularly updated, training plan."*
>
> *"…having an accurate work description that drives a formal training plan which is financially supported by the authority."*
>
> *"..by defining a training programme that is flexible to tailor for changes in the investigation environment and deliver the training."*

The effect of training on investigators is critical to ensuring their credibility to perform the required tasks. Interviewees discussed the importance of ensuring delivery of training as planned where local resources and the workload may affect this process.

> "…*resources are sometimes a hinderance to implementing training schemes in developing countries.*"
>
> *"The level of training to be offered to individuals should be assessed against the amount of available investigators, resources available and the investigation workload."*
>
> *"Appropriate allocation of time, resources and finances for training."*

In addition, an assessment of the outcomes of the conducted training should be considered. Ensuring staff competency by continuously assessing their benefits from training should be performed by maintaining training records to evaluate their training needs.

"….to enhance training through complete and accurate record-keeping and transparency."

"Provision of training, plus periodic (at least annual) testing."

"…to describe the required training and to keep the records of the received training."

Some interviewees pointed to the necessity to establish different levels of training to suit all investigators by offering more courses to cover the requirements, which should be established earlier.

"The State has to schedule the training of its investigators with respect to their different levels and needs."

"… Our SIA has appointed a training coordinator to ensure that new inspectors appointed are given the required training and that training for all inspectors is ongoing. The keeping of suitable records of such training is also an important requirement"

Due to the difficulty in conducting some training courses for investigators locally, cooperation with other States has to be considered in this matter. This can be translated as explained earlier by establishing MoU with other States to provide investigators with a high-quality level of training.

"….by following leading recognised world class examples of training like the NTSB."

"…. conferring with equivalent agencies in other states and also ICAO as to the level of training that their investigators receive."

4.6.6 Policies and Procedures

The emergence of the Policies and Procedures theme came from the need for internal guidelines to administer the conduct of the investigation. The authority (Organisation) will require internal policies to legalise different activities such as to be notified for any occurrence, which has an implication on safety.

"….as a general requirement, stipulated internal guidelines of the authority should be separated to notify on any occurrence in effort to promote safety"

In turn, it shall cooperate with the national security by reporting any unlawful act that might be discovered during an investigation.

"….to strengthen investigations for unlawful activities, cooperation between investigating body and national security should be enhanced."

The internal authority procedures shall facilitate the exchange of accident information and cooperation with other involved States. It should also implement internal processes and procedures to cover a variety of actions related to accident and incidents. For instance, the management response procedure has to be in place to ensure timely appointing of the investigation team, securing Air Traffic Controller (ATC) recorders, recovering of Flight Data Recorders (FDR) and Cockpit Voice Recording (CVR) and securing and timely collecting of perishable evidence.

"To promote safety and appropriate accident data management, recovering of (ATC) recorders, recovering of (FDR) and (CVR) should be safely secured"

Other areas which may be covered by the internal authority procedures, as highlighted by interviewees, include final report handling and administration.

"…in efforts to promote efficiency, authority ensures timely processing and administration of relevant investigation data before engaging of other states for review"

In connection with this, guidance for investigating operational, engineering, recorders and human factors aspects have to be made clear in the authority internal procedures. Such procedures shall also cover other activities such as non-release of sensitive documents or information related to the handling of the investigation process along with the safety recommendations administration. In addition, for what was classified as a family liaison procedure, it was emphasised

that the authority has to pay attention to deal with accident survivors and their families.

> *".. Keep the families and survivors up to date with the progress of the investigation and enables them to understand the complex nature of investigations"*

While participants did not develop this topic further, it was captured for the data collection using the survey.

4.6.7 Facilities and Equipment

The requirements to have appropriate facilities arrangements to enable the authority to conduct the investigation, as well as proper equipment arrangements, were among the suggested needs by interviewees.

> *"…investigation require properly illustrated facilities and equipment to ease work done by authority"*

While some respondents considered a recorder readout facility to be important for the authority, there was not total agreement among participants if such facility has to be owned due to being expensive and sometimes out of less-developed States budgets.

> *"Recorders readout equipment for CVR and FDR is required to cover different investigation tasks and foster the investigation process"*

> *"… it is difficult for small countries to afford the resources to own the readout facility as their continuous operation [keep the facility in operation way] is challenging"*

Other proper equipment suitable for the investigation site, which may include communication and transportation means were suggested to be available.

> *"…while on site, investigators require communication, transportation and protective gears"*

In addition, proper Personal Protective Equipment (PPE) and tools to enable investigators to conduct their investigation such as examining the wreckage were

also cited by interviewees, who also suggested referring to ICAO documents as guidelines in this matter.

4.6.8 Reporting Systems and Database

It was suggested during the interviews; the authority should have in place a mechanism of a reporting system for operators and stakeholders to notify any event including air accidents and serious incidents.

> *"…in effort to promote reporting system, stakeholders and operators should have mandate to give information in accordance to authority guidelines."*

In addition, the authority is also encouraged to establish a non-punitive voluntary reporting system to facilitate the collection of other information, especially about smaller events or near-misses. Moreover, building a database of the State occurrences would be a great benefit to the authority as was highlighted by interviewees. The analysis of any gathered information of such a database may further assist in capturing any information or trends to enhance aviation safety in the State.

> *"To enhance aviation safety, a database that puts into account all state occurrences is appropriate, stored accident information is used to evaluate the impact if shared across local systems."*

While the analysis findings suggested four main themes, which have extended impact over another four sub-themes as discussed, some other aspects flow from these interviews and are worth clarification. Because of the variation of the situation in establishing the authority among many countries, some interviewees highlighted the importance of assessing each individual State by conducting "*gap analysis*", to assist in providing an initial indication of the broad scope of gaps and the expected overall workload to be undertaken.

> *"A gap analysis must be conducted identifying where we are, where we need to be and what must we do to get there"*

Another point shared by respondents was that the progress in establishing the authority would largely depend on the available resources. It could be challenging to have all the required components in place at once.

> "*It is best to use the available resources to cover the first important bits then continue the process when more resources become available*"

Also, political support was considered to foster the process of establishing an authority by most of the interviewees.

> "*The disparity of resources and the reality of the terrain in small or third world countries may require local knowledge where bureaucratic consensual principals are not always realistic*".

Some interviewees went through the suggested option to initiate a Regional Accident Investigation Organisation (RAIO), especially when the State lacks the required resources (human and financial as interpreted by participants).

4.7 Discussion and Conclusion

Data gathered through interviews with SMEs from the field of air accident investigation were analysed using thematic analysis. The achieved results uncovered what can be classified as preliminary thoughts in developing the capability by the emerging of eight themes. In this vein, Ian Dey (1993) argues that there is "*no single set of categories [themes] waiting to be discovered. There are as many ways of 'seeing' the data as one can invent".*

Recalling the adopted definition of capability in an accident investigation context (refer to section 2.7.4), some of these themes as "*essential components"* aligned closely with the findings of the literature review but were not shaped by it. The researcher took great care to avoid leading any of the SMEs towards particular themes and as such, what has emerged is data-driven. It was always the intention to approach the data analysis inductively (See Braun and Clarke, 2006; Patton, 1990), where data coding was conducted without trying to align them to a pre-existing frame or the researcher's analytic preconceptions. However, it is acknowledged that being closely engaged in the topic under study may make it

difficult for the researcher to be free of theoretical and epistemological commitments as highlighted by Braun and Clarke (2006).

It is also acknowledged that the selection of the interviewees was from States based on their higher effective implementation of SARPs. Therefore, it tends not to include the experience of States setting up a new AIA. However, this does not mean that they have not assisted other States through the process or would lack insight as to what it may entail.

Another point concerns the level of the identified themes which was highlighted by Boyatzis (1998) as “semantic or explicit” level or “latent or interpretative” level. Braun and Clarke (2006) also indicated that in the semantic approach, the themes could be recognised through participants “*explicit or surface meaning of the data*”. In the ideal case, the analytic process involves a progression from a description by organising the data to show patterns in semantic content. Then, it is summarised to be interpreted to conceptualise the importance of patterns, their meanings and broader implications (Patton, 1990). By considering the identified themes from the previous analysis, it can be argued that the semantic level dominated the analysis process. Nevertheless, reflecting the achieved results to the field of the study, and recalling what was covered in the literature review, the themes revealed through the interviews are highly compatible with what is implemented in many developed States.

Considering Ryan and Bernard’s (2003) recommendation to check what could be missing from the collected data, the researcher did not recall during interviews any participant highlighting “learning from accidents” as a standalone topic. Even when discussing the investigation objectives, the emphasis was always related to avoiding any further occurrences where not-for-blame investigation principles can be applied. One possible explanation may be the preoccupation of the participants in addressing the aspects of the establishment of the AIA and the development of its capability at an earlier stage to the extent that places this topic as a later priority.

Bernard and Ryan (2010) pose the question of how to assess whether the identified themes are valid. They suggest that while there is "*no ultimate demonstration of validity*", the validity of the results highly depend on the judgment of the scientific community. As some researchers advocate allowing participants to examine and comment on the emerged themes (Lincoln and Guba, 1985, p.351), the following section demonstrates an expert panel review, also known as "*Delphi Technique*", to ensure the validity of the achieved results.

4.8 Themes Review and Verification

As described in the research methodology flow chart (figure 3-1), the initial framework, which was developed from a thematic analysis of SME interviews, required verification. Various methods can be used including further interviews, focus groups, expert panel reviews as well as nominal group techniques such as the Delphi technique, as highlighted in the literature (see Flick, 2014; Perera et al., 2006; Potter, Gordon and Hamer, 2004). Different researchers, including Babatunde, Perera and Zhou (2016) and Perera et al. (2006), have previously applied the expert panel review technique successfully in their studies (see Adeniyi, 2017; Boulkedid et al., 2011; Van de Ven and Delbecq, 1972).

When using the Delphi technique, questions are put to a panel of experts whose responses can be analysed, where rounds continue until group consensus is reached as highlighted by Powell (2003). The modified Delphi process for this study, which was performed as part of the expert review exercise, was conducted to ensure:

- The provision of greater detail about each of the emerged areas based on the analysis of the conducted interviews
- The use of constructive feedback from the expert panel review to ensure consistency among interviewees.

There were also some elements of the Delphi technique, such as anonymity of response and iterated controlled feedback from participants via two rounds (Dalkey, 1969) (see also Adeniyi, 2017) which were applied during this verification.

Eight experts engaged in the Delphi study. They were the same SMEs selected for the interviews, except for the academic staff and ICAO expert (refer to Section 4.4). Initially, a short survey was distributed to ask respondents to state their agreement regarding the emerged themes (they were also able to opt-out of answering if they had no opinion) (Mason and Alamdari, 2007). In the first round, 62.5% agreement for each theme was set as experts' consensus threshold, which means more than half of experts have to agree on each theme where the rest disagree. As Table 4-2 shows, the average score was calculated, and the lowest themes scored 83.3%. Consequently, all themes were promoted to the second phase of the experts' panel review.

Table 4-2 Number of responses and % agreement (agree) to the emerged themes

Statement: The following areas are essential for the establishment of the Accident Investigation Authority and developing its capability:	**D**	**N**	**A**	%**A**[2]
National State Legislation	0	2	6	100
Independence	0	0	8	100
Organisation	0	1	7	100
Personnel (Investigators)	0	0	8	100
Policies and Procedures	1	1	6	85.7
Facilities and Equipment	1	2	5	83.3
Training and Assessment	1	2	5	83.3
Reporting Systems and Database	1	2	5	83.3

(D = Disagree, N = No opinion, A = Agree, %A = % Agreement)

The second round was a qualitative review. It was more rigorous and can, therefore, be regarded as the main round of review for the verification of the emerged themes. It was performed by conducting short interviews over the phone. Further details were revealed about the position of experts in their response to the first round. For instance, one expert assumed the three themes (policies and procedures; facilities and equipment; and reporting systems and database) are covered by the existing 'organisation' theme and therefore had initially disagreed with them as being separate themes. This was the same case

[2] The percentage is calculated by removing the no opinion response.

for the training and assessment theme and the personnel theme. This slightly affected the agreement score of these areas, as shown in Table 4-2.

As consensus was reached about the emerged themes, it provided a high-level conceptual framework to explore in detail in the next phase of the project. The outcomes of the SMEs interviews and the modified Delphi exercises offered valuable insights for questionnaire design and distribution.

The following chapter will discuss the main phase of data collection from different sources using a survey questionnaire (Triangulation), which was designed based on the outcomes of the interviews. This step was deemed essential to investigate further and verify different topics that were mentioned by SMEs in the interviews and assist in developing and testing the framework.

5 FRAMEWORK DEVELOPMENT AND TESTING

As stated earlier, the study aims to identify the best processes and practices to develop the capability of air accident investigation in less-developed States. Following interviewing a sample of SMEs and the gathering of the initial data, which led to suggest an initial framework, this chapter, continues to explore developing the capability of the Accident Investigation Authority (AIA). Combining multiple measures to have an accurate picture and corroborate facts would enhance the research validity (Triangulation), especially if different approaches either reached the same results or provided further information. Where differences are found, this stimulates valuable discussion as to why this may be the case. (Denscombe, 2003; Neuman, 2014).

Therefore, an online questionnaire was selected to target the accident investigation community. This would contribute to fulfilling the third objective of this study by further refining the initial framework based on the collected evidence from the accident investigation community. The following section clarifies the questionnaire aspects such as design, sample selection, and the applied procedure during the data collection.

5.1 Designing the Survey

The systematic literature review and interviews with SMEs satisfy the background requirements for designing a sound questionnaire. According to Ison (2011), a successful collection of data critically depends on both the validity and construction of surveys. The ultimate target, when designing any survey questionnaire, should be making the research goals achievable, which include obtaining reasonable answers to the research questions. In this vein, Greenfield (1996, p.117) stated that;

> *"To conduct a survey successfully it is necessary, but not sufficient, to get the theoretical and statistical aspects of the design right".*

Questions should be formulated to allow participants to easily answering them "… *while the questions at the same time remain faithful to the research task*"

(Robson, 2002, p.242). When designing a self-completion questionnaire, the number of open-ended questions has to be minimised, as they require greater efforts in the subsequent analysis and can reduce the response rate.

Concerns about the nature of the participants who remain unknown to the researcher were dealt with by introducing a question at the beginning of the survey "*Please select the type of organisation you work for*" where the targeted participants were investigators who are working in an AIA. This question was followed by a more specific question "*Please choose your state accident investigation authority type from the list"* to identify their authority model.

A customised version of Qualtrics software for Cranfield University was chosen to distribute the questionnaire online, for several reasons. It is reliable, licensed and can manage the expected work for this study in a professional way (See Appendix C).

5.2 Structuring of the Survey

The survey was designed to flow smoothly (Neuman, 2014) by collecting more precise data about the themes that had emerged through the previous stages of the study. It was made up of 50 questions, the majority of which were closed-ended, asking for a structured and fixed response as they are simpler and faster to answer and analyse. In addition, eight open-ended questions were incorporated in the distributed survey to gain further understanding from the participants' experience. Mixing open-ended and closed-ended questions in the questionnaire can reduce the disadvantages of questions format and offers a change of pace and helps the interviewer to establish rapport as suggested by Neuman (2014). Moreover, the unstructured and free response of participants to the survey open-ended-questions can facilitate capturing more in-depth information and enhance the framework rationality (Neuman, 2014; Robson, 2002). The survey questions were a result of the data gathering from the conducted interviews in chapter 4 and pilot work (refer to section 5.2.1) (Robson, 2002).

The survey aimed to collect primary data about the best processes and practices within each area, named in this questionnaire as **'Dimensions'**. In most of the explanations, the word dimension has been used to represent the independent variables that contribute positively to their relationship towards the dependent variable, the capability concept.

5.2.1 Pilot Study

As highlighted by Greenfield (1996), instruments and procedures in the survey must be pretested. To make survey questions valid, they should measure the concepts they are intended to measure and to be reliable "*they should be answered the same way each time they are asked*" (Weisberg, Krosnick and Bowen, 1996, p.94). There was no concern about the language used in the questionnaire (English), as it is the standard international language for aviation, although more subtle concepts can still be difficult to convey in a second language. This study claims two types of validity; face validity, and content validity, as highlighted by Bowling (1997).

The pilot study was conducted in two phases: First, the survey was sent to two academics providing "*Panel or expert judgement validity*" according to Cavana, Delahaye and Sekaran (2001). The aim was to check the content validity by examining each question and ensuring it measures the theoretical construct (Burns, 1994) and that the instructions are unambiguous for participants (Mason and Alamdari, 2007). Also, this stage provided a check of the language/terminology used in the questionnaire, where the feedback identified three key points:

- The type of some questions should be modified
- Some abbreviations required clarification
- Some typographical errors needed correction

All points were addressed, and the questionnaire was deemed ready for the second phase of the pilot study, which involved four accident investigators who are not part of the final sample, but representative of the target population. The

purpose was to ensure the face validity of the questionnaire by checking THE clarity of its wording (Burns, 1994).

The feedback identified two key points:

- To add the choice of "*Other, please specify*" to some questions
- To change the order of some questions

There were no reported issues regarding either the questionnaire flow or the use of the software in answering the survey. All of the feedback was accepted and addressed in the final questionnaire.

5.3 Population and Samples

Identifying the research population offers a basis on which an adequate and appropriate sample strategy can be decided. Selecting samples is the way of choosing representative cases from the population (Collis and Hussey, 2003; Saunders, Lewis and Thornhill, 2009). For the current study, it should be made clear that not all States have a specific organisation dedicated to investigating accidents. If this is the case, then the investigation can still be conducted in an *ad hoc* way or under the umbrella of the regulatory body. Subsequently, it was decided that the most appropriate samples for this study are investigators from AIA's or from other organisations for whom the investigation of air accidents and incidents are part of their work.

The number of investigators varies in ICAO Member States and because of the specialised nature of the field of study; the population is very small (refer to Nixon and Braithwaite, 2018). According to Denscombe (2003), there is no need to use a large sample size in a research survey, especially in small-scale research which may involve between 30 and 250 cases.

Making contact with the target population was not a simple task. Therefore, as 'known' accident investigators were contacted, they were also asked for contact details of other investigators to enlarge the sample. The data collection process continued for four months, and finally, by only including those who stated that they have worked for an accident investigation authority, there were 86 worldwide

completed responses. The majority were from Europe (n=33, 39%) and North America (n=16, 19%) (See Figure 5-1) where the percentage is approximate. Participants' location was identified through the captured data by Qualtrics software where the location of five respondents was not determined for an unknown reason.

In their response to the type of organisation they work for, 50 (58%) participants were from single mode, whereas 36 (42%) were from multimodal, as shown in Figure 5-2.

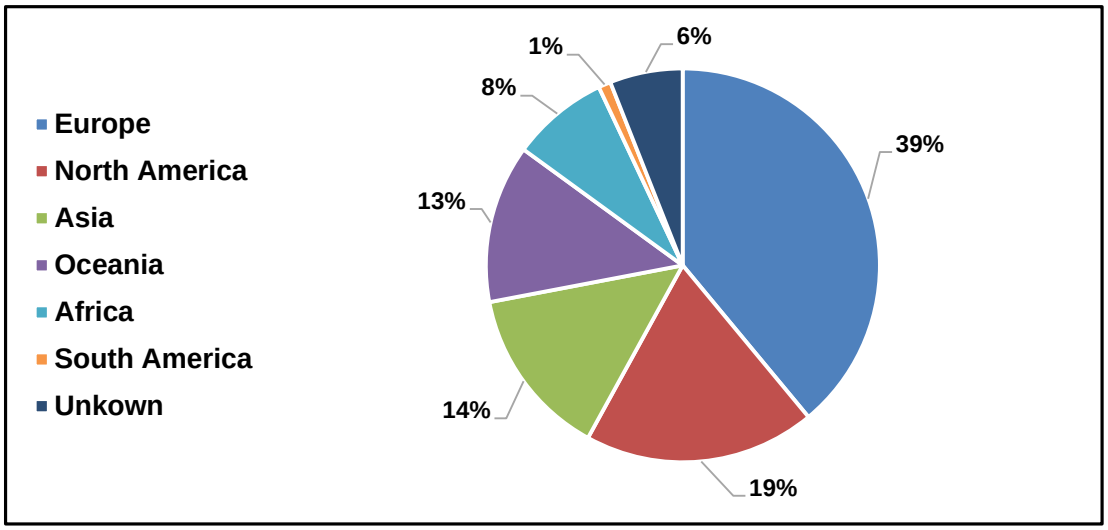

Figure 5-1 Survey Respondents Location

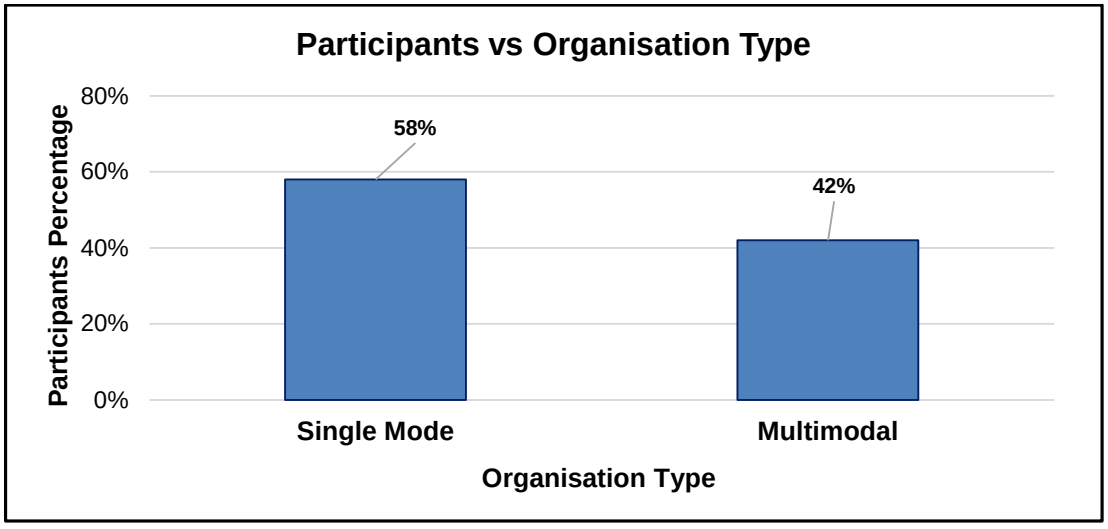

Figure 5-2 Participants' Organisation Type

5.4 Analysis Process Explained

The questionnaire featured a variety of question types. Questions' weight among different dimensions varied in both the amount and type of questions to ensure different analysis phases could be attained. Information used in this analysis "*was derived from questionnaire data*" (Creswell, 2013) with the assistance of other information sourced from the study early stages for comparison or cross-references purposes. There were two steps in the analysis:

- **Statistical Analysis of Dimensions Data**

This includes a descriptive analysis of different types of questions. Whenever it was felt necessary, additional statistical analysis was applied to gather further understanding. After preparing the dataset by extracting the answers from Qualtrics and performing data cleaning (Refer to section 3.10), it was then imported to SPSS. The data were coded as suggested by Neuman (2014) by assigning specific numbers to variable attributes. Each category of all variables as non-numerical information was converted into numbers then analysed using SPSS.

Additionally, 40 different factors, which were identified from the SME interviews, were analysed using the Relative Importance Index (RII) method. Examining the significance of these factors in different situations assisted in understanding their importance among the selected dimensions and for different accident investigation models (Results presented in 5.7).

- **Qualitative Analysis of Dimensions Data**

This covers different questions among different dimensions. This type of analysis was carried out to explore in-depth insights into the process of establishing the AIA and assist in achieving consistent results. This analysis is presented separately in chapter 6.

5.5 Survey Results and Findings

5.5.1 National State Legislation Dimension Findings

By referring to the findings in chapter 4 and to explore the situation between the AIA local legislation and Annex 13 SARPs, participants were asked: "*Is it important for the state to have its own accident investigation legislation and regulations?*" 73.3% of participants said *yes, it should have them in addition to what is laid down in Annex 13*. 26.7% said *No, Annex 13 is sufficient* (See Figure 5-3) (This result is discussed in details in section 6.2).

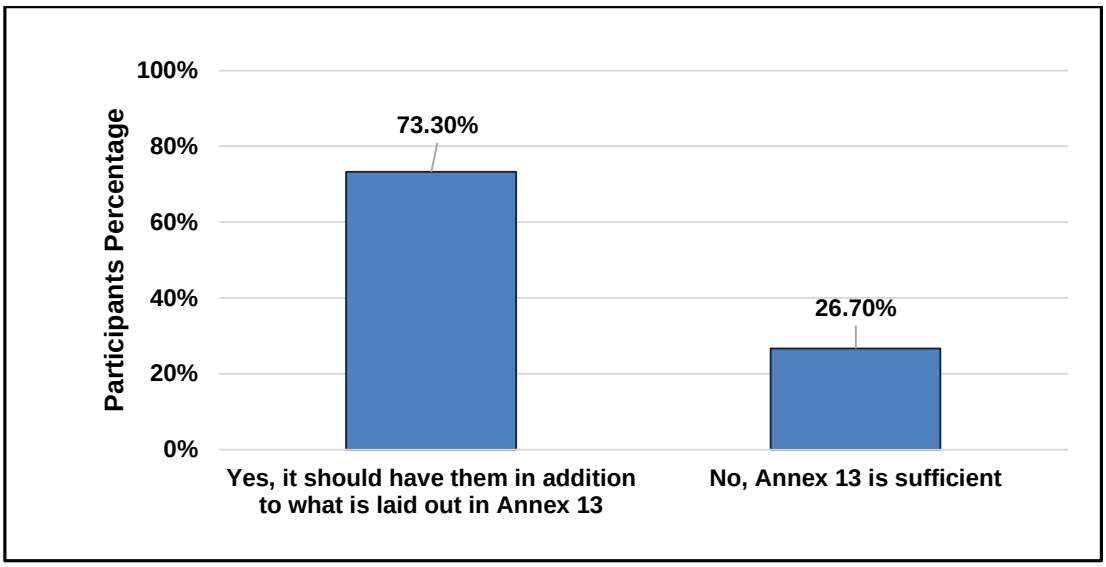

Figure 5-3 - Is it important for the state to have its own accident investigation legislation and regulations?

Further, participants were asked, "*what are the most reliable references for a state to develop its local accident investigation legislation and regulations?"* 97.7% (84 responses) of participants selected *ICAO Annex 13*. Also, 51.2% (44 responses) picked a *similarly sized State* option. Following that, 36% (31 replies) went on to choose *European Union Regulation 996/2010* and finally, 17.4% (15 replies) supported *the US Independent Safety Board Act of 1974* as least option.

Then, for a state which needs to develop its own legislation and regulations, participants were asked to state their opinions regarding different topics to be covered by the state legislation and regulations**.**

They were asked if "*the establishment of the accident investigation authority should be emphasised in the State legislation and regulations*". The majority, 76.7%, said they agree (16.3%) or strongly agree (60.4%). 5.8% said they neither agree nor disagree, and 17.5% said they disagree. Interestingly, having local legislation and regulation to enable the establishment of the authority also supports the positive responses in the requirements for the State to have its national legislation and regulations in addition to what is laid down in Annex 13 in the previous question.

In addition, 80.2% of 86 responses said they agree or strongly agree, while 16.3% said they disagree that "*the independence of the accident investigation authority from the regulator or other authorities should be emphasised in the State legislation and regulations"*.

73.2% out of 86 responses said they agree or strongly agree, whereas, 11.6% said they neither agree nor disagree and 15.2% said they disagree that "*the investigation process in compliance with Annex 13 provisions should be emphasised in the State legislation and regulation"*.

Then, respondents were asked whether "*the use of investigation safety findings in judicial inquiries shall be prevented".* Results show a high level of agreement as 73.4% said they either agree or strongly agree (see Figure 5-4).

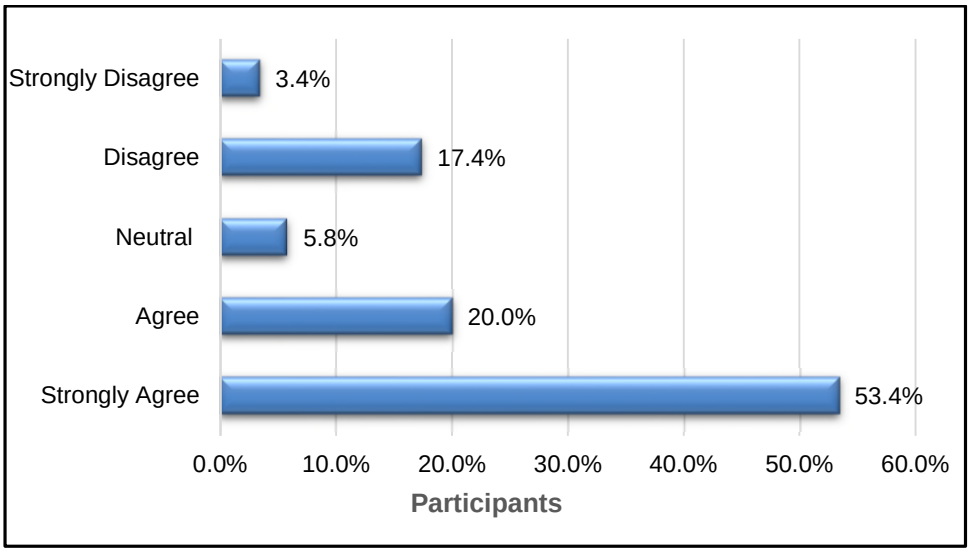

Figure 5-4 Preventing the use of investigation safety findings in judicial inquiries

Respondents were asked "*For a state which needs to develop its own legislation and regulations, please state your opinion for each of the following topics to be covered by the state legislation and regulations*." When asked if "…*the accredited representatives have the right to participate in the investigation process*", the majority of the participants' responses were either agree (24.4%) or strongly agree (52.3%), whereas 16.3% disagree and 7% neither agree nor disagree. This does not necessarily mean they disagree with the intent of Annex 13 but could suggest that up to 23.3% of respondents do not feel this needs establishing in legislation and regulation.

When asked if "*the State investigation authority shall be able to seek expert assistance from other States"*, out of 86 respondents, 80.2% said they agree (18.6%) or strongly agree (61.6%) that it needs to be established in legislation and regulation, whereas 15.1% said they disagree.

The response of participants to a question "*where should the purpose of accident investigation be described?"*, 73.5% selected in the State local legislation and regulations in accordance with Annex 13 option, whereas, 26.5% said as defined by Annex 13 provisions (no need to be included in local legislation and regulations). This finding was found to be largely consistent with the response to the first question, whether it *is important for the State to have its own accident investigation legislation and regulations*, which may indicate consistency in participants' responses.

5.5.2 Organisation Dimension Findings

The organisation dimension is one of the eight proposed scopes for States to develop their accident investigation capability. To further attempt to understand the principles of a specific country to decide what kind of mode to implement, participants were asked "*from your own perspective, what are the most important factors that are involved in deciding the organisation model for a certain state? i.e to be single mode or multimodal"*. Based on the gathered information from the conducted interviews and the literature review, five different factors are here suggested to be examined. These are:

- The Organisational Efficiency
- The Financial Resources of the State
- The State Land Size
- The State Traffic Size (Number of flights)
- Having Local Manufacturing or Maintenance Services

It was found that organisational efficiency as a factor contributes to almost two-thirds of the participants (62.7%) within the single mode, then by 37.3% within the multimodal organisation (See Figure 5-5).

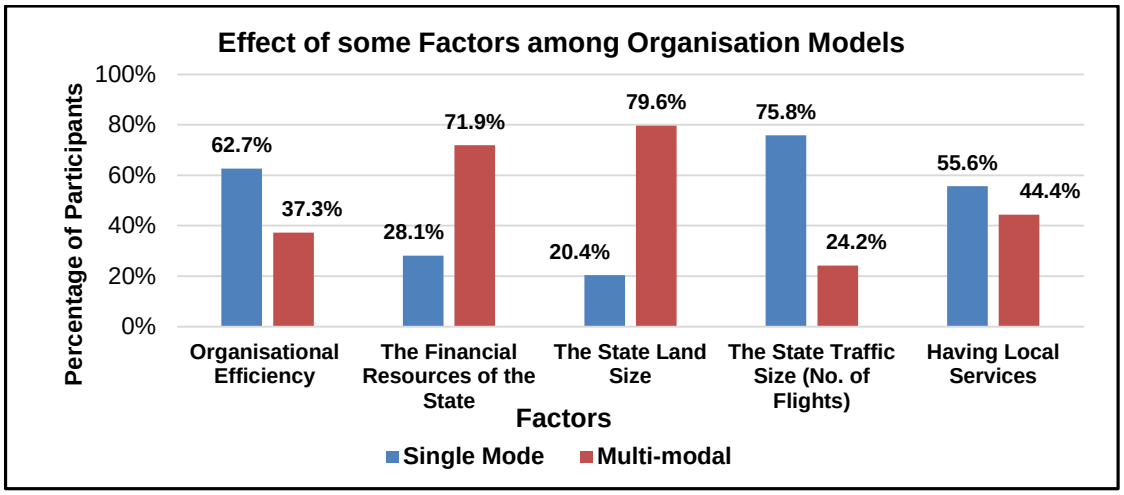

Figure 5-5 Different Factors Affecting the Organisational Modal

The data were analysed using a chi-square test (using SPSS) (Cochran, 1954) to determine the significant association between this factor and the selection of a State organisational model. Both the sample size and a number of cells are essential to ensure the validity of the chi-square test, as claimed by Elliott and Woodward (2007). Table 5-1 provides the observed and expected frequencies for each mode, where it is hypothesised that the proportion of cases expected to be equal in each group of the categorical variable.

Table 5-1 Frequencies for the Organisational Efficiency Factor

	Observed N	Expected N
Single Mode	47	28.7
Multi-modal	28	28.7
Don't know	11	28.7
Total	86	

The result of chi-square was statistically significant: χ^2 (2) = 22.63, $p < 0.05$ therefore, it can be concluded that there is a statistically significant association in the preference of the organisational efficiency factor among the State organisational models with less preference in favour of multimodal compared to the single mode.

The most affected by the financial resources factor is the multimodal organisation (refer to Figure 5-5) as stated by the participants (71.9% out of 75 responses after ignoring 11 participants who answered “do not know”).

The most affected mode concerning the State land size factor was multimodal in 79.6% of participants. The single mode found as the most affected by the State traffic size (number of flights) factor where about 75.8% of the participants stated that this factor would contribute significantly in choosing the single mode.

The final proposed factor was if the State has local manufacturing or maintenance services. Results show that both models have a closer influence under the effect of this factor (refer to Figure 5-5). This may suggest that with more manufacturing or maintenance activity in a country and the obligations of the State of manufacture, as outlined in Annex 13, there is an even higher demand for clear authority and responsibility to be included in the State national legislation.

From the obtained results, it is suggested that factors which encourage any State to decide on the initiation of the single mode organisation, are the State traffic size and the organisational efficiency whereas two factors were in the same strength (influence) in deciding multimodal organisation, which are the financial resources of the State and the State land size.

Table 5-2 shows the results of the chi-square test, which found to be statistically significant for all factors, ($p<0.05$). This may suggest that there is a statistically significant association in the preference of factors among the preferred models, i.e., single mode and multimodal.

Then, participants were asked based on their experience, to add “*any important factors that are involved in deciding the organisation model for a State”.* Out of the 86 respondents, 62 (72.0%) said, either “Don’t know” or did not answer this

question. Table 5-3 shows the replies of the remaining participants broken down into categories.

Table 5-2 Different Factors - Test Statistics

	The State traffic size (Number of flights)	Having local manufacturing or maintenance services	The State land size	The financial resources of the State
Chi-Square (df=2)	42.860	17.744	51.651	35.326
Significance	.001	.001	.001	.001

The most notable factor was the Government Decision (Political), by receiving the proper support from the government. The eight participants' answers regarding 'government decision' could be grouped with the four respondents' answers on Ruling Government Support (see Table 5-3) on the basis that participants concern was emphasising the need for strong political support to enable the establishment of the investigative authority. This level of support from the body politic was reported in the conducted interviews as necessary to enable the genesis of any such authority.

Table 5-3 Categories for other factors involved in deciding the organisational model

Q4 Categories	No. of Responses
Don't know or Didn't answer	62
Government Decision (Political)	8
Ruling Government Support	4
Accident and serious incident rates	3
State Aviation Act and Regulations	2
The investigation team was a branch of the regulator	2
Regulatory structure	2
Separation from the State's Regulatory Authority	2
Reputation and public trust	1

The financial resources were also among the outcomes of the interviews in chapter 4. When investigators asked, "*Should the state accident investigation authority need to have access to extra financial resources in the event of a major accident?*" The majority, 81.4% said: "*Yes*," while 15.1% (13 respondents) answered, "*No*" and 3.5% answered, "Don't know".

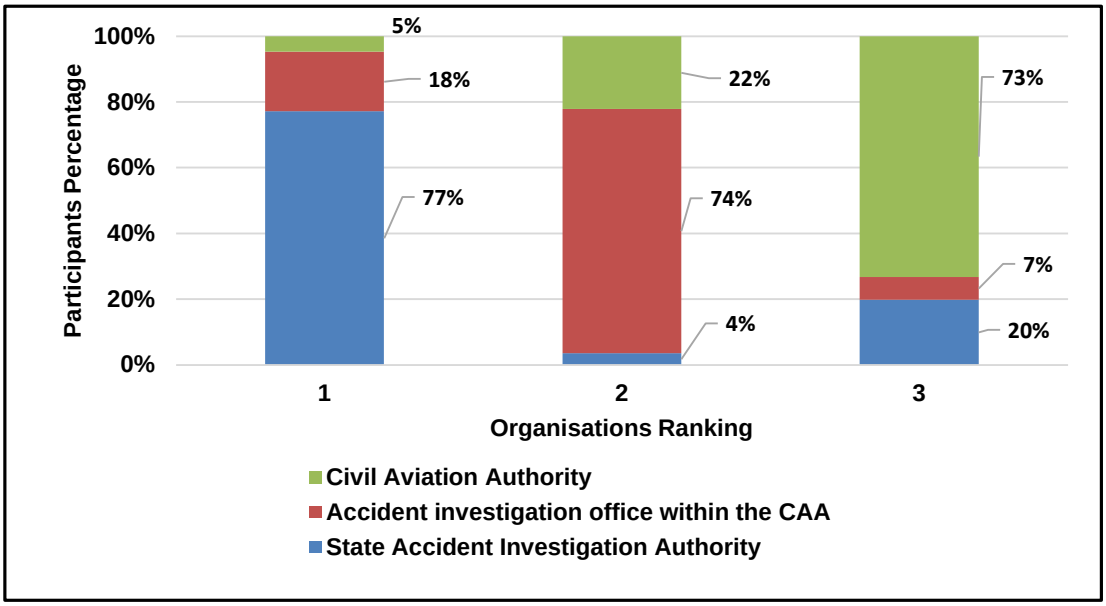

Figure 5-6 Which of the following organisation is likely to conduct an effective accident investigation?

By considering different organisation in ICAO Member States, a high percentage of participants (about 77%) selected the *State accident investigation authority* as the most likely to conduct a reliable accident investigation. The percentage of participants' choices and ranking is shown in Figure 5-6.

It can be seen that *accident investigation office under the umbrella of the civil aviation authority* came in as the second choice, whereas *civil aviation authority* as an organisation was the least popular choice for participants.

5.5.3 Independence Dimension Findings

The importance of the "Independence" for the AIA was recognised early in the research through the process of the literature review. The first investigation stage into its insights was by asking participants "*Does the state accident investigation authority have to be separate from the regulator and other authorities?*" The

majority, 68.6%, answered *yes, the structure should be separate* while 25.6% said *it could be partially separate*, whereas 5.8% consider *it is not necessary to be separate* (See Figure 5-7). This result is further discussed in section 6.3.

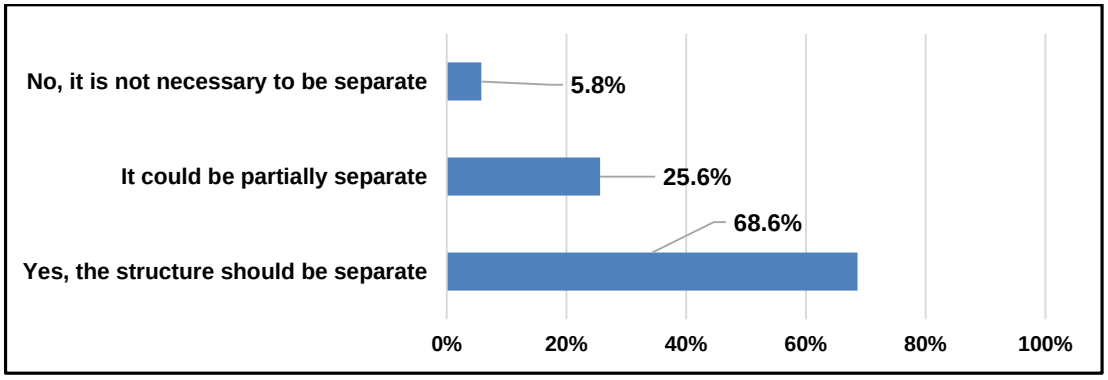

Figure 5-7 - Does the investigation authority have to be separate?

To investigate the common practice of the authority having the freedom to launch an investigation, participants were asked, "*should the state accident investigation authority need permission to launch an investigation after an air accident or incident?"* The majority, 69.8% answered "*No, no permission is required"*, but 25.5% said, "*sometimes it depends on each State"*. Whereas, 4.7% said, "*yes, permission is needed"*.

Aiming for further clarification from those who answered ***Yes permission is needed*** or ***sometimes it depends on each State*** (26 respondents), they were directed to specify from whom such permission has to be obtained, and their answers were as follows:

- Ministry of Transport (61.5%, 16 out of 26 respondents)
- Ministry of Justice (27%, 7 out of 26 respondents)
- Ministry of Interior (3.8%, 1 participant)
- Ministry of Defence if it is a military accident (7.7%, 2 participants)

To explore the level of protection of investigators towards their independence from the influence of judicial authority, participants were asked: "*Do safety accident investigators need to be protected against being called (to testify or similar activities) by the judicial authority?*" 64% of participants said *Yes, they should be protected by local legislation and regulations*, whereas 31.3% reported:

"*in some cases they are required to do so".* 4.7% said, "*No, they should not be protected, and they may be called at any time"*.

Further information was collected from participants who answered ***in some cases they are required to do so.*** Investigators may be called because of the key knowledge about the facts of the occurrence. They may have specific information not available from other sources, and such information is vital for court activities. They should, however, be prohibited from expressing opinions during a judicial process, as only the views of the AIA are published through the investigation final report and should be definitive. Another thought is that an investigator can be of help to the judicial authority and the support, in this case, maybe essential to assist the court to achieve the right decision.

For those who answered ***No, they should not be protected, and they may be called at any time,*** their argument was, judicial authorities should have access to all relevant information to investigate appropriately and in the case of investigators being assumed as the only source of this information, they shall be called for this reason. Some people strongly feel that the court/judge/judicial authority should have the ability to decide who needs to testify.

> "*If everybody has the right to refuse to testify, what would a fair judicial decision be based upon?*" as stated by one of the participants.

To clarify the form of the organisation independence, participants were requested to rank three independence options - *essential, ideal, and non-essential*. Results were as shown in Figure 5-8.

To identify the source of the decision to initiate an investigation, participants were asked: "*Who should decide whether to initiate a safety investigation?*" 65.9% of respondents selected "*the State investigation authority only"* whereas, 34.1% indicated that "*the State investigation authority in collaboration with the responsible Ministry"*. The strong result in favour of functional independence may suggest that without having the capacity to initiate an investigation (without referring to any other party in the State); the authority cannot exercise functional

independent. However, out of necessity, sometimes there is a need for input from other agencies/authorities regarding the initiation of an investigation.

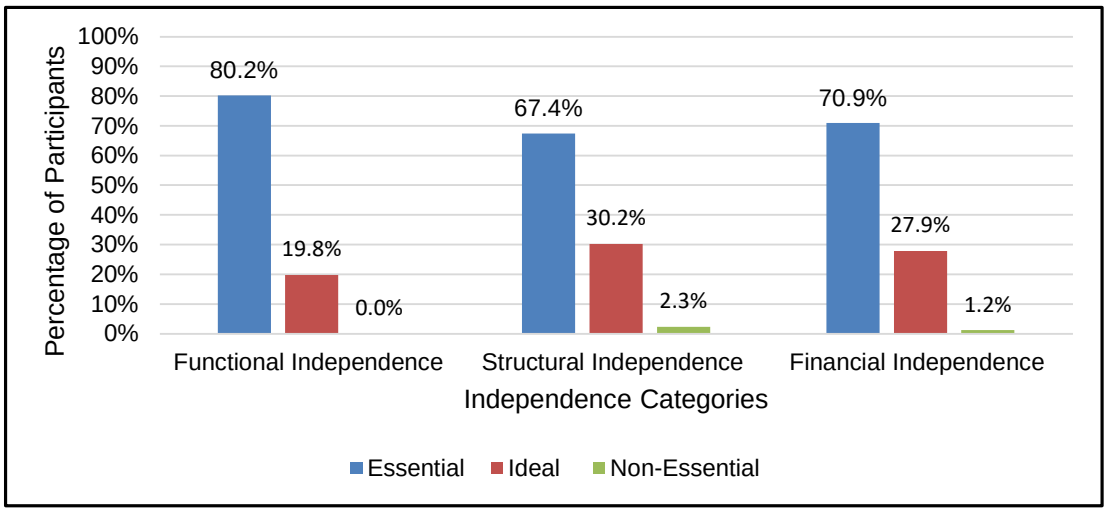

Figure 5-8 The Importance of the Independence Categories

To measure the independence as a concept when exercising activities that are linked to the investigation process, survey takers were asked: "*who has control at the accident site, including the available evidence (e.g. ATC and CVR records)?"* 60.5%, (52 respondents) stated that "*the authority appointed Investigator In Charge (IIC) should have full control*", whereas, about 33% said that "*the control is shared between the IIC and the judicial authority*" (See Figure 5-9). The positive response in favour of the IIC may be interpreted to the need to enhance the protection of investigation evidence.

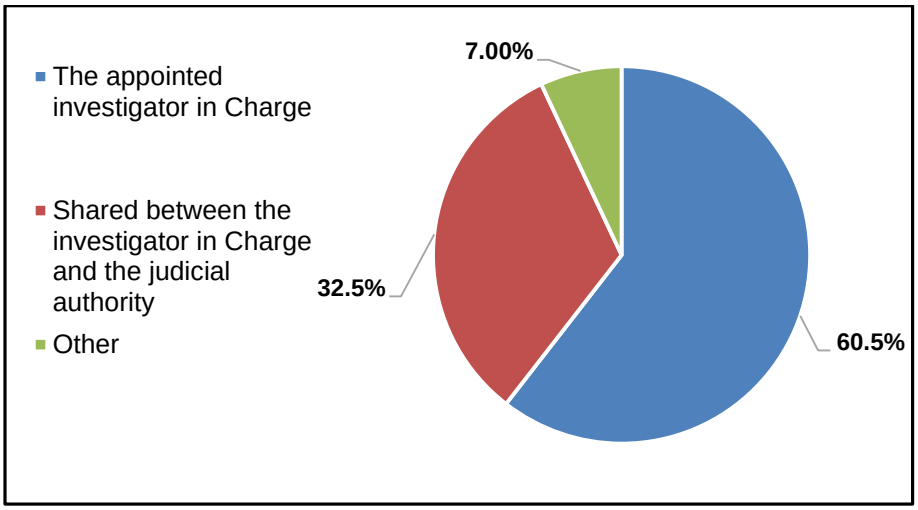

Figure 5-9 Who has control at the accident site including the available evidence?

By reviewing the contribution of participants who selected the option "*other*", their view was the AIA should have control unless criminal activity is determined. The judicial authority should be the main body in charge working in unison with the investigation authority. This view was found compatible with article 5.11 (*Informing aviation security authorities*) of Annex 13.

The most controversial answers were received as a response to the question "*Can recordings (e.g. ATC & CVR) be used for a purpose other than air safety investigation?*" The purpose was to explore different practices among participants in dealing with such records. While 29.1% of respondents said "*yes*, *they could be used"*, the majority 63.9% said "*No"*, whereas, 7% select "*Other*" option. To clarify the opinion of respondents who chose "*Other*" and "*Yes*" options by referring to their narrative answers, it was found that participants think recordings should be released and used for education, training, learning purposes and preventing accidents. In addition, concerning furthering safety outcomes, where there are clear learnings from the recorded data, this information should be used in a positive and pro-active way. Others, however, consider that the use of recordings may only take place after the investigation has been concluded, where other bodies such as judicial authority may wish to conduct their own investigation.

5.5.4 Personnel Dimension Findings

These findings aim to measure further, what allows investigators to perform their assigned work effectively. Participants were asked, "*For a State with a low rate of accidents and serious incidents is it difficult to maintain the preparedness of the investigators?"* Preparedness is the level of the skills of investigators and their currency to conduct the necessary investigation. The agreement in favour of such difficulty reached about 67.6% (see Figure 5-10).

Doing the job (*practising*) is essential for investigators to enhance their familiarisation with many different scenarios and situations, which they might encounter at the accident site. On the other hand, about a third of participants

(32.4%) did not feel it was difficult to maintain the preparedness of investigators. A further discussion can be found in chapter 6, section 6.4.

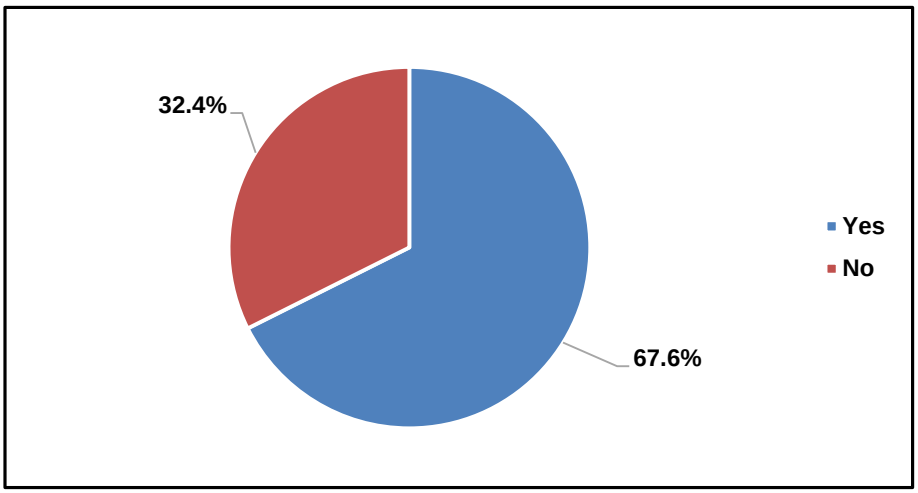

Figure 5-10 Is it difficult to maintain the preparedness of the investigators?

Aiming to discover what *can assist the authority to ensure the preparedness of the investigators*, 65.5% of participants selected the *participation in accident investigations* as the first option, while *participation in incident investigations* was ranked as second by 58.3% of the respondents. The third option chosen by 53.6% of participants was *conducting regular training*. The least recorded option was *observing other investigations that are conducted by other States*.

This question was analysed further by using Friedman's ANOVA for comparison of the selected options. Chi-square result = 88.172 with $p < 0.001$, concludes that there is a differential rank for the given options (See Table 5-4).

Table 5-4 Options Ranks

Option Selection	Mean Rank
Participating in accident investigations	1.61
Participation in incident investigations	2.33
Conducting regular training which includes OJT	2.62
Observing other States' investigations	3.44

The statistical results support the importance of options as participants ranked them; however, in reality, nothing can preclude the implementation of all options to ensure investigators preparedness.

Further, participants were asked, "*which of the following is likely to support the State investigation authority to conduct a reliable accident investigation*." By ranking the provided options, most to least important, results show *the participation of accredited representative system of ICAO Annex 13* as the first option by 71.4% of participants. Whereas, *signing MoU with other States* came as a second option (58.3%). The least favoured choice was *the support of an RAIO* (57.1%).

By conducting Friedman's ANOVA, the chi-square = 42.5 with $p < 0.001$. There is an overall statistically significant association between the mean ranks of the given options (See Table 5-5).

Table 5-5 Ranking of Options

Option Selection	Mean Rank
The participation of accredited representative system of ICAO Annex 13	1.44
Signing Memorandum of Understanding (MoU) with other States	2.16
The support of Regional Accident Investigation Organisation (RAIO)	2.40

Concerning the importance of job description for the authority's personnel, participants were asked "*is it important for a state accident investigation authority to have a job description for its personnel?*". Almost 73.8% agreed that *there should be a job description for the authority investigators*. The remaining 26.2% said *it depends on each authority* (A further discussion can be found in section 6.5).

When participants were asked *"should the job description be updated regularly?",* slightly more than two-thirds of participants support the job description to be updated regularly. On the other hand, 22.1% disagreed for the job description to

be updated where 5.8% (5 participants) had another opinion. In their opinions participants explained that if the contents of the job have changed, then the job description should regularly be evaluated.

Then participants were asked "*with regard to minimum requirements and qualifications for the investigators which have to be specified by the state accident investigation authority, please state your opinion*". The results show that 76.7% of participants consider that minimum requirements and qualifications for the investigators have to be in place.

To explore the matter of cooperation with other States, as discussed in chapter 4, participants were asked: "*is the state accident investigation authority required to sign Memorandum of Understanding (MoU) to support it in the process of investigation that conducted by its investigators?*" where participants were allowed to chose more than one answer. Among 103 inputs from participants, 46.6% (48 responses) considered this as not necessary. Whereas, 33% (34 responses) said *yes, the State is required to sign MoU with other States*. 20.4% (21 responses) supported the option where *the State is required to sign MoU with RAIO* (see Figure 5-11).

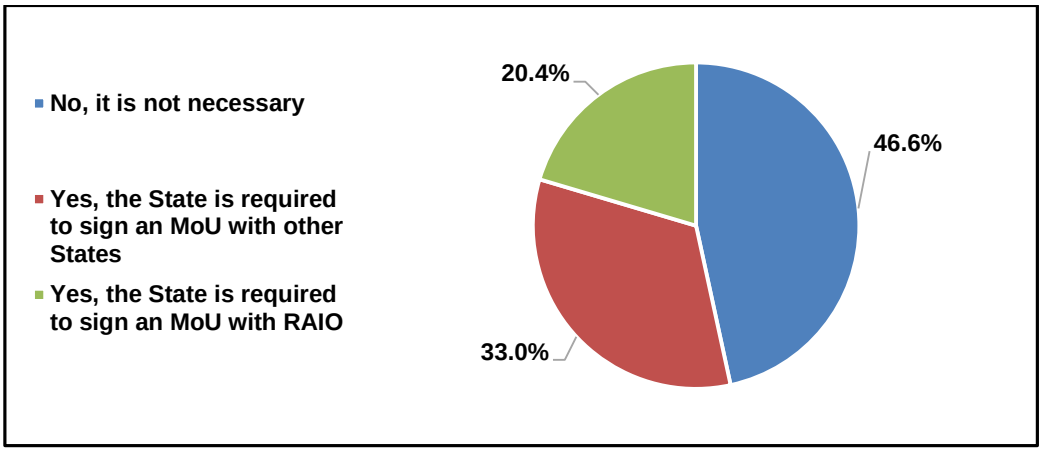

Figure 5-11 Signing MoU with other States and RAIO

Then, when participants were asked, "*does the State investigation authority need to take necessary measures to avoid possible conflict of interest when assigning investigators from outside the authority?"* Results show higher agreement

(66.7%) that the authority must ensure such conflict is avoided, which found to agree with the interviews results (see Figure 5-12).

However, 19% said "*sometimes despite the authority efforts, a possible conflict of interest might occur"*, while, 14.3% said, "*no; it is difficult to guarantee this"*.

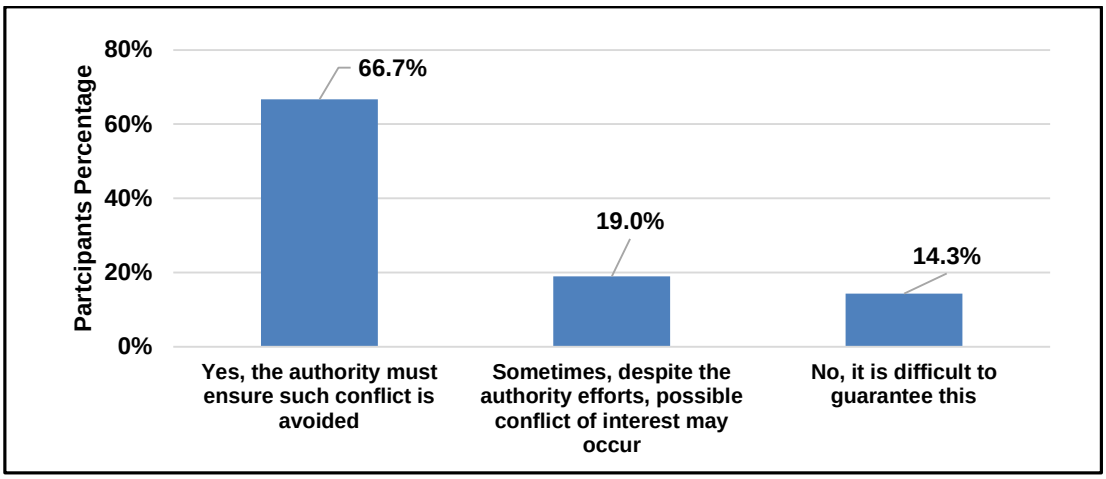

Figure 5-12 Avoid Conflict of Interest

5.5.5 Policies and Procedures Dimension Findings

The importance of this dimension can be highlighted as it covers the guidelines that govern the working ways of the AIA, as explained earlier (Refer to section 4.6.6). The first stage was to ask participants "*is the State accident investigation authority as a practice required to identify its plans to deal with different occurrences (e.g delegating or conducting the investigation)?*" From the given options, the majority of participants (77.8%) agreed. The only disagreement was if plans "*should be made public"* or be limited to an "*internal document"* as shown in Figure 5-13.

When participants asked if "*the AIA required to have official policies and procedures for the investigation tasks"*, the majority (81.7%) agreed which may highlight the importance of having official policies and procedures in place to organise the accident investigation tasks.

Usually, the investigation process is important for many parties, including the families of victims and survivors. They understandably become very interested in following up on the investigation stages hoping for valuable information that may

explain what happened to loved ones who lost their lives in the event. This topic was highlighted in both the SLR and SMEs interviews (Refer to section 4.6) and investigated further here.

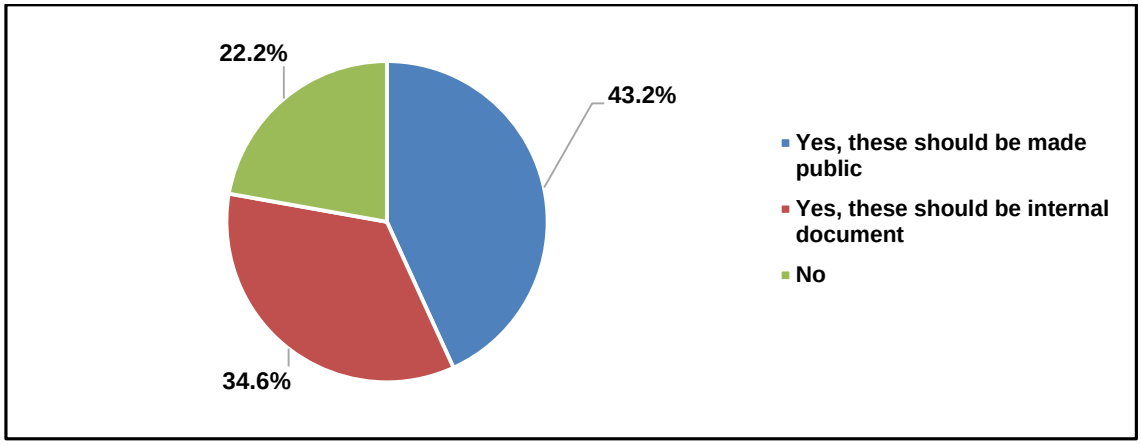

Figure 5-13 Identifying the AIA plans to deal with different occurrences

Nearly half of participants think the authority "*is not obliged*" to provide relevant information on the progress of the investigation to the families and accident survivors, as shown in Figure 5-14. This issue is further discussed in section 6.7.

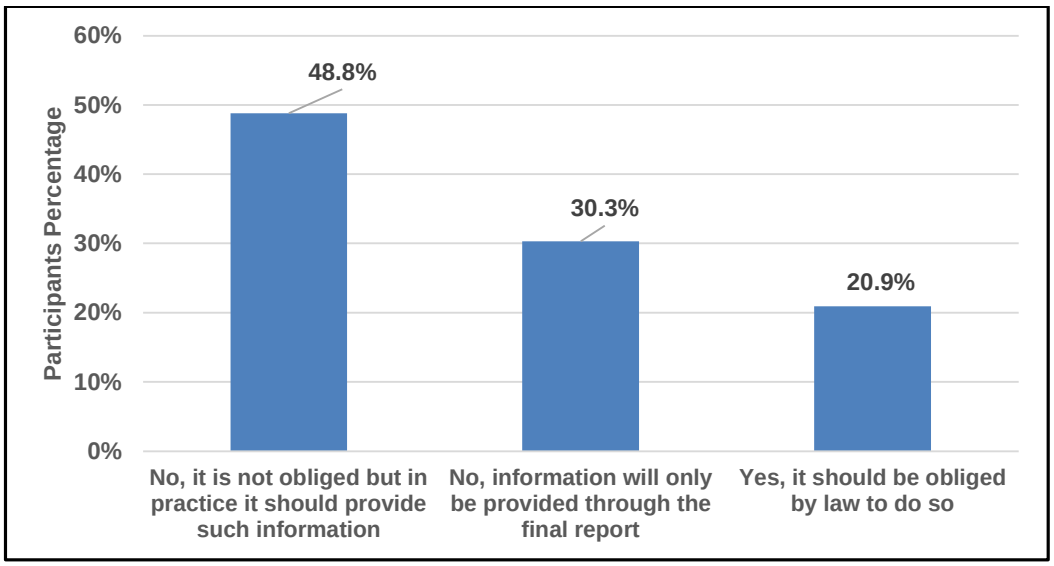

Figure 5-14 Providing Information to the Families and Accident Survivors

Then respondents were asked if "*the authority needs to keep updated correct contact details for other States investigation authorities and ensure updating such information regularly*". The majority (82.1%) agreed, which may suggest that the

AIA should implement a system to maintain such information and ensure its validity regularly.

5.5.6 Facilities and Equipment Dimension Findings

Another dimension which contributes to the development of the AIA relates to facilities and equipment. Participants were asked "*please state your agreement for each of the following statements*"

When asked if "*the authority should have FDR & CVR readout facilities even if it has a low rate of accident and incident*", just over half of the respondents showed disagreement to own such equipment under these circumstances. However, 24.3% either agree or strongly agree that such equipment should be made available, whereas, 24.5% kept a neutral side (See Figure 5-15).

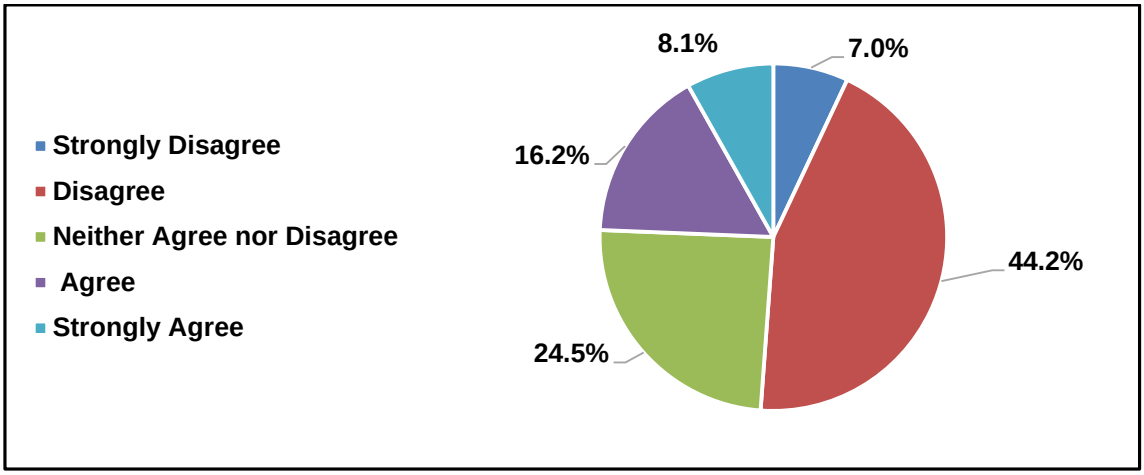

Figure 5-15 Having FDR & CVR Readout Facilities even the AIA has Low Rate of Accident and Incident

In addition, when asked if "*the authority is responsible to provide the required equipment (e.g tools and marking equipment) to enable its investigators to conduct the investigation",* the majority of participants, 74.4% either agree or strongly agree for the authority to bear responsible for providing such equipment. Whereas 15.1% think the authority should not provide the equipment and 10.5% kept a neutral position.

When asked if "*the accident investigation equipment are required to be kept in an updated list",* results show higher agreement up to 66.3% of participants while

17.4% did not agree and 16.3% could not formulate an opinion regarding this issue.

When participants were asked whether "*the authority is responsible to have special equipment to deal with hazards in the investigation site"*, the agreement among participants reached 73.2%. Whereas, 18.6% disagreed and 8.2% neither agree nor disagree.

Then participants were asked if "*the authority shall ensure the availability of storage facility to be used to protect the evidence and maintain the custody of the aircraft for such period as necessary".* A higher percentage of respondents (73.8%) agreed for such a facility to be provided by the authority while 17.8% disagreed and 8.4% kept a neutral position.

5.5.7 Training and Assessment Dimension Findings

The importance of this dimension can be sourced to its direct link to the investigators who are a vital element to any investigation. Initially, the majority of participants (79.8%) stated that "*the authority is required to establish a formal training system for its investigators"*. However, 20.2% answered, "*No, investigators will learn by practice in the accident site"*. The higher agreement may suggest that a formal training system for investigators to equip them with the right skills and maintain their currency is vital.

Aiming to identify the proper and right training that should be offered to accident investigators in connections with the interviews results provided in chapter 4, participants were asked to choose from many provided preferences. Interestingly, results show the "*human factors training"* was the most required topic (100% of respondents), (see Figure 5-16) which could suggest that, in today's accident investigation, the likelihood of human factors as a cause of accidents is considered high or that investigators recognise their limitations in this field.

> "*Human error has been implicated in 70 to 80% of all civil and military aviation accidents*" (Shappell and Wiegmann, 2000, p.i).

Following that, the "*initial formal training"* was cited by 96.5% of participants. Both the "*accident site safety*" and "*report writing training"* came next with 94.2% (81

out of 86 responses). Less favourable training was "*specialised technical training*, *news media and public relations training* and *data analysis training"*.

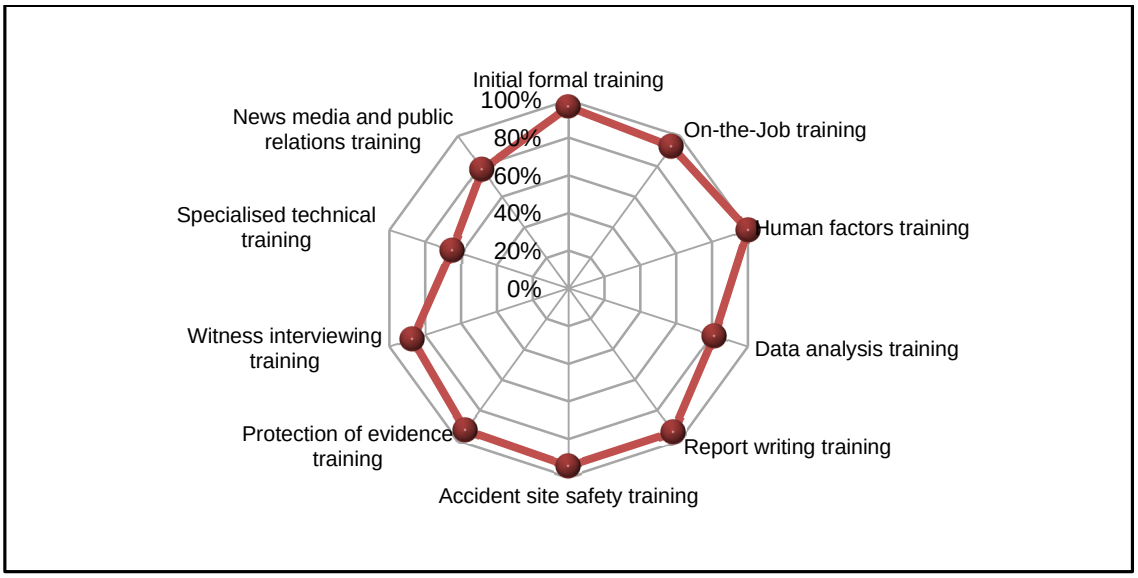

Figure 5-16 Radar Plot for the Important Types of Investigators Training

Then, participants asked *what is the best option for the authority to train its investigators? with a chance to chose more than one answer.* The recorded response was as follows:

- 76.7%, 66 out of 86 responses, answered to *cooperate with other States in its region*.
- 73.2%, 63 out of 86 responses, answered *to cooperate with internationally recognised training organisations.*
- 54.6%, 47 out of 86 responses, said that it was *to establish a local training centre to assist in the training of staff.*
- 26.7%, 23 out of 86 responses, selected *requesting ICAO assistance.*
- 8.1%, 7 out of 86 responses, thought more options in how to train State accident investigators should be added.

When participants were asked "*how investigators ensure their safety in the accident site"*, 81% of participants stated that "*they should receive regular training concerning their safety in the accident site"*. 19.3% said that "*no need for regular training as investigators will be familiar with how to be safe at the accident site based on their experience"*.

Participants were invited to state their opinion with many statements aimed at shaping the best processes and practice of knowledge in this area. The majority of participants agreed that "*the authority should develop a training plan for its investigators"* and such plan "*shall be updated regularly to reflect the investigators' training needs".* Also, "*the training plan should be implemented correctly"*.

In responding to if "*the training plan shall include appropriate tasks for the technical staff such as OJT"* and if "*the records of training shall be maintained and updated"*, the majority of the participants agreed with both statements. This result may indicate that the records for each trainee should reflect the amount of training received by the investigator, thus, assessing the need to attend any further training.

5.5.8 Reporting Systems and Database Dimension Findings

The participants were requested to state their opinions regarding some statements related to the need for the authority to have reporting systems in place as it begins to build its database. Results show a higher agreement among participants (66.3%) that "*the authority should implement a mandatory occurrence reporting system"*. Whereas 20.4% showed disagreement for this system to be in place, 13.3% kept a neutral position. The large agreement may suggest that securing a reporting system could easily facilitate the collection of information on actual or potential safety deficiencies.

In addition, there was a positive response for "*the authority to launch a voluntary reporting system"*. This result was linked to the need for this system to be non-punitive, and its information sources are protected as agreed by participants. Also, this may be attributed to its contribution to enhancing safety by involving others in reporting without fear of blame or liability.

There was high agreement amongst participants for "*the authority to establish an accident and incident database to ensure the effective analysis of safety information obtained from different sources"*. By exploring the benefits of the

analysis of the database information, findings show that all given options were at the same strength based on participants' selection, as shown in Figure (5-17).

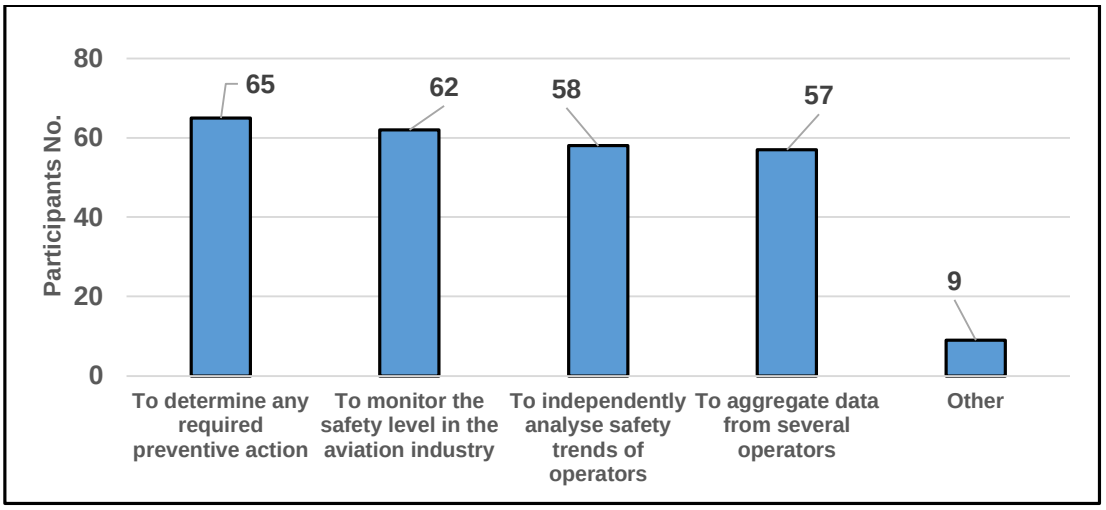

Figure 5-17 The benefits of the analysis of the database information

Nine participants added more options to highlight the benefits of analysing the database information as follows:

- To support the State Safety Programme.
- To identify critical shortcomings in international operations.
- To provide historical data to substantiate future investigations.

5.6 Discussion of Findings

The use of the survey promoted the chance to explore further the best process and practices as to how a less-developed country should establish its investigation authority, develop and maintain its capability. The data was derived from a satisfactory sample considering the target population, investigators in the field of air accident investigation. This phase was also conducted as part of "*Triangulation*" to validate the obtained results presented and discussed in chapter 4. Furthermore, the results found to be as largely aligned with those gained in the interviews with SMEs and further explored the necessary process. The questionnaire was based on specific measurements and their importance, as derived from SLR and the analysis of the interviews.

By examining the national / state legislation dimension, the importance of appropriate legislation and regulations to facilitate air accident investigation has been shown. Results also show their importance by strengthening the investigation's independence and ensure the credibility of the authority in the State. Generally, the answers to several questions suggested different activities related to the accident investigation have to be supported by the State / national rules. This, in turn, would ensure the conduct of a successful investigation and avoid conflict of interest with other State's parties.

While the majority of participants highlighted the need for the State to have its own national legislation, just above a quarter of participants, still considering Annex 13 is sufficient. Annex 13 provides common SARPs that are intended to be transposed by States into their national rules, as explained in the interviews section. Additionally, political influence could lead to some ICAO SARPs not being followed to the extent outlined in Annex 13. By ensuring the national legislation in place in relation to what is laid down in Annex 13, it is less likely that such influence will be in play. This also agrees with the SLR results where it was found that States incorporates international rules (SARPs) in their local regulations (see Dechy et al., 2012; Kahan, 1998; Stoop, 2004). One explanation might be participants who suggested Annex 13 is adequate are unconcerned or unaware of the effects of political influence on the investigative processes. Also, as mentioned in chapter one, both legislation and regulations in some Member States were found to be insufficient to assist with the correct and EI of ICAO SARPs (AIG Secretariat, 2008). Consequently, this drives to an important issue where ICAO Member States should highly consider accepting and complying with any issued SARPs by incorporating them in their local legislation. Otherwise, they have to report non-compliance status to ICAO.

After Annex 13 (as the international baseline standard) as a reliable reference, next came to align the legislation and regulations to that of a similar-sized State. One possible explanation may be attributed to the matter of resources to ensure any developments could also be resourced correctly or to the best of the State ability. It is suggested that the selection of EU Regulation 996/2010 to be third in

the order of preference may be explained as being primarily built on Annex 13 in the first instance.

Moreover, the questionnaire results of emphasising the establishment of the authority in the local legislation in addition to ensuring the independence from the regulator or other authorities may suggest that there is a high agreement among participants to consider this as a priority. The competitive effects with other investigative agencies and the natural bureaucracies of any State are more likely to be overcome if the authority is established adequately with national legislation. This may also support the results of higher agreement of participants for clarifying the purpose of accident investigation in the national legislation. Without this apparent authority, questions regarding jurisdictional overlap and coordination of investigation activities might be much more difficult to resolve. Furthermore, ensuring the principles of independence would highly require preventing the use of safety findings in judicial inquiries which need to be covered in the State national legislation. The agreement of participants for the ability of the State to seek support from other States along with ensuring the rights of the accredited representatives to participate in the investigation may be referred to the cooperation values between States. This was briefly explained in chapter 4 (Refer to section 4.6).

The questionnaire results gained from the organisation dimension assisted in further understanding of the effect of some factors on deciding the proper mode of the AIA. While the obtained results came in favour of a specific model, it seems complicated to attain a total agreement regarding what can contribute to deciding the proper model for a specific State. However, many other influences may have an impact on the decision to lean towards a particular mode as highlighted in the SLR such as political, social and government support (see Stoop and Kahan, 2005) which may work as a motivator in this case. On the contrary, a landlocked State with primarily aviation transportation might tend to implement a single mode based on its government's decision. However, in handling these factors and considering the participants' different modes, ***it may be important to acknowledge their bias in the obtained answers***.

The results show higher agreement among participants to assume the AIA as the most dependable organisation which may be explained to the principle of independence and matched with the SLR results (see Arnaldo Valdés and Comendador, 2011; Reuss, 2015; Smart, 2004). This was made clear in the 11th edition of Annex 13 by introducing a standard on the establishment of an independent authority (ICAO, 2016, pp.3–1). Whereas, any State missing this would have limited ability to exercise their independence, which may leave a room for conflict with other agencies in the State. Ideally, the authority which has legal support would benefit from extra financial resources to exercise its work.

Given the participants' response to the form of the organisation independence, the findings show high agreement that functional independence is required for the authority in the first instance. After that principle is established, compromises may be allowed in structural and financial areas, but these would be acceptable only if the capacity to undertake the work remains unaffected (see Figure 5-8). The more overlap there is in these areas; the more pressure to be applied to the investigation authority to accommodate the wishes of other agencies. What is important is that the AIA is seen as credible and convincing. Independence and professionalism are vital attributes to support the investigators' authority. However, "*independence*" does not mean that the authority would not be subject to administrative supervision by another higher body in the State to ensure transparency of its finances, administration, policies and working methods.

In deciding on the initiation of the safety investigation, while the results supported the authority to bear full responsibility and impartiality to do this, a percentage of participants hold an opinion that the decision should be shared with the responsible Ministry. In reality, the definition of accident drives the initiation of a safety investigation. In controlling the accident investigation site, nearly one-third (33%) of participants support the idea of sharing the control between the IIC and the judicial authority. In reality, it is suggested that there are advanced arrangements between the investigation and the judicial authorities that should cover these interactions. For instance, in the 11th edition of Annex 13 of July 2016, a new provision for cooperation with other parties in the State was introduced,

which may point to the benefits gained from such cooperation and ensure the termination of any possible conflict during the investigation process.

From the discovered insights of the Personnel dimension, the accredited representative system of ICAO Annex 13 emerged as the most powerful option to assist the AIA in conducting its investigation. From another perspective, the participation of investigators in accident and incidents investigation was found to be the most appropriate method to sustain the skills of investigators, as well as conducting regular training. This may propose that "**practise**" is vital for investigators in addition to training to maintain investigators' preparedness.

Results related to the selection of the support of RAIO to be the third and least desired option may be related to an awareness that aviation accidents are likely to involve States from a wide geographical range and NOT just the local region. The local RAIO may not be as helpful to an investigation as having a wide range of agreements with other individual States even they are not in the same region. In that vein, Annex 13 might be described as an international baseline understanding that includes all international States' actors and is, therefore, more likely to cover the relevant parties in any particular accident investigation. Therefore, when it comes to the MoUs, they have been relatively popular and provided a route to obtain assistance in investigations. In a less-developed country, the involvement or use of other States based on Annex 13 may not be as effective as when pointing out to an existing MoU with another country.

The questionnaire findings also support setting up minimum requirements and qualifications for investigators with a job description that updated regularly. This found to be aligned with the analysis of the interviews in chapter 4. The high agreement among participants for the authority to ensure measures are in place to avoid any conflict of interest when assigning investigators from outside the authority was compatible with ICAO recommendations on this matter that all investigators who are playing any role in accident investigation should be relieved of their other duties during the investigation phase.

The high agreement for the authority to have in place plans to deal with different occurrences (Refer to Figure 5-13) may assist the authority to apply the proper actions that should be followed in each event based on its resources. Investigating an accident within the territory of the State may require fewer resources than one that occurred far away (e.g., EgyptAir Flight 990 in the Atlantic Ocean), which may require greater resources. Having plans in place would ensure that any investigation could be resourced correctly or to the best of the authority's ability. In addition, this could assist the State in allocating the preliminary budget needed to carry out the required investigation.

Both the findings of the interviews and the survey highlight the importance of the authority to have in place its own policies and procedures. Such policies and procedures should incorporate the provisions of Annex 13 and the industry best practices, which may also include checklists for carrying out investigation activities. One of the USOAP findings highlighted that States which have policies and procedures in place were found to have fewer audit findings compared to States who are missing them or they found not completed or kept up to the required standard.

Perhaps the line to be drawn between a legal obligation and a matter of good practice may be explained by the requirement for flexibility. While the findings suggest the authority should not be obliged to provide real information about the investigation process to families' victims and survivors, in reality, many authorities show great support to keep a good relationship with them and maintain public confidence and people trust in the investigation process as highlighted by Stoop and Roed-Larsen (2009) and Smart (2004). Considering the importance of cooperation between States in the field of air accident investigation, the obtained results point towards keeping the updated contact information of other States' investigation authorities, which may be of help when required to assist in the process of investigation.

While only half of the participants did not agree for the authority to own readout facility when it has a low rate of accidents and incidents, one possible explanation is that such equipment is expensive. In addition, it is suggested that it is not

required to equip all accident investigation authorities, as cooperation is frequent on these matters between States taking into consideration the cost of keeping such equipment serviceable. In addition, while all results point towards the responsibility of the authority to afford the required facilities and equipment to facilitate the conduct of the investigation, it might finally depend on each State resources.

The findings also suggest that a formal training programme for the investigators has to be established. Due to the role of human factors in improving aviation safety, it might be considered essential to give training in human (including organisational) factors high priority. As a result, all the participants hold the view that human factors training is of paramount importance. This was in agreement with ICAO training guidelines, which emphasise the need for consideration of human factors issues in the investigation process (ICAO, 2003). In addition, results confirm that the investigation is a cooperative activity between States, which requires international assistance to achieve the expertise and required level of training. The responsibility of the authority should include a well-prepared plan, which covers the different and essential aspects for its investigators. The strong agreement to have a training plan and ensure it is regularly updated may be attributed to the need to maintain investigators readiness. In turn, this requires follow-up from the authority, where a mix of formal training, OJT and collaborative and regional training will ensure investigators are always kept in a learning loop.

The selection to cooperate with other States in its region and with internationally recognised training organisation may point to an international context. One explanation is that the realisation of the investigator's skills are very specific and might be in short supply locally. Perhaps the results are explained by that recognition of the international assistance, and that to achieve the expertise and the required level of training, the support is needed, from abroad by cooperation with other developed States and use of recognised training organisations. This may also explain the lower score for the establishment of a local training facility, as there would be precious few States that would have the required demand and resources to sustain such a facility.

Finally, the development of a reporting system that provides for mandatory reporting achieves a high degree of agreement and facilitates the collection of information on actual or potential safety deficiencies. However, it is up to each State to select the way of setting up its database and decide how to operate its reporting system, as long as it respects the independence of the AIA.

5.7 Deciding the Importance of Factors for Different Cases

As stated in Chapter 3, the research methodology incorporated many different activities including a literature review and conducting interviews with SMEs. These activities led to identifying many indicators and factors, which classified as important for the establishment of the authority in less-developed countries, thus develop and maintain its capability.

In general, 40 different factors were identified which related to many areas. They were presented in turn through the distributed survey. Then the collected data were analysed using the Relative Importance Index (RII) method.

The RII was used to rank the different factors by cross-compare their relative importance as perceived by the respondents. The analysis incorporated two different cases as follows:

- Study the effect and ranking of these factors among a selection of some dimensions.
- Study the effect and ranking of the factors among the different models (single mode, multimodal).

5.7.1 Relative Importance Index (RII) Method

The RII method is widely used to determine the relative importance of different factors, such as the various causes of delay (see Kometa, Olomolaiye and Harris, 1994; Sambasivan and Soon, 2007). This method was adopted based on the numerical scores provided by the inputs of the participants.

Although there is a chance of using a scale of 7 or 10, the selection of the 5-point Likert scale was justified as to its popularity in the literature (Revilla, Saris and Krosnick, 2014). Through the 5-point Likert scale in the distributed survey, scores were recorded to reflect the positive and negative attitude of participants' inputs. Then, scores were transformed to the RIIs to determine the relative ranking of the factors and their selected areas. The RIIs were calculated using the following formula:

$$\mathbf{RII} = \sum \frac{\boldsymbol{W}}{(\boldsymbol{A} * \boldsymbol{N})} \qquad \textbf{5-1}$$

Where W is the weighting given to each factor by the respondents, ranging in this case from 1 to 5, where 1 is the least important, and 5 is the most important. A is the highest weight, i.e., 5 in this case, and N is the total number of respondents, i.e., 86 in this study. The higher the value of RII, the more important the factor. Each input RII perceived by all respondents was used to assess the general and overall rankings, aiming to gain a whole picture of factors that positively contribute to developing each area.

5.7.2 The Examined Factors

The organisation dimension was excluded as it was examined through many different inputs in the designed questionnaire. Also, this area is almost transparent, as the established authority has to be separate from the regulator and other agencies in the State. Such separation could be achieved by an emphasis on the structural independence (which is another excluded dimension) of the organisation which ensures functional and financial independence. The third area that was also excluded is personnel. It could be beneficial if this area were to be covered in this attempt, but it was excluded because: first, it was well covered by different and deep enquiries in the distributed survey. Second, including those three areas may jeopardise the response rate of the survey by making it lengthier. Therefore, five Likert scale questions representing 40 factors were the base for using the calculation of RII. The factors are presented in Appendix D and were divided as follows:

- National Legislation (**NL**) 8 factors
- Policies and Procedures (**PP**) 15 factors
- Facilities and Equipment (**FE**) 8 factors
- Training and Assessment (**TA**) 5 factors
- Reporting Systems and Database (**RD**) 4 factors

5.7.2.1 Finding Discussion

RII was calculated and ranked using the collected data from participants. The results are shown in Appendix D, Table D-1. The mean RII was achieved by calculating the RII average for each area, and then the five areas were ranked based on their mean RII, as shown in Table 5-6.

Table 5-6 Ranking of Dimensions

Group of Factors	RII	Rank
National Legislation related factors	0.8442	1
Training and Assessment related factors	0.8376	2
Policies and Procedures related factors	0.8209	3
Facilities and Equipment related factors	0.7907	4
Reporting Systems and Database related factors	0.7886	5

The national legislation dimension and its related factors were the most important according to its RII average, with an aggregated RII of 0.8442. Training and assessment came as a second with an aggregated RII of 0.8376. The respondents attributed this to the top three factors of the availability of a training plan, the correct implementation of the investigators' training plan, and maintaining and updating of training records (See table 5-7). The study also sought to establish the extent of the policies and procedures area factors. The results undertaken found that this area emerged as the third with an aggregated RII of 0.8209. After that, the facilities and equipment area came as the fourth with an RII of 0.7907. The last and least important area was the reporting systems and database. This category demonstrated the least aggregated RII of 0.7886.

The most 25% important factors among these dimensions are shown in Table 5-7, and the least 25% important factors are shown in Table 5-8.

Table 5-7 Most Important Factors

No.	Most Important Factors	Dimension	RII	Rank
1.	Effective separation of the investigation process from any administration and/or judicial proceedings	NL	0.877	**1**
2.	Emphasise the independence of the AIA in the Legislation and Regulations	NL	0.8747	**2**
3.	The ability of AIA to seek expert assistance from other States	NL	0.8626	**3**
4.	The availability of a process to deal with accident and incident notification during and outside of work hours	PP	0.8554	**4**
5.	The availability of process to deal with notifying other involved states and ICAO as appropriate of an accident promptly	PP	0.8554	**4**
6.	A quick decision to recover Flight Recorders (FDR & CVR)	PP	0.8554	**4**
7.	Prevention of access to the investigation site by unauthorised people	NL	0.8506	**7**
8.	The availability of a training plan for the AIA investigators	TA	0.8482	**8**
9.	Emphasise the establishment of the AIA in the Legislation and Regulations	NL	0.848	**9**
10.	The availability of procedure to record responses to safety recommendations issued by the State	PP	0.8386	**10**
11.	The availability of means of communications and transport for the use of investigators at the site	FE	0.8386	**10**

Table 5-8 Least Important Factors

No.	Least Important Factors	Dimension	RII	Rank
1.	The availability of FDR & CVR readout facilities even with a low rate of accident and incident	FE	0.6434	**40**
2.	Launching of voluntary reporting system	RD	0.7325	**39**
3.	Implementation of mandatory reporting system	RD	0.7735	**37**
4.	The availability of a procedure to send the final report to ICAO, as appropriate	PP	0.7735	**37**
5.	Keeping of the accident investigation equipment in an updated list	FE	0.7831	**35**
6.	The availability of a procedure to complete the final report ASAP	PP	0.7831	**35**
7.	The availability of a policy to send a preliminary report to ICAO and other involved States	PP	0.788	**33**
8.	Emphasise the investigation process as per Annex 13 provisions in the Legislation and Regulations	NL	0.795	**32**
9.	Ensure a preventive action is made regarding any recommendation received from other States	PP	0.7976	**31**
10.	Ensuring all investigation field kit, including essential personal items, are packed ready to proceed to the accident site	FE	0.7976	**31**

5.7.3 States' Accident Investigation Models

To study if participants from different models would consider the same factors from a similar or different perspective, the same technic of RII is used. This attempt is to further study some factors, which may contribute to deciding the appropriate organisation model for a particular State, i.e., to be single mode or multimodal as explained in 5.5.2. The targeted factors were treated using SPSS software to select a single case every time (single mode or multimodal), where the response to these factors was studied. The RII was calculated and then ranked, and the results are shown in Appendix D, Tables D-2 and D-3.

5.7.3.1 Single Mode Findings

For the single mode, the national legislation was the most important area due to its average RII with an aggregated RII of 0.7890. The second in the sequence was the area of training and assessment, with an average RII of 0.7680. Policies and procedure factors also contributed to making this area come third with a RII value of 0.7611. The results show facilities and equipment emerged as the fourth most important area with an aggregated RII of 0.7370. The last area is the reporting systems and database. This category had the least aggregated RII of 0.7250.

5.7.3.2 Multimodal Findings

For the Multimodal, the training and assessment was the most important area with an aggregated RII of 0.928. The second in the sequence was the national legislation area with an average RII of 0.917. Policies and procedure factors came as a third with a RII value of 0.897. The reporting systems and database emerged as the fourth most important area with an aggregated RII of 0.858. The last area is the facilities and equipment with aggregated RII of 0.850.

As the factors were ranked among two groups, i.e., single mode and multimodal, it is worth to identify and test the strength of a relationship (degree of agreement) between the two groups (Sedgwick, 2014). One of the non-parametric tests is Spearman's rank-order correlation. It measures the strength and direction of the association between two ranked variables (Laerd Statistics, 2013). A correlation

is the size of an effect which can be expressed by a guide of which Evans (1996) suggests for the absolute value of r which classified as “strong” if the result was from 0.60-0.79.

A Spearman's rank-order correlation was run using SPSS to determine the relationship between 40 factors of two groups, as shown in Table 5-9. Findings show a strong, positive correlation between the two groups, which was statistically significant ($r_s(38) = .676$, $p < 0.01$).

Table 5-9 Correlations between Groups

			Single Mode	Multi-modal
Spearman's rho	Single Mode	Correlation Coefficient	1.000	.676
		Sig. (2-tailed)	.	.000
		N	40	40
	Multi-modal	Correlation Coefficient	.676	1.000
		Sig. (2-tailed)	.000	.
		N	40	40

The above result may point to a high degree of agreement between respondents regarding single mode and multimodal groups in the ranking of the importance of areas factors apart from the overall result where areas between two groups are ranked differently.

5.7.4 Summary

As it was presented, many factors found to have an impact on some of the dimensions which contribute to establishing the AIA. The RII of those factors was quantified and ranked along with their areas and according to the computed RIIs and their importance level. According to the previous findings and results, different inputs were captured to assist in the development of the proposed framework where Table 5-10 shows the most 25% important factors for both models (Single mode and Multimodal).

Table 5-10 Most Important Factors for Different States' Accident Investigation Models

No.	Single Mode		Multimodal	
1	Emphasis he independence of the AIA in the Legislation and Regulations	NL	Emphasis he independence of the AIA in the Legislation and Regulations	NL
2	Effective separation of the investigation process from any administration and/or judicial proceedings	NL	Effective separation of the investigation process from any administration and/or judicial proceedings	NL
3	Emphasis the establishment of the AIA in the Legislation and Regulations	NL	The availability of a policy to immediately inform aviation security in the State when an act of criminal interference is involved or suspected	PP
4	The ability of the AIA to seek expert assistance from other States	NL	A quick decision to recover Flight Recorders (FDR & CVR)	PP
5	The availability of a process to deal with accident and incident notification during and outside of work hours	PP	The availability of a training plan for the SAIA investigators	TA
6	A quick decision to recover Flight Recorders (FDR & CVR)	PP	Emphasis the establishment of the AIA in the Legislation and Regulations	NL
7	Prevention of access to the investigation site by unauthorised people	NL	Prevention of access to the investigation site by unauthorised people	NL
8	The availability of a process to deal with notifying other involved States and ICAO, as appropriate, of an accident promptly	PP	The ability of the AIA to seek expert assistance from other States	NL
9	The participation of accredited representatives in the investigation process	PP	The availability of a process to deal with accident and incident notification during and outside of work hours	PP
10	The voluntary reporting system is non-punitive, and its information sources are protected	RD	Providing the State conducting the investigation with any relevant information regarding the aircraft and flight crew involved in the occurrence ASAP	PP

5.8 Framework Dimensions Review

To further understand the perspective of participants concerning the dimensions, they were requested to prioritise their implementation by ranking them. Participants can value these dimensions equally highly, but it is different if they have been asked to rank them in a hierarchy compared to one another (Neuman, 2014). The mean rank was as represented in Table 5-11 while Figure 5-18 depicts a radar plot showing the participant's percentage and dimensions ranking.

Table 5-11 Ranking of Dimensions

Framework Dimensions	Rank	Mean Rank
National Legislation	1	2.41
Independence	2	2.75
Organisation	3	3.74
Policies and Procedures	4	4.27
Personnel	5	4.28
Training and Assessment	6	5.69
Facilities and Equipment	7	6.37
Reporting systems and database	8	6.48

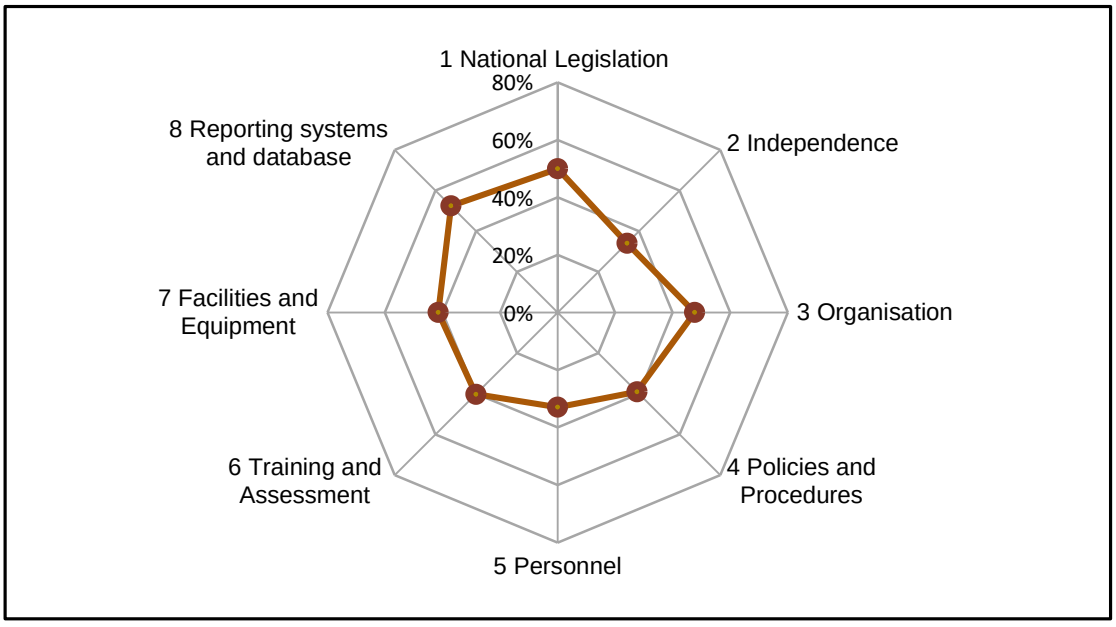

Figure 5-18 Radar Plot for Percentage and Ranking of Dimensions

To analyse this question by using Friedman's ANOVA, the data were ranked within participants across the given dimensions. The chi-square = 251.45 with $p < 0.001$, which means that there is an overall significant association between the mean ranks. To further explore these differences, a further test (Wilcoxon) which offers multiple comparison procedures was employed to compare all possible pairs between dimensions (28 total comparisons in this case).

The result of the Wilcoxon test shows a significant association between all the total cases of dimensions except five pairs, which show no significant association (see table 5-12). The five pairs were found to be related to dimensions which were in sequence in the obtained ranking. One possible explanation for the non-significance is the difficulty in managing one dimension independently from others due to an overlap between their contents.

Table 5-12 Dimensions Comparisons (non-significant, p > 0.001)

No.	Comparisons Areas		(2-tailed)
1.	National Legislation	Independence	**.057**
2.	Organisation	Policies and Procedures	**.008**
3.	Organisation	Personnel	**.032**
4.	Policies and Procedures	Personnel	**.832**
5.	Facilities and Equipment	Reporting systems and database	**.271**

5.9 The Eight Dimensions Framework (8DF)

As a result, to the demonstrated analysis, the framework, which represents a clear way for less-developed States to develop their air accident investigation authority, is presented in Figure 5-19. The suggested approach comprised of four phases, which are further explained in Table 5-13.

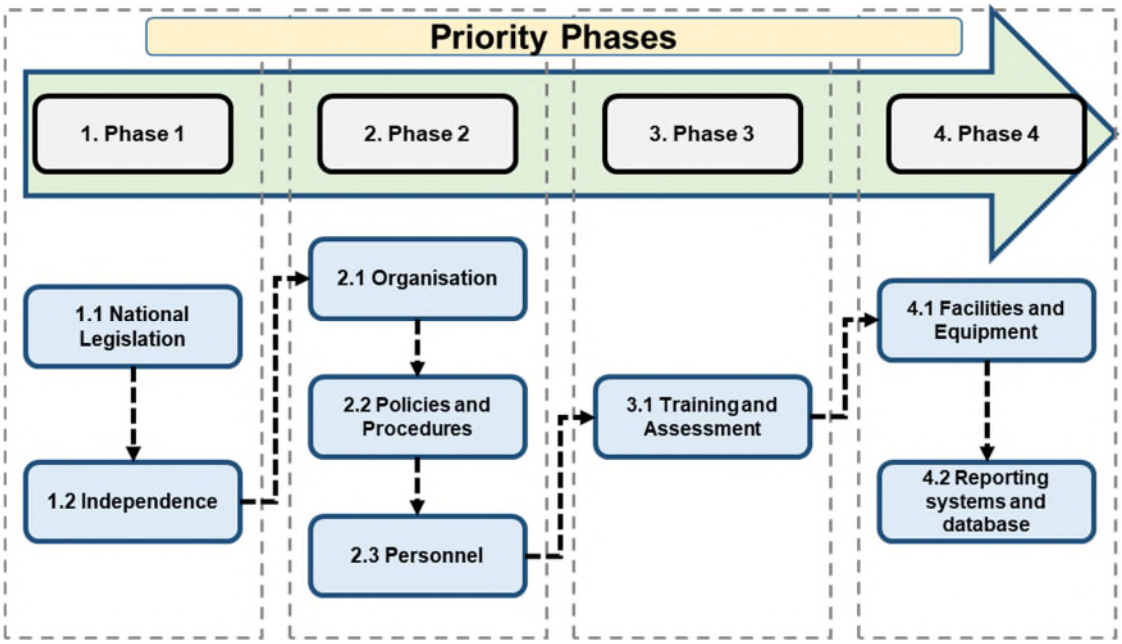

Figure 5-19 Eight Dimensions Framework (8DF)

To summarise, theoretically, the national legislation dimension was highly valued by participants. Then it moves on to ensure the independence of the authority and setting up the organisation including the selecting of the right model. Next, it is a question of working on establishing the policies and procedures of the organisation which has to be chosen in one of the known models and ensuring the training programme is ready for the investigators who should undergo a selection process. Ensuring the availability of the appropriate facilities and equipment follows and, finally, establishing reporting systems and a database. Practically, a State may choose which order it deals with these dimensions. However, there are some rules and good practices to be gained from the experience of some developed States. Therefore, cooperation and requesting the assistance of these States would assist in achieving the best results.

Table 5-13 Eight Dimensions Framework (8DF) Phases Explained

Phases	Dimension	Steps	Identified Knowledge
Phase 1	1.1 National Legislation	o Establish national legislation and regulations according to what is laid down in Annex 13 SARPs o The most reliable references to assist in developing the national legislation and regulations are: • ICAO Annex 13 • Legislation and regulations of similarly sized State • Regulations EU996/2010	o Ensure the following are covered in the national legislation and regulations: • Emphasise the establishment of the AIA • The purpose of the accident investigation is described in accordance with Annex 13 SARPs which is to prevent accidents and incidents and not to apportion blame or liability. • Emphasise the Independence of the AIA from the regulator and other authorities (See 1.2) • Prevent the use of investigation safety findings in judicial inquiries • The investigation process is in compliance with Annex 13 provisions including: o Being separate from any administration and/or judicial proceedings o The rights of the accredited representatives to participate in the investigation process • The ability to seek expert assistance from other States
	1.2 Independence	The AIA has to be separate and independent from the regulator and other authorities in the State	o It should also have the following in place: • Functional Independence (requires no permission to launch an investigation) • Financial Independence (as the State resources allow). • Structural Independence (as the State local circumstances allow). • The protection of investigators from testifying in the court by judicial authorities • The control over the investigation site including the available evidence such as ATC and aircraft recordings

			• Prevent the use of recordings (e.g. ATC & CVR) for a purpose other than air safety investigation
Phase 2	2.1 Organisation	o The AIA can withstand any pressure or interference from other organisations in the State and existing in one of the following models: • Single Mode specific to air accident investigation. Factors in favour of this selection are: o Organisational efficiency, o Traffic size o Having local service. • Multimodal responsible for transport accident investigation. Factors in favour of this selection are: o Financial resources, o State land size and o Having local service.	o The AIA should have the following: • Has access to extra financial resources when needed • Has the ability to conduct air accident investigations itself. However, it can allow the following: o Participation of the accredited representative system of ICAO Annex 13 o Sign an MoU with other States o Participate in an RAIO to get support from more developed States
	2.2 Policies and Procedures	o Develop a set of policies and procedures to organise the investigation activities o The AIA should have in place plan to deal with different occurrences	The AIA should have a procedure manual in place where the following have to be covered: • Relevant information on the progress of the investigation is provided to the families and accident survivors • Updated correct contact details for other investigation authorities

			• A process to deal with accident and incident notification during and outside of work hours • Notifying other involved States and ICAO as appropriate of an accident promptly • Providing the State conducting the investigation with any relevant information regarding the aircraft and flight crew involved in the occurrence • Providing the State conducting the investigation with any relevant information concerning dangerous goods • A policy to send a preliminary report to ICAO and other involved States • A policy to immediately inform aviation security in the State when an act of criminal interference is involved or is suspected • Flight Recorders (FDR & CVR) are timely recovered • Prevent publication of a draft report or any document obtained during the investigation process • Finish the final report process ASAP • Amend the final draft report as required • Send the final report to all involved States • Send the final report to ICAO as appropriate • The issue of safety recommendations at any investigation stage • Record responses to safety recommendations issued by the State • Preventive action is made regarding any recommendation received from other States
	2.3 Personnel	o Highly knowledgeable and experienced personnel are working for the AIA o The investigation is led by staff who are fully working for the AIA	• Staff preparedness is maintained by the following: o Participating in accidents and incidents investigation o Conducting regular training which includes OJT o Observing other States investigations

			• A job description is in place for the staff which is normally updated regularly • Minimum requirements and qualifications for the investigators are in place • Part-time investigators, when assigned, are relieved from their original duties during the investigation process • Necessary measures to avoid possible conflict of interest among part-time staff to be implemented

Phase 3	3.1
	Training and Assessment
		o Establish a formal training system for investigators where the required level of training is provided for each investigator
		o The required training can be achieved by:
		  • Cooperate with other States in the region
		  • Cooperate with an internationally recognised training organisation
		  • Establish a local training centre
		Requesting ICAO assistance
			The AIA has an existing training plan to ensure the following:
			• Cover of different training needs for its investigators
			• The training plan is implemented correctly
			• Include appropriate tasks for the technical staff such as OJT
			• Training records should be maintained and updated
			  • The training should cover different levels of programmes and be provided to the staff through different channels

Phase 4	4.1 Facilities and Equipment	o The AIA has in place proper facilities and equipment which assist in the smooth running of investigations	The proposed facilities and equipment should cover the following: • Updating list of all equipment in place and all investigators are aware of it • Special equipment for investigators to deal with hazards at the investigation site is available • The availability of means of communications and transportation for the use of investigators at the site • The readiness of the investigation field kit and essential personal items • The availability of a storage facility

	4.2 Reporting systems and database	o The AIA has in place reporting systems and database	The AIA shall ensure the following: • Accident and incident reporting system to enable receiving occurrences notifications • The reporting system shall be non-punitive, and its information sources are protected • Establish an accident and incident database

6 FRAMEWORK RATIONALE AND VALIDATION

The questionnaire contained eight open-ended questions to elicit further understanding from the participants' experience as "*open-ended questions are recognized to increase the richness of the data collected"* (Powell, 2003, p.376).

The collected data was analysed using NVivo11, and it clarified further rational information about the framework dimensions. Also, the validation of the proposed framework is introduced using a case study and constructive evaluation of two Accident Investigation Authorities.

6.1 Analysis Process Explained

All participants' answers were analysed and grouped into categories where appropriate. Participants inputs were exported from "*Qualtrics*" without alteration (Bartunek and Seo, 2002) and then organised in a separate word file for each question before importing them into NVivo. Specific themes discovered within each question using thematic analysis. Rubin and Rubin (2005) referred to coding as a process to assist in identifying different data units such as theme, event, or topical marker appearances. Bazeley (2007, p.66) stated that;

> "*coding in qualitative research, in its simplest sense, is a way of classifying and then 'tagging' text with codes, or of indexing it, in order to facilitate later retrieval*"

However, the aim of this analysis was not to identify differences in inputs among individuals or groups, as is the case in quantitive data analysis in Chapter 5. The goal instead was as "…*quantification can sometimes help us sort fact from fancy and, thereby, improve the validity of qualitative research*" (Silverman, 2007, p.113). Therefore, the focus was on broad topics by collating respondents inputs and ideas. This process provides a rough estimate of each theme's importance in revealing general patterns in the data analysis.

With regard to the analysis of coded data, the target would be "…*building toward narratives and description*" (Rubin and Rubin, 2005, p.224) by sorting and summarising respondents feedback then combining the data so that

"….*overlapping parts of a narrative or complementary understandings of a concept is straightforward"* (Rubin and Rubin, 2005, p.228). As the emerged information from the analysis is qualitative, the analysed results will appear in descriptive, narrative form rather than as a scientific report (Creswell, 2013, p.260). The analysis of respondents' data was performed by initially, identifying any recurrent words and themes or topics that participants indicate during the interview process. (Crawford, 2017; Creswell, 2013). Then, the most commonly used words were determined when referring to a topic of interest. Then, start looking for exact words or broadening the search to find frequently occurring concepts by using the finding matches. In addition, quotations from participants were used to clarify the presented analysis when possible. All "*personal quotations*" are not linked to any of the survey participants (Richards and Morse, 2007). However, no obvious bias was noticed between single-mode and multimodal investigators in their responses which may be related to the neutral phrasing of questions.

6.2 The Importance of Existing Legislation and Regulations in the State

Participants who answered Q4 as "*Yes, it should have them in addition to what is laid out in Annex 13*", 63 investigators (73.3%) out of 86, were directed to answer Q5. ***Why is it important for the state to have its own accident investigation legislation and regulations?*** to further explore such importance. Granting legal power to the standards and recommended practices found in Annex 13 was one of the emerged themes. This may explain the high percentage of participants (Refer to 5.5.1) who agreed that the State should develop its local legislation and regulations based on Annex 13 rules. For instance, one of the respondents stated that;

> *"The legislation basis for the Act and regulations must come from the State's lawmakers, amending the provision of Annex 13 as necessary to make the Annex 13 principles work."*

Annex 13 has no power to establish the required legislation within a State; it simply contains SARPs which are not directly applicable at the national level and need appropriate measures to be implemented into the existing domestic legislation. This may indicate that ICAO Member States have not felt obliged to implement individual elements of Annex 13's SARPs once they found it impracticable to do so. Therefore, national legislation is required to ensure the necessary legal power to collect and protect data for the conducted safety investigations and provide the legal foundation for establishing the authority and demonstrating its primacy in evidence collection, establishing findings, making recommendations, etc. One of the participants stated that:

> *"Annex 13 does not have legal status. If a State strives to meet its commitment to investigate accidents and incidents, promulgation of local legislation is necessary for investigators to perform their investigative work".*

This may highlight the power of this document as being a reliable reference for States, although ICAO does not have the legal authority to enforce SARPs, as it demonstrates the willingness of States to comply with them.

The second theme to emerge related to **independence** – separation of the NIA's activity from that of judicial or regulatory authorities. Whilst legislation and regulation based on Annex 13 aims to provide a legal framework to facilitate independence, the concept is rather broader, covering the functional independence and separation from all other elements of the aviation system:

> *"Provide independence to the investigation agency"*
>
> *"Independence and fairness to those involved (non-biased)"*

The third theme regards **the relationship with other authorities** in the State. The unpredictable nature of air accidents means that investigation is rarely a straightforward process, especially in the absence of agreements to manage the relationship between different authorities in the same State. Every party should, therefore, be aware of their responsibilities and ensure they do not inhibit or undermine the investigation or act in such a way that may taint or destroy valuable

evidence. Failure to do may negatively affect the investigation's credibility or effectiveness.

> *"State legislation reflects cultural and legal differences. For example the process of Investigation and the relation between the investigation authority and the different interested party"*

The last theme was to **protect the organisation and investigators**. Local legislation is needed to ensure that evidence is protected and investigators have sufficient authority to gain access to the accident site without obstruction from other States' agencies. Each State operates under a slightly or significantly different legislature. Therefore, a legislation system is needed to ensure smooth conduct of the accident investigation.

6.3 Why does the authority need to be separate from the regulator and other authorities?

Fifty-nine participants, who answered Q9, with "Yes, *the structure should be separate**"*** (Refer to section 5.5.3), were directed to answer another conditioned question, to explore further ***why does the authority need to be separate from the regulator and other authorities in the State?***

While 11 respondents (19%) did not provide feedback for this question for unknown reasons, the majority of those who responded (25 respondents, 43%) linked such separation to the need for the investigation authority to be independent to avoid conflict of interest which may affect the credibility of its work.

> *"The role of the state accident investigation authority is to carry out investigation while the regulator is responsible for compliance monitoring"*
>
> *"The function is different. One is to regulate the other is to investigate"*
>
> *"To maintain independence and to be able to conduct a thorough investigation without conflict of interest"*
>
> *"The full independence is crucial. No one questions our safety recommendations and conclusions"*

The core work of the conducted investigation depends primarily on the independence of its activities, which make possible the cooperation of people who are involved in the accident to provide essential information. In addition, as highlighted in the interviews, other authorities such as the regulator may be found to be one of the causes or contributing factors that led to an accident or serious incident due to deficiencies in its safety oversight performance.

> *"Independence is required to ensure all available evidence is provided"*
>
> *"The regulator might be part of the cause"*
>
> *"To analyze and make recommendations to advance transportation safety, the regulator is often included in the investigation process"*

Besides, the separation of the authority by ensuring its independence assists in avoiding political and commercial pressure.

> *"Independence, avoid political pressure, avoid commercial pressure"*

As was demonstrated in the analysis of the interviews, there was agreement among participants that ensuring the separation of the structure assists in keeping findings pure and unbiased.

> *The findings of an accident are very important to the continuous improvement of aviation safety.*

6.4 Difficulties of Maintaining the Preparedness of Investigators

Following on from Q22, 58 respondents, who answered "Yes" were directed to answer question Q23, "***Why is it difficult to maintain the preparedness (skills and currency) of the Investigators?"*** The most cited reasons were lack of practice on the accident site and lack of training and exercises.

For the lack of practice on the site, many experts (30, 44%) explained that if the investigators' skills are not used regularly, they will gradually decline. Investigators need to practice their knowledge and skills continuously by being involved in investigation activities.

> "*Too few investigations will erode previous accident experience*"

"*Field practice and simulations are essential. Prolonged sitting behind a desk can erode the perishable skills of an accident investigator"*

The more investigations investigators attend, the more opportunities they have to sharpen their skills and become more competent.

"*The experience of an investigator grows with the number and variety of investigations"*

Methods, if not practised regularly, will be more challenging to apply and therefore, the investigator will be less efficient in the running of the investigation.

For the lack of training and exercises, which was highlighted by 18 participants, in the case of absence of actual accident investigation experience, investigators need to attend regular training to maintain their currency and skills. However, such training may lack some features of real accidents such as witnesses as reported by some participants:

"The value of simulated training events, over the longer period, do not match the intensity and difficulty of a real investigation with real aircraft and more pointedly real witnesses"

In addition to the reasons mentioned earlier, ten of the participants (15%) highlighted the lack of experience of investigators as a third important reason, which affects their preparedness. The expertise of investigators is generally linked to their practice at the accident site, which in turn is a feature of aviation activity and accident rate.

"*Training classes and investigation manuals can't provide so much--it's ultimately the actual job and experience of investigating that provide the best skill"*.

"..the proficiency makes up with experience in real scenarios"

Usually, no two investigations share the same circumstances, so the investigator needs to build a bank of experience by attending different accident investigation events to be competent.

6.5 The Importance of a Job Description for the Investigators

Another conditional question was introduced to the participants to inquire about "***Why is it important to have a job description for the investigators in place?"*** Some feedback indicated that investigators need to know their rights and duties to work within their scope and can provide clarity of the assigned duties and responsibilities, which helps to avoid any possible conflicts.

> *"…outlines responsibilities and expectations"*
>
> *"To develop the responsibilities, duties and work assignment to each individual to prevent double work and confusion"*
>
> *"It outlines the employees duties within and out of the organization and details which employee is responsible for which tasks.*

Investigators' performance can be assessed by referring to their job description, which can establish the boundaries of the investigator's activity

> *"Once you have job descriptions defined you can then organize training and determine competencies because you have set a baseline through the job description"*

Moreover, it could be vital in deciding the training needs of investigators.

> *"So that an investigator may know the scope of his job related to his experience. Also, this allows to pinpoint which type of training he needs most to follow"*
>
> *"Job descriptions will help develop employment and training requirements"*

For an investigator position, this will ensure that the best candidate is hired and that the investigator receives the appropriate training and right equipment to perform the job effectively.

> *"To set down the minimum requirements for hiring safety investigators"*

6.6 The Meaning of “Suitably Qualified Investigator”

The collected data shows that the participants' opinion to answer this question can be linked to two issues. First, the investigator characteristics and personality, and second, the requirements that the investigator has to meet before and after embarking the investigation. For the former, the ability to organise and manage certain activities, and being a good listener or communicator arguably some of the most important traits.

Looking at the investigation process, accident investigators should be logical to fulfil the objective of the safety investigation, remain independent and see the big picture of the system failures.

For the latter, most of the participants agreed that the qualified investigator must have a background experience in the industry, as well as a strong knowledge of investigation theory and techniques. The qualified investigator should have been formally trained by an accredited organisation and become familiar with the investigation process.

> *“has experience and qualifications appropriate to the specific area of investigation involved”*
>
> *"An investigator meeting the minimum requirements and qualifications and who has experience in the field he/she has to investigate, e.g. engineering or operational field”*
>
> *“A background in the industry, a strong knowledge of investigation theory and technique, and access to specialists as required”*
>
> *“Operating experience and specific education”*
>
> *“Adequate training and experience”*

Additionally, the investigator must meet the job description requirements and achieve technical or operational competency levels. Table 6-1 covers most of the collected inputs for what participants thought for a suitably qualified investigator.

Table 6-1 What does the term "suitably qualified investigator" mean to you?

Relevant aviation background	Trained	Good communicator
Ability to not pre-judge	Qualified	Knowledgeable
Be driven by the evidence	Competent	Logical
Open to criticism	Experienced	Educated
Has the technical skills	Confident	Analyser

6.7 Why is it required for the authority to provide information to the families and accident survivors?

This question aimed to further explore the responsibility boundaries of the investigation authority in providing relevant information on the progress of the investigation to the families and accident survivors (refer to Q37). Then it tried to explore further the opinions of the participants who chose two answers:

- Yes, it should be obliged by law to do so (18, 20.9% out of 86 responses)
- No, it is not obliged, but, in practice, it should provide such information (42, 48.8% out of 86 responses)

Project maps in NVivo were used to both visually explore and/or present the results, as can be seen in Figure 6-1.

While 21 participants (35% out of 60 participants) did not answer the question or said they do not know, most of the emerged themes were nearly at the same strength. One is that, showing strong support to keep families abreast of the progress of the investigation, but not necessarily every little finding. Additionally, supporting families' victims is a decent/human thing to do. From one side, it could be seen as a moral duty to keep them informed about the progress of the investigation. It is a human right for families to know the causes of death of their loved ones and an approach for a government to share emotional care with people who are suffering and want to understand what happened and what is being done to prevent future accidents.

> *"The accident will have changed their lives significantly and they are often desperate for information about what happened"*

On the other hand, victims' next of kin, may have valuable information that investigators need in the process of their investigation.

> *"Families and survivors can be powerful advocates to effect safety action. Conversely, they can also exercise significant negative influence if they are not kept informed about the investigation"*

Another opinion as presented by one participant:

> *"The pace of the investigation is slower than the families want and therefore there is a pressure created on the investigative agency"*

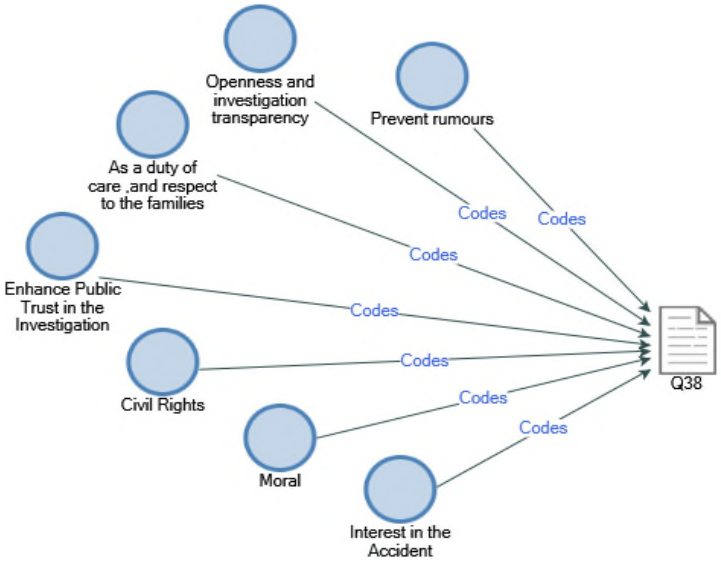

Figure 6-1 The Layout of the Main Themes for Q38

Some participants indicated that the efficacy of the entire system would be damaged if the public did not trust it. Therefore, being open and transparent about factual information is crucial to the long-term success of the system. If regularly informed throughout the investigation, families will probably have more confidence in the investigation results rather than if the investigation process has been opaque to them. One participant stated that:

> *"They should also be made aware that the investigation takes time, it is better to keep them informed than to have them questioning and going to the media to understand what is happening"*

Another participant highlighted this issue as:

"The families of victims are strongly supported by the politicians, hence, the politicians (the government) would like to see the acc inv agency providing any information they can to the families"

As a conclusion, it is suggested that adopting an approach to keep close contact with families and survivors will benefit the investigation and its outcomes.

6.8 How does the accident investigation authority ensure the required level of training for each investigator?

While the industry represented in ICAO has a published training guideline, Circular 298, the approach behind this question was to understand further how the authority can ensure the level of training for each investigator. Figure 6-2 shows the most obtained themes. From participants' responses to this question, the authority should conduct a Training Needs Analysis and plan investigators' training based on an assessment of the investigators' job description. The environment and the daily tasks related to the investigator should contribute to deciding the required training. Some respondents recommended preparing a training profile for each investigator position, measuring each investigator training against his position' profile; developing and implementing an individual formal and OJT plan. The proposed training target should be developed based on existing standards and expectations.

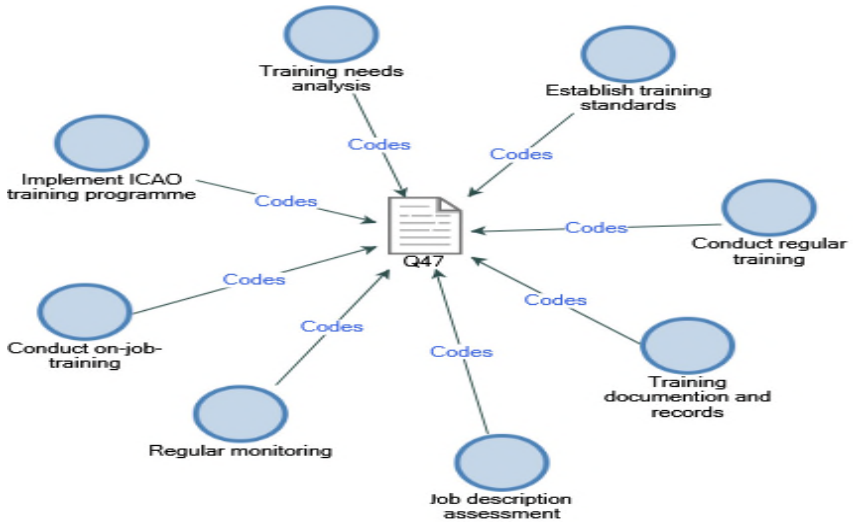

Figure 6-2 The Layout of the Main Themes for Q47

The authority should establish a list of minimum training requirements for its investigators by following ICAO training guidelines, especially for newly-appointed investigators. Training should be conducted regularly and documented to facilitate the follow-up of each investigator's needs and ensure timely completion of training. In addition to formal training, investigators should be allowed to attend forums and seminars to be aware of developments in the field and other States.

6.9 Framework Validation

Both chapters 5 and 6 described the analysis of the data collected from the survey, which led to the development of the 8DF framework. The purpose of this section is to describe the methods used to validate the proposed framework, which was undertaken by a two-step process as follows:

- Case Study related to a recent real experience of one ICAO Member State in establishing its Accident Investigation Authority.
- Constructive Evaluation against the real-world experience of Accident Investigation Authorities of two States.

Employing these two methods aims to validate the quality and strength of the refined 8DF framework and ensure that the proposed phases (as shown in Figure 5-19) are logical.

6.9.1 Case Study

To provide context for the reader, a case study of recent experience (2009) of a less-developed country in establishing its national investigation authority and developing its capability in the field of air accident investigation is presented. The aim is to check how closely the approach taken by the State aligns with what has been found in this research. The case study represents an attempt to meet one of ICAO's expectations by separating the AIA from the regulator (Refer to section 1.2).

6.9.1.1 The Beginning and the First Tasks

Prior to launching the Accident Investigation Branch (AIB) in the Kingdom of Saudi Arabia, the situation was similar to many less-developed States where the responsibilities of investigating aviation occurrences were assigned to the State's aviation regulator, the General Authority of Civil Aviation (GACA). According to Koshy (2015), the first Director-General of Saudi AIB, the principal reason for establishing an independent agency was to comply with ICAO SARPs. The start-up period was very challenging as many projects elements were running concurrently. The first step in launching the new body was to ensure it was covered and protected by local legislation and regulations which required GACA to introduce internal amendments using resolutions. The powers and responsibilities of the new AIB had to be identified to all local stakeholders. This was followed by an essential step to select the right personnel to manage the organisation' different tasks.

The selected team was then responsible for laying down the foundation of the agency, including developing the required policies, procedures, and processes. As highlighted by Koshy (2015), the focus of the team should be inside to "*tend the house*" and outside to define the agency obligations by determining a long-term strategy and outlining the organisation's scope.

The initial focus was to form the required structure of the organisation and have the job description and assigned authority for each position in place. It was important to define and procure the required resources for the agency to be able to embark on its role. These included staff recruitment and facilities and equipment such as offices, lab facilities, transport etc.

6.9.1.2 Ensuring the Independence of the AIB

The aim behind establishing the Saudi AIB was to form an independent agency from the regulator, as stated by Koshy (2015). Three different features of independence were considered: functional, administrative and financial independence. While it was possible to attain functional independence from the beginning, the Saudi AIB has relied on administrative and financial support from

GACA while it builds its own financial and administrative capabilities towards the target date of 2018.

6.9.1.3 AIB National and International Cooperation

The strategy adopted by the AIB was to try and benefit from the experience of other respected accident investigation authorities around the world. Koshy (2015) noted that it was essential to "*…take time to visit others who have been in this business for a while*". Over three years (2013-2015), the AIB kept a busy agenda, which included a series of visits to investigative authorities in many countries. These visits were the milestones for the AIB to understand what to prioritise and afford further insights, which support in "*building a good rapport quite fast*" (Koshy, 2015).

In its region, the Saudi AIB began coordination with other States, which had an excellent experience in the field. The cooperation included training activities in the field of accident investigation and dealing with safety professionals and investigators to gain further understanding and experience in the field.

At the State level, the AIB continued to work effectively and closely with the regulator and other service providers to avoid isolation and to increase the awareness level of who the AIB was. Additionally, Memorandums of Understanding (MoU) were signed with other agencies to assist in facilitating the investigation process. The conclusion highlighted by Koshy (2015) was,

> "*Don't isolate yourself. To be effective, you need to go out and work with others locally, regionally and internationally*".

Some more tasks are in progress to build the required experience and capabilities to create a recorders' laboratory.

6.9.1.4 Considerations and Results from the Case Study

The case study raised several critical points. The decision of the Saudi AIB to visit several different AIA's worldwide to benefit from their experience may acknowledge different ways of establishing an AIA between States. In other words, there is no *single* way to set up a national investigation body and, as

demonstrated in the SLR, the experience of States is varied considering the different models they apply, which is supported by Koshy's (2015) view in advocating visiting other States to benefit from their expertise in this field.

While most of the identified 8DF dimensions were highlighted in the process of launching the Saudi AIB (refer to Table 6-2), in Koshy (2015), there was no clear information related to the investigator's selection process and their training or the assessment criteria to ensure their currency.

An important issue was the time required to get the new body to the point where it was working effectively. Resources did not seem to be a matter of concern as launching the Saudi AIB benefited from strong political and financial support from the State. However, the expectation for the AIB to be totally independent of the regulator was set as a longer-term objective. In addition, the case study highlighted the importance of national and international cooperation to assist the AIB in performing its function. The most common cooperation is likely to be with the State/s of design and manufacture, or local parties in the State by signing MoUs, as also highlighted in the survey results (see section 5.5.4).

Another insight regards independence level. Total independence may result in isolation, which would negatively affect the AIA's main targets and aims. Duties and requirements of other parties have to be considered and justified. This is supported in the survey results through support for the accredited representative system of Annex 13 as the first option to support the lead accident investigation authority and for technical advisors to work through them.

Table 6-2 Direct Observations from the Process of Launching the Saudi AIB – Source - (Koshy, 2015)

Dimension	Observation
National State Legislation	*"The Regulator (GACA) amending articles of the Civil Aviation Act transferring the authorities from the Regulator, and GACA making internal amendments by resolutions."* *"A very important first step was the establishment of the AIB Regulation."* *"The AIB Regulation was required to define the authorities officially for operators, service providers, pilots, air traffic controllers, airports and other regulators to understand who the AIB was and to understand the authorities of the AIB."* *"…determine required regulatory changes."*
Independence	*"A decision was made in 2009 to transfer the authority for aviation occurrence investigation to an agency independent from the regulator."* *"…applying for a budget, getting financial authorities for the office and staff."* *"The strategy looked at three areas in detail: functional independence, administrative independence and financial independence."* *"100% functional independence was required from day one."* *"The AIB strategy calls for developing its own financial and administrative capabilities in 2018."*
Organisation	*"…define an organizational structure."* *"Many tasks were required including getting an approved organizational structure."* *"…deciding several changes to what its organizational structure should look like."*
Personnel	*"Getting the right people on board in any start-up including a government agency is very important."* *"…getting job descriptions."* *"…created a core team that could conduct occurrence investigation in a professional manner."*
Policies and Procedures	*"The team being put together would be responsible for building a system, policies, procedures and processes."* *"Establishing Memorandums of Understanding (MOUs) with other agencies that an investigative authority requires to coordinate within an accident investigation is an important task."* *"The importance of MOUs cannot be underestimated."*
Facilities and Equipment	*"…getting a budget for the desired lab facilities."* *"…getting vehicles, equipment and most importantly a temporary facility as well as an approval for a permanent facility."* *"…concentrate efforts in building the desired investigative and lab capabilities."* *"…gave us additional insight into some capabilities that we felt should be established in our Ops room design as well as in our recorder labs."* *"…for bringing material analysis capabilities and competency including technology and skills transfer."* *"…We also realized that the experience and capabilities to locate recorders was not adequate and would have to be built."*
Training and Assessment	*"…improved regional coordination in training by offering seats to states."*
Reporting Systems and Database	*"GACA had previously developed a software database for occurrence tracking which the AIB now utilizes for its own occurrence tracking."*

6.9.2 Constructive Evaluation of AIA's

Step two of the validation phase involved validating the eight dimensions framework (8DF) (see table 5.13) against the real-world experience of two AIA's – the Nigerian AIB and UK AAIB. The evaluation process can be summarised as follows:

- Obtain consent to participate in the validation process from both AIAs (by email for the NAIB and face to face for the UK AAIB).
- Introduce the research study and framework criteria to allow experts (representing the AIA) to comment on its phases and elements by answering the guiding questions.
- Request overall opinion about the proposed 8DF.

The following guiding questions were used to assist experts from both authorities in assessing the 8DF:

- How appropriate is the proposed framework in supporting less-developed States in developing their AIA capability?
- What else could be added to each framework phase?
- What other aspects could be missing in the framework phase's elements?
- Do you have any comments on the implementation of the framework dimensions?
- Do you have any additional experience or advice for AIA's establishing themselves or developing their capability?

6.9.2.1 The Rationale for Selecting AIA's

The Nigerian AIB (NAIB) was selected because it had:

- Recently succeeded in building its AIA capability to a higher standard (Since 2006, based on the Civil Aviation Act 2006).
- A good reputation in the field of the study.
- Scored highly in compliance during ICAO UOSAP (*83% in 2016 Audit*) (ICAO, 2018).

In addition, the NAIB adopted a vivid vision "*to be one of the foremost accident investigation bodies in the world striving towards improved aviation safety*."

Second, the UK AAIB was selected because it had:

- A good reputation in the field of the study.
- Proven record of accomplishment investigating major accidents and serious incidents.
- Scored highly for compliance during ICAO UOSAP (*82.95% in 2018 Audit*) (ICAO, 2018).
- Previous experience in assisting other States in developing their AIA capability.
- Acted as an accredited representative on many occasions, especially as State of Design and Manufacture.

6.9.2.2 The 8DF Framework Evaluation

The representatives of both AIAs widely agreed with the appropriateness of the framework. A number of relatively minor recommendations were made and are presented in Table 6-3 along with comments from the researcher. Generally, both the NAIB and the UK AAIB provided constructive feedback, and none of their recommendations negatively affected the framework integrity – the majority were aimed at providing clarification, including the suggestion to slightly adjust the name of the eighth dimension.

In summary, the validation indicated that the 8DF is appropriate to support less-developing States in developing their capability. Also, the 8DF was considered as in line with ICAO Annex 13 SARPs, which makes it as suitable to the industry side to be followed by many Sates.

- For the question ***what else could be added to each framework phase, and the other aspects could be missing in the framework phase's elements***, the NAIB assumed it as good enough, and none could be added to the elements. However, the UK AAIB concluded it as "*equally appropriate*" for any size of State either developed or less-developed. The emphasise in the case of less-developed States is the need to sign MoUs to seek assistance in case of short of investigators or the use of recorders facilities of other States, which was covered already in the 8DF.

Table 6-3 Evaluation of the 8DF Stages and Elements

1. Stage	2. AIA	3. AIA's Assessment and/or Comments	4. Researcher's Response
1.1 National Legislation	Nigerian AIB	The identified key elements are good except the following: • For preventing the use of investigation safety findings in judicial inquiries, national laws have supremacy over any regulations, ICAO SARS and Annexes. Evidence gathered during the investigation including the non-disclosure items may be requested by law court(s).	• This point granted higher agreement in the survey findings, greater than 73%. The difference in States internal circumstances may have led the NAIB to be conservative regarding this point. The researcher decided to acknowledge but not incorporate this point, especially it was not highlighted in the UK AAIB assessment.
	UK AAIB	The steps and elements are fine except the following: • Amend the second point of the steps to be more defined in the second option and less defined in the third option. • Clarify the Authority of the AIA in the elements section. • Clearly define the purpose of the accident investigation in the elements part.	• The word "sized" was re-defined to mean (Land area, traffic and State economy) • The third option has been amended to read (Well-established and tested regulations such as EU996/2010) • A statement to emphasise the authority was added • The accident investigation purpose was clearly defined.
1.2 Independence	Nigerian AIB	• Total/Functional independence is critical in the establishment of any authority, which is the NAIB situation.	• No action required.
	UK AAIB	The steps and elements are fine except the following: • Ensure the AIA can demonstrate authority during the process of the investigation.	• A statement was added in the steps to ensure the AIA can demonstrate authority as requested.
2.1 Organisation	Nigerian AIB	• AIB Nigeria currently operates the single mode system but is in an advanced stage of transforming into a multimodal system.	• No action required.
	UK AAIB	• Clearly distinguish the resources to cover two situations, day-to-day tasks and in case there is a major accident.	• The suggested point was addressed
2.2	Nigerian AIB	• This is also correct. The NAIB has a document that stipulates our policy and the procedures we employ in carrying out the investigations.	• No action required.

Policies and Procedures	UK AAIB	This section is "*all very well and good*". Suggestions of corrections are as follows: • Emphasise the AIA "***Administrative*"** in the steps. • Some points need to be re-ordered	• "***Administrative*"** was added • Points in this section were re-ordered as suggested
2.3 Personnel	Nigerian AIB	• The NAIB does not have any part-time investigators. Instead, experienced hands are recruited as contract staffs and where necessary, subject matter experts are called in.	• No action required.
	UK AAIB	• Add the words "***Appointment of appropriate*"** to the first step. • Some points need to be re-ordered	• "***Appointment of appropriate*"** was added • Points in this section were re-ordered as suggested
3.1 Training and Assessment	Nigerian AIB	• Agree with this. There should be a well thought out and robust need-based training programme for the investigators in line with the ICAO training manual and circular 298.	• No action required.
	UK AAIB	• Some of the points listed in the steps section need to be moved to the elements' side	• The identified points were moved as suggested
4.1 Facilities and Equipment	Nigerian AIB	• The Nigeria AIB is doing this. Agree with this proposal.	• No action required.
	UK AAIB	• Slightly reword the point in the steps section to include words "***or access to***" • Slightly modify two points in the elements section for clarifications	• All the suggested items were amended
4.2 Notification System and Investigation Database	Nigerian AIB	• Agree with this. AIB Nigeria is doing this.	• No action required.
	UK AAIB	• Modify the name of the dimension to read as "***Notification System and Investigation Database***" instead of "***Reporting Systems and Database***" • Clearly state the notification system is available 24 Hours a day, 365 days a year	• As a response to this feedback, a review of the thematic analysis process was performed by the researcher led to a conclusion that the name of this dimension came by using proper words "***Reporting Systems and Database***" which spelt out by some interviewees. Also, there was no feedback granted from SMEs during the expert panel reviews. However, the change only affected the dimension name and did not affect its contents "*the elements*"; thus, the researcher accepts this, and all the suggested points were modified and amended.

- The NAIB acknowledged that in their attempt to establish their AIA, their approach was similar to that formalised in 8DF. This led them to improve their investigation capability significantly.
- The UK AAIB stated that the State support by affording the required resources is important to assist in establishing and improving the AIA capability.
- For *prioritising the implementation of the framework dimensions*, the NAIB sees the implementation as provided is logical. While the UK AAIB share the same opinion, additional feedback was captured about the national legislation phase, which is the most important but the slowest phase. The process of having the legislation issued might take years, which might require the State to deal with other dimensions and phases concurrently.
- The NAIB advice for new established AIA's they should follow the established path of other AIA and in line with the ICAO Annex 13 recommendations. Also, The NAIB recommended that the AIA starts with single mode system, specific to air accident investigation before venturing into a multimodal system.
- In line with the advice of the NAIB, the UK AAIB also recommends any State thinking of establishing its AIA to "*get a partner*" to guide it through the process. Also, the State AIA has to commit to starting, go and finish the process and ensure trained staff are committed to working for the AIA itself.

The final framework after the validation phase of both AIAs is shown in Table 6-4, where the suggested recommendations are shown in **bold.** Also, all the requested recommendations have been applied to the modified maturity model in Table 6-5.

6.10 Summary

Different valuable insights were discovered through the inputs of participants, which assisted in clarifying and understanding the process of developing the AIA capability in less-developed States.

While the framework validation was performed in two phases, the achieved results found to have some match. The attempt of the Saudi AIB to seek assistance by visiting other States was highlighted in the feedback of both NAIB and UK AAIB. Being guided by other leading State is an important step to benefit from its experience in this field, which again point to the importance of cooperation internally and externally. State resources and commitment are a milestone to continue this process. However, the difference in internal circumstances of States may lead to consider different prioritisation for the implementation of dimensions such as the expected delays in issuing the required legislation and regulations.

Table 6-4 Eight Dimensions Framework (8DF)

Phases	Dimension	Steps	Identified Knowledge
Phase 1	1.1 National Legislation	o Establish national legislation and regulations according to what is laid down in Annex 13 SARPs o The most reliable references to assist in developing the national legislation and regulations are: • ICAO Annex 13 • Legislation and regulations of similarly sized State (Land area, traffic and economy) • **Well-established and tested regulations such as** EU996/2010	o Ensure the following are covered in the national legislation and regulations: • Emphasise the establishment of the AIA • The purpose of the accident investigation is described in accordance with Annex 13 SARPs **which is the prevention of accidents and incidents and not to apportion blame or liability**. • Emphasise the Independence of the AIA from the regulator and other authorities (See 1.2) • **Emphasis the Authority of the AIA to investigate the State accidents and incidents** • The investigation process is in compliance with Annex 13 provisions including: o Being separate from any administration and/or judicial proceedings o The rights of the accredited representatives to participate in the investigation process o The ability to seek expert assistance from other States o Prevent the use of investigation safety findings in judicial inquiries

	1.2 Independence	o The AIA has to be separate and independent from the regulator and other authorities in the State o **The AIA can demonstrate authority during the investigation process**	o It should also have the following in place: • Functional Independence (requires no permission to launch an investigation) • Financial Independence (as the State resources allow). • Structural Independence (as the State local circumstances allow). • The protection of investigators from testifying in the court by judicial authorities • The control over the investigation site including the available evidence such as ATC and aircraft recordings • Prevent the use of recordings (e.g. ATC & CVR) for a purpose other than air safety investigation
Phase 2	2.1 Organisation	o The AIA can withstand any pressure or interference from other organisations in the State and existing in one of the following models: • Single Mode specific to air accident investigation. Factors in favour of this selection are: o Organisational efficiency, o Traffic size o Having local service.	o The AIA should have the following: • Has sufficient financial resources **for day to day tasks** to comply with its legal obligations • Has access **to extra resources to cover major accident** such as: o Participation of the accredited representative system of ICAO Annex 13 o Sign an MoU with other States o Participate in an RAIO to get support from more developed States

		• Multimodal responsible for transport accident investigation. Factors in favour of this selection are: o Financial resources, o State land size and o Having local service.	
	2.2 Policies and Procedures	o Develop a set of policies and procedures to organise the investigation activities o The AIA should have **administrative** in place to plan and deal with different occurrences o The AIA should be able to publish Investigation Reports, produce and manage safety recommendations.	o The AIA should have a procedure manual in place where the following have to be covered: • Updated correct contact details for other investigation authorities • To notify other involved States and ICAO as appropriate of an accident promptly • To deal with accident and incident notification during and outside of work hours • To deal with the appointment and working of the Accredited Representative to provide the State conducting the investigation with any relevant information such as: o The aircraft, flight crew and passengers' information involved in the occurrence.

			o Dangerous goods if any • To immediately inform aviation security in the State when an act of criminal interference is involved or is suspected • Flight Recorders (FDR & CVR) are timely recovered to arrange to extract their information. • Relevant information on the progress of the investigation is provided to the relevant authorities, accident victims families and survivors • Ensure the protection of documents obtained during the investigation process such as a final draft report in accordance with the State local legislation • Ensure investigation reports are completed in a timely manner • Send a draft report to other involved States (as required) for review and comments • Ensure comments in the draft final report are reviewed and incorporated • Send the final report to all involved States and ICAO as required • Safety recommendations are made available at the earliest opportunity as required. • Record responses to the issued safety recommendations • Proper handling of any safety recommendations received from other States

	2.3 Personnel	o **Appointment of** appropriate and experienced personnel are working for the AIA o The investigation is led by staff who are fully working for the AIA	• A job description is in place for the staff which is updated regularly • Minimum requirements and qualifications for the investigators are in place • Have a process to appoint seconded personnel from other organisations in the State who: o Should be relieved from their original duties during the investigation process o Have necessary measures to avoid possible conflict of interest • Staff preparedness is maintained by the following: o Participating in accidents and incidents investigation o Conducting regular training which includes OJT o Observing other States investigations
Phase 3	3.1 Training and Assessment	o Establish a formal training system for investigators where the required level of training is provided for each investigator	• The AIA has an existing training plan to ensure the following: o Cover of different training needs for its investigators o The training plan is implemented correctly o Include appropriate tasks for the technical staff such as OJT o Training records should be maintained and updated o The training should cover different levels of programmes and be provided to the staff through different channels • The required training can be achieved by: o Cooperate with other States in the region o Cooperate with an internationally recognised training organisation

			o Establish a local training centre o Requesting ICAO assistance
Phase 4	4.1 Facilities and Equipment	o The AIA has in place **or access to** proper facilities and equipment to assist in conducting the investigations	• The proposed facilities and equipment should cover the following: o Updating list of all equipment in place and all investigators are aware of it o Appropriate equipment (PPE) is available and investigators trained to use them o The availability of means of communications and transportation o The readiness of the investigation field kit and essential personal items o The availability of secure storage facility for wreckage
	4.2 Notification system and investigation database	o The AIA has in place a **Notification system and investigation database**	o The AIA shall ensure the following: • Accident and incident notification system to enable receiving occurrences notifications **24 hours / Day, 365 Days / Year**. • The notification system shall be non-punitive, and its information sources are protected • Establish an accident and incident database

6.11 Modified Maturity Model

Having developed the final eight-dimension framework, the last step in the methodology (see figure 3-1) is to develop a maturity model to assist AIAs through the implementation.

6.11.1 Developing Maturity Model

When designed appropriately, maturity models provide a framework to visualise the future, the required situation and the development of plans for improvement. They also offer a measurement against which an organisation can examine its processes and can guide the way from an immature to a developed process. They are easily comprehensible, straightforward to instigate and fairly disciplined (Rose, 2013). There are many proposed methodologies and frameworks that outline the phases of developing maturity models (see De Bruin et al., 2005; Poeppelbuss and Roeglinger, 2011). The maturity model developed as part of this study is a modified one specifically developed to offer prescriptive guidelines on how to make improvements or to compare different levels of the evolution of the AIA. Its content has been driven by the eight-dimension framework and outcomes of the interviews and questionnaires.

The model was developed based on the steps described by Rose (2013): firstly, to describe the transition of the AIA capability concerning the framework dimensions; secondly, to determine the scale. The model describes a three-level evolution from *ad hoc* level (initial) to the optimal one. The selection of the three-level scale is based on both ICAO USOAP findings and the results of this study where Member States follow three categories, based on who is handling the accident investigation in the State (AIG Secretariat, 2008) (refer to section 1.2). Thirdly, the aim is to develop the expectations for each component level which was developed from the results of this study. It is acknowledged that this model has some limitations which are discussed in section 7.7.

Table 6-5 Modified Maturity Model to show the evolution of the Accident Investigation Authority

	• **No real organisation is in place. The control of and responsibility for the air accident investigation is within the local regulator**	• **A specific organisation in the form of bureau or office exists under the umbrella of the local regulator**	• **The organisation clearly exists. It could be known as the State Accident Investigation Authority (AIA)**
	Initial	**Defined**	**Optimised**
Organisation	• The investigation is conducted in an *ad hoc* manner through transit committees, which are formed upon the occurrence of an air accident or incident • Has no visible organisational structure • Depends on assistance from an accredited representative system of ICAO Annex 13 • Likely to be involved with other States to form an RAIO to acquire the required support • The State may hand control of an investigation to another State or RAIO	• Has no independent resources to conduct an investigation • Exist in the structure of the local regulator organisation as a Bureau or office • Can Sign MoUs with other States • Can depend on the support of the RAIO • Depends on assistance from an accredited representative system of ICAO Annex 13 • Conflict of interest is likely to exist (being part of the local regulator)	The AIA can withstand any pressure or interference from other organisations in the State and existing in one of the following models: o Single Mode specific to air accident investigation o Multimodal responsible for transport accident investigation • Has sufficient financial resources for day to day tasks to comply with its legal obligations • Has access to extra resources to cover major accident such as: o Participation of the accredited representative system of ICAO Annex 13 o Sign an MoU with other States o Participate in an RAIO to get support from more developed States
National Legislation	• There are no legislation and regulations in place or very limited one which can be assumed as insufficient to ensure the credibility of the investigation process • The authority and the assigned committees may depend on Annex 13 provisions as a reference to run the investigation • Difficulties are encountered during different phases of the investigation due to a lack of rules	• Limited legislation and regulations in place • The investigation is conducted in accordance with the available local legislation and regulations and Annex 13 provisions • May have some difficulties when conducting the investigation due to limited rules to maintain and organise the investigation process	The AIA has existing legislation which reflects the provisions of Annex 13 SARPs and is in agreement with the following: • Emphasise the establishment of the AIA • The purpose of the accident investigation is described in accordance with Annex 13 SARPs, which is to prevent accidents and incidents and not to apportion blame or liability.

	to maintain and organise the investigation process • Interference from other agencies is likely to occur due to lack of local legislation and regulations	• A chance for possible interference from other agencies due to the limited legislation and regulations	• Emphasise the Independence of the AIA from the regulator and other authorities • Emphasis the Authority of the AIA to investigate the State accidents and incidents • The investigation process is in compliance with Annex 13 provisions, including: o Being separate from any administration and/or judicial proceedings o The rights of the accredited representatives to participate in the investigation process o The ability to seek expert assistance from other States • Prevent the use of investigation safety findings in judicial inquiries
Independence	• Independence does not exist or is compromised • A decision to initiate an investigation requires permission • Conflict of interest during the process of investigation can occur • Investigators can attend court process • The use of recordings (e.g. ATC & CVR) for a purpose other than air safety investigation can occur	While financial and structural independence does not exist, there may be partial functional independence in place • The decision to initiate an investigation could still require permission • Investigators can still need to attend the court process • Possible conflict of interest • There is still a possibility of using recordings (e.g. ATC & CVR) for a purpose other than air safety investigation	• Generally, the AIA is separate and independent from the regulator and other authorities in the State. It can demonstrate authority during the investigation process. It should have the following in place: • Functional Independence (requires no permission to launch an investigation) • Financial Independence (as the State resources allow). • Structural Independence (as the State local circumstances allow). • The protection of investigators from testifying in the court by judicial authorities • The control over the investigation site including the available evidence such as ATC and aircraft recordings • Prevent the use of recordings (e.g. ATC & CVR) for a purpose other than air safety investigation

Policies and Procedures	• No policies or procedures in place to organise and control the investigation process. • Not all actions taken can be predicted • Has no procedure manual in place • Has no visible plans to deal with accidents and serious incidents	• May have limited policies and/or procedures in place, but not up to the level to control and organise the investigation process • May have limited procedure manual in place • May has limited plans to deal with different accidents and incidents	The AIA has in place a set of policies and procedures to organise the investigation activities and has administrative in place to plan and deal with different occurrences. It has a procedure manual which shall include the following: • Updated correct contact details for other investigation authorities • To notify other involved States and ICAO as appropriate of an accident promptly • To deal with accident and incident notification during and outside of work hours • To deal with the appointment and working of the Accredited Representative to provide the State conducting the investigation with any relevant information such as: o The aircraft, flight crew and passengers' information involved in the occurrence. o Dangerous goods if any • To immediately inform aviation security in the State when an act of criminal interference is involved or is suspected • Flight Recorders (FDR & CVR) are timely recovered to arrange to extract their information. • Relevant information on the progress of the investigation is provided to the relevant authorities, accident victims families and survivors • Ensure the protection of documents obtained during the investigation process such as a final draft report in accordance with the State local legislation • Ensure investigation reports are completed in a timely manner

			• Send a draft report to other involved States (as required) for review and comments • Ensure comments in the draft final report are reviewed and incorporated • Send the final report to all involved States and ICAO as required • Safety recommendations are made available at the earliest opportunity as required. • Record responses to the issued safety recommendations • Proper handling of any safety recommendations received from other States
Personnel	• No specific staff are identified to conduct the investigation • The personnel are likely to be working with the local regulator and may be assigned to conduct the investigation when needed. • Staff experience cannot be precisely determined • No job descriptions in place • The selection of staff is not based on minimum requirements and qualifications • The staff can be permitted to continue conducting their original duties during the investigation • Conflict of interest is hardly avoided	• There are specific staff identified within the entity that is responsible for the air accident investigation • The staff number maybe not enough for the assigned tasks • The staff skills and knowledge may vary and not be up to the required standard • The investigation is likely to be conducted with the assistance of staff from other departments • There may be minor requirements and qualifications considered in the selection of staff • Conflict of interest is likely to happen	The AIA should appoint appropriate and experienced personnel and has in place: • A job description is in place for the staff which is updated regularly • Minimum requirements and qualifications for the investigators are in place • Have a process to appoint seconded personnel from other organisations in the State who: o Should be relieved from their original duties during the investigation process o Have necessary measures to avoid possible conflict of interest • Staff preparedness is maintained by the following: o Participating in accidents and incidents investigation o Conducting regular training which includes OJT o Observing other States investigations

Training and Assessment	• No formal training system is in place • It is likely that no training plan exists • Basic training may be provided for some staff in an irregular and disorganised manner • No proper records of training are in place	• A formal training system and training plan may be in place for the entity as part of the main organisation • There may be limited training programmes for the staff in place • Limited training records may be in place	The AIA has in place a formal training system for its investigators where the required level of training is provided for each investigator. • It should have an existing training plan to ensure the following: o Cover of different training needs for its investigators o The training plan is implemented correctly o Include appropriate tasks for the technical staff such as OJT o Training records should be maintained and updated o The training should cover different levels of programmes and be provided to the staff through different channels • The required training can be achieved by: o Cooperate with other States in the region o Cooperate with an internationally recognised training organisation o Establish a local training centre o Requesting ICAO assistance
Facilities and Equipment	• Has no proper facilities and equipment in place • The working environment for the investigators at the accident site is unsafe due to the existing hazards and absence of special equipment	• Limited facilities and equipment may be found which include special equipment for investigators to deal with hazards in the investigation site • Limited availability of communications and transportation means for the use of investigators at the accident site • Investigation field kit and essential personal items may be found • The storage facility may exist	The AIA has in place or access to proper facilities and equipment to assist in conducting the investigations. • The proposed facilities and equipment should cover the following: o The proposed facilities and equipment should cover the following: o Updating list of all equipment in place and all investigators are aware of it o Appropriate equipment (PPE) is available and investigators trained to use them

			o The availability of means of communications and transportation o The readiness of the investigation field kit and essential personal items o The availability of secure storage facility for wreckage
Notification System and Investigation Database	• There may be a primitive accident and incident notification system in place, but no proper reporting system and no database exist	• Accident and incident notification system is in place but maybe less effective • A limited accident and incident database may be found but is not effective	The AIA has in place a Notification system and investigation database • The AIA shall ensure the following: o Accident and incident notification system to enable receiving occurrences notifications 24 hours / Day, 365 Days / Year. o The notification system shall be non-punitive, and its information sources are protected o Establish an accident and incident database

7 DISCUSSION AND CONCLUSION

As discussed previously, the research aim was to identify the best processes and practices to develop the capability of air accident investigation in less-developed States, and thus, to understand what is required to build and maintain such capability to assist in conducting an accident investigation.

The purpose of this chapter is to discuss how the results and analysis of the various stages of the study combine to draw overall conclusions. The contribution to knowledge, research limitations and suggestions for future research are also introduced.

7.1 The Rational behind Developing a Framework

While SARPs for Aircraft Accident Investigation exist within ICAO Annex 13, the literature review demonstrated minimal guidance as to how to create a new accident investigation authority and to build its capability. Most of the existing capability models serve specific fields, and therefore, are difficult to apply in other areas without substantial modification. This led to the development of a new framework, which describes the essence of capability in aircraft accident investigation. Specifically, the approach to the 8DF framework came as a result of an attempt to address the question of how less-developed States could develop their AIAs capability. In this process, it was necessary to consider fundamentals such as the evolution of the concept of the investigation and look at different approaches to a safety investigation. It was also essential to study the objectives behind the investigations in general and associate them with what is being currently practised in this field.

The current status of ICAO Member States was evaluated through the review of USOAP - the only such audit that is implemented internationally. Eighty five countries scored below the global average with effective implementation of standards and recommended practices (SARPs) scores ranging from zero to 55.7%. The implication was twofold. On the one hand, this may be classified as a global problem affecting aviation safety. On the other hand, it may indicate that there is a gap in understanding as to how to achieve compliance. The existing

literature lacked the appropriate knowledge to assist less-developed States in tackling their findings and improving their current situation. Still, it was rich with studies to suggest a further improvement for already developed States.

7.2 USOAP Audit at a Glance

The foundation of commercial aviation safety worldwide could be characterised as being based on compliance with ICAO SARPs.

ICAO depends upon National Aviation Authorities to adopt SARPs into their local legislation and regulations with minimal change, although there is a provision (known as Notice of Variance) which allows some changes for local circumstances. Following that, regulators will typically perform specific audits[3] in addition to some other measures to check the compliance of the entities[4] for which they have responsibility. If local entities meet the local standards, this can indicate the standardised level of safety across the industry in the State. In simple terms, if all countries complied with ICAO SARPs through their local regulations, this would indicate the worldwide, standardised level of safety.

Given the number of Member States in the world (currently 193 in 2018), the standard (global average level of compliance) is affected as many States fall short of that level of safety (Refer to section 1.4.2). If the discussion focused on the already developed States, then complying with ICAO SARPs may be viewed as a minimum standard, and therefore, such States may exceed that standard. As the target of accident investigation is broadening towards resilient systems by strengthening safety in general (Cedergren and Petersen, 2011; Stoop and Dekker, 2012), there is a growing movement to performance-based regulation and risk-based oversight (See UK CAA, 2019) to focus on the areas of greatest need. If the aviation sector of that State is performing well, then arguably, the regulator needs to do little more than monitor performance, i.e. the aviation

[3] The Accident Investigation Authority is an exception – these are not audited in this way so as to preserve their independence – they only audited through USOAP.
[4] Entities may include aircraft operators, airports, air navigation service providers, maintenance repair and overhaul organisations, equipment manufacturer etc.

entities are achieving the State's mission by maintaining high levels of safety. The consequence of implementing such a system is that the State will use its finite resources appropriately and devote efforts based on the importance of each task or target (See ICAO, 2017b).

At the international level, ICAO monitor SARPs compliance of member States through USOAP. Considering the philosophy of USOAP audits, the judgment of '*effectiveness'* is based on compliance with ICAO SARPs, rather than the actual performance of that State or its entities. Thus, USOAP could be seen as a compliance-based measure rather than performance-based measure and therefore might be assumed as '*traditional'* in its approach. In addition, USOAP targets all Member States using the same measures – which exclude their *actual* capability. When it comes to the area of air accident investigation, this might be considered as extremely difficult as there may be a specific State, which is technically compliant with SARPs but has no major accidents for many years (Refer to section 2.1). In this case, compliance might not necessarily be a good indicator of the State's readiness or competence to investigate a major accident.

This is why the word 'capability' was adopted during the research to describe the full breadth of not just complying with SARPs, but also to demonstrate the State readiness in performing the investigation tasks. There are possible alternative words that could have been used, but the selection of it comes from its comprehensive meaning (Refer to section 2.7).

7.3 Is Capability Absolute?

The SLR suggested that the capability as a concept within the field of air accident investigation is vague and poorly defined, which aligns with Collis' (1994) view. Indeed, within the studied area, no explicit description was found to describe capability or suggest what it can include - either from the published literature or the industry point of view. This raises an important question; is capability absolute?

The SLR also highlighted different interpretations of 'capability' across disciplines. Capability does not look the same in every case or situation (see

Barney, 1991; Ethiraj et al., 2005; O'Regan and Ghobadian, 2004). Within the field of air accident investigation, it could be challenging to achieve a clear definition of it as argued by Ulrich and Smallwood (2004) that there is no universal list of capabilities. As demonstrated in the SLR (refer to section 2.7.1) What organisational capability can comprise is based on different objectives and reveals how the same concept is viewed and used in different forms. The current research approach describes a meaning for capability as a concept. The capability development was linked with the "*uncertainty"* of less-developed States to establish their AIA as demonstrated in the SLR. Despite defining of different possible areas that deemed necessary for this process, there may have been other aspects, which contribute in the formula of identifying the capability in the studied area based on different circumstances of States. This can be further braced by Schreyögg and Kliesch-Eberl (2007) view that capability represents a superior way of allocating resources together and not to assume it as a single resource. This appears to support the results of the empirical study when capability was viewed in addition to the eight areas as a function of political and financial resources of each State. In short, terms defining the capability in this area may be seen as complicated and may require adjustment for each State. This supports the need for a gap analysis to assess the specific situation of each State.

To conclude, capability is not absolute, but it can be described in different contexts and levels of abstraction, as highlighted in the literature and corroborated by the findings of this research.

7.4 Capability Development versus Maintaining

As previously mentioned, the poor capability can be observed with different countries, which lack a specific body to handle the responsibility of investigating accidents or where such a body exists but is not functioning as required, for example due to a conflict with other agencies in the State. What can be drawn from the best processes and practices to assist States in improving and increasing their capability level based on the results of this study may need to be

updated due to the continuous improvements in this field. Recalling what was cited in the literature as highlighted by Stoop and Roed-Larsen (2009) that maintaining public confidence is behind the constant development of accident investigation, even developed States need to work very hard towards this aim as global air transport is experiencing remarkable growth. As an example, private and commercial aircraft fleets, which many accident investigation authorities have to deal with, are changing significantly.

In some cases, investigators only become familiar with the complexity of new equipment when an accident occurs. Also, because of the advanced technology used in the new generation aircraft such as the Boeing 787 or Airbus A350, the experience and expertise of safety investigators, normally gained through the investigation process for previous generation aircraft, may be limited. Therefore, considering the importance of accident investigation in terms of improvements to aircraft design (Waycaster et al., 2018), it becomes essential for investigators to work closely with stakeholders such as manufacturers, regulators and operators to become far more familiar with the design and operation of modern new-built aircraft. Practically this will require collaboration between the AIA and other parties locally, regionally and internationally.

ICAO Member States are also subject to changes in SARPs (such as Annex 13) and when that document changes, amendments will take place to the policies and procedures for the individual AIA whilst remaining consistent with the applicable legislation. As a result, further research or study should consider any future changes to the investigation criteria and process.

Investigators play a key role in evidence protection, collection and to establish why the accident occurred. According to Nixon and Braithwaite (2018), they are typically characterised as holding an abnormal state of knowledge and technical skills in the aviation field. As highlighted in the SLR, Investigators who are involved in the investigation process are the decisive factors in ensuring the investigation's credibility and where their personal qualities have an extraordinary impact on the investigation process (see Dechy et al., 2012).

In terms of investigating human performance, people tend to react to standard circumstances by applying knowledge which has been effectively demonstrated in familiar and well-known situations (Stoop and Roed-Larsen, 2009). However, inadequate training of investigators may affect the States with both low and high rates of occurrences. One example which was highlighted in the SLR regarded the lack of using systemic analysis tools in the investigation process by investigators (Underwood and Waterson, 2012) due to many reasons. These include a lack of learning opportunities due to workload demands and the presence of many obstacles to access the relevant research information to facilitate the use of a systemic analysis technique (Underwood and Waterson, 2013). Therefore, the credibility of the AIA's could be threatened if inadequate attention is given to the safety investigators' training requirements.

When looking at the investigation process, "*There are never any simple "truths" to be found, hence no simple way of learning from experience. Any lesson learned is limited by the assumptions on which the investigation is based*" (Hollnagel, 2008). From an analogy perspective, as the investigator was assumed as the most vital unit to facilitate the learning process from investigating accidents (Njå and Braut, 2010), investigators must exhibit a wide range of technical skills. In turn, these need to be associated with the abilities that may need to be applied infrequently but on a massive scale. The challenge that many AIA's face is; how to maintain the technical proficiency of safety investigators. The study results demonstrate that options such as participating as observers in another State's accident investigation might be of benefit to the investigators to maintain their skills and currency up to a certain level, but, is not as effective as practising the job and become familiar with changes at the system and subsystem levels. The findings that were drawn from the questionnaire point towards the importance of "***Practice***" to maintain the preparedness of investigators (refer to 5.5.4 and 6.4). Thus, it can be argued that the adopted definition of capability for this study claimed its importance for any State AIA, which needs to be prepared to handle accidents and incidents effectively. Therefore, looking longer term, options such as investigating incidents and attending training linked to practical

sessions are of importance to maintain the competency of investigators and ensure their readiness to perform the required job.

AIAs are dependent on the professionalism of their safety investigators to succeed in conducting a thorough investigation, and as such, it is fundamental to them complying with their national and international obligations. However, such dependence may be questioned if there is not sufficient emphasis on investigator training to ensure long-term success. The guidelines for future training should include a diversity of topics to boost investigators' technical proficiency for both the near and far terms. The training that investigators should receive should cover not only fundamental investigative techniques but also cross- and multi-disciplinary work to cope with unpredictability of situations that they may face at an accident site. Investigators require a balance of frequent (recurrent) training and practice to maintain their proficiency.

In their empirical study to explore multilevel learning processes, Hovden, Størseth and Tinmannsvik (2011) introduced some standards which comprised learning conditions followed by outcomes changes. The suggested standards were built based on the investigation process to improve the followed procedures to ensure a satisfactory level of learning from these events. Ensuring the investigation' independence and publishing the investigation reports shortly after the event were among the criteria suggested. While the former is essential in aircraft accident investigation, the latter can be difficult to implement. An investigation may last for several years in some complicated cases, such as the case of Air France 447, which took three years for the final report to be published.

7.5 Safety Management System as an Approach

As noted in the SLR, the implementation of SMS in aviation has become widespread. As a reactive method, accident investigation plays a vital role in the continuous improvement of the aviation system by studying the root causes of accidents and considering the learned lessons from the analysis of events, thereby promoting the development of corrective actions and corresponding improvements to the aviation system, including the SMS. While mandatory State investigations are mostly limited to accidents and serious incidents, the

successful deployment of a mature safety management environment in the State, also facilitates investigations into less serious events (ICAO, 2013). This can exclude any bias concerning the selection of accidents to investigate and creating additional opportunities to investigate different events, as highlighted in the SLR. In addition, it has a positive impact on the learning from accident investigation at the higher levels in the organisation hierarchy. It can also anticipate investigating factors at the organisational level by using systemic analysis tools (see Furniss, Curzon and Blandford, 2016).

7.6 Contribution of this Research

This study has attempted to clarify the nature of capability as it relates to state-led 'ICAO Annex 13' aircraft accident investigation, which led to proposing a framework made of eight dimensions. Further refinement and testing of the proposed framework were undertaken by distributing a questionnaire to experts in the field of air accident investigation. The collected data was analysed which assisted in uncovering new insights to assist less-developed States in developing and maintaining their AIA capability. The primary contributions to knowledge are as follows:

- **Theoretical contributions**

1) A novel framework has been developed and validated to assist less-developed States in establishing their accident investigation authority, and for developing and maintaining its capability.
2) A detailed description of the best processes and practices from experience of the field of air accident investigation using a mixed-methods approach.
3) Guidance for States to develop their accident investigation capability to help prioritise and monitor actions.

- **Practical contributions**

The findings of this study are of immediate benefit for organisations in less developed countries that may be tasked with establishing or improving the aircraft accident investigation function.

7.7 Research Limitations

As is to be expected in research, there are certain limitations, which require clarification. Firstly, although care was taken in the selection of participants and the management of interviews, there is the possibility of interviewees' bias. For example, it would be difficult to judge whether participants favour their own AIA's approach to the appropriate organisation mode simply because of their familiarity with it (refer to sections 4.6.3, 5.6). The researcher was mindful of this risk and tried to draw conclusions from a range of evidence.

Secondly, considering feedback from participants that "*..each state has its own social and legal traditions*", it is possible that the approach to delivering effective safety investigations may, in reality, vary between States. This was observed between participants, especially in terms of how to prioritise the implementation of the framework dimensions.

It is fully anticipated that further changes in accident investigation (including methods, facilities, equipment, databases notification etc) will occur in the future. While the research contributes to developing capability in this field by clarifying the process of establishing the AIA, to some extent, the study may be seen as a "*snapshot*" of the current status rather than a fixed, long-term view.

The limitations relating to the developed maturity model could be linked to its level of subjectivity. Such models should be used cautiously, especially if an assessment is made directly against the maturity model descriptions. Positively, excellence in one aspect of the model may help to compensate for deficiencies in another element. Negatively, deficiencies in other areas may also negate strengths on other elements,

Finally, the researcher acknowledges that there were some important factors which may have a significant impact on the development of the capability of air accident investigation, but which were not fully covered by this study such as a State's resources and political support.

7.8 Future Work

Based on USOAP audit findings, ICAO introduced the Regional Accident Investigation Organisation (RAIO) as a solution for the less capable States to rectify their deficiencies in establishing an effective and efficient accident investigation system. By having a regional investigation system in place, this would allow the sharing of resources which would assist States in meeting their obligations (Costa, 2011). Whilst it is possible that many Member States are aiming to formulate their region's RAIO, to date, there are few events where such an organisation has investigated an aircraft accident. Some such investigations have led to criticism about their investigation outcomes – such as the investigation of the Tu-154M crash in Smolensk, Russia, by the InterState Aviation Committee (IAC). Further review of the effectiveness of RAIOs may be valuable. Indeed, it may be beneficial if the proposed framework can be utilised to collect data from RAIO States to examine the best way to formulate an effective regional organisation.

Finally, the methodology and results may also be of interest to other analogous sectors such as marine and rail transport. However, consideration must be given to the different working environment, legislation and methods.

7.9 Conclusion

The International Civil Aviation Organisation (ICAO) provides a clear set of Annex 13 Standards and Recommended Practices (SARPS) for the aviation industry. These are designed to be implemented by the Member States, enabled through national legislation. The aim is to support a safe, secure and sustainable aviation industry through standardisation across the world.

The investigation of accidents and serious incidents plays a key role in ensuring safety by learning lessons. To achieve this, each Member State is expected to implement SARPs. However, as ICAO's Universal Safety Oversight Audit Program (USOAP) demonstrates, a large proportion of States do not fully comply with the SARPS in this area.

Whilst compliance is used by ICAO as a proxy for States being able to meet their obligations under Annex 13; it only represents part of the story. Being compliant with SARPs is one thing and does not necessarily demonstrate capability. Being available and able to do the job - in other words, being capable is different. For the less-developed States, the path towards greater compliance is not clear.

The idea that full compliance with SARPS is sufficient for States to demonstrate their capability is oversimplistic and unhelpful. Knowing, which aspects to start with and how they may accelerate progress towards becoming more capable (and compliant) are important. This thesis has collected and analysed data from a range of sources including the academic and technical literature, and experienced aircraft accident investigators to offer a framework for less-developed countries as well as a maturity model to evaluate their progress across the eight dimensions.

The findings present a valuable guide to building capability in the investigation of accidents and serious incidents. The opportunity that this framework offers is beyond how to achieve compliance with ICAO SARPs; rather, it supports Member States in maintaining the ability to perform the required investigative tasks. This work assists the aviation sector in learning from occurrences as part of global efforts to improve aviation safety and in ensuring that in keeping with ICAOs stated policy '*no country is left behind*'.

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APPENDICES

Appendix A USOAP EI for States Scores below the Global Average in the Accident Investigation Area

No.	State	UOSAP Score	No.	State	UOSAP Score
1.	Cook Islands	0.0%	44.	Seychelles	29.4%
2.	Djibouti	0.0%	45.	Bulgaria	29.9%
3.	Lesotho	0.0%	46.	Qatar	30.4%
4.	Bhutan	1.1%	47.	Zambia	31.0%
5.	Palau	1.1%	48.	Slovenia	31.1%
6.	Micronesia	1.1%	49.	Estonia	32.2%
7.	Central African	2.1%	50.	India	32.4%
8.	Haiti	2.2%	51.	Peru	33.0%
9.	Nauru	2.3%	52.	Vanuatu	33.3%
10.	Gabon	5.4%	53.	Trinidad and Tobago	34.8%
11.	Angola	6.5%	54.	Algeria	35.5%
12.	Samoa	6.7%	55.	Swaziland	39.8%
13.	Tonga	8.5%	56.	Kenya	40.9%
14.	Cameroon	8.6%	57.	Moldova	41.3%
15.	Guinea-Bissau	8.6%	58.	Panama	42.2%
16.	Solomon Islands	8.6%	59.	Thailand	42.2%
17.	Andorra	10.5%	60.	Luxembourg	42.4%
18.	Comoros	10.8%	61.	Slovakia	43.0%
19.	Marshall Islands	11.1%	62.	Fiji	44.1%
20.	Benin	11.8%	63.	Timor-Leste	45.2%
21.	Sierra Leone	11.8%	64.	Chad	45.2%
22.	Equatorial Guinea	12.8%	65.	Madagascar	45.2%
23.	Bahamas	13.3%	66.	Mauritius	45.2%
24.	Monaco	14.1%	67.	Tanzania	46.1%
25.	Liberia	15.1%	68.	Azerbaijan	46.2%
26.	Rwanda	15.1%	69.	Barbados	46.2%
27.	Suriname	15.2%	70.	Oman	46.2%
28.	Guyana	15.4%	71.	Kazakhstan	46.7%
29.	Eritrea	18.2%	72.	Kuwait	47.1%
30.	Libya	18.3%	73.	Malta	47.8%
31.	Nepal	18.3%	74.	Montenegro	48.4%
32.	Syrian	18.9%	75.	Armenia	49.8%
33.	Mozambique	19.4%	76.	Ukraine	50.0%
34..	Congo	20.2%	77.	Belarus	53.2%
35.	San Marino	20.6%	78.	Gambia	54.8%
36.	Cabo Verde	22.2%	79.	Senegal	54.9%
37.	Malawi	22.2%	80.	Brunei	55.0%
38.	Lithuania	22.6%	81.	Togo	55.3%
39.	Guinea	22.8%	82.	Jamaica	55.4%
40.	Papua New Guinea	23.7%	83.	South Africa	55.5%
41.	Sao Tome & Principe	23.7%	84.	Croatia	55.6%
42.	Albania	25.8%	85.	Zimbabwe	55.7%
43.	Congo	29.0%			

Source Safety Audit Results - Retrieved January 2019

Appendix B Interview Consent Form and Ethics Form

PhD in Transport Systems

Study Title: Developing the capability of air accident investigation

PARTICIPANT CONSENT FORM

Participant number: _____

Date: _____

I, _____ (please print your name in block capitals) confirm that I agreed to participate in the study of developing the capability of air accident investigation. I agree to the conversation being recorded and transcribed for analysis.

I understand that this study is being conducted towards a PhD degree and although the information I provide will be used by Cranfield University for research purposes, it will not be possible to identify any specific individual from the data reported as a result of this research. All personal information that I provide will be treated in the strictest confidence, and I have been provided with a participant number to ensure that all raw data remains anonymous. The data collected will only be used for research purposes as part of the current project. The results will be written up as a thesis.

I am free to withdraw from this project at any stage during the session simply by informing the researcher, for whom contact details have been provided.

I confirm I have read completely and fully understand the information provided on this form and therefore give my consent to taking part in this research.

Signature (Participant): _____ Date: _____

Signature (Researcher): _____ Date: _____

Cranfield UNIVERSITY

Cranfield University Research Ethics System (CURES)

Part 1: Summary Details

Lead Researcher (Applicant)

Title	First Name	Surname
Mr	Abdul	Abushalla

School: SATM

Email: a.m.abushalla@cranfield.ac.uk

Lead Researcher status: (•) Student ( ) Staff

Course Enrolled

PhD in Transport Systems

Please confirm which project type your application is supporting

- (•) Thesis
- ( ) Group Project
- ( ) Other

Co-Researcher

Title	First Name	Surname

School:

Email:

Short title of project

Developing AAI Capability

Project ID: 0880

Full title of project

The development of aircraft accident investigation capability

Abstract

The Research examines the capability in the aircraft accident investigation field. It is expected through the Study process not only to be familiar with the current situation of the capability but also to know how to develop it to an acceptable level. It is anticipated to come across many phases as follows:
- The first phase to have unstructured interviews with selected experts in the field of Aircraft Accident Investigation to explore the features and the components of Accident Investigation Capability.
- The second phase which is (the Pilot Study) to assure the credibility of the questionnaire that will be formulated following to the first phase.
- The third phase which is the main study will contain structured and semi structured interviews and may be a questionnaire distribution where the targeted people will be experts in the Aircraft Accident Investigation field either are retired people or still working with respected Accident Investigation Agencies or Manufactures as appropriate.

Lead Supervisor

Title	First Name	Surname
Professor	Graham	Braithwaite

School: SATM

Email: g.r.braithwaite@cranfield.ac.uk

If the supervisor details above are missing or incorrect, please contact cures-support@cranfield.ac.uk

Intended start date of project: 05/05/2015

Intended end date of project: 05/05/2018

Intended start date of data collection: 01/12/2015

Please note: you must not begin your research until approval has been given by CURES.

Will the research be sponsored or funded by an external organisation?

- ○ Yes
- ◉ No

Please click on 'Next' in left hand actions bar to move forward to Part 2

Part 2: Ethical Risk

The following questions will help determine the level of ethical risk that your project entails.

Firstly, please give us your own assessment of the ethical risk level of your project. The University has 4 risk levels (see help information). If you have any doubts as to which category is appropriate the higher risk category should be used.

Level 2: Risks to the researcher/participant are no greater than those typically encountered in ordinary life

Please select any that apply:

- ☐ Animals are involved in my research
- ☐ My research involves living organisms/biological agents and could potentially impact other entities outside the laboratory
- ☐ People may be seriously harmed in the course of the research
- ☐ The proposed research could adversely affect the reputation of the university
- ☐ The research data is about illegal activities or will be collected from those engaged in illegal activities, or has itself been collected illegally

- ☑ None of the above

Please select any that apply:

- ☐ The research will involve the collection and use of 'relevant material' under the Human Tissue Act 2004
- ☐ There are significant power differences present, or dual or other complicating relationships exist
- ☐ The research will deal with material that is obscene or violent in content
- ☐ The risk is greater than that experienced by participants in their daily lives
- ☐ The research interacts with members of potentially vulnerable groups (e.g. children, the elderly, those with learning difficulties, prisoners etc.)
- ☐ Harm for participants and/or researchers is likely (physical, emotional, psychological, career, financial)
- ☐ National infrastructure will be impacted negatively (e.g. power grid)

- ☑ None of the above

Please select any that apply:

- ☑ Data is gathered from human participants
- ☐ The project will involve the collection or use of sensitive information, the disclosure of which may cause potential harm
- ☐ My research has defence or security implications
- ☐ My research is based on unpublished material

- [ ] None of the above

Will your research require obtaining informed consent?

- (•) Yes
- ( ) No
- ( ) Not applicable

Will participants be able, during the data gathering phase, to freely withdraw or modify their consent and to ask for the destruction of all or part of the data that they have contributed?

- (•) Yes
- ( ) No
- ( ) Not applicable

Will your research adhere to the duty of confidentiality?

- (•) Yes
- ( ) No
- ( ) Not applicable

Are there any conflicts of interest?

- ( ) Yes
- (•) No
- ( ) Not applicable

Please comment on any other ethical issues that may arise from your project

NIL

Please click on 'Next' in left hand actions bar to move forward to Part 3

Part 3: Methodology and Expertise

By completing the following information on your research methodology will help us match your application with the most appropriate reviewer(s).

What type of research design will you be using? (tick all that apply)

- [ ] Experimental
- [ ] Quasi-experimental
- [ ] Cross-sectional or survey
- [ ] Longitudinal
- [x] Case study
- [ ] Comparative

What type of research strategy will you employ?

- ○ Qualitative
- ○ Quantitative
- ◉ Mixed methods

Which methods will you be using? (tick all that apply)

- ☐ Experimental - design
- ☐ Experimental - field
- ☐ Experimental - laboratory
- ☐ Randomized controlled trial / other intervention study
- ☑ Interview
- ☐ Observation
- ☐ Focus groups
- ☑ Questionnaires/surveys
- ☐ Action research
- ☐ Personal documents
- ☐ Medical records
- ☑ Literature review
- ☐ Systematic review
- ☐ Secondary data analysis
- ☐ Advisory/consultation/collaborative groups
- ☐ Other

Please describe briefly the population that you will study

The study will focus on the development of the capability in aircraft accident investigation aiming to understand the most appropriate ways to build it when it is not existing or deficient.

How will you evaluate (validate/verify/analyse) your data?

- ☑ I will collect the data and then determine whether there are significant groupings or trends present (information-theoretic models)
- ☐ I will test a hypothesis
- ☐ Other

Please assign your research project to one of the University Themes

Transport Systems

Please click on 'Next' in left hand actions bar to move forward to Part 4

Part 4: Specialist Studies

This section relates to research around health and defence topics. For most applications the questions will not be applicable.

Have you ensured that your study complies with The Human Tissue Act 2004 and its nine codes of practice?

- ○ Yes
- ○ No
- ◉ Not applicable

Are you conducting research involving human participants undertaken, funded or sponsored by the Ministry of Defence?

- ○ Yes
- ◉ No

Is the research taking place in or through the National Health Service (NHS)?

- ○ Yes
- ◉ No

Please click on 'Next' in left hand actions bar to move forward to Part 5

Part 5: Supporting Documents

You are encouraged to upload a research protocol if this is common practice in your area of study. In addition, please upload any supporting documents you may have that will help reviewers understand your research design such as questionnaires, interview schedules, participant information sheets, consent forms, case for support etc. (dependent on study)

Type	Name	Date	Version	Size	
Supporting Document	CONSENT FORM	CONSENT FORM.docx	28/10/2015	1	28.8 KB
Supporting Document	Questionnaire	Questionnaire.docx	28/10/2015	1	30.0 KB

Please click on 'Next' in left hand actions bar to move forward to Part 6

Part 6: Declarations and Signatures

Researcher Declaration

- The completed form is accurate to the best of my knowledge and belief.
- I undertake to abide by Cranfield University's Ethics Policy in undertaking this project.
- I understand that ethical approval for projects, and that the seeking and obtaining of all other necessary approvals and permissions prior to starting the project is my responsibility.
- I understand that I must not begin the research until I have received approval from the Cranfield University Research Ethics System (CURES).
- I understand that any significant changes that I would like to make to this project after receiving approval from CURES, will require a new application to be submitted.

Researcher Signature

Supervisor Declaration

- I confirm that I have read and fully support this application and will be acting as the supervisor of the lead researcher (student) for this project.
- I have checked that the application has been completed correctly and is of good quality.
- In my opinion, the proposal is viable.
- I understand that the lead researcher I am supervising must not begin the research until they have received approval from the Cranfield University Research Ethics System (CURES).

Supervisor Signature

Students must obtain a signature from their supervisor prior to submission

Once both signatures are in place, you may submit the application using the action button in the left hand bar

Appendix C Survey Questionnaire

Block 1

Developing the Capability of Air Accident Investigation

Dear Participant,

This survey forms a main part of my PhD research and results are expected to be included in the final thesis. This study is an attempt to clarify a vague concept based on the current situation in aircraft accident investigation field to inform future practice. The questionnaire is intended to collect data about different dimensions defining current practices, methodologies, and level of resources available to the civil air accident investigation. In accepting to be part of this study, your participation is highly appreciated as the provided information will contribute to a greater understanding of the current situation as well as providing a base-line for potential future studies. It is emphasised that any individual contribution will not be disclosed and will be treated in a confidential manner.
It is fully understood that the gathering information will contribute to general statistics on the air accident investigation topic. You are entirely free to withdraw from the participation in this study at any time. For any further information or more explanation, please don't hesitate to contact the Researcher on this email:

a.m.abushalla@cranfield.ac.uk

Personnel information collected through this questionnaire is solely for contact purposes and will not be disclosed to others or in the research. It is entirely voluntary as to whether you provide this information.
This survey will contain 10 pages which include this page (Front Page), Questionnaire, submission of your response and end of survey page. All questions have been designed to capture information about the best practice of the state accident investigation authority. Questions are not related to participant's organisation, so please feel free to provide your view based on your experience.

Notes:

- Some questions have display logic, so their appearance is based on the respondent's answer.
- In completing this questionnaire, you are kindly invited to provide your "***Personnel View***" of the "BEST PRACTICE" in the field of air accident investigation, aiming in the situation you think is the best.
- To clarify the meaning of some words that are being used in this research, the accident investigation "authority" represents the " agency", "body" or "organisation" which is responsible for the conduct of air accident investigation on behalf of the state.
- Once you finish answering questions on a page, it is not possible to return back again.
- Your response will be recorded on our database when you finish answering all questions in the survey. Any survey left "unfinished", will be deleted by the end of the period of this study and will not be used in the analysis phase.
- This survey can be finished in different sessions. Your first answers will not be lost if you decide to continue finishing it later provided using the same device and browser.
- If, when you finish this survey, you wish to have a copy from your answers, you will be able to print "PDF" format copy.

"By clicking "*Next*" you agree to participate in this survey"

Q1 Please select the type of organisation you work for:

- ○ Accident investigation authority
- ○ Civil aviation authority
- ○ Aircraft Manufacturer
- ○ Operator (Airline, Maintenance organisation)
- ○ Other, please specify

Q2 Please choose your state accident investigation authority type from the list

- ○ Single Mode (Aviation only)
- ○ Multimodal (two or more transport modes)

Other, please specify

Q3a From your own perspective, what are the **most important factors** that are involved in deciding the organisation model for a certain state? i.e to be single mode or multimodal,

(**Please answer at least for the Mode that apply for your organisation**)

Drag items and drop them as appropriate.

	Single Mode	Multimodal
The State traffic size (Number of flights)		
Having local manufacturing or maintenance services		
The State land size		
The financial resources of the State		
Organisational efficiency		

	Don't know

Q3b From your experience, if you know any **important factors** that are involved in deciding the organisation model for a state, please add them here, otherwise please write **Don't Know** to continue.

Q4 Is it important for the state to have its own accident investigation **legislation and regulations**?

- ○ Yes, it should have them in addition to what is laid out in Annex 13
- ○ No, Annex 13 is sufficient
- ○ Other, please specify

Q5 Why is it important for the state to have its own accident investigation **legislation and regulations**?

Q6 What are the most reliable references for a state to develop its local accident investigation **legislation and regulations**?

(Please select all that apply)

- ☐ ICAO Annex 13
- ☐ The US Independent Safety Board Act of 1974
- ☐ European Union Regulation 996/2010
- ☐ Legislation and regulations of another similar sized state
- ☐ Other, please specify

Q7 For a state which needs to develop its own **legislation and regulations**, please state your opinion for each of the following topics to be covered by the state **legislation and regulations**

	strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The establishment of the accident investigation authority should be emphasised in the State legislation and Regulation	○	○	○	○	○
	strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The independence of the accident investigation authority from the regulator or other authorities should be emphasised in the State legislation and Regulation	○	○	○	○	○
	strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The investigation process in compliance with Annex 13 provisions should be emphasised in the State legislation and Regulation	○	○	○	○	○
	strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
	○	○	○	○	○

	strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The investigation process should be separate from any administration and/or judicial proceedings					
	strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Access to the investigation site should be prohibited to unauthorized people	○	○	○	○	○
	strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The use of investigation safety findings in judicial inquiries shall be prevented	○	○	○	○	○
	strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The accredited representatives have the right to participate in the investigation process	○	○	○	○	○
	strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The state investigation authority shall be able to seek expert assistance from other States	○	○	○	○	○

Q8 Where should the **purpose** of accident investigation be described?

- ○ In the State local legislation and regulations in accordance with Annex 13
- ○ As defined by Annex 13 provisions (no need to be included in local legislation and regulations)
- ○ Other, please specify

Q9 Does the state accident investigation authority have to be separate from the regulator and other authorities?

- ○ Yes, the structure should be separate
- ○ No, It is not necessary to be separate
- ○ It could be partially separate

Q10 Why does the state accident investigation authority need to be separate from the regulator and other authorities?

Q11 Should the state accident investigation authority need to have access to **extra financial resources** in the event of a major accident?

- ○ Yes
- ○ No
- ○ Don't Know

Q12 Which of the following organisation is likely to conduct a reliable accident investigation? Please rank them in order where the most reliable in the top

(**Drag items to rank**).

- Accident investigation office under the umbrella of civil aviation authority
- Civil aviation authority
- State accident investigation authority

Q13 Should the state accident investigation authority need **permission** to launch an investigation after an air accident or incident?

- ○ Yes, permission is needed
- ○ Sometimes, it depends on each state
- ○ No, no permission is required

Q14 Please specify from where such **permission** has to be obtained,

- ○ Ministry of Transport
- ○ Ministry of Justice
- ○ Other, please specify

Q15 Do safety accident investigators need to be **protected** against being called (to testify or similar activities) by the judicial authority?

- ○ Yes, they should be protected by local legislation and regulations
- ○ In some cases they are required to do so

○ No, they should not be protected and they may be called any time

○ Other, please specify

Q16a Please provide more information to clarify why in some cases they are required to do so?

Q16b Please provide more information to clarify why they should not be protected and they may be called any time?

Q17 The state accident investigation authority shall have **independent organisation** and the independency shall be:

	Essential	Ideal	Non-essential
Functional Independence from regulator	○	○	○
Structure Independence from regulator	○	○	○
Financial Independence from regulator	○	○	○

Q18 **Who should decide** whether to initiate a safety investigation?

○ The state accident investigation authority only

○ The state accident investigation authority in collaboration with the responsible Ministry (e.g Ministry of Transport)

○ Ministry of justice

○ Other, please specify

Q19 **Who has control** at the accident site **including the available evidence (e.g ATC and CVR records)?**

- ○ The Accident Investigation Authority appointed investigator in Charge should have full control
- ○ The Police and Judicial authorities should have full control
- ○ The authority and the control over the accident site is shared between the investigator in Charge and the judicial authority
- ○ Other, please specify

Q20 Can recordings (e.g ATC & CVR) be used for a purpose other than air safety investigation?

- ○ Yes
- ○ No
- ○ Other, please specify

Q21 If Yes, Please specify for what purposes?

Q22 For a state with a low rate of accidents and serious incidents, is it difficult to maintain the **preparedness (Skills & Currency)** of the Investigators?

- ○ Yes
- ○ No
- ○ Other, please specify

Q23 Why is it difficult to maintain the **preparedness** (skills and currency) of the Investigators?

Q24 Which of the following can assist the state accident investigation authority to ensure the **preparedness** of the investigators to conduct their tasks? Please rank them in order where the most important is in the top

(**Drag items to rank**).

- Conducting regular training which includes on-the-job training

- Observing other investigations that are conducted by other states
- Participation in incident investigations
- Participating in accident investigations

Q25 Which of the following is likely to support the State accident investigation authority to conduct a reliable accident investigation? Please rank them in order where the most reliable is in the top

(**Drag items to rank**).

- Signing Memorandum of Understanding (MoU) with other States
- The support of Regional Accident Investigation Organisation (RAIO)
- The participation of accredited representative system of ICAO Annex 13

Q26 Is it important for a state accident investigation authority to have **a job description** for its personnel?

- ○ Yes, there should be a job description for the authority investigators
- ○ No, a job description is not essential
- ○ It depends on each state accident investigation authority

Q27 Why is it important to have **a job description** for the investigators in place?

Q28 Should the **job description** be updated regularly?

- ○ Yes
- ○ No
- ○ Other, please specify

Q29 Is the state accident investigation authority required to sign **Memorandum of Understanding (MoU)** to support it in the process of investigation that conducted by its investigators?

(**More than 1 answer is possible**)

- ☐ Yes, the state is required to sign MoU with other States
- ☐ Yes, the state is required to sign MoU with a Regional Accident Investigation Organisation (RAIO)

☐ No, it is not necessary for the state to sign any MoU with other states or a Regional Accident Investigation Organisation

Q30 With regard to minimum requirements and qualifications for the investigators which have to be specified by the state accident investigation authority, please state your opinion from the following:

- ○ Minimum requirements and qualifications for the investigators have to be in place
- ○ Only minimum requirements have to be available
- ○ Only minimum qualifications should be available
- ○ No, it is not necessary for the state accident investigation authority to have in place such requirements and qualifications.

Q31 When assigning part time investigators to participate in an accident investigation, do they need to be **relieved** from their original duties during the investigation process?

- ○ Yes, the investigators should focus only on their investigation duties
- ○ Ideally, sometimes the investigators still need to perform their original duties as there is not enough staff to replace them
- ○ No, they can continue their original duties as well as participating in the investigation

Q32 Does the state accident investigation authority need to take necessary measures to avoid possible conflict of interest when assigning investigators from outside the authority to participate in an investigation?

- ○ Yes, the authority must ensure such conflict is avoided
- ○ Sometimes, despite the authority efforts, possible conflict of interest may occur
- ○ No, it is difficult to guarantee this

Q33 What does the term **"suitably qualified investigator"** mean to you?

Q34 Is the State accident investigation authority as a practice required to identify its **plans** to deal with different occurrences (e.g delegating or conducting the investigation)?

- ○ Yes, these should be made public
- ○ Yes, these should be internal documents
- ○ No
- ○ Other, please specify

Q35 Is the State accident investigation authority required to have **official** policies and procedures for the investigation tasks?

- ○ Yes
- ○ No
- ○ Other, Please specify

Q36 What should a State include in its **Policies and Procedures** to deal with an accident or incident?

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A process to deal with accident and incident notification during and out of work hours.	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A process to deal with notifying other involved states and ICAO as appropriate of an accident in a timely manner	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A policy to provide the state conducting the investigation with any relevant information regarding the aircraft and flight crew involved in the occurrence as soon as possible	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A policy to provide the state conducting the investigation with any information concerning dangerous goods on board the aircraft without delay (The State when acting as a state of operator)	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A policy to send a preliminary report to ICAO and other involved states when the maximum mass of the aircraft involved in accident is over 2250kg	○	○	○	○	○

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A policy to immediately inform aviation security in the state when discovering an act of criminal interference is involved or is suspected	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A procedure to ensure Flight Recorders (FDR & CVR) are recovered and their read out is conducted without delay	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A procedure to prevent publication of a draft report or any document obtained during the investigation process without the consent of the state conducting the investigation	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A procedure to ensure the final report is completed as soon as possible	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A procedure to ensure amendment to the final draft report is made based on the comments of participated states, or append the comments to the final report	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A procedure to send the final report to all states involved which include any state having suffered fatalities or serious injuries to its citizen	○	○	○	○	○

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
and any state which provide relevant information, significant facilities or experts					
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A procedure to send the final report to ICAO as appropriate	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A procedure to ensure safety recommendations to be issued at any investigation stage to any national or international organisation	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A procedure to record responses to its issued safety recommendations	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
A procedure to ensure when receiving a recommendation from another state to inform this state within 90 days about the preventive action taken or the reason why no action will be taken	○	○	○	○	○

Q37 Is the state accident investigation authority required to provide relevant information on the progress of the investigation to the families and accident survivors?

- ○ Yes, it should be obliged by the law to do so
- ○ No, it is not obliged but in practice it should provide such information
- ○ No, information will only be provided through the final report
- ○ Other, please specify

Q38 Why is it required for the state accident investigation authority to provide such information to the families and accident survivors?

Q39 Does the State accident investigation authority need to keep updated correct contact details for other states investigation authorities and ensure updating such information regularly?

- ○ Yes
- ○ No
- ○ Other, please specify

Q40 **Please state your agreement for each of the following statements;**

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The State accident investigation authority should have appropriate facilities to conduct the investigation	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The State accident investigation authority should have FDR & CVR readout facilities even it has a low rate of accident and incident	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The State accident investigation authority is responsible to provide the required equipment (e.g tools and marking equipment) to enable its investigators to conduct the investigation	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
Accident investigation equipment are required to be kept in an updated list	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The State accident investigation authority is responsible to have a special equipment to deal with hazards in the investigation site such as protective equipment	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
Means of communications and transport shall be available for the use of investigators in the site	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The State accident investigation authority must ensure that all investigation field kit and essential personal items are packed and ready to proceed to the accident site immediately and at any time	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The state accident investigation authority shall ensure the availability of storage facility to be used to protect the evidence and maintain the custody of the aircraft for such period as necessary	○	○	○	○	○

Q41 Is the state accident investigation authority required to establish a **formal training** system for its investigators?

○ Yes, it is required

○ No, investigators will learn by practice in the accident site

Q42 What kind of **training** should the State accident investigation authority offer to its investigators?

(**Please select all that apply**)

☐ Initial formal training

☐ On-the-Job training

- ☐ Accident site safety training
- ☐ Protection of evidence training
- ☐ Specialised technical training (e.g Non Destructive Testing - NDT, Recorders - CVR, FDR .. etc)
- ☐ Human factors training
- ☐ Witness interviewing training
- ☐ Data analysis training
- ☐ Report writing training
- ☐ News media and public relations training
- ☐ Other, please specify

Q43 What is the best option for the state accident investigation authority to train its investigators?

(Please select all that apply)

- ☐ Requesting ICAO assistance
- ☐ Cooperate with other states in its region
- ☐ Establish a local training centre to assist in the training of the staff
- ☐ Cooperate with internationally recognised training organisation
- ☐ Other, please specify

Q44 How do the authority investigators ensure their safety in the accident site?

- ○ Investigators should receive a regular training concerning their safety in the accident site
- ○ No need for regular training as Investigators will be familiar with how to be safe in the accident site based on their experience.
- ○ Other, please specify

Q45 **Please state your agreement with each of the following statements;**

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The State investigation authority shall develop a training plan for its investigators	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The developed training plan shall be updated regularly to reflect the	○	○	○	○	○

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
investigators training needs					

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The training plan shall be implemented correctly to ensure the investigators credibility	○	○	○	○	○

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The training plan shall include appropriate tasks for the technical staff such as on-the-job-training	○	○	○	○	○

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
Records of Training shall be maintained and updated	○	○	○	○	○

Q46 What does the term **"well trained investigator"** mean to you?

Q47 How does the state accident investigation authority ensure the required **level of training** for each investigator?

Q48 **Please state your agreement for each of the following statements;**

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The State accident investigation authority should implement a mandatory occurrence reporting system to facilitate the collection of information on actual	○	○	○	○	○

	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
or potential safety deficiencies					
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The State accident investigation authority should launch a voluntary occurrence reporting system	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The voluntary occurrence reporting system must be non-punitive and its information sources protected	○	○	○	○	○
	Strongly agree	agree	Neither agree nor disagree	Disagree	Strongly Disagree
The State accident investigation authority has to establish an accident and incident database to ensure the effective analysis of safety information that obtained from different sources	○	○	○	○	○

Q49 What are the benefits behind the analysis of the database information?

(**Please select all that apply**)

- ☐ To determine any required preventive action
- ☐ To monitor the safety level in the State aviation industry
- ☐ To independently analyse safety trends of operators in the State
- ☐ To aggregate data from several operators
- ☐ Other, Please add more in the following space

Q50 The following are proposed to be the most appropriate elements in developing the air accident investigation capability for any state. From your experience, please rank them (**1 = the most important, 8 = the least important**).

(**Drag items to rank**).

- Reporting Systems and Database
- Personnel (Investigators)

- Policies and Procedures
- Training
- Organisation (The structure)
- Facilities and Equipment
- Legislation and Regulations
- Independence

Q51 If you wish to contribute by adding any additional information to benefit this research, please add it in the following space:

Q52 Do you agree to be contacted for more discussion about this questionnaire through your provided contact information? (**Please note that, this information will remain confidential and will not be used in the data analysis**)

- ○ Yes
- ○ No

Q53 Please provide your contact details:

- ☐ Job Title
- ☐ Email
- ☐ Contact Number (Optional)

Appendix D Relative Importance Index (RII) Tables

Table D-1 RII and Ranking of Model Factors, Respondent Score

Dimension	No.	Statement	Respondent scores					RII	Rank
			1: Very low importance	2: low importance	3: Medium importance	4: High importance	5: Very high importance		
National Legislation	1.	Emphasis on the establishment of the AIA in the Legislation and Regulations	0	15	5	14	52	0.8480	**9**
	2.	Emphasis on the independence of the AIA in the Legislation and Regulations	0	14	3	10	59	0.8747	**2**
	3.	Emphasis on the investigation process as per Annex 13 provisions in the Legislation and Regulations	0	13	10	32	31	0.7950	**32**
	4.	Effective separation of the investigation process from any administration and/or judicial proceedings	0	13	5	8	60	0.8770	**1**
	5.	Prevention of access to the investigation site by unauthorised people	0	14	6	14	52	0.8506	**7**
	6.	Adequate prevention from the use of investigation safety findings in judicial inquiries	3	15	5	17	46	0.8120	**27**
	7.	The participation of accredited representatives in the investigation process	0	14	6	21	45	0.8337	**15**
	8.	Ensure the ability of the AIA to seek expert assistance from other States	0	13	4	16	53	0.8626	**3**
Policies and Procedures	1.	The availability of process to deal with accident and incident reporting during and outside of work hours	0	14	4	16	52	0.8554	**4**
	2.	The availability of process to deal with notifying other involved states and ICAO as appropriate for an accident promptly	0	14	4	16	52	0.8554	**4**
	3.	Providing the State conducting the investigation with any relevant information regarding the aircraft and flight crew involved in the occurrence ASAP	0	15	4	22	45	0.8337	**15**
	4.	Providing the State conducting the investigation with any relevant information concerning dangerous goods on board the aircraft without delay	0	16	10	14	46	0.8169	**23**
	5.	The availability of policy to send a preliminary report to ICAO and other involved States	0	15	14	21	36	0.7880	**33**

Dimension	No.	Statement	Respondent scores					RII	Rank
			1: Very low importance	2: low importance	3: Medium importance	4: High importance	5: Very high importance		
Policies and Procedures	6.	The availability of policy to immediately inform aviation security in the State when an act of criminal interference is involved or is suspected	0	16	5	17	48	0.8337	**15**
	7.	A quick decision to recover Flight Recorders (FDR & CVR)	0	14	6	12	54	0.8554	**4**
	8.	The availability of procedure to prevent publication of the draft report or any document obtained during the investigation process	2	15	8	14	47	0.8145	**25**
	9.	The availability of procedure to complete the final report ASAP	0	16	10	28	32	0.7831	**35**
	10.	The availability of procedure to amend the final draft report	0	15	7	23	41	0.8169	**23**
	11.	The availability of procedure to send the final report to all States involved	0	15	6	26	39	0.8145	**25**
	12.	The availability of procedure to send the final report to ICAO as appropriate	1	15	16	19	35	0.7735	**37**
	13.	The availability of a procedure to issue safety recommendations at any investigation stage	0	16	4	18	48	0.8361	**12**
	14.	The availability of a procedure to record responses to safety recommendations issued by the State	0	15	6	16	49	0.8386	**10**
	15.	The availability of procedure to ensure a preventive action is made regarding any recommendation received from other States	0	15	10	25	36	0.7976	**31**
Facilities and Equipment	1.	The availability of proper facilities in the AIA to conduct the investigation	0	40	22	10	14	0.8120	**27**
	2.	The availability of FDR & CVR readout facilities even with a low rate of accident and incident	7	14	21	38	6	0.6434	**40**
	3.	Adequate investigation equipment to be provided by the AIA	0	18	5	20	43	0.8120	**27**
	4.	Keeping of the Accident investigation equipment in an updated list	0	15	14	23	34	0.7831	**35**
	5.	The availability of special equipment to deal with hazards in the investigation site	0	16	8	14	48	0.8265	**21**
	6.	The availability of means of communications and transport for the use of investigators at the site	0	15	6	16	49	0.8386	**10**

Dimension	No.	Statement	Respondent scores					RII	Rank
			1: Very low importance	2: low importance	3: Medium importance	4: High importance	5: Very high importance		
	7.	Ensuring all investigation field kit including essential personal items are packed to proceed to the accident site	1	16	10	18	41	0.7976	**31**
	8.	The availability of storage facility for the AIA	0	15	9	21	41	0.8120	**27**
Training and Assessment	1.	The availability of a training plan for the AIA investigators	0	14	6	15	51	0.8482	**8**
	2.	Making regular update for the developed training plan	0	14	6	21	45	0.8337	**15**
	3.	Ensure the implementation of the investigators training plan	0	15	6	17	48	0.8361	**12**
	4.	The availability of appropriate tasks for the technical staff in the training plan	0	15	6	18	47	0.8337	**15**
	5.	Maintain and update of training records	0	14	7	18	47	0.8361	**12**
Reporting systems and database	1.	The implementation of mandatory reporting system	1	16	14	18	37	0.7735	**37**
	2.	Launching of voluntary reporting system	1	19	16	22	28	0.7325	**39**
	3.	The voluntary reporting system is non-punitive and its information sources are protected	1	16	6	15	48	0.8289	**20**
	4.	Establish Accident and incident database	0	16	7	17	46	0.8193	**22**

Table D-2 RII and Ranking of Model Factors, Respondent Score for Single Mode

Dimension	No	Statement	Respondent scores Single Mode					RII	Rank
			1: Very low importance	2: low importance	3: Medium importance	4: High importance	5: Very high importance		
National Legislation	1.	Emphasis on the establishment of the AIA in the Legislation and Regulations	0	13	1	8	28	0.8040	**3**
	2.	Emphasis on the independence of the AIA in the Legislation and Regulations	0	13	0	7	30	0.8160	**1**
	3.	Emphasis on the investigation process as per Annex 13 provisions in the Legislation and Regulations	0	13	3	15	19	0.7600	**22**
	4.	Effective separation of the investigation process from any administration and/or judicial proceedings	0	13	2	4	31	0.8120	**2**
	5.	Prevention of access to the investigation site by unauthorised people	0	14	2	7	27	0.7880	**7**
	6.	Adequate prevention from the use of investigation safety findings in judicial inquiries	1	15	2	11	21	0.7440	**32**
	7.	The participation of accredited representatives in the investigation process	0	13	1	13	23	0.7840	**9**
	8.	Ensure the ability of the AIA to seek expert assistance from other States	0	13	0	10	27	0.8040	**3**
Policies and Procedures	1.	The availability of process to deal with accident and incident reporting during and outside of work hours	0	14	1	7	28	0.7960	5
	2.	The availability of process to deal with notifying other involved states and ICAO as appropriate for an accident promptly	0	14	1	9	26	0.7880	**7**
	3.	Providing the State conducting the investigation with any relevant information regarding the aircraft and flight crew involved in the occurrence ASAP	0	14	1	13	22	0.7720	**14**
	4.	Providing the State conducting the investigation with any relevant information concerning dangerous goods on board the aircraft without delay	0	16	2	8	24	0.7600	**22**
	5.	The availability of policy to send a preliminary report to ICAO and other involved States	0	15	5	9	21	0.7440	**32**
	6.	The availability of policy to immediately inform aviation security in the State when an act of	0	16	2	10	22	0.7520	**27**

Dimension	No	Statement	Respondent scores Single Mode					RII	Rank
			1: Very low importance	2: low importance	3: Medium importance	4: High importance	5: Very high importance		
		criminal interference is involved or is suspected							
	7.	A quick decision to recover Flight Recorders (FDR & CVR)	0	14	2	6	28	0.7920	**6**
	8.	The availability of a procedure to prevent publication of the draft report or any document obtained during the investigation process	0	14	3	9	24	0.7720	**14**
	9.	The availability of the procedure to complete the final report ASAP	0	15	6	13	16	0.7200	**36**
	10.	The availability of procedure to amend the final draft report	0	14	3	11	22	0.7640	**18**
Policies and Procedures	11.	The availability of a procedure to send the final report to all States involved	0	15	2	14	19	0.7480	**30**
	12.	The availability of procedure to send the final report to ICAO as appropriate	1	15	6	9	19	0.7200	**36**
	13.	The availability of a procedure to issue safety recommendations at any investigation stage	0	16	1	9	24	0.7640	**18**
	14.	The availability of a procedure to record responses to safety recommendations issued by the State	0	15	2	8	25	0.7720	**14**
	15.	The availability of procedure to ensure a preventive action is made regarding any recommendation received from other States	0	15	3	11	21	0.7520	**27**
	1.	The availability of proper facilities in the AIA to conduct the investigation	0	14	4	10	22	0.7600	**22**
	2.	The availability of FDR & CVR readout facilities even with a low rate of accident and incident	3	27	8	6	6	0.66	**40**
	3.	Adequate investigation equipment to be provided by the AIA	0	17	1	10	22	0.7480	**30**
Facilities and Equipment	4.	Keeping of the Accident investigation equipment in an updated list	0	15	5	12	18	0.7320	**35**
	5.	The availability of special equipment to deal with hazards in the investigation site	0	16	2	7	25	0.7640	**18**
	6.	The availability of means of communications and transport for the use of investigators at the site	0	15	2	9	24	0.7680	**17**
	7.	Ensuring all investigation field kit including essential personal items are	1	16	2	10	21	0.7360	**34**

Dimension	No	Statement	Respondent scores Single Mode					RII	Rank
			1: Very low importance	2: low importance	3: Medium importance	4: High importance	5: Very high importance		
		packed to proceed to the accident site							
	8.	The availability of storage facility for the AIA	0	15	4	9	22	0.7520	**27**
Training and Assessment	1.	The availability of a training plan for the AIA investigators	0	14	2	9	25	0.7800	**11**
	2.	Making regular update for the developed training plan	0	14	2	10	24	0.7760	**12**
	3.	Ensure the implementation of the investigators training plan	0	15	2	11	22	0.7600	**22**
	4.	The availability of appropriate tasks for the technical staff in the training plan	0	15	2	11	22	0.7600	**22**
	5.	Maintain and update of training records	0	14	3	11	22	0.7640	**18**
Reporting systems and database	1.	The implementation of mandatory reporting system	1	15	9	8	17	0.7000	**38**
	2.	Launching of voluntary reporting system	1	15	8	13	13	0.6880	**39**
	3.	The voluntary reporting system is non-punitive and its information sources are protected	0	14	3	6	27	0.7840	**9**
	4.	Establish Accident and incident database	0	14	3	8	25	0.7760	**12**

Table D-3 RII and Ranking of Model Factors, Respondent Score for Multimode

Dimension	No	Statement	Respondent scores Multimode					RII	Rank
			1: Very low importance	2: low importance	3: Medium importance	4: High importance	5: Very high importance		
National Legislation	1.	Emphasis on the establishment of the AIA in the Legislation and Regulations	0	2	2	8	24	0.935	**6**
	2.	Emphasis the independence of the AIA in the Legislation and Regulations	0	0	1	4	31	0.967	**1**
	3.	Emphasis the investigation process as per Annex 13 provisions in the Legislation and Regulations	0	0	5	18	13	0.844	**36**
	4.	Effective separation of the investigation process from any administration and/or judicial proceedings	0	1	1	3	31	0.956	**2**
	5.	Adequate prevention to access the investigation site by unauthorised people	0	0	2	8	26	0.933	**7**
	6.	Prevention of access to the investigation site by unauthorised people	2	0	1	6	27	0.911	**18**
	7.	The participation of accredited representatives in the investigation process	0	1	3	10	22	0.894	**23**
	8.	Ensure the ability of AIA to seek expert assistance from other States	0	0	2	8	26	0.933	**7**
Policies and Procedures	1.	The availability of process to deal with accident and incident reporting during and outside of work hours	0	0	1	10	25	0.933	**7**
	2.	The availability of process to deal with notifying other involved States and ICAO as appropriate of an accident in a timely manner	0	0	1	8	27	0.925	**16**
	3.	Providing the State conducting the investigation with any relevant information regarding the aircraft and flight crew involved in the occurrence ASAP	0	1	1	11	23	0.911	**18**
	4.	Providing the State conducting the investigation with any relevant information concerning dangerous goods on board the aircraft without delay	0	0	8	6	22	0.933	**7**
	5.	The availability of policy to send a preliminary report to ICAO and other involved States	0	0	7	14	15	0.844	**36**
	6.	The availability of policy to immediately inform aviation security in the State when an act of	0	0	1	8	27	0.944	**3**

Dimension	No	Statement	Respondent scores Multimode					RII	Rank
			1: Very low importance	2: low importance	3: Medium importance	4: High importance	5: Very high importance		
		criminal interference is involved or is suspected							
	7.	A quick decision to recover Flight Recorders (FDR & CVR)	0	0	2	7	27	0.939	**4**
	8.	The availability of procedure to prevent publication of the draft report or any document obtained during the investigation process	2	1	4	6	23	0.861	**33**
	9.	The availability of procedure to complete the final report ASAP	0	1	2	17	16	0.867	**32**
	10.	The availability of procedure to amend the final draft report	0	1	2	13	20	0.889	**25**
	11.	The availability of a procedure to send the final report to all States involved	0	0	2	14	20	0.933	**13**
Policies and Procedures	12.	The availability of procedure to send the final report to ICAO as appropriate	0	0	8	12	16	0.844	**36**
	13.	The availability of a procedure to issue safety recommendations at any investigation stage	0	0	1	11	24	0.933	**7**
	14.	The availability of a procedure to record responses to safety recommendations issued by the State	0	0	2	10	24	0.922	**17**
	15.	The availability of procedure to ensure a preventive action is made regarding any recommendation received from other States	0	0	5	16	15	0.856	**34**
	1.	The availability of proper facilities in the AIA to conduct the investigation	0	0	4	14	18	0.878	**29**
	2.	The availability of FDR & CVR readout facilities even with a low rate of accident and incident	3	13	11	8	1	0.650	**40**
	3.	Adequate investigation equipment provided by the AIA	0	1	2	11	22	0.900	**22**
Facilities and Equipment	4.	Keeping of the Accident investigation equipment in an updated list	0	0	7	13	16	0.850	**35**
	5.	The availability of special equipment to deal with hazards in the investigation	0	0	4	8	24	0.911	**18**
	6.	Means of communications and transport for the use of investigators at the site	0	0	2	8	26	0.927	**15**
	7.	Ensuring all investigation field kit including essential personal items are packed to proceed to the accident site	0	0	6	9	21	0.883	**26**

Dimension	No	Statement	Respondent scores Multimode					RII	Rank
			1: Very low importance	2: low importance	3: Medium importance	4: High importance	5: Very high importance		
	8.	The availability of storage facility for the AIA	0	0	3	13	20	0.894	**23**
Training and Assessment	1.	The availability of a training plan for the AIA investigators	0	0	2	7	27	0.939	**4**
	2.	Making regular update for the developed training plan	0	0	2	13	21	0.906	**21**
	3.	Ensure the implementation of the investigators training plan	0	0	2	8	26	0.933	**7**
	4.	The availability of appropriate tasks for the technical staff in the training plan	0	0	2	9	25	0.928	**14**
	5.	Maintain and update of training records	0	0	2	8	26	0.933	**7**
Reporting systems and database	1.	The implementation of mandatory reporting system	0	1	4	11	20	0.878	**29**
	2.	launching of voluntary reporting system	0	5	7	9	15	0.789	**39**
	3.	The voluntary reporting system is non-punitive and its information sources are protected	0	3	1	10	22	0.883	**26**
	4.	Establish Accident and Incident database	0	2	2	11	21	0.883	**26**