A Model of Trust in the Work of an Air Traffic Controller

A thesis submitted to the University of Dublin,
Trinity College, for the degree of
Doctor in Philosophy

June 2005

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Declaration

The work described in this thesis is, except where otherwise stated, entirely that of the author and has not been submitted as an exercise for a degree at this or any other university.

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Summary

The research summarised in this thesis aimed at understanding the role of trust in the work of an air traffic controller (hereafter controller), as well as identifying the salient characteristics that a controller uses to decide whether to trust another or the technology they use in their work.

In this research, trust was understood as an expectation of the other's future behaviour, as a decision that involves risk, and as something that is developed in time, with experience. Trust was defined as a choice based on an expectation that expresses a willingness to act on the basis of the words, actions or a decision of another.

In the multi-disciplinary literature reviewed, in a number of domains competence was considered to be relevant for trust. The literature also suggests that it is necessary to follow an approach that understands trust from the point of view of the trustor (i.e. the person making the decision to trust another).

A model of trust was developed based on a review of the literature on trust and on an understanding of the domain gained through the observation of controllers at work, and information collected from questionnaires, focus groups, informal and structured interviews.

The model of trust was defined as being composed of three elements: Self, Belief, and Control. *Self* refers to the trustor's self-confidence and general attitude towards others and towards technology. *Belief* refers to the set of expectations, mental models or constructs that guide the way others are judged, as well as the way the world the trustor inhabits is understood. *Control* refers to the procedures, formal and informal rules that guide structure and constrain interactions, both between people, and between people and technology. Considering trust as depending on a judgement of how able the other (both human and technology) will be to fulfil a controller's expectations during their work, competence was chosen as the most relevant belief in the trusting behaviour of a controller.

A tri-partite study was carried out with French, Irish and Italian controllers to understand the characteristics of a competent controller and technology. The final result of this study was a number of 'rulers' of competence, which described the characteristics of a competent controller and technology, from least important to most important. The salient characteristics considered relevant by controllers were found to vary across nationalities. These 'rulers' of competence were used in a study carried out with Irish and Italian controllers to validate the model of trust.

A scenario-based questionnaire was developed, consisting of a series of ten stories describing a scene of a controller at work. The competence of the controller and/or the technology described in each scene was manipulated using the competence rulers. From the results of the scenario-based questionnaire study a degree of support was found for the Self and Belief components of the model. Although the manipulation of competence did not have a significant effect on decisions to trust the controller or technology described in the scenarios, a significant positive correlation was found between trustworthiness and competence ratings.

Further research is necessary, in particular with reference to the Control component. The differences found between nationalities advocate the need to further investigate the effects of working and national culture, as well as individual differences, on controllers' judgments of competence and trustworthiness for both people and technology.

This thesis has contributed to an understanding of the role and development of trust in Air Traffic Management by suggesting a structured approach to study trust, which will support the sharing and comparison of findings in the future, and by proposing a model of trust, which has been in part validated.

Acknowledgements

I wish to acknowledge Barry Kirwan for his support, constant encouragement and friendship. Without his help, this thesis would have never been written.

I am thankful to Alistair Jackson for the wonderful opportunity he provided me with and to EUROCONTROL Experimental Centre for the generous grant that supported this research as well as providing such a free and stimulating environment in which to work. I am also thankful to Nick McDonald for accepting to supervise this research.

For their support during the past year I am grateful to Integra S/A and Tony Joyce.

I am deeply indebted to a number of controllers who over the years have taught me all I know about air traffic control. Thank you to Christy Costello, Angelo Scorciarino, Paul Conroy, Philippe Averty and Kevin McGrath.

I am extremely grateful to the controllers at Athis-Mons, Ciampino, Dublin, Lyon, Maastricht, Milano, Roissy, Seattle, and Shannon who were so welcoming and generous in sharing their time and experience. I would like to especially mention Dani Berthelier, Sasa Martina, Mario Tiberia, Valerio Giuganino, Marco Gadda, Ally Carty, Donnie Mooney, Michael Thomson, and Jerry Traynor.

Thank you to Glenn Zink for organising my visit at Lyon ACC. Thank you also to controllers at Aix, Bordeaux, Brindisi, and Reims for filling out my questionnaires.

Thank you to the numerous controllers contacted via email and involved in simulations, as well as the operational staff at the Experimental Centre, who filled out my questionnaires and shared their ideas with me. Thank you Steven Bancroft and Andrea Pechhacker.

Furthermore, I would like to thank the project managers and simulation staff who always found time to fit my research needs into their busy schedules. In particular I wish to thank Motto Houlihan, Peter Eriksen, Franck Ballerini, Karim Zehal, Laurence Rognin, Andy Barff, Roger Lane, Rod McGregor, Peter Csnarnoy. For pointing me towards the right people thank you to Christian Pusch, Geraldine Flynn, Nigel Makins, Antoine Vidal, and Jean-Pierre Nicolaon. For the opportunity to be an observer in a simulation at CENA thank you to Lise Menuet, and to work in a simulation thank you to Mary Flynn.

Finally, I wish to thank my parents, Michael, and Nancy for their support and my friends, especially Mariya, Laura, Rinaldo and Sylvain.

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LIST OF ABBREVIATIONS

ACC	Air traffic Control Centre
AIB	Accident Investigation Bureau
ANS	Air Navigation Service
ASM	AirSpace Management
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
CFMU	Central Flow Management Unit
CFS	Collaborative Forum of air transport Stakeholders
CHIRP	Confidential Human factors Incident Reporting Programme
CNS	Communications, Navigation, and Surveillance
EEC	Eurocontrol Experimental Centre
FIS	Flight Information Services
FL	Flight Level
FPPS	Flight Plan Processing System
HCI	Human Computer Interaction
HMI	Human Machine Interface
IATA	International Transport Association
ICAO	International Civil Aviation Organisation
Nm	Nautical miles
NSTB	National Safety Transport Board
OJT	On the Job Training
OJTI	On the Job Training Instructor
SID	Standard Instrument Departures
STAR	Standard Terminal ARrivals
STCA	Short Term Conflict Alert
VDU	Visual Display Unit

Chapter One: This Thesis

1.1. Chapter Overview

The present chapter introduces the domain of interest, air traffic control, and the subject of this thesis, trust (1.2.). The rationale for studying trust in the work of an air traffic controller is described in section 1.3., and section 1.4. provides an overview of the thesis and its content.

This thesis is concerned with trust in the work of an air traffic controller. In differing degrees trust impacts all our interactions, with both people and technology. The research summarised in this thesis aimed at understanding the role of trust in the work of an air traffic controller, as well as identifying the salient characteristics that an air traffic controller uses to decide whether to trust another or the technology they use in their work. In order to explain these, a model of trust was developed, containing three elements. Furthermore, it was concerned with understanding how trust may influence air traffic controllers' acceptance of new technology.

1.2. Trust in the Work of an Air Traffic Controller

Air traffic control is a complex, collaborative activity, with well-established and successful work practices (MacKay, Fayard, Frobert, & Médini, 1998). Present Air Traffic Management systems are either loaded to their maximum capacity or are approaching such a level (Jorna, 1995). The traditional way of increasing capacity is to divide airspace into smaller sections; so more traffic is controlled by more air traffic controllers. The communication load of coordinating between sectors, however, increases as a function of the number of sectors per airspace. There is a limit beyond which the reduction in workload due to controlling less aircraft is compensated by the amount of time spent coordinating with other controllers on the telephone (Bellorini & Vanderhaegen, 1995). Another strategy is to introduce technology to support air traffic controllers. Decision support tools are expected to increase capacity by removing some of the routine tasks from the controller and by providing more accurate information (Eurocontrol, 2001).

The calibration of an air traffic controller's trust in others and in technology is perceived as relevant today for a number of reasons. The literature on trust assumes trust to be a precursor of cooperation (Deutsch, 1958; Baier, 1986; Kramer, 2001). Air traffic controllers (hereafter referred to as controllers) accomplish the safe and efficient air traffic control of aircraft by collaborating with colleagues and pilots through technology (e.g. radio/telephone), and by using information provided by technology (e.g. radar).

The control of traffic is strongly dependent on humans (Baker, 1996). In many centres in Europe there is a shortage of controllers which is being addressed through controller mobility and a trend towards the standardisation of training (Eurocontrol, 2000). The movement of controllers implies that in time a certain number of elements that naturally support common understanding between team members, such as common training and national culture, may no longer be in place. Thus, there is an increased interest in understanding the development of trust and its role in team work and cooperation in order to ensure that the salient characteristics that guide an appropriate trusting of colleagues are not lost, but maintained in the future.

In parallel to these developments, related to the shortage of controllers, continued reliance on the human element alone in the control of air traffic is expected to lead to a crucial imbalance between system capacity and demand (Eurocontrol, 1998). As the introduction of new technology is perceived as increasingly necessary (Eurocontrol, 1999; 2003a) so is an understanding of the mechanisms that optimise its interaction with air traffic controllers.

There are a number of factors that influence the acceptance and use of technology, such as its reliability and its perceived need by the users (Muir, 1989; Zuboff, 1988). One of the most interesting and less understood of these mediating elements is trust (Sheridan & Farrell, 1974).

Where technology has been designed without appropriate attention to its users, its introduction has resulted in a less than optimal use by the operators (Bainbridge, 1983; Wiener, 1987), who have found themselves unable to intervene in cases where the technology failed (Wiener & Curry, 1980).

In order to design tools which a controller will use appropriately, it is necessary to make explicit many of the natural cooperation mechanisms that are implicit between humans (Bellorini & Vanderhaegen, 1995). One of these mechanisms is the calibration of trust in technology (Muir, 1987).

Hopkin (1995) argues that new technology may remove the salient characteristics that both controllers and pilots use to assess the trustworthiness of others and the information provided by the technology they use. Hopkin gives as an example the fact that transmitting data between controllers and pilots by replacing voice with a text message, even if this is of high quality, will remove the manner, phrasing and pacing of speech that are salient characteristics in assessing the trustworthiness of the speaker (1995: 347). With regard to the trustworthiness of the technology, Hopkin (Ibid.) describes how the noise and echoes characteristic of the primary radar, have been removed in the newer secondary radar systems, providing less information on false signals. Another example of the same phenomena is provided by multi-frequency radio systems, which selects the strongest and best signal and cancels other signals. This means that if two pilots call at the same time, the newer technology blanks out the weaker signal. In older radio systems if two pilots called a controller simultaneously the controller would have been alerted of another missed communication by a squealing sound or buzz, supporting a correct calibration of trust in the reliability of the technology. The reason why this interference does not appear on new radios is the consequence of a design choice. Although the quality of the communication is much superior today, there is an important risk of missing a communication. Design decisions thus influence the way a controller uses technology but sometimes all the consequences of these decisions are not understood. According to Hopkin (1995), examples such as these have resulted in controllers being cautious in trusting new technology.

In differing degrees, it has been argued that trust mediates all our interactions with both people and technology (e.g. Luhmann, 1979; Golembiewski & McConkie, 1975; Lee & Moray, 1992). When we choose to trust another we are deciding if they are 'good enough' to carry out the task we are delegating to them, or if the automation is 'accurate enough' to give us the right information to make an informed and correct decision. A decision to trust a colleague and delegate a task to him/her, or to base an action on the information provided by technology, is then effectively the choice of a control strategy.

This thesis is aimed at identifying the characteristics a controller may use in judging colleagues and technology as trustworthy. A model of trust was developed and the hypothesis that a controller's trust in a colleague or in the technology available to him/her depends on a judgement of competence, identified as a salient characteristic in influencing trust and understood in the controller's terms, was investigated. Issues related to the study of trust and the use of a common approach to understanding trust in others and in technology are addressed. Furthermore, lessons learned from carrying out research in an applied setting are summarised.

1.3. The Rationale of this Thesis

The work described in this thesis was sponsored by Eurocontrol Experimental Centre (EEC). The research began as a study in the development of a controller's trust in decision-support tools, and the relation between the development of trust in tools and its acceptance. This interest was based on the pioneering work carried out by Muir (1989), who developed the first laboratory-based study to investigate the role of trust as an intervening variable in human-machine interactions in a supervisory control situation.

In the doctoral proposal of this thesis the overall objective of the research was described as "to develop a better understanding between human and machine, where the human is an air traffic controller and the machine is an automated system". Muir's work was consolidated by Lee & Moray (1992; 1994) in a series of studies that re-defined some aspects of her model of trust, showing that use of technology was influenced not only by trust, but also by the confidence the operator has in their own abilities.

Although Muir's (1989; 1994) work was the first in the area of human-machine interaction, the fact that all participants in her studies were university students raises questions on the generalisation of results to other domains. The safety and effectiveness of the Air Traffic Management (ATM) system is strongly dependent on the expertise and knowledge of controllers. It was necessary to explore whether it was possible to use a similar approach to that Muir and her colleagues in the domain of ATM, where decision-makers are experts and the system is complex and dynamic.

In the initial phase of the research the focus of the thesis moved from future to present day systems. During visits to control centres, carried out to learn about the work of air traffic controllers, it was found that trust has an important role in the way controllers work in present day systems, in their strong reliance on both their colleagues and the technology available to them. Furthermore, trust in their own abilities is something that is nurtured in the early stages of their training.

Trust was found to effectively have a role in the whole ATM system. Controllers reported learning to trust their colleagues with experience, and trust influencing the way they choose to delegate tasks to others or spend time monitoring their behaviour.

Pilots are continuously instructed by controllers and so have to have trust in air traffic controllers (McMillan, 1999; Dusire, 2000) and air traffic controllers have to trust that pilots will comply with their instructions once they have acknowledged them (Weston, 1983). Trusting others and the technology appropriately is seen as an effective workload management strategy (Wilson, 2000).

The focus of the thesis thus moved to first address methodological issues regarding the study of trust in an applied setting, and then to understand what controllers' trust in others and technology depends on in present day systems. The lessons learned in studying the ATM system of today are believed to be a necessary step to considering trust in future technology and decision support tools.

1.4. An Overview of this Thesis

This thesis has been written in eight chapters. The present chapter introduces the problems addressed by this research and summarises the content of the thesis, which suggests a structured way of looking at trust in an applied domain, here Air Traffic Management. The organisation of the thesis is represented in Figure 1.1.

INTRODUCTION TO THE RESEARCH SUMMARISED IN THE THESIS	
Chapter one	Introduction
Chapter two	Trust literature review
Chapter three	Introduction to Air Traffic Management domain
PRELIMINARY RESEARCH	
Chapter four	Understand the work of an air traffic controller
	Trust according to controllers
FORMULATING HYPOTHESES	
Chapter five	A model of trust in the work of a controller
TESTING HYPOTHESES	
Chapter six	Competence according to controllers
Chapter seven	The relation between competence and trust
DRAWING CONCLUSIONS	
Chapter eight	Conclusions and future research

Figure 1.1. The structure of this thesis

The decision to structure the thesis in this manner was made to underline the development of the research as a whole, which was characterised as much by the objective to describe a model of trust in the work of a controller, as by an exploration of ways in which trust could be studied in the domain of interest. It was decided to write the thesis without following the standard introduction, method, results and discussion format. This was to emphasise the way the research developed, from an initial qualitative approach to a quantitative approach. The initial part of the research, as described in the first four chapters, was characterised by a qualitative approach to the study of trust. This part of the study aimed at understanding on the one hand how trust had been conceptualised in the literature, and, on the other hand, at gaining a clear picture of the domain and work of an air traffic controller. Finally, this initial part was concerned with identifying the meanings controllers give to the word trust, and the role it may play in their collaboration with others and use of technology. Chapter five describes the model of trust developed on the basis of this qualitative work. The subsequent chapters describe the quantitative research aimed at finding support for the model as defined. Studies aimed at understanding competence from a controller's perspective, and its relation to their trusting behaviour, are described in chapters six and seven. Finally, chapter eight closes the thesis with conclusions and future work.

The following paragraphs briefly summarise the content of each chapter.

In order to study of the role of trust in the work of a controller and suggest a model of its development, it was first necessary to review the relevant trust literature.

Chapter two summarises the literature reviewed on trust. This review provided an understanding of the complexity of the concept and an appreciation of the richness of approaches used in the multi-disciplinary studies on the subject. Trust was understood as an expectation of the other's future behaviour, as a decision that involves risk, and as something that is developed in time, with experience. Competence was considered in a number of domains as being relevant for trust. Finally, the literature suggested that it was necessary to follow an approach that understood trust from the point of view of those studied (e.g. couples, managers, controllers.

Chapter three introduces the domain of Air Traffic Management to the reader who may not be familiar with this domain.

Chapter four describes the methods used and results found in the initial phases of the research, which aimed at acquiring a sound knowledge of the activities involved in the work of a controller, as well as understanding what trust meant to them.

This information was collected through a number of visits to operational centres, focus groups, questionnaires, and the participation in simulations.

When carrying out a study in an applied domain it is fundamental to acquire a good understanding of the domain. This is beneficial both for the researcher, who will be able to dialogue with the population studied, and thus interpret correctly the information received, but also for the domain, that will be able to benefit from the researcher's findings. Furthermore, this exchange is essential to justify the funding of such a project.

Chapter five summarises the approach taken in the study of trust in the work of a controller, and introduces the model of trust derived from the literature reviewed in chapter two and the understanding of the domain described in chapter four.

Trust was defined as a choice based on an expectation that expresses a willingness to act on the basis of the words, actions or a decision of another. The point of view taken was that of a controller, and the scope of the study was a working position, thus comprising the controller with whom the working position is shared, the controllers in the adjacent sector with whom he/she is in contact, and the technology available at the console.

A model of trust was developed and described in terms of three components: Self, Belief, and Control. *Self* refers to the self-confidence and general attitude of the trustor towards others and towards technology. *Belief* refers to the set of expectations, mental models or constructs that guide the way others are judged as well as the way the trustor understands the world they inhabit (i.e. the context). *Control* refers to the procedures, formal and informal rules that guide structure and constrain interactions, both between people and between people and technology. Considering trust as depending on a judgement of how able the other (both human and technology) will be to fulfil a controller's expectations during their work, competence was chosen as the most relevant belief in the trusting behaviour of a controller. This choice is in accordance with the theories on which Muir's (1989; 1994) model was based, and with the trust literature in general (chapter two).

Chapter six reports the results of a tri-partite study carried out with French, Irish and Italian controllers to understand the characteristics of a competent controller and technology. The study consisted of an information collection task, a card sorting task, and a paired comparisons task. The final result of these three tasks was a number of 'rulers' of competence, which described the characteristics of a competent controller and technology, from least important to most important. The salient characteristics were found to vary across nationalities, in judging the competence of both a controller and technology.

Chapter seven introduces the methodology followed to test the relation between competence and trust and describes the results of the study carried out with Irish and Italian controllers. A scenario-based questionnaire was developed, consisting of a series of ten stories describing a scene of a controller at work. Based on the rulers of competence for Irish and Italian controllers, the competence of the controller and/or the technology described in each scene was manipulated. Although the manipulation of competence did not have a significant effect on decisions to trust the controller or technology described in the scenarios, a significant positive correlation was found between trustworthiness and competence ratings. The analysis of individual scenarios identified issues for further research.

With regard to the specific approaches chosen, Table 1.1. provides an overview of the methodologies explored and describes a trend from an initially more qualitative, contextually-rich approach (e.g. observations, interviews), to more quantitatively-oriented methodologies (e.g. paired comparisons, scenario-based experiments). It can be argued that a study of trust necessitates both types of methods due to the fact that it is a multi-dimensional construct. Thus, trust depends on a number of variables that have to be first identified. However, due to the large number of dimensions identified by the literature, it is necessary to focus on those deemed most salient in order to gain an insight into their dependency.

Chapter eight summarizes the research described in the thesis to achieve a better understanding of the role of trust in the work of a controller. The chapter considers the findings in relation to the three components of the model proposed (chapter five), and identifies issues to be addressed by future research.

1.5. Summary of Chapter

This chapter introduces the problems addressed by this research and summarises the content of this thesis, which suggests a structured approach to look at trust in an applied domain.

The study of trust in the work of an air traffic controller is necessary because the literature on trust considers it to be a precursor of cooperation. A controller' work is based on cooperating with others and with technology, albeit today to a limited extent. Understanding how to best optimise these cooperative behaviours is important today for two reasons. On the one hand, there is a trend for controllers to become more mobile. Consequently, training is becoming more standardised and there is a risk that culturally- or national-specific enablers of cooperation be omitted. Thus, it is important to identify the enablers of cooperation between controllers. On the other hand, due to traffic growth technology is expected to become more of a team member and less of a tool. Thus, it is necessary to identify ways to optimise the interaction between controllers and the technology they use in their work.

The way this thesis has been written reflects the development of the research it summarises. The study of the role of trust in the work of a controller was first qualitative and then quantitative. The qualitative research is summarised in the first half of the thesis, and was concerned with specifying the problem, defining trust and understanding the domain. On the basis of this work, a model was described, according to which to understand trust one needs to consider three elements called self, belief and control. More generally, trust depends on characteristics of the trustor (i.e. the person that choses to trust), on characteristics of the trustee (i.e. the person, organisation, structure, or technology) as perceived by the trustee, and on the characteristics of the context. The second part of the thesis summarises the quantitative research carried out to validate the model of trust. Two main studies were carried out to accomplish this and are described in chapters six and seven. Chapter eight summarises the main conclusions and issues for future research.

Table 1.1.

Question	Methodology	Main answers	Relevant chapter
What is trust?	Literature review	Trust is a multi-dimensional construct. The context of the choice to trust is relevant but needs to be explored further	Chapter two
What does trust mean to a controller?	Questionnaires	Important to their work. Trust means believing, relying, depending.	Chapter four
What is the nature of the job of a controller & what are their tasks?	Observations Questionnaires	Team work. Redundancy of information. Believing and double-checking	Chapter three Chapter four
Who may the controller choose to trust or not trust in his/her work?	Observations Questionnaires	Self, others (controllers & pilots), technology & management.	Chapter four
What may a controllers trust in others & technology depend on?	Questionnaires Focus groups Semi-structured interviews	Ability, experience, communication, reliability, proof through testing.	Chapter four
How can trust in the work of a controller be modelled?	Synthesis of the analysis of trust literature &knowledge of domain.	Trust was modelled in terms of three components: self, belief, & control. The most relevant belief for a controller was hypothesised as being competence.	Chapter five
What is competence according to controllers?	Information collection task. Card sorting task. Paired comparisons exercise.	Competence in colleagues and in technology can be described in terms of a number of characteristics. These were found to vary between participant French, Italian and Irish controllers.	Chapter six
Does a judgement of competence influence a controller's choice to trust another controller or technology?	Scenario-based experiment administered to controllers in the form of a questionnaire.	Ratings of competence & trustworthiness were correlated in the replies given by both Italian & Irish controllers. The manipulation of lower & higher competence did not significantly influence a decision to trust.	Chapter seven

Note. The table summarises the questions asked in the research described in the thesis, the way they were addressed, the main findings and the relevant chapter.

Chapter Two – Literature on Trust

2.1. Chapter Overview

This chapter summarises the literature reviewed on trust, highlighting the main approaches, models or findings that influenced the research developed in this thesis. The first section (section 2.1.) provides an introduction and overview to the study of trust. Section 2.2. focuses on research carried out in human-human trust, in psychology it has focused on interpersonal relations, in sociology the role of trust has been considered in mediating social groups within a social context, and in organisational psychology trust has been conceptualised as a variable influencing the effectiveness of working relationships. Section 2.3. provides an overview of the research carried out in human-machine trust, focusing on Muir's (1989; 1994) work.Section 2.4. briefly describes the research on distrust or mistrust. Section 2.5. contains the main issues in the literature that influenced the research described in this thesis. The final section (section 2.6.) is a summary of the chapter's contents.

2.2. The Study of Trust

The etymology of the word trust is related to true and faithful (Chaucer, 2000). Trust is naturally associated with something positive, although this needs to be distinguished from morally appropriate (Baier, 1986; Gambetta, 1988).

Not only is trust vital to personal growth and development (Bowlby, 1973; Erickson, 1953), but also to learning (Rotter, 1967), cooperation (Deutsch, 1958; Good, 1988; Kramer, 2001), and effective team work (Zand, 1972). It has been argued that trust is a salient factor in influencing the dynamics of all social systems: interpersonal, group, and organisational (Golembiewski & McConkie, 1975).

Sheridan (1988) first identified the importance of trust in the use of technology, and Muir (1987) described its role as that of an 'intervening variable' in an operator's control strategy whilst interacting with automated tools.

Trust "in the broadest sense of confidence in one's expectations, is a basic fact of social life" (Luhmann, 1979: 4). Indeed trust seems to be fundamental to function in complex and interdependent societies, where "in every facet of our lives we are dependent on other people to behave in accordance with our expectations" (Tschannen-Moran & Hoy, 2000: 3-4).

As early as the 17th century, philosophers had identified trust as an expectation of others that provides a certainty which is necessary to guide our interactions with others, "a passion proceeding from the belief of him whom we expect or hope for good, so free from doubt that upon the same we pursue no other way" (Hobbes, 1994), and an essential feature of the relation between citizens and their government, entrusted with the protection of common rights (Locke, 1960).

Research on trust would appear to have been motivated from its absence or perceived decline. Baier writes "we inhabit a climate of trust as we inhabit an atmosphere and notice it as we notice air, only when it becomes scarce and polluted" (1986: 234).

In their thematic overview of the study of trust in American psychology in the 20th century, Tschannen-Moran & Hoy (2000) write that the systematic study of trust by social scientists began in the late 1950s, early 1960s, following the escalating suspicion created by the Cold war and by the optimism that science could resolve the arms race that had followed. An example of this work is that carried out by the behavioural psychologist Deutsch (1958), who operationalised trust as cooperation and found that increased communication between players in Prisoner's Dilemma games supported trust (Deutsch, 1960a).

In the late 1960s, Tschannen-Moran & Hoy (2000) identify the disillusionment and suspicion of the new generation with their institutions and authorities, as the force behind the focus of the study of trust turning to individual personality traits that influence judgements on the trustworthiness of politicians, media, and parents, amongst others (Rotter, 1967). Rotter defined interpersonal trust as "generalised expectancy held by an individual that the word, promise, oral or written statement of another individual or group can be relied on" (1980: 1).

By the 1980s, with an increasing divorce rate and changes in the structure of the American family, Tschannen-Moran & Hoy (2000) describe how research on trust concentrated on romantic interpersonal relationships (Johnson-George & Swap, 1982; Larzelere & Huston, 1980; Rempel, Holmes & Zanna, 1985). In their influential model on the development of trust in close relationships Rempel et al. (1985) suggest that trust is a dynamic expectation that undergoes predictable changes with time and experience. Three components of trust were identified as the basis of trust at different points of the development of the relationship. Rempel and his colleagues argued that the dispositional attributions made to the partner become increasingly abstract and evolve from reliability (based on 'acts'), to dependability (based on 'dispositions'), to faith (based on 'motivation'). Experience was considered essential because trust involves a willingness to put oneself at risk and thus with time feelings of security are able to increase with trust. The model is hierarchical in the sense that "there is a developmental progression in terms of time and emotional investment required to establish each component and in terms of the level of attributional abstraction each demands" (1985: 98).

Tschannen-Moran & Hoy's (2000) overview concludes with the shift in technology and society that characterised the 1990s and gave rise to the study of trust in the introduction of new technology (Zuboff, 1988), the relation between trust and use of automation (Muir, 1994; Jian, Bisantz, & Drury, 2000), as well as the role of trust in economic societies (Fukuyama, 1995) and organisations (Kramer & Tyler, 1996).

The study of trust in the 21st century is concerned with its role in optimising virtual teams (Rocco, 1998; Jarvenpaa & Leidner, 1999; Dibben & Panteli, 2000) and the development of electronic commerce (Kim & Moon, 1997; Cheskin/Sapient, 1999; Crawford, 2000; Egger, 2000; Riegelsberger & Sasse, 2001), as well as the understanding of trust as a human value, the manipulation of which in the design of new technology raises a number of ethical issues (Friedman, 1997; Friedman & Grudin, 1998).

This overview of the study of trust in time provides an idea of how wide-ranging research on trust has been. This diversity creates the first problem a researcher addresses in the study of trust, as "efforts to measure trust… are so variegated that the results of any two or more studies are not necessarily comparable" (Golembiewski & McConkie, 1975: 132). Effectively, as Lewicki & Bunker argue that there has been "remarkably little effort to integrate these different perspectives or articulate the key role that trust plays in critical social processes" (1996:115).

Mc Knight & Chervany (2001) suggest a classification scheme as a method to differentiate one conceptual type from another. They distinguish between three types of trust: impersonal/structural, dispositional and personal/interpersonal.

Impersonal/structural means that trust is founded on social or institutional structures, and is not a property or state of a person. *Dispositional* means that trust is based in the personality of the trustor, who may have a general tendency to trust others. Erickson described this as an "essential trustfulness of others as well as a fundamental sense of one's own trustworthiness" (1968: 96). *Personal/interpersonal* means that trust is specific to a certain person in a certain situation, unlike dispositional which is cross-situational.

Together with the breadth of definitions, Mc Knight & Chervany (2001) note that the perceived attributes of the trusted party are also varied according to type and domain of research. The attributes mentioned more frequently in their extensive literature review were: benevolence/caring/concern, competence, good will/good intentions, and honesty.

The severity of the homonymy of the research on trust is such that Lewicki & Bunker (1996) compared the definition of trust to the story of the six blind men and an elephant. Each man perceived the elephant differently because of the narrow portion of the elephant they felt.

This variability is due to a number of reasons: firstly what is important to trust varies from situation to situation (Mc Knight & Chervany, 2001), secondly trust exists at multiple levels of analysis (i.e. individual, group, organisation, institutional) (Mishra, 1996). Finally, each discipline has approached the study of trust from its own weltanschauung (world view) using its own lens and filters (Lewicki & Bunker, 1996).

Following Gabarro (1978) who, unlike most researchers, used the understanding of trust of the population he was studying (i.e. company managers), Mc Knight & Chervany (2001) suggest to start with a grounded, common sense, understanding of trust and to then relate it to the literature. Luhmann (1979) had argued for a similar approach as well. Thus, the first part of the research described in this thesis concentrated on understanding the domain of interest (chapter three) and what trust meant to air traffic controllers (chapter four).

This thesis is concerned with understanding controllers' trust in others and in the technology they use in their work. The following two sections of this chapter highlight the findings of a number of studies in the literature of interpersonal and human-machine trust.

2.3. Interpersonal Trust

This section reviews research carried out in psychology, sociology and organisational psychology. It begins with Gambetta's multidisciplinary definition:

> "Trust (or, symmetrically, distrust) is a particular level of the subjective probability with which an agent assesses that another agent or group of agents will perform a particular action, both *before* he can monitor such an action (or independently of his capacity ever to be able to monitor it) *and* in a context in which it affects *his own* action" (1988: 217).

This defintion will be used in this section to highlight the main issues of the interpersonal trust literature reviewed.

The fact that trust is described as a subjective probability means that trust is based on an individual's theory of how another will behave on future occasions (Good, 1988: 33). Good (1988) argues that to understand trust it is necessary to understand the cognitive operations which underlie an individual's perceptions and beliefs on the nature of their social world.

The measurement of trust is problematic as it can either be considered an absolute value (i.e. present or absent) or in terms of degrees, and thus a value on a scale, whereby above a certain threshold trust is considered present and below absent. Gambetta (1988) remarks that the threshold varies with different people, but also for the same person in different contexts. For this reason, trust has being described as a contextually dependent variable (Marsh & Meech, 2000). This is an example of Mc Knight & Chervany's (2001) impersonal/structural type of trust.

Researchers (Luhmann, 1979; Eurocontrol, 2003b) have also made the distinction between confidence that is considered an absolute value and trust that varies. However, the distinction between confidence and trust is valid in English, but not in other languages (e.g. French and Italian), suggesting that the concept of certainty underlying the two words may be the same. The most convincing solution is that proposed by Marsh (1994) and represented below (Figure 2.1.).

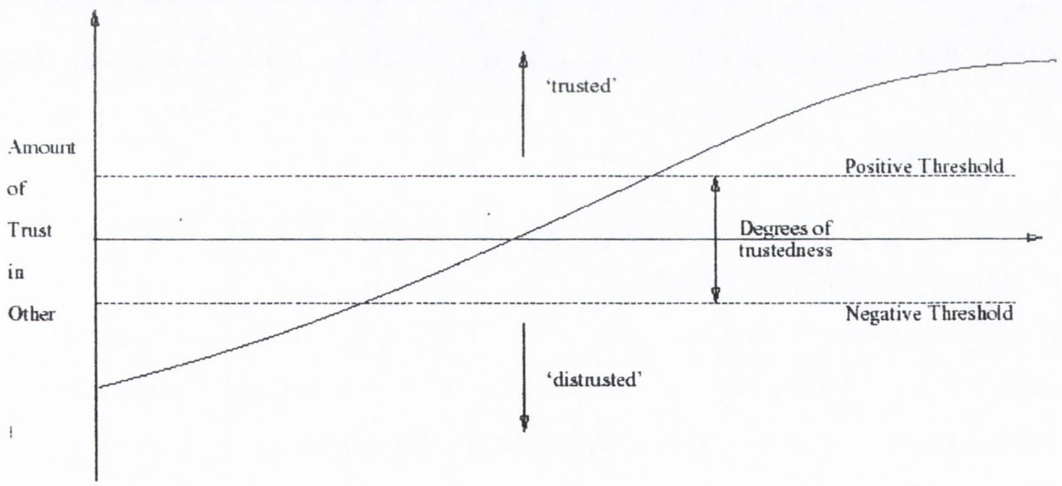

Figure 2.1. Positive and negative thresholds for trust. Reproduced from Marsh (1994:42).

According to Marsh (1994) a trustor will trust a trustee above a certain threshold, and not trust a trustee below a certain threshold. Between the positive and negative thresholds there is a grey area within which the trustee may be trusted, only in certain situations or contexts, but not all the time.

Returning to Gambetta's (1988) definition, he notes that the 'condition of ignorance' or uncertainty is central to the notion of trust. Luhmann (1979) described the function of trust as a means of dealing with complexity. It is only in ignorance that the trustor can decide to take a risk, thus putting themselves willingly in a condition of vulnerability where the potential for loss exceeds gain (Deutsch, 1958; Zand, 1972; Good, 1988; Luhmann, 1988). If the possible damage were not greater than the advantage, the choice to trust would simply be a matter of rational calculation (Luhmann, 1988: 98). Mishra (1996) argues that one's willingness to be vulnerable to another in business settings is based on the belief that they are (a) *competent*, (b) *open*, (c) *concerned*, and (d) *reliable*. This acceptance to be vulnerable has also been defined in terms of yielding control or power (Shapiro, 1987). Mayer, Davis & Schoorman (1995) also focused on trust as willingness to be vulnerable to the other and developed a model of trust based on the trustor's perceived attributes of the trustee in terms of *ability* (competence), *benevolence* (concern) and *integrity* (motivation).

2.3.1. Trust as a property of individuals

Following Lewicki & Bunker (1996), research on trust in the field of psychology has concentrated on two different conceptualisations of trust which, in terms of Mc Knight & Chervany's (2001) classification scheme, are equivalent to a dispositional and an impersonal/structural conceptualisations of trust.

Personality theorist have described trust as a psychological construct or trait, that individuals develop in varying degrees, depending on their personality experiences and prior socialisation (Deutsch, 1960b). Rotter defined trust as a "generalized expectancy held by an individual that the word, promise, oral or written statement of another individual or group can be relied on (1980: 1).

The focus of this research is on individual differences or differences in group averages (e.g. college students) across time. From a methodological point of view this research is predominantly based on psychometric scaling techniques.

The second conceptualisation of trust is represented by studies in laboratory experiments using Prisoners' Dilemma games, in which two people have the choice to collaborate or compete and their gains depend on the strategies the participants choose. In the most simple version of the game, if both participants collaborate the highest gains are accrued. If both do not collaborate no losses are incurred. However, if one only collaborates, the other other's gains are highest, higher then if both collaborated.

A behavioural interpretation of trust is proposed that equates trust with cooperation with others. Research following this conceptualisation focuses on the determination of situational variables that increase the level of trust or cooperation. Communication was shown to increase the choice to cooperate with the other, and thus trust (Deutsch, 1960a).

The relation between choice and trust has been made in the literature by many researchers (e.g. Baier, 1986).

Kramer (2001) argues that we rely on a number of rules to help us assess problems and make decisions or choices. According to the 'social auditor' model, individuals possess various kinds of rules to use when trying to make sense of what to do in trust dilemma situations (Ibid.). 'Interpretation rules' help categorise situations through mental models of social representations of others, self representation about one's own competence in judging others, and situational schemas. On the basis of the way the situation is understood, 'action rules' are used to determine the behaviour the trustor should choose to respond to the situation. According to this model, decision makers monitor the consequences of the choice of the rules and learn from their experience.

One of the 'interpretation rules' regarded the trustor's general attitude towards others, and Kramer (2001) found that 80% of the senior executives he interviewed were *social optimists* or *panglossians*, who consider most people to be fundamentally trustworthy. The remaining 20% of the participants to Kramer's (2001) interview, whom he called *social vigilants* or *pessimists*, who felt it necessary to continuously monitor others for any evidence of lack of trustworthiness. This categorisation between optimists and pessimists will be used in the model described in chapter five.

2.3.2. Trust as a property of social groups

In sociology, trust has been understood as a property of collective units, relations among people and not psychological states of isolated individuals (Lewis & Weigert, 1985). Luhmann (1979; 1988) argues that for a sociological theory of trust to be adequate it must bridge the interpersonal and systemic levels of analysis, which rely on rules to enforce behaviours and protect individuals. The function of trust is to reduce complexity and thus trust bridges between the individual and the collective allowing the individual to cope with living in an uncertain social environment (Luhmann, 1979).

The sociologist Barber (1983) considered the 'meanings and dilemmas' of trust in the American family, government, business and professions. Barber (1983) described trust as a composite of three expectations: the persistence of natural physical, biological and moral social order; of technical competence; and fiduciary responsibility. The first expectation was considered to be the basis for all other forms of trust as it establishes constancy and provides the basic conditions for social and physical interactions. Technical competence is related to future performance, understood to be based on knowledge, capabilities and expertise. Fiduciary responsibility refers to the expectation that a domain expert will not abuse their power, that people feel moral and social obligations not to cheat others in situations where their expertise would allow them to.

Extending Luhmann and Barber's work, Lewicki & Weigert (1985) argue that trust has cognitive, emotional and behavioural dimensions which merge into a unitary social experience. Trust is based on a *cognitive* process that has been described by Luhmann as "overdrawing" on the information base (Lewicki & Weigert, 1985:970). In other words, a cognitive base supports the choice of whom to trust, in what way and under what circumstances. This cognitive base serves as a platform for a cognitive 'leap' beyond the expectations that reason and experience would warrant. Other ways of saying this is that trust is believing without independent evidence (Rotter, 1967), or that trust is most relevant when we cannot predict behaviour (Held, 1968).

The element of risk is accepted as necessary for trust (Lewicki & Weigert, 1985; Dasgupta, 1988; Good, 1988). Luhmann (1979) emphasises that if there were no risk in the decision to trust, it would only be hope.

The *affective* component in trust is an emotional bond between those who participate in the relationship and is considered to be present in all types of trust, but to be most intense in close interpersonal relationships. The distinction between an affect- and cognition-based dimension of trust has been made by other researchers (e.g. McAllister, 1995).

The *behavioural* enactment of trust means taking a risk and acting as if the uncertain future of others' actions were certain, with the knowledge that negative consequences will result if expectations are not met. In other words, trust is believing without independent evidence (Rotter, 1967). Barber (1983) described this as expecting that others will act competently and dutifully. The behavioural dimension of trust reinforces the cognitive and emotional one (Lewicki & Weigert, 1985).

In terms of Mc Knight & Chervany's (2001) classification of trust models, Barber's expectation model and Lewicki & Weigert's cognitive process are equivalent to dispositional conceptualisations. The affective and behavioural component fall within the category of personal/ impersonal models.

2.3.3. Trust as a property of organisations

In the management and organisational psychology literature, trust between organisations has been measured through scales, such as the Organisational Trust Inventory (Cummings & Bromiley, 1996), where trust has been shown to depend on common goals, keeping commitments, negotiating honestly and avoiding to take excessive advantage of others.

Lewicki & Bunker (1996) proposed a model of interpersonal trust focusing on working relationships, suggesting a three-step model of trust, where the achievement of one step enables the development of trust at the next level, from *calculus-based* (where trust is based on a rational choice and vulnerability is accepted based on a cost and benefit analysis) to *knowledge-based* (where trust is based on the ability to predict others' behaviour) to *identification-based* (where trust depends on mutual understanding).
This model falls within all three of Mc Knight & Chervany's (2001) classification of trust models.

2.4. Human-Machine Trust

Trust in technology is considered to be essential in system performance (Sheridan & Farrell, 1974; Riley, 1994; Wickens, 1992).
The first laboratory-based study to investigate the role of trust as an intervening variable in human-machine interactions was developed by Muir (1989) in her doctoral work. Muir (1994) identified four main attributes of trust: the fact that it is an expectation, that it is future-oriented, has a specific and not a general referent, and can relate to a number of properties of that referent.

Muir defined trust as:

> "the expectation, held by a member of a system, of persistence of the natural and moral social orders, and of technically competent performance, and of fiduciary responsibility, from a member of the system, and is related to, but not necessarily isomorphic with, objective measures of these qualities" (1988:75).

Muir (1994) developed a model of trust in machines based on Barber's (1983) taxonomy and Rempel et al.'s (1985) models of the development of trust in a partner over time. The way these two models were crossed is represented in Table 2.1.

Table 2.1.

Basis of expectation at different levels of experience			
Expectation	**Predictability (of acts)**	**Dependability (of disposition)**	**Faith (in motives)**
Persistence			
Natural physical	Events conform to natural laws	Nature is lawful	Natural laws are constant
Natural biological	Human life has survived	Human survival is lawful	Human life will survive
Moral social	Humans and computers act 'decently'	Humans and computers are 'good' and 'decent' by nature	Humans and computers will continue to be 'good' and 'decent' in the future
Technical competence	J's behaviour is predictable	J has a dependable nature	J will continue to be dependable in the future
Fiduciary responsibility	J's behaviour is consistently responsible	J has a responsible nature	J will continue to be responsible in the future

Notes. An integrated model of trust in human-machine relationships, created by crossing Barber's (1983) model of the meanings of trust (rows) with Rempel et al.'s (1985) model of the dynamics of trust (columns). Statements in the cells exemplify the nature of a person's expectations of a referent (J) at different levels of experience in a relationship. Reproduced from Muir (1994:1916).

Muir (1994) argued that Barber's (1983) model of the meanings of trust as expectations and Rempel et al.'s (1985) model of the dynamic development of trust are not inconsistent. Barber's model provides the broader context and Rempel et al.'s model the dynamic factor needed to explain how trust changes.

Muir & Moray (1996) carried out two experiments using a simulated pasteurising process control system to validate this integrated model. The results of these experiments suggest that operator's subjective ratings of trust, together with the characteristics of the technology which determine trust, can be used to predict an operator's control strategy.

A strong positive correlation was found between trust and use of automation. The consequences of faults were also found to affect trust. If operators found a systematic bias in a system they learned to compensate for it, and their levels of trust did not change.

With regard to the meaning of trust in a machine, "the expectation of competence best captures what operators mean when they say they trust a machine" (Muir & Moray, 1996:

442). A strong relation between operator's judgement of the *competence* of the machine, defined as the extent to which it does its job well, and the amount of trust placed in the machine was found.

A strong negative relation between trust and monitoring was also found, which suggests trust is indeed a mediating variable in the control strategy chosen by an operator in their interactions with technology.

Finally, it was found that operator's trust changed little with experience. Due to the fact that the participants in Muir's studies were university students it is important to ascertain whether this is true in Air Traffic Management, a domain where decision-makers become experts with experience and time

Lee & Moray (1992) argued that the two models on which Muir (1994) based her integrated model were not as much orthogonal as complementary. They proposed a variation of the model that also took into consideration Zuboff's (1988) case study based work, according to which when introducing new technology into the workplace three aspects of the dynamics of trust should be considered. Zuboff described a *trial-and-error* period, a period during which the technology is *understood*, and a final development of *faith* in the system. Lee & Moray's (1992) model is represented below in table 2.2.

Table 2.2.

	Barber (1983)	Rempel et al. (1985)	Zuboff (1988)	Time
Purpose	Fiduciary responsibility	Faith	Leap of faith	
Process		Dependability	Understanding	
Performance	Technically competent performance	Predictability	Trial-and-error experience	
Foundation	Persistence of natural laws			

Note. An integrated model of the relationships between the different dimensions of trust. Adapted from Lee & Moray (1992: 1247).

According to their model trust depends on four dimensions. The first dimension is the *foundation of trust* and it represents the persistence of natural laws according to Barber (1983). The second dimension of trust is that of *performance* and it regards the expectation of "consistent, stable and desirable performance or behaviour" (Lee & Moray, 1992: 1246). The third dimension is process, which depends on the underlying qualities and characteristics that govern behaviours, such as traits and dispositions in people, or control algorithms in machines. The fourth and final dimension is that of *purpose*, which regards the motivation or intent of others. Time and experience may lead to the development of trust from foundation to purpose.

Lee (1992) was interested in how experience and learning influenced the operator's trust in automation and, in a series of experiments, looked at the relation between the development of trust in time and the reliability of the system. Lee & Moray (1994) carried out an experiment that found that changes in trust levels were related to control strategies. The development and erosion of the operator's trust was analysed by varying the system's reliability, in terms of type and frequency of failures. Operators adopted a wide variety of strategies to cope with the faults, sometimes at the cost of a great increase in workload. It was found that once lost, trust was only slowly regained. Furthermore, use of automation was found to be related to the operator's level of self confidence and could also be explained by individual biases towards the use of automation or less.

Lee & Moray's (1994) results have been confirmed by further studies that have shown that users generally tend to trust their own capabilities more than the ability of a device to complete a task (e.g. Liu, Fuld & Wickens, 1993).

Once again, the participants in these studies were students, so further research is needed to find whether biases towards automation are also present in professions that are trained to use automation.

Lee & Moray (1994) concluded that an operator's intervention in an automated system is governed to a large extent by the operator's trust in the efficacy of the automated systems, but also by their self-confidence in their abilities as manual controllers (Moray, Hiskes, Lee, & Muir, 1995). Moray & Inagaki (1999) proposed that whether trust and self-confidence determined the use of automation depended on the system and the operator's experience. Riley (1989) has suggested that together with trust several other factors may influence the use of automation, including the amount of risk and uncertainty associated with the task, the operator's knowledge of the automation and their self-confidence, as well as their level of workload when deciding whether to use the automation.

The models of trust in technology reviewed can be classified as dispositional because of the importance given to self-confidence, or personal/impersonal due to the relevance given to salient characteristics of the trustee that influence the trustor's decision to trust. Little importance has been given to the procedures that guide the trustor's use of the information provided by technology and the context within which trustor and technology interact.

2.5. Distrust or Mistrust

This review has necessarily been extremely selective and has only highlighted the main definitions, models and approaches to the study of trust to emphasise the influence of previous work on this thesis. An important issue in the study of trust that has not been mentioned is distrust or mistrust.

Although some researchers argue they are opposite (e.g. Rotter, 1967; Gambetta, 1988; Deutsch, 1962), most theorists agree that the two words are conceptual opposites of separate constructs (McKnight & Chervany, 2001). In other words, one may trust and distrust the same person under different circumstances, although if they trusted and distrusted the same person at the same time this would result in cognitive dissonance. Luhmann (1979) has argued that distrust is a functional equivalent of trust, in that one chooses between the two. Muir, Lee and Moray were all concerned with what type and frequency of system failures lead to and reinforced mistrust in the technology. In their studies they found that if failures are predictable, operators do not express lack of trust, but their trust level stays constant for as long as they can predict failures (Moray, Hiskes, Lee & Muir, 1996).

Zand (1972) introduces the idea of a *spiral of trust*, whereby "trusting behaviour begets trusting behaviour and mistrusting behaviour seems to foster more mistrusting behaviour" (Golembiewski & McConkie, 1975: 177). With regard to mistrust, doubt is stronger than faith, in the same way as fear is more powerful than hope (Bentham, 1948) and is thus self-perpetuating.

Govier wrote that "Distrust impedes the communication which could overcome it . . . so that suspiciousness builds on itself and our negative beliefs about the other tend in the worst case towards immunity to reputation by evidence" (1992:56).

Although this thesis will not address distrust or mistrust, it should be said that the literature is not definitive as to whether these concepts are opposite to or completely different to the concept of trust. Like trust, however, distrust or mistrust have been described as self-perpetuating and thus, at least in theory, the process that describe their development may be similar to that of trusting relationships.

2.6. Concluding Remarks

This section describes how the literature review influenced the research summarised in this thesis, in terms of the concept of trust, the approach to studying trust and previous trust models.

Two issues concerning the concept of trust were found to be common across different domains of research. The first was the understanding of trust as an expectation, as an individual's theory of how others will behave (Good, 1988:33). This suggested that to study trust in the domain of Air Traffic Control it was necessary to understand controllers' theories of how others will behave. This was achieved in part through observations, questionnaires, and interviews (chapter four), and in part from a review of the literature on decision making (chapter five).

The second aspect found to be common across human-human and human-machine studies of trust was the understanding of trust as a yielding of control. In the interpersonal literature this was described as a willingness to be vulnerable to others, in the organisational psychology in terms of risk, and in human-technology literature as delegating responsibility to another (Shapiro, 1987; Mayer et al. 1995; Mishra, 1996). Based on this assumption, it was necessary to identify who these 'others' may be in the work of a controller. How this was achieved is described in chapter four.

With regard to the study of trust, the main issues identified as relevant in the literature were the definition of the term, the scope of the research and level of analysis chosen.

Across domains agreement exists on the diversity in definitions of trust and approaches used to study it. A number of researchers (Gabarro, 1978; Luhmann, 1979; Mc Knight & Chervany, 2001) argue that a study on trust should have a grounded approach, beginning with the understanding of the term by the population studied. This means identified what trust means to controllers, which was achieved in chapter four. Furthermore, due to the fact that what is relevant to trust varies according to the situation (Marsh & Meech, 2000), it is necessary to understand what situations are relevant to trust in the work of a controller. The information summarised in chapter four suggests the situations and roles believed to be relevant to a controller's trusting behaviour.

Finally, the level of analysis needs to be chosen, from a dyad, to a team, to an organisation. This will depend, to an extent, on the definition of trust. The choice made regarding this issue is described in chapter five.

Starting from the assumption that trust influences all interpersonal relations, it was essential to clearly establish the scope of the inquiry and identify which relations were relevant when talking about a controller trusting someone else or technology. In order to do this not only was a good understanding of the domain necessary but information needed to be collected on the roles that are relevant to controllers when talking about trust. In the literature trust was considered to be relevant in effective teamwork, thus it was necessary to understand who is part of the team within which a controller works.

Based on the literature on interpersonal trust, relations characterised by dependency, need, reliance, belief, mutual understanding, as well as situations in which a choice to collaborate needs to be made, had to be considered. In terms of rules used to describe one's general attitude towards others, Kramer (2001) distinguished between optimists and pessimists. This distinction will be used in the model described in chapter five.

With regard to the characteristics found to be relevant to trusting others, the main ones were self-confidence, competence, personality, and experience Concerning trust in technology, competence was highlighted as salient from the literature, as well as ease of use, need, and reputation. Before considering the features of technology that are relevant to trust however, it was necessary to clarify what technology was relevant to controllers in their work and understand whether it was relevant to them

With regard to trust in machines competence was found to be a relevant characteristic, but the level of experience of the trustor was not

With regard to theories of trust, Mc Knight & Chervany (2001) formulated three categories within which studies on trust can be described, according to whether they focus on the trustor, the trustee, or the context where the trustor and trustee interact. This categorisation was used in the description of different models of trust in the literature review and it highlighted how trust studies have often been limited to the trustor's expectations of the trustee, to the characteristics of the trustee or to the properties of the context where the trustor and the trustee meet. This is not necessarily a weakness, however, it is important to be explicity about the scope of the approach chosen and to justify the choice of focus.

Mc Knight & Chervany's classification was also considered in the definition of the tri-partite structure of the model described in chapter five. The model of trust that was developed in fact encompasses three aspects of trust in terms of the structure of the context (*structural*), the characteristics of the person trusted (*interpersonal*), and the characteristics of the person trusting (*dispositional*).

2.7. Chapter Summary

The review of the literature summarised in this chapter provided the structure of departure for the research described in this thesis.

The scope and variety in approaches to the study of trust highlighted the necessity not only to define the term trust, but also to describe the context within which trust is being studied and the scope of the enquiry.

The definition of trust has changed in time and varies according to the domain of study. This renders problematic making comparisons between studies. Mc Knight & Chervany (2001) provide a framework to distinguish between models of trust that focus on the characteristics of the trustor, the trustee, or the context. This framework was used in this chapter when describing the literature reviewed and will be used throughout the thesis.

Using Gambetta's (1988) definition of trust three of the issues highlighted in the literature on interpersonal trust were described. The first issue is the fact that trust is based on a subjective interpretation of one self, others or the context, and thus it is necessary to understand an individual's perceptions and beliefs on the nature of their social world to understand trust. The second issue refers to the measurement of trust, which has been considered either a binary or a continuous variable. The third issue is the centrality of uncertainty to the notion of trust, as trust implies a willingness to be vulnerable to the other.

The literature on human-human trust or interpersonal trust was described in terms of a property of individuals, social groups, and organisations.
Trust as a property of an individual has been described in terms of a personality characteristic, which develops in time, or as a choice to collaborate based on rules used to assess problems and make decisions. Trust has also been considered as a property of social groups, where one's expectations of the others' behaviour depends not only on one's attitude towards others in general, as described in the psychology literature, but also on the role of the other in the social context. Finally, trust in organisations has been considered in terms of the role of experience in supporting shared understanding and reducing risk.

With regard to the literature on human-machine trust, the first laboratory-based work was carried out by Muir (1989) who developed a model, later refined by Lee & Moray (1992), that focused on the characteristics of the trustee, in this case technology, as well as those of the trustor, in this case an operator or user, and the role of time and experience in changing the trustor's expectations of a trustee. This work provides the foundation for future research on human-technology trust. As most of the research has been carried out in the laboratory using students as participants, the two aspects that need to be further clarified are the role of context and of the trustor's experience in influencing decisions to trust.

In terms of Mc Knight & Chervany's (2001) categorisation, in the literature reviewed on human-technology trust more relevance has given to the features of the trustee and trustor and less attention to the procedures dictating the use of the information provided by the technology.

To conclude, it can be said that the study of trust is multidisciplinary. Definitions, models and approach have indeed been varied and in most cases comparison across fields of research is not straightforward. However, it can be said that trust plays a role in interpersonal relationships and the use of technology, it is something that guides decisions on others' future behaviours, and these decisions depend to an extent on the ability of the trustee, as judged by the trustor. In many studies (e.g. Barber, 1983; Mishra, 1996; Muir & Moray, 1996) a judgement of competence, whether the trustee is another or a machine, was identified as a relevant variable in determining the trustor's choice to trust.

To conclude, this chapter has provided a brief overview of the multidisciplinary study of the multidimensional concept of trust. Definitions, models and approach have indeed been varied and in most cases comparison across fields of research is not straightforward. However, it can be said that trust plays a role in interpersonal relationships and the use of technology, it is something that guides decisions on others' future behaviours, and these decisions depend to an extent on the ability of the trustee, as judged by the trustor. In most fields of research it is agreed that a judgement of competence, whether the trustee is another or a machine, is a relevant variable in determining the trustor's choice to trust (e.g. Barber, 1983; Mishra, 1996; Muir & Moray, 1996).

The next chapter has been written to provide an introduction to the domain of interest of this thesis: Air Traffic Management (ATM).

Chapter Three: An Introduction to Air Traffic Management

3.1. Chapter Overview

This chapter provides an introduction to Air Traffic Management (ATM) for the reader who may be unfamiliar with the domain.

The first section (section 3.2.) describes the different components of the ATM system in order to show how the flight of an aircraft is planned and organised in advance, as well as in real-time, and thus controlled at a number of levels. Section 3.3. provides a brief introduction to how safety, the main goal of ATM, is assured. This section is followed by a high level description of the nature of a controller's work (section 3.4.).

An aircraft is controlled by controllers who have different qualifications according to the type of airspace controlled. The different types of airspace are first introduced (section 3.4.), followed by a description of the different types of control (section 3.6.). Effectively these two sections describe at a high level different ways of looking at an aircraft's flight, from the perspective of the aircraft's journey from one airport to another, and from the more limited perspective of a controller from the ground.

Section 3.7. describes in more detail a generic flight from the perspective of a pilot and of a controller. These illustrations serve to provide additional detail in context.

The final section (section 3.8.) closes the chapter with a summary of its contents.

3.2. Air Traffic Management

Air Traffic Management (ATM) involves the overall planning, organising and control of aircraft movements (ICAO, 1991). ATM is a sub-system of the Air Navigation System (ANS) that is composed of people, procedures and equipment providing ATM and CNS (Communication Navigation and Surveillance) services (Ibid.) (Figure 3.1.).

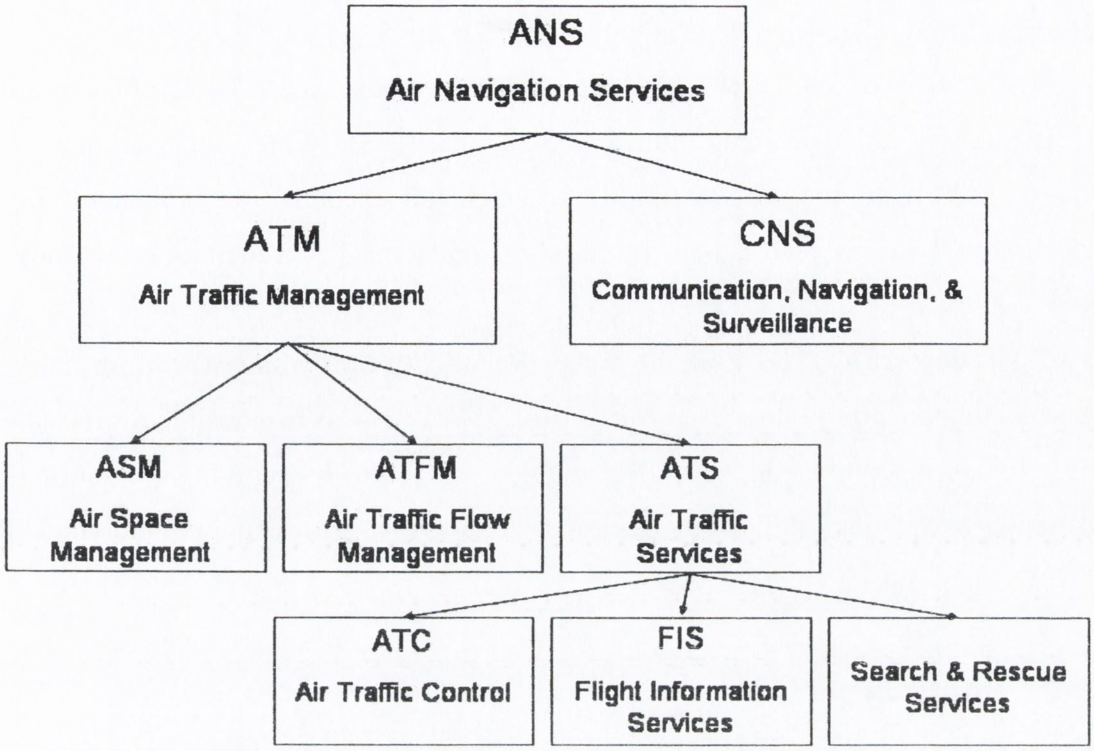

Figure 3.1. The ANS provides ATM and CNS services. ATM has three functions: ASM, ATFM and ATC.

The general objectives of ATM are to enable airspace users (i.e. pilots and airlines) to meet their planned times of departure and arrival, and to adhere to their preferred flight profiles with minimum constraints and without compromising the agreed levels of safety (ICAO, 1984).

ATM consists of a ground component and an air component, both of which are needed to ensure the safe and efficient movement of aircraft during all phases of operation.

The ground component refers to all the activities related to flights that are carried out on the ground. These activities comprise the actual organisation of the airspace and planning of traffic, and thus happen before an aircraft takes off.

Each national airspace is divided into a number of sectors, which are volumes or airspace, that are crossed by a number of routes, equivalent to double-lane motorways or shipping lanes (Hopkin, 1995), and along which pilots fly their aircraft.

The ground component includes the organisation of airspace in sectors and of the route network (ASM, AirSpace Management), ensuring that the amount of traffic planned to transit through each sector does not exceed the system capacity (ATFM, Air Traffic Flow Management) (Figure 3.1.).

The airborne component of ATM refers to the interaction between air and ground to attain the general objectives of ATM (e.g. the means that allows pilots and controllers to communicate). Effectively, the airborne component of ATM comprises the actual control of aircraft from their origin to destination (Air Traffic Services).

Air Traffic Services (ATS) (ICAO, 1991) provide three services: Air Traffic Control (ATC), the provision of Flight Information Services (FIS), and the notification to appropriate organisations of the need for a search and rescue service (i.e. identifying the location of the aircraft in distress, alerting fire-fighters and coordinating emergency services, etc.).

The objectives of ATC focus on the prevention of collisions while expediting and maintaining an orderly flow of traffic (ICAO, 1984). ATC is responsible for the safe, orderly and expeditious flow of traffic and this is achieved by applying separation (i.e. distance) between aircraft and by issuing clearances (i.e. instructions) to individual flights. The focus of this thesis is on ATC.

3.3. Safety in ATM

Safety is the first goal of ATM (ICAO, 1984) and thus also the main objective of the work of a controller.

In order to ensure the safe separation between aircraft, controllers consider aircraft as being surrounded by a 'bubble of space' that should never be infringed. The size of this imaginary bubble has standard dimensions but varies according to the type of airspace. For example, over the Atlantic Ocean both horizontal (latitudinal and longitudinal) and vertical separation are increased.

Safety is also ensured through standard procedures that allow expectations to be shared by the different actors in the ATM system, as well as a certain amount of predictability that is built into the system. This element of predictability is supported, for example, by structures such as fixed routes (Eurocontrol, 2001).

Moreover, there are large error margins (Leveson, de Villepin, Srinivasan et al., 2002) as well as a considerable amount of redundancy designed into the system (Rognin, Salembier, & Zouinar, 2000). This redundancy is created through overlapping expertise of staff, procedures that ensure mutual checking, and the support of technology that provides information from different sources.

An example of redundancy in the ATC system is the procedure in place that requires pilots to read-back to the controller instructions just given by the controller. This confirms to the controller that the instruction has been heard and understood by the correct pilot. The information provided by a pilot is not always read back by the controller, but is compared with that provided by the radar. For example, if the pilot reads back an instruction correctly the controller then monitors the aircraft's trajectory on the radar screen, to ascertain that the instruction has been followed.

Controllers often refer to the importance of redundancy, describing teamwork as having an "*extra pair of eyes and ears*" that ensure nothing is forgotten, misunderstood or missed. In other words, controllers who work together monitor each other for consistency, ensuring that inconsistencies are noticed and the reason for the discrepancy immediately addressed. To summarise then, safety in the work of a controller is ensured by a certain number of fixed structures that support predictability of aircraft's actions, redundancy built into the system, both in terms of multiple sources of information provided by technology, and in terms of mutual checking carried out between pilots and controllers and between controllers working together.

3.4. The Work of a Controller

The nature of the work of a controller is cognitive (Eurocontrol, 1997) in that it consists of a constant prioritisation of responses, the recognition of patterns that trigger well-known scripts, as well as the rapid identification of new solutions (Lenorovitz & Phillips, 1987). Among the number of cognitive skills of controllers Niessen and his colleagues (1999) argue that anticipation of future events is one of the most relevant. In order to anticipate the controller relies on expectations. These play an important role in mediating the cognitive processes of a controller because they provide a means to organise the information a controller sees and hears (McMillan, 1999).

Expectations however have also shown to be dangerous, as they contribute to supplementing inconsistent or incomplete information and sometimes the expectations are incorrect and thus the information is understood inappropriately (Palmer, 1995).

The work of an air traffic controller can be described as that of a decision maker in a dynamic, changing environment. Brehmer (1992) summarises Edwards' (1962) four characteristics of dynamic decision making as a series of decisions with a goal, that are not independent from one another, and that are made in a context that is changing both autonomously and as a consequence of the decision maker's actions. In addition to these characteristics, Brehmer (1992) argues that it is necessary to consider the fact that decisions are made in real time. In others words, decision makers are not free to make decisions when they feel ready to do so, but have to take decisions according to the demands of the environment. This is at the same time part of the expertise of a decision maker and an important source of stress.

One way to cope with this stress is to use a decision strategy similar to Simon's (1957) 'satisficing' one, according to which the first option that works is considered, not the best option. In other words, dynamic decision makers aim at finding a compromise between a good strategy for controlling the decision task and a strategy that allows the decision maker to control the rate at which he/she has to make decisions (Brehmer, 1992: 213). This can be interpreted in the context of a controller's work in terms of a compromise between the traffic demands and the controller's workload level. Controllers then balance the changing demands of the traffic with the limitations of their cognitive resources.

Before the introduction of radar, ATC was procedural and was carried out by providing aircraft with instructions via radio, according to standard procedures, and by keeping track of their positions as reported by pilots. This type of control was suited to low traffic density and a low workload environment (Laios & Giannacourou, 1995).

With radar, it became possible to monitor the progress of more flights, as accurate information on their altitude and speed was made available. This meant that the controller could be more flexible in choosing ways of separating aircraft.

The work of a controller changed in nature, with procedures acting as guidelines to decisions in a dynamic situation rather than standard instructions which, nevertheless, contributed to ensuring a shared understanding and predictability in terms of well defined mutual expectations between the different actors in the ATM system (e.g. controllers and pilots).

A controller's work today requires carrying out highly proceduralised sub-tasks while finding creative solutions to problems and determining which procedures to apply and when to apply them (Leronovitz & Philipp, 1987). Thus, controllers are often referred to as managers of a sector of airspace or managers of information from a number of different sources. For this reason, in describing the work of a controller, Air Traffic Control is sometimes used interchangeably with Air Traffic Management, suggesting a controller's job is more than 'simply' controlling traffic (Hollnagel et al. 1994).

In this thesis Air Traffic Control (ATC) will be used to refer to the work carried out collectively by controllers who provide a service to pilots. Air Traffic Management (ATM) will be used to refer to the domain of concern, which includes the service provided by ATC.

The next two sections describe the way in which the airspace is organised and the different types of control according to the type of airspace.

3.5. The Organisation of the Airspace

In order to talk about the organisation of airspace, the distinction needs to be made between regulated and non-regulated airspace (ICAO, 1984). Regulated airspace is divided into volumes of space called sectors, and is subject to international navigation rules that dictate how aircraft are allowed to operate (ICAO, 1984). European airspace is currently divided into a complex patchwork of sectors managed by 41 Air traffic Control Centres (IATA, 2002).

The main regulated airspace is controlled airspace, which is under the responsibility of ATC and consists of airways (i.e. corridors of airspace) that run from one beacon to another (Figure 3.2.). Beacons that are navigation aids that direct the pilot from one point in space to another along a route.

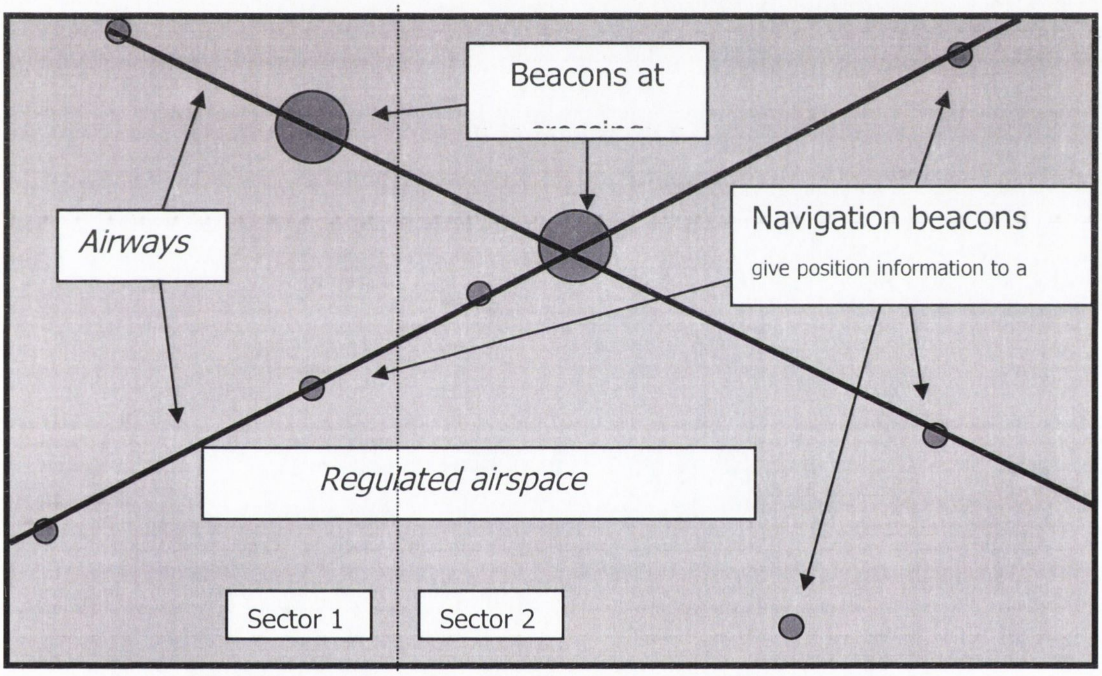

Figure 3.2. A representation of two sectors in regulated airspace, navigation beacons, beacons at crossings and airways.

Each of the 32 member states of Eurocontrol have divided their national airspaces, the boundaries of which are clearly defined, into sectors, that can change dimensions according to traffic levels or other constraints (e.g. military activity). The airway system is fixed as well, and is the equivalent of the motorway network that crosses the national European countries' boundaries in an often seamless way.

Airways can be thought of as multi-story motorways. They may have two lanes, one lane for aircraft flying from east to west and one lane for aircraft travelling from west to each. These lanes can also have a number of different floors or levels. For example, east to west traffic may flight at Flight Level (FL) 250 (i.e. 25,000 ft) and west to east traffic at FL260. Such an organisation implies that at FL250 and FL260 there will be a number of traffic lanes of aircraft all flying in the same direction.

The skill of a civil controller consists in ensuring that at the crossing point of airways aircraft are safety separated, and, at the same time, an efficient flow is achieved. Inevitably at crossing points aircraft are in conflict (i.e. if their progression is not regulated they will reach the crossing at the same time), thus the work of a controller can be said to consist of conflict detection and conflict resolution.

Although it has been suggested that airspace can be looked at as a puzzle made of sectors, another way of looking at airspace is in terms of the position of the sectors with reference to their closeness to an airport and altitude. According to this view, airspace is divided, from the ground at an airport upwards, into: ground, tower, terminal, and en route airspace (Figure 3.3.).

Although procedures and equipment vary significantly according to both the type of airspace as well as the state, it is possible to generalise and talk about ATC and ATM at a high level of description.

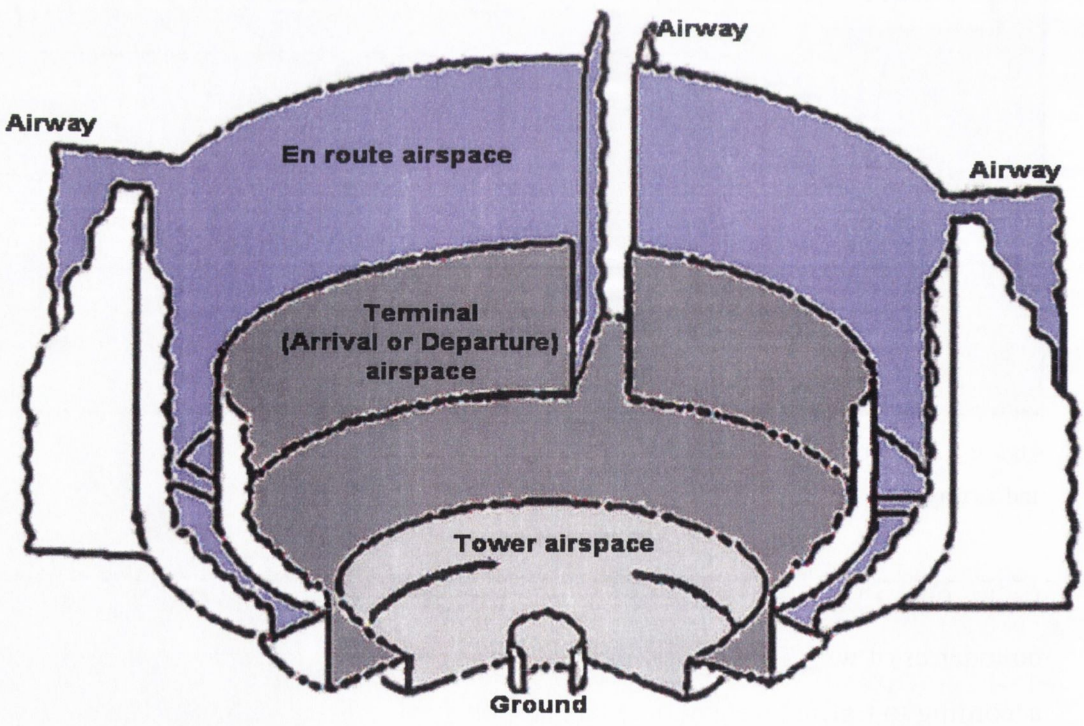

Figure 3.3. A representation of different types of airspaces: en route, terminal, tower and ground, as well as airways. Image modified from En route and Terminal airspace configuration. Reproduced from http://www.mlit.go.jp/koku/04_hoan/e/serv/airs/04.html

On the basis of this organisation it is possible to talk of different types of control, as will be explained in the next section.

3.6. Types of Control

Depending on the phase of the flight it is possible to distinguish between ground control (i.e. from the gate at the airport of origin to take-off or from landing to the gate at the destination airport), terminal control (i.e. from take-off to a specified distance from the airport, or from a specified distance to the airport of landing), en-route control (i.e. in between the departure terminal area and the arrival terminal area), and, in some cases, oceanic control (e.g. in Europe over the Atlantic Ocean, where procedural control is used) (Figure 3.4.).

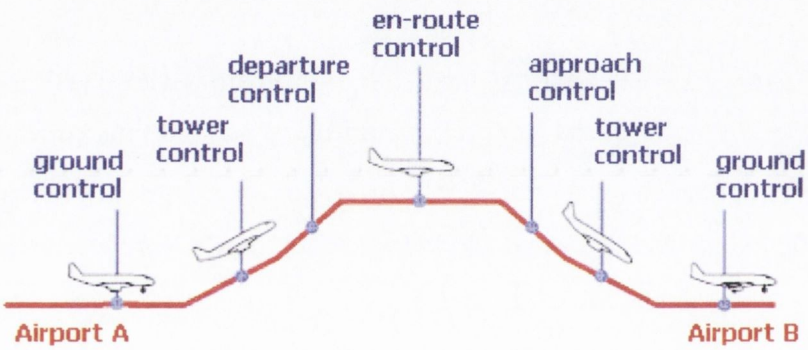

Figure 3.4. The picture describes the different phases of a flight from Airport A to Airport B. The image was modified from a Profile of a typical commercial flight. Reproduced from http://travel.howstuffworks.com/air-traffic-control2.htm

Aircraft are controlled at airports for the arrival and departure flight phases, and in Air Traffic Control Centres (ACCs) for the intermediate or en route phase.

In en-route control a team of two or three controllers, each of whom has a different function, controls each sector. In most Eurocontrol states there is a controller (i.e. Planning controller) who is in charge of planning the organisation of the incoming traffic and who co-ordinates with adjacent sectors, and a controller (i.e. Executive or Tactical controller) who is in charge of talking with the pilots and maintaining aircraft under his/her responsibility separated (Figure 3.5.).

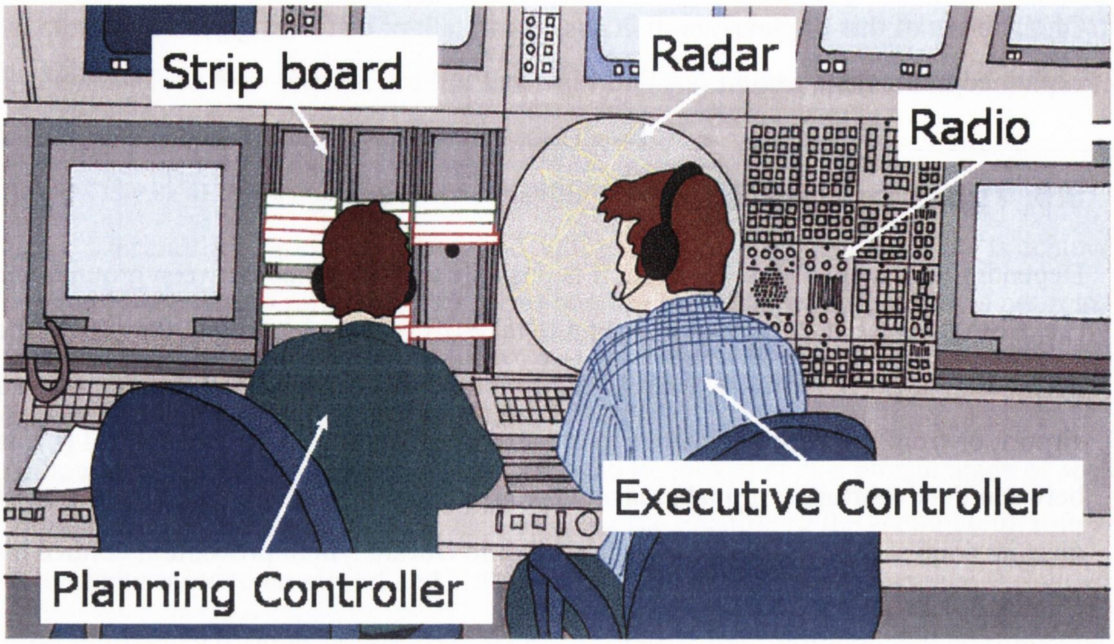

Figure 3.5. Two controller at work. On the right an Executive controller (EC), on the left a Planning controller (PC). The EC has the radar in front of him. The PC has the strip board in front of him.

In some centres there is a third controller (Co-ordinator) whose task is to ensure an efficient coordination between the two controllers, and with the surrounding sectors.

The controllers who manage the different phases of a flight have different ratings, or qualifications. The skills and knowledge required to control different sectors varies (Kirwan, Evans, Donohoe et al., 1997).

In airport towers we find ground-movement and tower controllers. In ACCs we find approach controllers and en-route controllers, as well as oceanic controllers, who are qualified to control aircraft without radar.

The number of controllers assigned to a sector and the division of tasks depends on the amount and complexity of the traffic. This varies between centres but also within centres at different times of the day. Usually the Executive controller watches traffic on a radar screen that is shared with the Planning controller, who has a strip board in front of him/her. In some centres both controllers have radar.

The organisation of radio frequencies is variable. The Executive controller is normally the one who speaks to pilots; the Planning controller may have the capability to do so or may not. Each sector is connected to adjacent sectors or centres, as well as the watch manager's desk, through phone lines. All equipment have one or two fall-back systems.

3.7. A Flight from Different Perspectives

Although they work together, pilots and controllers have very different perspectives on the nature of their collaboration.

From the point of the view of the pilot, a flight plan describing the itinerary that the pilot (or airline) would like to fly is filed at least 12 hours before the flight is due to take-off. Once this is accepted by the CFMU (Centre of Flow Management Unit in Brussels, Belgium) it is input into the central Flight Plan Processing System (FPPS). ATFM (cf. section 3.1.) is carried out on the basis of this information.

Once a pilot enters the cockpit the flight plan has been established, sent to the concerned states, and fed into the Flight Management System of the aircraft. Before turning on engines a pilot calls the tower and talks to the ground controller, who will give the instructions to turn the engines on and to push back from their gate. In a large airport another controller may take over at this point (i.e. tower controller) and will give the instruction for take-off and initial route information.

Busy airports have standardised initial departure and arrival routes that are called SIDs (Standard Instrument Departures) and STARs (Standard Terminal ARrivals).

Once the aircraft has taken off the pilot is instructed to contact the terminal control frequency. The terminal area controller will give the pilot information on how to continue his/her climb and shortly after instruct the pilot to contact another frequency in order to speak to an en route controller at an ACC.

The flight will progress with a series of instructions on altitude, heading and speed, as well as changes of frequency that correspond to communicating with different sectors and thus a number of controllers. The aircraft's passage across sectors and national boundaries is seamless.

Approaching an airport the en-route controller will transfer responsibility of the aircraft to the terminal area, from the pilot's point of view this corresponds to a change of frequency. The terminal controller will provide instructions either on the correct STAR to follow or on the descent route, as well as weather conditions.

Upon landing, the pilot will be asked to contact the frequency of the tower controller, who will guide the aircraft to its stand.

From the point of view of a controller a flight is relevant to their work for a short time before it enters and leaves his/her sector, and for the time it is under their responsibility and positive control (i.e. in radio contact).

The route the flight has been planned to fly (i.e. as input in the FPPS, mentioned above) in the sector under the controller's responsibility, is provided to him/her on a strip. Strips can be in paper format or in electronic format. The electronic strips do not necessarily refer to an electronic representation of a paper strip, but to the electronic provision of the information contained in the strip.

In most Eurocontrol member states paper strips are still used. These are printed approximately 20 minutes before the aircraft enters the sector and provided to the Planning controller to organise the traffic in advance. When the aircraft actually arrives in the sector the Executive uses the strips to know the ideal route that the aircraft is planned to fly. This planned route can either be that from the FPPS or one that has been changed by the planning controller, in coordination with the adjacent sector. When controllers make changes to the route they mark them on the paper strip, which thus becomes a history of the aircraft's flight through the sector.

The activities related to organising, marking and moving strips on the board support the development of the picture of the traffic (Albright et al. 1995; Bentley et al., 1992). The representation of the current traffic situation in a controller's working memory is referred to as 'picture' (Whitfield & Jackson, 1982). This representation is conceived of as an active construction of meaningful relations between elements of a situation (Niessen et al., 1999) that supports the prediction about future states (Rouse & Morris, 1986), and changes with the dynamic environment.

To the controller, an aircraft on its own has no meaning in the sense that it is part of a flow of traffic that needs to be managed safely and efficiently, either according to pre-determined patterns, such as take off sequences, or according to flexible plans that involve organising a dynamically changing traffic situation.

As described in section 3.4., it should be clear that the management of traffic is carried out within a set of constraints dictated by airspace configuration, as well as by internal procedures and working methods. Working methods are developed and learned by controllers with experience.

The picture is thus framed or constrained by a mental representation of rules, procedures and airspace that is achieved through training and continually developed through experience (Kirwan et al., 1997).

Muller (1996) describes the job of a controller as applying strictly defined procedures and abiding by countless regulations, while being confronted with new situations that need substantial flexibility in their response. The present situation is provided by the radar picture and the future one by information provided by the strips.

The fact that a flight is controlled by as many controllers as sectors it flies through means that controllers are strongly dependent on each other and that their ability to do a task is partly dependent on someone else doing other tasks (Harper et al. 1989). Fairburn et al. (1999) talk about this dependence in terms of the conceptual notion of 'joint activity', whereby a series of 'joint actions' are performed by a number of participants who coordinate their activity through methods that are mutually understood. In this context, Sire (1998) talks about social representations as being a reference system that is used to interpret a situation, providing people with beliefs about which behaviour to adopt next. These beliefs contribute to collaboration in a team because they provide implicit coordination between activities.

The reliance on others, both people and technology is an important aspect of the job of a controller, and particularly relevant to the study of trust in their work. Leronovitz and Phillips write that there is a strong dependency of controllers on the equipment they use, with which they "must develop a certain type of rapport . . . and be able to have complete confidence in its performance and reliability" (1987: 1776).

3.8. Chapter Summary

This chapter provided a brief overview of the functions of the ATM system, with a particular focus on ATC. The first goal of ATM, and thus of the work of a controller, is safety. Efficiency in the flow of traffic is the second goal. These two goals are achieved by controllers through conflict detection and resolution. The decision making strategies a controller uses are learned through training and experience, and are constrained by the architecture of the airspace, rules and procedures. A controller's work is the result of team work, and is strongly reliant on procedures, implicit and explicit, as well as on technology.

These procedures create a framework or a structure within which a controller takes decisions, which at the same time limit decision making and support expectations by other controllers and pilots.

The next chapter describes the methods used and information collected in the initial phase of the research, which focused on collecting information on the work of a controller and controllers' attitudes and understandings of the role of colleagues, pilots, technology and trust in their work.

Chapter Four: Understanding the Work of a Controller

4.1. Chapter Overview

This chapter describes the initial information collection phase of the research aimed at the researcher's familiarisation of the domain and understanding of the role of trust in the work of a controller.

The information was collected through observations, three questionnaires, and structured interviews. Each method of inquiry is prefaced by a brief discussion on the methodology used. The presentation of the methods and results in this manner is consistent with the way the inquiry developed in time, becoming richer in terms of the detail of results with an increasing appreciation of the domain of interest.

In order to learn about the nature and organisation of work, and gain an insight as to the type of technology available in present-day centres, visits and observation periods were carried out (section 4.2.).

To attain an understanding of controllers' attitudes towards colleagues, pilots and technology, as well as the role of trust in their work, three questionnaires were designed (section 4.3.). These questionnaires included questions that asked for examples of trust, over-trust or lack of trust, following a critical incident technique approach.

After administering the first questionnaire it was found that a limitation of this method of information collection was the lack of detail provided in the examples reported. For this reason, a series of focus groups were carried out to complement replies to a second questionnaire. The third questionnaire, focusing on ten questions found to be most informative on the nature of a controller's trust in others and technology, provided the possibility to analyse opinions of a number of controllers working in different countries.

Finally, examples describing the development of trust in trainee controllers and in new technology were collected through semi-structured interviews (section 4.4.).

Section 4.5. closes the chapter with general conclusions from the three approaches to understand the work of a controller.

Due to the length of this chapter, summarises have been written at the end of each of these sections to facilitate the task of the reader.

4.2. The Information Collection Phase

The initial phase of the research was an information collection phase and was characterised by a qualitative approach to research. This phase had two aims: to become familiar with the work of an air traffic controller, and to understand what trust meant to the controllers interviewed and its role in their work. Thus, on the one hand, a number of approaches were used to gain an appreciation of the work of an air traffic controller, identifying the relevant 'others' in their work. On the other hand, attention was given to conceptualising trust in the way it was understood by controllers and assessing its relevance in their work.

Although this phase had two aims, the results have been reported together in this chapter. There are three reasons for this choice. Firstly, with the exception of observations, the information to fulfil the two aims was collected at the same time. Secondly, together this initial part of the study forms the qualitative approach to the study of trust. Thirdly, together with the literature review, the results of this qualitative approach contributed to the development of the model described in chapter five.

It should be said that the results are specific to certain European states. The nationality of the controllers is mentioned when this was agreed with participants. Although to an extent it is possible to generalise and talk about European rather than, for example, North American ATM, there are a number of important differences between states in terms of working methods (Eurocontrol, 2000).

Differences between states and centres exist in terms of working methods, but also in terms of technology and procedures, organisational as well as national culture.

The nationality of participants and/or type of airspace is often an essential key to an appropriate interpretation of findings. On the other hand, there are issues related to confidentiality that need to be considered, as well as the difficulties of reporting in a neutral or non-judgmental way whilst making comparisons between states. The implications of these differences and issues related to the manner in which it was chosen to report them, are referred to in discussing the findings within each section.

At this point, it is opportune also to mention the fact that in all the studies carried out and reported in this thesis the possibility to control the sampling process of participants was very limited. The reader should be aware of the difficulties that researchers encounter in having access to a large sample of controllers in studies on ATM.

4.3. The Observation of Controllers at Work

In order to carry out research in a complex system, such as ATM, it is essential to have a good understanding of the domain of application (Hutchins 1995b; Vicente, 1999) and to learn to see the system from the perspective of those working within the system (Sanne, 1999). Hutchins (1995a; 1995b) revolutionised cognitive psychology by arguing that cognition is distributed between humans and artefacts, and in order to understand cognitive processes it is essential to observe cognition 'in the wild', spending time in the domain of interest learning from the expert decision-makers who are the focus of the study. Hutchins (1995b) suggests that manuals are a good starting point before spending time learning in the actual domain of interest. Unfortunately training manuals proved difficult to access, and were thus not used. A review of the literature specific to the domain provided the first introduction to ATM.

The nature of the work of a controller is cognitive (Eurocontrol, 1997) and the anticipation of future events is amongst the most important skills of a controller (Niessen et al., 1999). With experience, controllers learn to focus on a few relevant features of the traffic giving most of their attention to 'events' that are considered potential conflicts and less to the 'aircraft constellations' that have been judged to be safe (Ibid.). An understanding of these relevant feature necessitates an awareness of formal and informal work practices (Bentley et al., 1992), as well as of the informational and communication resources used by a controller to do his/her job. These aspects of a controller's work cannot be appreciated without a contextual inquiry (Hughes, Randall, & Shapiro, 1988; Sanne, 1999).

Hopkin writes "air traffic control is complex, more so than it seems at first . . . to an uninformed observer, most of air traffic control is not inherently meaningful, and it has only become meaningful to the controller because of training" (1995: 153).

Training and professional practice provide controllers with different types of knowledge and cognitive skills to meet the specific demands of tasks in such a complex system (Niessen et al., 1999). Controllers learn to use expectations as "hypotheses about the future based on experience, i.e. derived . . . from our stored patterns, scripts or schemas" (Roske-Hofstrand & Murphy, 1998) as one of the many strategies that controllers use to regulate their workload (Sperandio 1971). This would suggest that a lot of what makes up a controller's expertise is internalised with training and practice. Thus, a combination of observational and informal interviews appeared an appropriate approach to start a study of the work of a controller.

4.3.1. The Observer

A number of observations were carried out, in both operational centres and during simulations held at the Eurocontrol Experimental Centre (EEC).

On two occasions the role of the researcher in the observation of controllers at work during simulations, was to provide human factors support. With regard to the degree of intrusion, defined as "the degree to which the observed personnel are aware of the physical presence of the observer" (Kirwan & Ainsworth, 1992: 55), in most cases the level was usually observed observer. In observations of controllers at work in their centre or during simulations those observed were aware of the presence of the observer, who was co-located with them. In two cases, however, the observer was a participant in the simulation, as the researcher had the opportunity to participate in simulations designed to give non-controllers an opportunity to experience carrying out the tasks of a controller in a realistic situation with simulated traffic and operational experts acting as instructors. In other two cases it is possible to talk about non-observed observer, when the researcher sat in the jump-seat of two commercial flights and observed the work of controllers from a pilot's perspective.

4.3.2. Organising a visit

Due to the lack of a formal way of requesting a visit to a control centre, with time a protocol was developed. When organising a visit it is not possible to inform all controllers in the centre of the visit, the nature of the study and reason for the observation. It follows that spending time in a control room for a number of consecutive shifts means that even if the watch manager or supervisor is always aware of the presence of the visitor, the controllers starting their shift after the beginning of the visit may think the person is a new trainee or simply a visitor and not realise they are a researcher. Variability does exist with regard to the effectiveness of internal communication channels, depending on the size of the centre. Furthermore, the amount of information exchanged between controllers will depend on the organisation of working rosters. Whether all controllers working on a shift know each other, or whether each controller works following an individual shift, thus changing team regularly, can influence the quality of internal communications as well.
The protocol was conceived for ethical reasons. In highlighting the main ethical concerns that a researcher carrying out ethnographical studies needs to address, Hammersley & Atkinson (1995) report that it is necessary to not only inform those studied about the research in a comprehensive and accurate way, but also to gain their unconstrained consent. This was problematic in the observations carried out. Although informed consent

forms cannot be collected from all those working in the control room, it was understood that an effort needed to be made to at the very least inform participants about when the visit would take place and why it was being made.

The protocol developed included sending an introductory email to a senior member of management, explaining the motivations of the visit, the activities that were going to be carried out (e.g. observation, interviews) with the relevant material attached (e.g. hypotheses to be tested, objectives of observations, interview protocols). Furthermore, it was necessary to make contact with staff in the control room, to ensure that as many controllers in the room as possible would be made aware of the visit. Departmental guidance material and guidance from NASA (Williams, 2002) were used to develop consent forms for one-to-one interviews.

Although in one case a poster was prepared to explain the nature of the study, in most cases a request was made for the explanatory notice to be put up on the board in the staff or control room. Using such an approach in this domain was a novelty and controllers strongly appreciated being informed of their role as informants, the researcher's expectations, and their rights as participants in a psychological study.

4.3.3. Exploratory visits

Initially the focus of the visits was to learn about the nature and organisation of the work. Very general questions on shifts, shared tasks, responsibilities and requirements were asked. Working hours vary from state to state, as well as between centres, as they are mainly agreed with the unions. With regard to roles and responsibilities, their definition is part of the skill that is acquired with time, and formal descriptions are at a very high level. The cooperation of controllers sitting at a working position can be described using a Venn diagram (Balfour, 1966), that effectively represents how a planning and executive controller have their own tasks and responsibilities, but can share them according to workload and experience or expertise. In other words, as is represented in Figure 4.1., there are a number of tasks that are the sole responsibility of the Planning controller (e.g. to co-ordinate and resolve conflicts ahead of time) and of the Executive controller (e.g. to talk to aircraft and to resolve conflicts in real time), but there are also a number of tasks that are either shared or can be carried out by either one of the controller (e.g. the choice of a strategy for conflict resolution). In the case of the cooperative tasks, establishing clearly responsibility can be problematic.

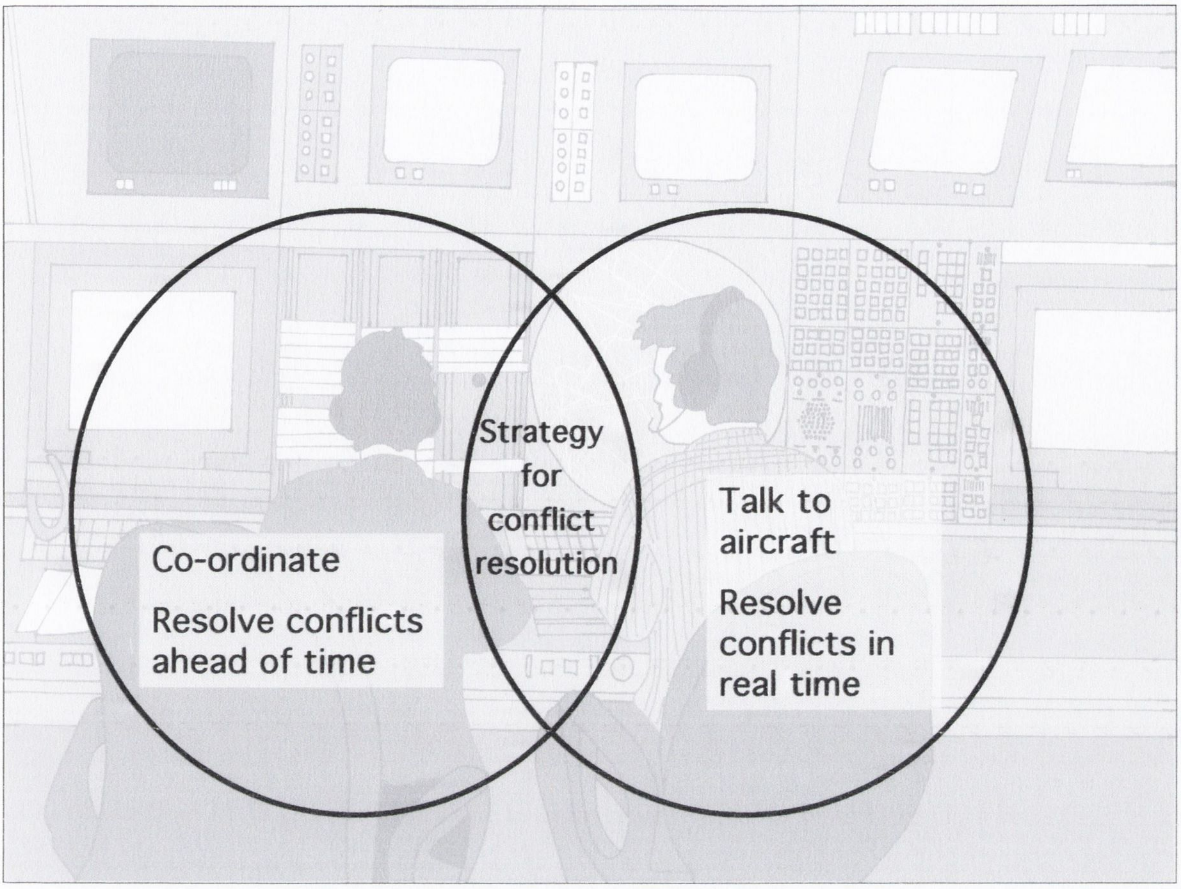

Figure 4.1. A Venn diagram representing the shared tasks, skills and responsibilities between a planning controller (on the left) and an executive controller (on the right). The shared tasks, skills and responsibilities are represented by the overlapping area in the middle. Examples of the tasks are given within each area.

The space shared by the two controllers can be understood in a number of ways: shared understanding (i.e. a common picture of the traffic), shared airspace and responsibility (i.e. a sector is under the active control of the executive but the planner is responsible for the organisation of the traffic surrounding the sector, entering and exiting it), or shared competencies (i.e. the same training, ratings or qualification).

The way controllers share this space was found to be different between centres, depending not only on the design of the airspace and the phase of the flight controlled, but also on the degree of familiarity between controllers. For example, those who have worked all their career in the same team know their colleagues very well, and reported being able to "*guess*" what their colleague was going to do next. The ability to do so, not only is an effective team resource management strategy, but is also known to depend on familiarity with the other team members and the clarity with which their intent is described (Klein, 1999: 232). Controllers describe the importance of this shared understanding in terms of redundancy that supports safety by providing flexibility and extra resources to compensate for human limitations in perception and attention.

An understanding of the way controllers are trained and achieve their ratings on different sectors and in different centres was gained. Variations here are starting to lessen, as many countries suffer from shortage of staff, and thus mobility is an increasing phenomenon. It should be said that one of the main roles of Eurocontrol is to achieve harmonisation across states, also in aspects such as licensing and training.
Procedures shared across centres according to international (i.e. ICAO) regulations and those specific to certain airspaces were learned, as well as details on the type of equipment and its basic functioning.

The radar and the radio are the standard tools used by a controller today. However, radar screens are increasingly being substituted by computer screens that support the presentation of more information. In addition to alarms and safety nets new system include medium-term conflict prediction tools and the possibility to share and transmit information from one interface to another. This changes substantially the nature of the work, which becomes increasingly reliant on the synthesised information provided by the new technology.
For example, electronic flight strips are available in centres at Rome and Maastricht, but not in the Dublin ACC. This influences not only the distribution of tasks between planner and executive controllers, but also the workload and the quality of the information, which in an electronic system should be more up-to-date. This is due to the fact that with the electronic strip the changes made to the route of an aircraft are input directly into the FPPS. Where paper strips are used, changes are transmitted to the next sector by telephone. On the other hand, paper strips can be used as a reminder (e.g. for the next shift of the opening or closing of an airspace) or as a sign that responsibility has been passed from one controller (e.g. ground movements controller) to the next (e.g. tower controller). This would suggest that in the introduction of new technology equal attention needs to be given to the new and old functionalities (i.e. specific technical capabilities) on which a controller relies (Hopkin, 1995).

Technology varies across states, and can be found to be used differently within the same state. For example, in Copenhagen Airport a closed-circuit television system is used to selectively display part of one controller's workspace to another (Berndtsson & Normark, 1999). In this way controllers can see which aircraft the previous sector is controlling.

The same system was observed in another control centre, switched off. When queried, controllers explained that they had tried to use it for some time, but colleagues' heads often obscured the vision of the screen and it was found simpler to communicate directly with the colleague sitting across the room.

Differences in use of technology can be also observed within a centre as well as between. For example, in one centre controllers working in approach used a system that helped them sequence aircraft. On a VDU (visual display unit) controllers could see the list of incoming flights complete with minutes to lose (i.e. the amount of time the aircraft has to lose before flying over a certain point in space, in order not to disrupt the flow of traffic) so as to have a good sequence (i.e. safe and efficient). The system had been developed by one of the controllers on their team who had previously worked in a larger ACC where this system had been introduced and certified. As the controller had a software engineering background he/she asked if he/she could create a replica. The management of the centre accepted and his/her team was supportive by giving them extra time off position to develop the tool. The controller's team helped test the tool as well, suggesting changes and improvements.

Watching a different team working in the same centre, it was observed that they never looked at the VDU. When questioned about the tool controllers explained they did not trust the information to be reliable, furthermore it was something management had introduced and they had not got training on it. The controllers reported not understanding where the information came from and whether to rely on it.

This episode would suggest that a tool can be used or not used for a number of reasons, which go beyond its design features. This example also suggests that user participation in the development of new technology, training, and the way in which its introduction is managed, can impact its use and trust by controllers.

4.3.4. Focused visits

With experience visits became justified by particular objectives, such as understanding co-operative mechanisms between controllers working together, studying the way technology was used, and focusing on how changes in working methods, procedures and technology are introduced and accepted by controllers.

These visits were characterised by a more structured approach to observation, such as described by Dray (2001). The focus of the visit, in the form of questions to be answered or initial hypotheses, was defined before observation. A record was kept of the observations made and information gained through informal interviews.

It was decided not to use video or audio tapes, as it was found that many of the controllers were not comfortable with this. Furthermore, video footage is labour-intensive and difficult to interpret unless it is complemented by screen shots, face shots and audio-recordings. Notes were taken in such a manner as to allow controllers to see what was being written, and comment on them at the end of their shift. Where possible, an open approach was preferred, that favoured the probing of those observed for explanations when opportune.

In the period during which the research described in this thesis was carried out ACCs in France, Ireland and Italy, as well as Maastricht Upper Airspace Centre (The Netherlands) and Seattle Air Route Traffic Control Center (USA), were visited. All together approximately 40 days were spent in operational centres, observing controllers at work and carrying out informal interviews.

Informal interviews imply very few assumptions about what is important in the work studied. Thus, especially at the early stages of research, this method of inquiry offers a significant benefit compared to more structured interview techniques (Berndtsson & Normark, 1999). The effectiveness of this technique, however, relies on the availability of informants in terms of time, opportunity and willingness to answer questions. Morse (1998) argues that because of the nature of the data collected, qualitative researchers have to find participants who not only have the experience in the topic and are willing to cooperate, but who are also able to reflect and share this experience.

Learning to judge when it is the right moment to ask a controller at work questions is something that is gained with practice, in terms of knowing "[to be] attentive to what people say, to ask questions rather than expose options, to listen rather than talk, to keep out of the way when there is a critical situation, to keep quiet when there is a high tempo situation" (Sanne, 1999: 50). Time has to be spent in the control room and the controllers observed need to feel comfortable being observed.

As argued by Dray (2001) in contextual inquiry the rapport with those observed is essential, as it not only allows one to explain the reason for the visit, but also to collect additional information on impressions and inferences. Most important, from an ethical point of view this approach respects the right of those observed to know what information the researcher is looking for.

Observational techniques do have limitations. For example, information supporting expectations is most readily found, rather than disconfirming hypotheses (i.e. confirmation bias). To counter this it was found useful to articulate hypotheses and expectations before carrying out the visit, and during the observation making an effort to seek for anomalies in what was being observed. Anomalies were the source of insights both in the system studied and in the researcher's pre-conceptions.

A second limitation of observational techniques resides in the power of the role of the researcher, as perceived by those observed. This needs to be considered and can, to an extent, be addressed through self-awareness, as the first step towards transcending bias (Cox & Beale, 1997). During the visits carried out, it was necessary to address the implications of an academic researcher and a student sponsored by Eurocontrol according to those observed.

4.3.5. Section summary

The starting point of this research was the assumption that for applied research to be valid a good understanding of the domain has to be gained.

To achieve this knowledge, exploratory and focused visits to ACCs were carried out. A protocol was developed to organise visits, in order to ensure controllers observed were informed of the nature of the researcher's visit and reasons for being observed. Exploratory visits were followed by observations with clearly stated goals (e.g. to understand how procedures moderated cooperative mechanisms used by controllers). Controllers' tasks, roles and responsibilities were learned, as well as the importance of teamwork and redundancy, of both information and resources, in a safety-critical environment. The relevance of procedures in dictating the decision-making of controllers was identified. This was important as it suggested that an understanding of the decision-making framework within which a controller works, where procedures create expectations shared by all actors, was necessary to clearly distinguish decisions to trust from decisions to follow procedures. An understanding of the technology controllers use in their work was also acquired, together with differences within and across centres in the way it is accepted and used.

Finally, the strengths and limitations of observational techniques were mentioned.

To conclude it can be said that differences were found in working methods, procedures and technology, both within and across centres. Thus, it is problematic to speak about general air traffic control. It was found, however, that interactions between controllers and with pilots were relatively proceduralised, in that tasks and responsibilities are defined. Thus, in some cases there is no question of trusting or not trusting another of the information provided by them/it, as the responsibility of accuracy lies with them. Understanding this framework was essential to distinguish between when a controller decides to trust and is simply following a procedure, which is known and assumed by other actors in the system.

4.4. Three Questionnaires

As mentioned above, the nature of the work of a controller is cognitive. Thus, to understand the way controllers' represent their work, their relation with others (controllers and pilots), and attitude towards the technology they use in their work, it was necessary to complement the understanding of the domain acquired through observations with a direct questioning of experts. Three questionnaires were thus developed.

The aim of these questionnaires was to address issues raised from the literature review summarised in chapter two. Thus, information concerning the definition of trust and expectations of others was elicited. Based on the literature on interpersonal trust, relations characterised by dependency, need, reliance, belief, mutual understanding, as well as situations in which a choice to collaborate needs to be made, had to be considered. It was necessary to identify such situations in a controller's work. Furthermore, it was necessary to identify roles of important others for controllers, as well as who they considered team members or actors with whom to collaborate. Finally, the literature suggests a number of characteristics as relevant to a trustor choosing to trust another person or technology. Information on the salient features of a trustee to be considered trustworthy by a controller was also collected.

The following sections introduce and summarise the main findings of three versions of questionnaires (Appendix A).

The main advantage of questionnaires is that they can be administered simultaneously and remotely to a group of respondents. However, attention needs to be given to the formulation of questions as well as to the way in which the tool is administered.

Although experimenter effects on research outcomes have been well documented (Rosenthal, 1966; Wilson & Corlett, 1989), it was felt that questionnaires were appropriate at the beginning of the research to gain information that reflected expert's opinions and attitudes in a domain unfamiliar to the researcher.

A general objective of the three questionnaires was to understand what controllers understood trust to be, whether it was relevant to what they did, and if so, what role it may play in their work. Although a few of the questions were maintained in all versions, the focus changed, reflecting a clearer understanding of the domain, as well as growing confidence in the subject matter, resulting in more specific questions, as well as a more appropriate interpretation of replies.

In designing and administering the questionnaires, lessons were also learned on the development of tools to collect information from experts, as well as on how to obtain permission and support to administer questionnaires in control centres from management and administration. For example, in the first pilot 35 questionnaires were printed and two incomplete questionnaires were returned. With afterthought, it became clear that not only the questions had been unclear but that both management and controllers had not been adequately or appropriately briefed on the nature and rationale of the exercise.

An understanding of the technical language and context of work, gained from observations and informal interviews, supported a more effective design of the questionnaires, as well as a more precise interpretation of answers. The use of the English language in the formulation of questions addressed to a majority of non-English mother-tongue respondents, as well an awareness of the image projected by the researcher, became issues to which particular consideration was given. Furthermore, the way in which information collected was going to be used, had to be made clear to participants and management alike.

Each of the following sections introduce the focus and concern of the questionnaire, the participants and administration of the tool, and summarise the results according to the themes described in the introductory section.

In analysing the results summarised in the next three sections a thematic analysis, as described by Hayes (2000), was followed. This consisted in:

- transcribing replies
- reading through notes and sorting items of interest into proto-themes
- attempting a first summary based on the examination of the proto-themes
- re-examining the transcripts for discordant information, as well as supporting data to illustrate the theme
- summarising the information collected according to themes.

Table 4.2. provides an overview of the number of respondents to each questionnaire, the number of questions in each tool, and the way it was administered.

Table 4.2.

Questionnaire No.	No. of Participants	No. of Questions	Administration
One	7	Part 1: 40	Simulation
	24	Part 2: 20	Simulation (parts 1&2 in group session)
	21	Part 3: 13	At ACC by senior controller
Two	14	Part 1: 12 Part 2: 12 Part 3: 11	Focus group
Three	14	10 questions	Simulation Email

Note. A summary of the number of participants and questions in each section of the three questionnaires. The last column specifies the context in which the questionnaire was administered.

4.4.1. Questionnaire One

The first questionnaire was called the 'Cooperation Questionnaire' (Appendix A 1) and was designed to collect information on controllers' beliefs and expectations of both their colleagues and the technology they use, as well as anecdotes from their operational experience, about failures that could be attributed to over-trust or distrust.

The need to collect this information was identified in the literature review. Thus, questions regarding the expectations of respondents towards others, the characteristics that signalled trustworthiness in another or in technology, and the type of relationship with colleagues and pilots, were asked. The name of the questionnaire reflected the nature of the questions, regarding how controllers collaborated with other agents in their domain (identified with the general term *referents*), and the fact that respondents were being asked for their collaboration in sharing anecdotes.

Following the first visits to control centres the ATM system was understood as being a team composed of controllers, pilots and technology. In order to control aircraft safely and effectively controllers interact with pilots and other controllers through technology and with technology. Based on this description a number of *referents* of trust (i.e. trustees) were identified: self, others (controllers and pilots), and technology (Bonini, Jackson & McDonald, 2001).

As mentioned in chapter two self-confidence, that can be understood as trust in one's own abilities to accomplish a task, had been identified by Lee & Moray (1992) as related to trust. Based on the visits carried out to operational centres, the most relevant others in the work of a controller were hypothesised to be colleagues in the control room and in adjacent centres, as well as pilots. Technology finally was seen as necessary for the accomplishment of the task of controlling.

An understanding of the way these referents were described, as well as their relation to the controller, was considered necessary to gain an insight into the controllers' sharing of tasks, cooperation and trusting behaviour.

Taking Muir's studies as a model, the researcher's intention was to collect examples in which trust had a role and use them in simulations. Furthermore, it was felt that antecedents of trust could be learned by eliciting critical incidents (Flanagan, 1954), where a critical incident was understood as an "event observed within task performance that is a significant indicator of some factor defining the objective of the study: (Castillo, 1997: 13). Examples of lack of trust or trust were elicited, as a situation considered significant by an expert is generally one that has lead to a lesson being learned and is for this reason memorable (Kirwan & Ainsworth, 1992).

Although questions on trust were included, in part one of the questionnaire the questions explored concepts that were identified in the literature as being related to trust, such as reliance, having confidence in another, and believing them (Luhmann, 1988; Riley, 1994).

Administration and format

A pilot version was administered to 18 controllers involved in three simulations at EEC and the replies suggested controllers were not very forthcoming with providing examples either of their own shortcomings or of failures of the system . Thus, a number of questions were rephrased, and emphasis on both negative and positive events was included. Furthermore, questions asking for personal details on the informant (e.g. nationality, age, number of years of operational experience) were removed. These fields in fact had not been completed in the majority of cases. In time it was learned that anonymity was a necessary pre-requisite for a controller to complete a questionnaire, unless the researcher was well known to the respondent and was trusted.

Three groups of controllers completed the questionnaire (Table 4.2.). The first group of respondents (N = 7) was administered the questionnaire by a senior controller involved in the running of the simulation they were taking part in.

In the administration of the questionnaire to the second group of controllers (N = 24) the researcher was given the opportunity to introduce the tool and talk about the research to the participants, who compiled the first two parts in a group session with the researcher present. Participants had the opportunity to discuss issues they agreed or disagreed with.

The completed third part of the questionnaire was returned the next day, having been completed at home.

Finally, the controllers in the third group of participants (N = 21) were not involved in a simulation, but were given the questionnaire by a fellow controller in their centre, and completed it in their own time. The researcher received the replies by post.

With regard to the format, each questionnaire was prefaced by a cover letter describing the research objectives of the study as concerned with understanding how to model the interaction between controllers and other people, and controller's use of technology.

The survey was made up of a total of 73 items: 35 questions (open and closed ended) and 40 statements that respondents were asked to assess using a 5-point Likert scale (from 'strongly disagree' to 'strongly agree').

The questionnaire was divided into three parts. This was to allow respondents to fill the parts separately, during breaks or between exercises of the simulation. Individual sections were introduced by a brief description of the content of the questions.

Part one (Appendix A 1.1.) focused on team work. This first part was composed of 40 statements that related to working alone or in a team, the role of the other agents in the ATC system, believing and double-checking the information they provided, as well as sharing perspectives and understanding. From the visits carried out to operational centres a number of referents were identified as members of a controller's team or relevant others in their work. This section focused on understanding whether these referents were indeed considered relevant by controllers in their work. Furthermore, the use of the information provided by technology was considered.

Part two (Appendix A 1.2.) focused on the respondent. Questions were asked on the role of self-confidence, on the most important aspect of a controller's work, as well as on the sources of information that were considered reliable, and the role of others as support. These questions aimed at understanding in some detail a controllers' expectations towards others as well as who was considered as a team member.

Furthermore, the relation between co-operation and trust was explored as the literature assumes them to be related. A definition of trust was sought in order to use controllers' point of view in studying trust, as suggested by a number of researchers (Gabarro, 1978; Mc Knight & Chervany, 2001). A number of closed-ended questions regarding trustworthy characteristics identified in the literature were included. Finally, due to the fact that in both the human-human and human-machine literature competence was considered as a salient characteristic in influencing a trustor's decision to trust an open-ended question was included asking for a description of a competent controller.

In *part three* (Appendix A 1.3.) the focus was on technology, its role and characteristics influencing its use. Questions were also asked on believing the information provided by the technology and by others in the ATC system. The aim of this section was to understand respondents' attitudes towards the technology used in their work. In the literature reviewed (Muir, 1989; Lee & Moray, 1992) trust had been operationlised as use, thus questions were formulated to understand what the use of information provided by technology and others depended on. A simplified scenario taken from the incident literature available on Internet was used to understand whether respondents were biased towards humans or technology as providers of reliable information.

Participants

The questionnaire was administered to a total of 52 respondents, of which 31 controllers were involved in simulations conducted at the EEC and 21 completed the questionnaire in their control centre (Table 4.2.).

Results

The results have been summarised in four sections. The first section concentrates on the questions that dealt specifically with trust, the majority of which were contained in the second part of the questionnaire. The following three sections refer to the referents of *self, others, and technology*. In each section, responses from the first part of the questionnaire have been summarised first, followed by those from the other two parts.

Trust

In the second part of the questionnaire respondents were asked to define trust in terms of its role in ATC system, as well as what their level of trust in fellow controllers, pilots, and technology depended on.

Respondents agreed that trust is an important element for the system to work properly (36% of replies), and it permeates the whole system (20%). One controller wrote: "*I believe what I see on radar, I should believe what I hear on the radio/telephone, I must have faith in my colleagues*". Trust was considered in terms of a belief (26%), and appeared to be calibrated to the different elements in the system (15%).

Overall respondents defined trust as a belief in others' ability (36%), and confidence in the equipment (31%). To describe what being a trustworthy controller means, one respondent wrote: "*self-confidence, [being] knowledgeable and [having] experience*".

With relation to other people, trust was described as a belief in someone's competence (86%), their commitment to work to their ability (15%), and provide accurate information (26%), as well as being able to rely on others (17%), as one respondent wrote: to "*look out for you*".

Concerning the technology, trust was reported as referring to confidence in the equipment (15%) and knowing that one can depend on the correctness of the information (50%). Controllers' understanding of trustworthy people and technology had in common reliability and confidence in the accuracy of information. One controller wrote: "*in the same way that people trust or not their colleagues, I trust or not the system I work with*".

Self confidence

Controllers defined self-confidence as being reliable (11% of replies) and responding fast to the pressures of time and traffic (13%). It is acquired with experience (4%), and considered essential to keep a situation under control (46%). As one controller wrote, "*the subjective feeling of mastering the situation is even more important than the objective control of it*". Being confident then means believing in ones abilities (15%), and this helps make fast decisions (48%).

Another controller explained that "*it is important to come across confident because if your instructions are issued clearly and confidently, they will not be questioned, and it is more likely they will be complied with*". Self-confidence was understood as believing in oneself (15%), and results in other people believing you (29%).

Other people (controllers and pilots)

Respondents were asked questions on their attitude towards other controllers and pilots, as they rely on them to do their job, and towards the technology they use in their work.

The respondents considered that controllers in their centre (95% of replies), and to a lesser degree those of adjacent centres (71%), were members of their team. Only half of the controllers agreed that pilots (49%) and technology (49%) are part of their team, whereas under *others* they (3%) listed the co-ordinator or team leader, administration or management, assistants , engineers and technicians.

This was not in line with what was expected, as pilots had been considered as team members in the initial description of the ATC system. The conceptualisation resulting from the replies provided is shown in Figure 4.2. The amount of shared space represents the extent to which controllers felt the *referent* was a member of the team. Those closest were controllers working on the same sector. Management was considered furthest away.

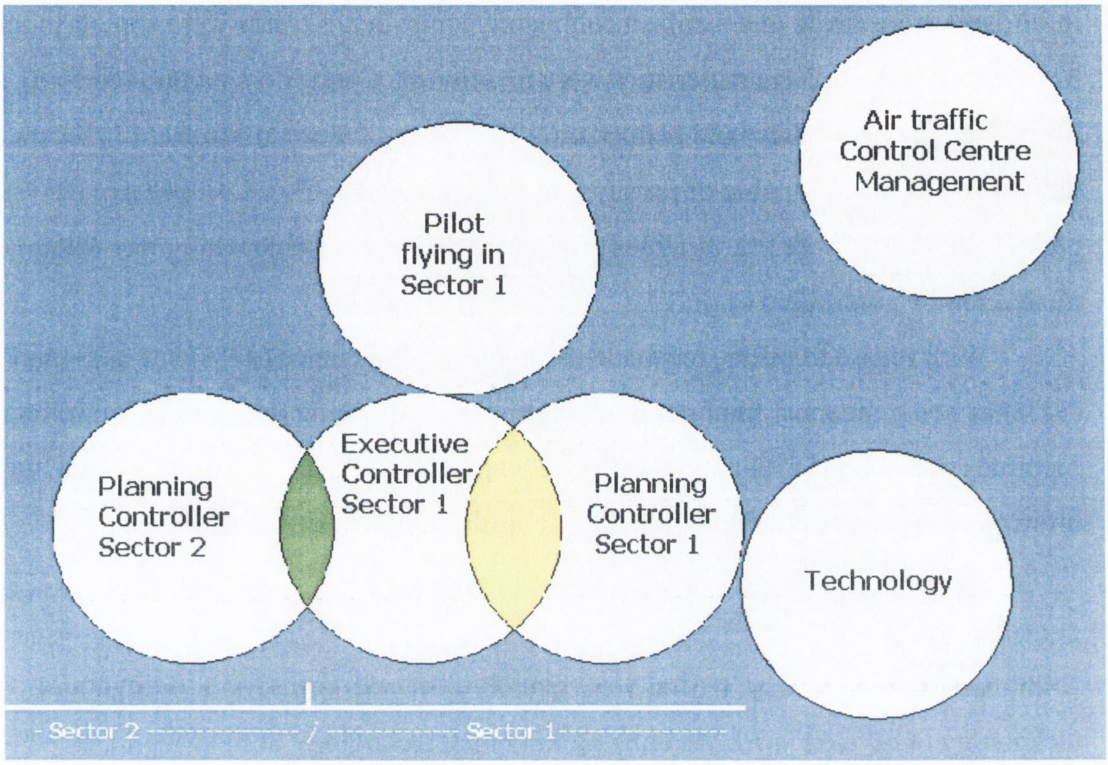

Figure 4.2. The conceptualisation of ATC system following the analysis of replies in Questionnaire One, according to which controllers consider colleagues and controllers in adjacent centres as part of their team.

With regard to the way other controllers were described, having self-confident colleagues was reported as being important (98% of respondents). All groups of respondents reported not believing the information provided by controllers (51% of replies) and pilots (64%) all the time, nor always agreeing on decisions made by fellow controllers (91%).

The replies suggest that both technology (95% of respondents) and humans (87%) are not considered completely reliable. Hence, in the ATM system confidence in oneself (89%) and trust in others (87%) are perceived as essential to do the job, but also distrust, such as doubting (75%) and double-checking (64%), plays a part in the work of a controller. This results in a paradox. Controllers report that trusting is an essential part of their work, but at the same time the comparison of information between two sources is an integral part of their decision-making processes.

These replies also suggest trust and distrust are not considered as opposites, but perhaps different resource management strategies.

Overall, respondents agreed that they needed others to be able to carry out their job (98% of respondents), not only as a source of help and support, but also to monitor their work like a "*second pair of eyes and ears*".

In order to collect information on the expectations respondents have of colleagues, informants were asked to describe a competent controller. Replies were similar in that with 52 respondents only 5 characteristics were mentioned. Controllers mentioned being self-confident (22% of replies) and being calm (22%), a good decision-maker (20%) and team member (16%), and capable of readily admitting mistakes (6%). Competence (65%) and personality (20%) were the variables that were reported as influencing most whether they trusted fellow controllers or not.

With regard to pilots, respondents reported competence (48%) and personality (32%) as being the most important characteristics influencing their trust. Controllers reported relying on (55%) and needing (82%) pilots, but do not always believing the information provided by them (64%) and thus double-checking it(89%).

Technology

With regard to technology, replies were equally split with regard to needing more technology to do their work, and having too much technology in their work, as 51% of respondents agreed with both these statements.

With regard to the characteristics that controllers believe influence whether they trust technology in their work, the highest number of respondents (42% of respondents) replied that *ease of use* was the most important. Under the *other* heading, 4% of respondents talked about demonstration, proof of reliability, usefulness, and the importance of experience in making a decision, as well as test periods and training.

When asked whether the occurrence of an inconsistency in the system changed their level of trust in the system, most controllers (84%) replied that it did, however this did not change their level of trust in the whole system, but only in the *element that did not work.*

To maintain present levels of traffic the support of technology was understood as being essential (73%), nonetheless in the open-ended section of this question controllers stressed that technology has to remain a support, and should not take over the control (42%) and decision making (48%), which are the two aspects they reported enjoying most of their job.

Conclusions

To summarise, trust was considered in terms of a belief, and controllers talked about calibrating trust to the different elements in the system. The consequence of this calibration is that the information from the several sources is used differently. In other words, controllers reported depending on them differently. To perform their job controllers reported needing to believe the information provided to them, but recognised that experience was important in teaching them to calibrate their belief. Experience, with all referents, was found to be an essential characteristic in moderating trust.

Self-confidence was considered necessary because it supports fast decision making, as well as the feeling that one is able to keep the situation under control. Controllers and pilots appeared to be represented quite differently, one as a member of their team and the other as a client to whom a service is provided. From the replies provided by controllers it would appear that trust has a different role in interactions with these two referents. In one case both believing and relying were considered appropriate, whereas in the other, relying was necessary, and believing was not as important. This may be due to the fact that interactions with pilots can be described using procedures, whereas those with colleagues are not as well defined.

A comparison between the examples provided by respondents, would suggest that those provided by controllers that completed the questionnaire with the researcher present were slightly more detailed. The lack of clarity that some controllers found in the questions may have been compensated by answers received during the completion of the tool.

A last comment to be made is the fact that the variety of answers confirmed the description in the literature of a controller as a decision-maker in a dynamically changing environment. In analysing the results it was understood that there is not one way to control, as the work of a controller is strongly reliant on expert judgement that comprises both knowing what the right decision to take is and when to take it.

The questionnaire had a number of shortcomings. With regard to the administration, it was not always under controlled conditions. However, the opportunity to administer directly two parts of the tool to the second group of respondents suggested that group discussion was a source of rich information.

With regard to format, in part one all statements were positively directed; this may have influenced response style. In terms of the analysis, as many of the controllers were not English mother tongue, a certain amount of interpretation was necessary.

Overall, and despite these weaknesses, the information gathered was useful in supporting an initial conceptualisation of trust from the point of view of participating controllers.

4.4.2. Questionnaire Two

The aim of the second questionnaire (Appendix A 2) was to collect information on controllers' trust in people (i.e. controllers and pilots) and technology, as well as the attitude towards change (i.e. the introduction of new technology).

As for the first questionnaire, the questions regarded the respondents' expectations towards others and the identification of characteristics believed to be related to a decision to trust another controller, pilot, management, or technology. In this second version, however, questions were more specific using the experience acquired administering the first questionnaire. In administering the first questionnaire the researcher was given the opportunity to administer part of the tool simultaneously to all respondents. While replying to the questionnaire controllers raised issues and discussed questions and answers openly. Following this experience, it was decided to administer the second questionnaire as part of a focus group, where discussion amongst participants, exchange of ideas and opinions are encouraged and supported by a moderator.

A focus group is "a data collection technique that capitalizes on the interaction within a group to elicit rich experiential data" (Ashbury, 1995: 414). A focus group involves a group of people discussing a specific set of issues, problems or research questions to explore the range of perspectives around a particular issue (Hennink & Diamond, 1999).

Focus groups were first established in market research (McDonagh-Philip & Bruseberg, 2001) as an answer to the need for non-directive interviewing (Hennink & Diamond, 1999). As this method aims at shifting attention from the interviewer's agenda to the attitudes and opinions of participants, it was particularly suited to exploring controller's perspectives and ideas, and collecting examples of experiences shared and commented by controllers.

Focus groups are conceived as group discussions in which the objective is not to reach consensus, but to explore the range of perspectives around a particular issue (Hennink & Diamond, 1999). Participants are encourages to exchange ideas in an open atmosphere, and influence each other by responding to comments in the discussion (Krueger, 1988: 18).

A focus group is planned around a number of issues, set by the moderator and summarised in a *question route*. The discussion however is moderated and not directed. The characteristics of the groups should be homogeneous (Hennink & Diamond, 1999), and a focus group study usually consists of a minimum of three focus groups (Krueger, 1988).

Administration and format

The structure of the questionnaire was maintained as tri-partite, allowing the researcher to moderate the focus group in between the completion of the three parts, and write notes reporting the discussion between participants, while respondents completed the next part of the questionnaire. In other words, part one was administered, followed by a group discussion, followed by part two, during which time the researcher took notes on the discussion that had just taken place, followed by another discussion and so on.

The focus groups were held in the ACC in a room set aside for the purpose, and lasted between an hour and a half and two hours.

The format of the focus groups was introduced at the beginning of the session and was identical for all groups. The researcher introduced the study, explaining that the rationale of the exercise was to learn more about their work and understand what features or characteristics may influence their trust.

The general themes of each of the three sections were: *trust in people*; *trust in technology*; and *change* (i.e. the introduction of new technology). Participants were encouraged to ask questions and make comments at all times. An effort was made to include everyone in the group discussion, either asking a question and having each participant answer in turn, or directly probing the quieter participants (e.g. "do you agree or disagree?"; "well, answers to this question have been quite different, what is your opinion?").

The moderator was aware of the importance of body language and non-verbal signals.

It was not possible to ascertain whether the fact that participants worked together supported or inhibited disclosure. The literature is ambivalent on the benefits of participants who are familiar with each other (Hennink & Diamond, 1999).

With regard to the analysis the same process as that described for questionnaires was followed. A first reading provided general impressions, patterns, common issues and the identification of particularities. The second reading involved focusing on certain issues and reflecting on whether replies supported these or not.

With regard to the format of the questions, the first part of the questionnaire (Appendix A 2.1.) was on the theme of trust and teamwork and was made up of ten open-ended questions, and two multiple-choice ones.

The second part (Appendix A 2.2.) focused on trust in those with whom a controller works and cooperates with. Twelve questions were included (four open-ended; three closed-ended; five multiple-choice).

The third part (Appendix A 2.3.) was concerned with a controller's work, interaction with technology and attitude towards change. It included eleven questions (five closed-ended; three open-ended; three multiple-choice).

Participants

Fourteen operational controllers took part in this study (Table 4.2.). Four focus groups were carried out, with the number of participants varying from two to five in each group.

Results

The results have been summarised according to a thematic analysis, in other words a way of organising or reading material in relation to specific issues or themes.

As the questions asked to the groups of controllers were related to those in the questionnaire, they will be reported in the summary of the replies, following the main themes of the questionnaire.

Trust and Teamwork

Participants described trust as "*believing someone*"(11% of replies), "*having confidence in their way of doing the job*" (35%), "*without having to check on them*" (8%). Trust was portrayed as being able to rely on others (3%), and implied holding expectations about their behaviour (27%), abilities (11%) and timing (3%). When one trusts another, one is characterised by a lack of inhibition "*one feels free to express one's mind and opinions*".

In one multiple-choice question trust was found to mean having confidence in someone (93%), relying on someone (57%), and believing someone (36%). Trust was reported as not meaning needing, depending, or having faith in someone.

All controllers agreed that trust was important in their job because "*one needs to be sure pilots do what they say they will do, know how people work and their limits, and share a common understanding with them*".

In one of the focus groups participants expanded on this issue, explaining that after technical knowledge they believed trust was the most important aspect of their job, due to its relation with team work. In order to work efficiently it was considered important not to have to continuously check what others are doing and thus be able to take for granted they are doing their job well. Controllers need to believe that the pilot will comply with their instructions as soon as possible, as well as the fact that the information provided by their colleague is correct.

In another multiple-choice question respondents were given a list of roles in their work environment (e.g. airports, assistants, management, pilots, etc.) and asked to select the members of their team. Controllers in their centre (50% of replies) and others centres (19%), pilots (19%) and technical equipment (11%) were chosen.

When asked whether they thought there were any differences between the trust one has in a colleague and the trust one has in a friend, most respondents (86% of respondents) felt there was. Respondents explained that there is no affective component in a professional relation. One controller wrote: "*you don't need to like a colleague to trust him*", and that in the two cases trust is dependent on different variables. Respondents agreed that in the case of a colleague trust depends on competence (50% of replies) and ability. (14%) In the case of a friend, it depends on honesty (21%).

The type of relationship between the person who trusts and the person trusted then seemed to be relevant to what trust depended on. Another comment that can be made is that in both cases (i.e. trust in a colleague and in a friend) something is shared. With a friend it may be interests, whereas with a colleague it could be the achievement of a goal or of a task.

When probed as to what participants thought helped them have a common understanding, respondents explained that having the same training (47% of replies) and knowledge (20%), as well as experience of working together (3%) supported achieving this.

More than half of the respondents (64% of respondents), on the other hand, did not agree that they shared a common perspective with management. However, more controllers agreed (71%) than disagreed (29%) with the statement according to which they work in an organisation they consider trustworthy. When asked about the characteristics of an ATC system should have to be considered trustworthy in focus groups most participants (71%) reported being unable to reply. One controller said that a trustworthy organisation would have to be "*able to learn from ones mistakes, communicate well.*"

To summarise this first part, trust was reported as being relevant in a controller's work (93% of respondents). With regard to trust in colleagues trust was understood as relying on them, their competence, and ability, without having to monitor their actions. Members of their team were considered to be controllers, pilots, and technology. Opinions on sharing a common picture with pilots were divided, whereas there was agreement that this was not the case with management. Having a common perspective seemed to be considered relevant to trusting.

Trust and Co-operation

Respondents reported that their trust in a new controller depended on a first impression (20% of replies), as well as the trainee's knowledge (25%) and ability to learn (20%). The new controller's attitude towards the team (35%) was also considered important.

All respondents (100%) agreed that they work better with a controller whom they trust. When asked what they believed influenced their trust in a colleague, all respondents selected *competence* from a list of characteristics. *Experience* (73% of replies) and *personality characteristics* (67%) were also considered important. *Age* and *use of phraseology* were not chosen from the list. With regards to trusting a pilot (93%) and trusting their management (93%) most respondents selected *competence*.

In comparing the descriptions of a competent and a trustworthy controller provided by the replies of participants, the competent controller has among other qualities that of being trustworthy.

Most of the respondents (90% of respondents) believed that *knowing one's limits* was the most relevant characteristics in attributing trustworthiness to a controller. Other characteristics selected were being *a fast decision-maker* (28% of replies), being *experienced* (25%), *proactive to problems* (25%) and *self confident* (22%).

All but one controller gave either an example of an episode in which they had trusted a controller too little or too much, and the lesson they had learned from the episode. A third of the examples described trusting the next sector to do something or behave in a certain way, and their trust being misplaced. Another third of the examples regarded relations with trainees, either trusting them too much and realising too late, or leaving the trainee in control and accepting they may have a better solution, albeit less experience. The other examples were more specific, such as learning not to trust a certain controller who was unaware of their abilities.

Finally, in the last question controllers were asked if they agreed with the statement whereby in the same way that people misunderstand each other's intentions, the respondents sometimes do not understand the system they work with. The question aimed at clarifying the role of shared intentions in the work of a controller. Controllers were equally split in their response. Some of them understood "system" as colleagues (67% of replies), others the technology (16%) and others managers (16%).

One controller wrote: "*Even if we are doing the same job [we don't all] share the same definition of control, the same philosophy. Some prefer to accelerate the traffic even if they give a worse situation to the following sector, others prefer to behave according to the following sector*".

Another respondent wrote: "*I do not understand the logic of working [inside the technical system]. But I have (and generally succeed) to understand the information . . . that this system tries to give me*". A third participant replied that: "*From time to time we don't know exactly what the others*" (i.e. controllers, managers) want, but "*you can't work if you don't understand the system you work with because you depend on it*".

Although individual differences in working styles exist, it is necessary to have a certain degree of shared expectations. In this section then, competence and knowledge of own abilities and limitations were deemed important to attribute trust in colleagues. Examples given described an incorrect calibration of trust in a colleague regarded holding incorrect expectations of their abilities.

Technology and change

In the final part of the questionnaire respondents were questioned about their understanding of the technology used in their work. The characteristics used to judge it trustworthy or untrustworthy, as well as the aspects felt to be important in their job.

The most interesting aspect of the results of this questionnaire were the examples given by participants, revealing trust as something related to relying on others after assessing their ability.

The word trust was used in talking about a number of relationships (e.g. with colleagues, pilots, etc.) but the basis of their trust in these others appeared to vary, from an assessment of their ability and performance, for colleagues and technology, to a necessity in the case of pilots.

Many controllers (71% of replies) wrote that they would think of their technical equipment as a *partner*, two replied *subordinate*, and one as a *decision-making aid*. None selected *team member*.

The following question inquired as to whether their perception of technology would change in the future. Eight controllers out of fourteen did not think that the way they thought of the technical equipment in the future would change.

When asked what they thought influenced their trust in a newly implemented piece of technology controllers wrote that their *experience* with the system was important (13% of replies), both in terms of *training* (3%) and *learning its limits* (10%), as well as in terms of gaining confidence of its *reliability* (17%) and the fact *it works properly* (10%). The fact that it has been *tested* was reported as essential (20%), and that its *functions are similar to the previous system* (3%), as well as being *simple to use* (10%) and *efficient* (17%).

When questioned whether the occurrence of an inconsistency in the system changed their level of trust in the system, many controllers (79%) agreed. One controller wrote: "*trust is regained when the element is changed, someone confirms it is fixed and it will not happen again, and it works again*". Another respondent believed that "*the better I know about how it works technically, the more I trust it. I need to know how a tool works to trust it.*" With regard to the characteristics influencing trust, *reliability* was the one most frequently selected (78% of respondents), and none of the respondents selected *provider*.

The aspects of their work that most controllers reported never wanting to give up were *decision-making* (50%), *responsibility* (21%), and *working in a team* (29%).

In the final question, asked whether they would more readily believe the radar or the pilot when confronted with inconsistent information, most controllers (79%) chose the *radar*. This was explained not only by the fact that "*we are trained to trust our equipment, our technology*", but also that in this particular case it is more often the pilot that confuses the call-sign of their aircraft.

In the focus group controllers clarified this explaining the procedures in place that would ensure it was possible to ascertain the source of the correct information. Procedures play an important role in guiding controllers' decisions.

To summarise then, with regard to technology its role was variously described as that of a partner, subordinate, and decision aid, but not as a team member. In trusting new technology experience and understanding the functionalities were considered relevant aspects, and with technology in general reliability was important and the fact it works properly.

Whilst trying to understand why respondents chose radar over pilot the researcher realised that the analysis of the explanations given by controllers suggested the relevance of the procedures in helping them identify the correct information. It was thus hypothesised that trust was related to the type of relation a controller described as having with the other (e.g. relying on colleagues, depending on pilots and technology), and that the presence of trust depended on both the characteristics of the other but also on the procedures or rules in place that mediated the way for example responsibility was shared between the trustor and trustee.

4.4.3. Third Questionnaire

The third questionnaire (Appendix A 3) focused on four themes that reflect the main questions asked in this thesis. The *first theme* referred to the definition of trust according to controllers. The *second theme* concerned understanding the role of trust in the work of a controller. The identification of the characteristics deemed relevant by respondents in attributing trust to colleagues, to pilots, and to technology was the *third aspect* of interest. Finally, the *fourth theme* was addressed by one question that explored the way in which a controller chooses to trust the information provided by another or that provided by technology.

Seven of the ten questions that comprised this short questionnaire had been used in previous questionnaires, where their wording had been found to be clear and replies to be particularly informative.

Administration and format

Seven of the controllers were administered the questionnaire during a simulation and replied during their breaks. The other respondents received the questions by email and completed it in their own time at home.

The questionnaire consisted of ten questions in a number of formats: four open-ended, two closed-ended and four mixed format (i.e. closed-ended followed by a request for further clarification).

Participants

A total of 15 controllers replied to the third questionnaire (Table 4.2.).

The questionnaires were anonymous and the only details associated with the replies were gender and nationality. Respondents were from Austria, Belgium, Ireland, Italy, The Netherlands, and the UK.

Results

The results have been summarised according to the four themes outlined in the introduction to this section.

The definition of trust

Two questions were dedicated to exploring controllers' understanding of the concept of trust. According to the respondents, trust means "*believing information*" (43% of replies) and is something that develops over time (14%) and allows you to carry out your job because it means that others will do what you expect them to do (43%). One controller described this as expecting "*your colleague to be competent and help you out, in the same way you would help them out if they were in difficulty*".

A second controller described trust as "*the ability to rely on another*" and to believe the other will not only "*perform his duties as good as you would do them yourself*" but also that they will "*behave in an honest and transparent way in the best of their knowledge*". Another controller wrote that trust is: "*accepting at face value what you see or hear based on previous experiences [and this understanding is something that] develops over a period of time . . . it allows you to carry on your job in the knowledge that others will do what you expect and are competent and if you are in trouble they will help you out and in turn you will help them out.*" This reply suggests a reciprocal dependency in a trusting relationship.

With regard to trust in a new controller, it was reported as depending on their ability to listen (30%) and accept criticism (70%).

The role of trust in the work of a controller

All respondents agreed that trust was important in their job. One respondent explained that it reduces workload because without trust one "*would have to constantly double-check that one's requests and commands are carried out*". This was generalised to the whole system: "*if you cannot trust the system, you cannot work*".

The lack of trust was thus operationalised as double-checking. On the other hand, "*You should trust your colleagues but you have to verify (check) what they did before handing over a flight*". Trust is considered by controllers to be essential in their job (100% of respondents) but at the same time controllers rely on their colleagues to double-check their work (14% of replies).

Respondents were asked to think of an episode in which they had mis-calibrated their trust in another controller and the lessons they learned from such an experience. Six examples were given. Two examples referred to a controller who had been trusted too much; two episodes in which a controller had been trusted too little, and one exemplifying the development of trust and its calibration.

The first example provided was a situation in which two aircraft were due to go to the next airspace with a 16-minute gap between them, and ended up with a 10-minute separation. The mistake was not seen until the next centre advised. This had happened because the controller, who was working as an executive on the first sector, had not double-checked with his colleague who was doing the planning, and had trusted the planning controller too much. The lesson learned by the respondent was that sometimes when two controllers work together for a long time, familiarity can become complacency, and thus trust may be misplaced. This suggests that trust implies an implicit understanding between two people, which has as a consequence a reduction of exchanges of information. When this implicit understanding is mutual, trust is positive, when the understanding is misplaced however, the lack of communication may mean that the actors continue working on the basis of misguided expectations. Zuboff (1988) had identified a similar effect with the way operators placed too much trust in new technology, and did not intervene when the technology failed.

In the second example, a controller described what he called the "*halo effect*" or "*self-fulfilling prophesy*", according to which if one knows that a controller is good in tower he/she is expected also be good on radar. Well-calibrated trust is then related to specific.

The third example revealed that personality is not a good predictor of trust, as a controller considered rowdy proved to be a very competent controller during an emergency.

With regard to the development of trust, an example in a training setting was given. The trainee was unsure of what to do and asked the trainer. Instead of reproaching the trainee for not knowing what to do, the trainer advised him. He noticed that after a few minutes the trainee not only succeeded in bringing the situation under control, but also appeared to be working with more confidence. Here trusting one's capacities is something that is learned gradually, in this case, under the supervision of a more experienced controller. The result of trusting someone would appear to empower them with a feeling of control. This may be associated with the feeling of having responsibility.

These examples suggest that trust is something controllers are familiar with, and that they are aware of the role trust plays in their work.

Trust in colleagues, in pilots, and in technology

Question four asked controllers what influenced their trust in a new controller (e.g. a trainee). In general, their trust depends on *personality characteristics* (15% of replies), features related to *working in a team* (6%), and *competence* (15%). More specifically, the personality characteristics were "*being self-confident*" (6%), their "*general character*" (9%), and an "*awareness of their limitations*" (3%).

With regard to teamwork, their attitude to others was important (3%). Their capacity to listen (3%) and willingness to both accept advice and criticism (24%) were relevant. The judgement of team members (9%) was also mentioned.

Lastly, their technical and procedural knowledge (3%) and ability to identify and solve problems (3%) were listed.

When asked what respondents thought influenced most how much they trust a controller they work with, the characteristics selected more often were *competence* (46%) and *use of phraseology/language* (25%), followed by *experience* (28%).

In describing a trustworthy controller all respondents agreed it was someone that *knows his/her limits well* (10%) and is *proactive to problems* (10%). A trustworthy controller is *self-confident* (7%), *dependable* (8%), *motivated* (7%), *cautious* (7%), and *intuitive* (7%). Furthermore, he/she is *predictable to others* (6%) and a *good colleague* (7%).

With regard to the way he/she works, a trustworthy controller has *good planning skills* (7%), *always follows procedures* (8%), *uses the correct phraseology* (1%), is *reactive to problems* (6%), and is a *fast decision maker* (6%). Additional characteristics of a trustworthy controller suggested by respondents were *adaptability* (1%), *"knows a mistake is always behind the chair* (1%), and *imagination* (1%)

With regard to trust in pilots on frequency, the most frequently selected option was *competence* (65% of respondents), in terms of their adherence to rules and perceived understanding of instructions.

Trust in pilots was most frequently considered by respondents to depend on *competence* ('as inferred from their response to instructions' and 'as inferred to their use of phraseology and language') (65%). *Airline* (30%) was considered a salient feature too, as it gave indications of the quality and competence of the pilot. The pilot's *voice, tone and confidence* (5%), was mentioned too.

The replies to the question asking about respondents' trust in a newly implemented piece of technology can be summarised under four headings (Table 4.3.).

Table 4.3.

Technology				
	Training (i.e. before introduction)	**Transition (i.e. during introduction)**	**Technology's characteristics**	**User/Technology**
Percentages	Opportunity to learn in non op. Environment	Impact of change on working method	Reliability	Feeling of control
	Quality of training materials	Quality of manuals	Operates well all the time	9%
	Ergonomic/user friendly	7%		Level of technical/operational compliance
	Familiarity	Smoothness of transition	4%	
	Confidence in instructor	2%	Product provider (track record)	Belief in its effectiveness
Groups of Factors				

Note. A summary of the characteristics that respondents listed under the *other* section in the question on characteristics of trustworthy technology (Question 9: "What do you think influences your trust in a newly implemented piece of technology?") organised according to groups of factors (x) and increasing percentages (y) from 2% to 11%.

The first two groups of characteristics have a time distinction: factors related to the period *before* the introduction of the new technology and factors related to the transition period *during* the introduction of the new technology. With regard to the training, being given an opportunity to learn to use the new technology in a non-operational setting is important (11% of replies), as well as the quality of the written material and manuals (9%), that help the user understand how the technology works. How easy the system is to learn to use (4%) is important, whether it is ergonomic and user-friendly (7%), as well as its "familiarity" (4%) or, as one controller mentioned in his/her answer, how similar the functionality of the new technology is to the one previously used. Confidence in the person who is instructing the operators (2%) was mentioned too. The smoothness of the transition from one technology to the other is relevant (4%), as well as how much the change will influence the controller's working method (11%).

The third group of factors relates to the features of the actual technology. Here respondents listed reliability (i.e. operates properly all the time) (11%) and the product provider (2%), which suggests a previous track record. Lastly, the fourth group of determinants is related to feeling in control of the situation (11%), believing in the effectiveness of the technology (2%), and how well it meets the controllers' needs (7%).

Choosing whether to trust a pilot or technology

In the last question, participants were asked to imagine a situation in which on their radar they watch an aircraft with label ABC123 enter their sector. A pilot then calls them and identifies himself/herself as AB125[4]. They were then asked to decide whether their first thought would be to believe the information provided by the pilot or that on their screen. Five out of seven respondents (71% of replies) chose the radar.

The explanation provided most often (25% of replies) was that it was more likely that the pilot, rather than the controller, had made the mistake, was corroborated by respondents' past experience of both controllers and pilots mispronouncing call signs. According to informants, it is not difficult to get a wrong call sign. One controller outlined the appropriate procedure to follow in such a case: consult the flight strip and to ask pilot to confirm call sign. However, he commented that it would be unusual to get two such similar call signs so close, and actually have the two flights so close together in the air.

With regard to the two controllers who did not choose radar, the respondent who chose both wrote that he would not be inclined to believe one rather than the other because there would be an equally valid number of reasons for both to be mistaken. The respondent explained that it is plausible that different flight plans are held in the cockpit and in the system on ground. Equally feasible is that the pilot said the wrong call sign or that the controller heard the wrong call sign. Finally, another flight operating elsewhere may have come on the wrong frequency and even if the controller saw differently, he might have been talking to somebody else.

From experience and knowing how the technology works, as well as the procedures pilots and controllers follow, respondents felt it was more likely the pilot be mistaken. Experience plays an essential role in teaching a controller to hold the appropriate expectation.

Concluding remarks

The questionnaire aimed at exploring what participant controllers thought about the role of trust in their job, and at collecting the most salient characteristics for ascribing trustworthiness to colleagues, pilots and technology.

Controllers wrote that trust means believing information, being confident that one's expectations of others' behaviour are met, and feeling in control of the situation. Trust was

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[4] Report Number A95A0167 (1996), Transportation Safety Board of Canada. Available at http://www.tsb.gc.ca/ENG/

related to effective team-working and to the reduction of workload. Trusting the members of the team meant not having to double-check between sources of information. Checking colleagues' behaviour however, such as "*looking over their shoulder*", was considered part of the job too. The paradox was expressed as "*when you trust someone you do not check their behaviour; but when someone trusts you, they expect you to check theirs*". Trusting others then means not having to monitor their behaviour, whilst at the same time relying on them.

From a number of replies it was found that trust and control were also felt to be related. Trusting is associated with feeling in control, whilst at the same time it means yielding control to another.

Trust can result in complacency. For example, after two controllers work together for a long time they accumulate a 'library' of expectations of the other's behaviour which may be considered reasonably reliable. Familiarity however, may easily turn into complacency, and mistakes or misunderstandings become harder to notice.

With regard to technology being considered trustworthy, replies would suggest it should be transparent, support an understanding of what it is doing, and provide feedback to the user.

With regard to trusting a colleague *competence* and *use of phraseology/language* resulted being the most frequently selected. *Personality* was less relevant. *Experience*, on the other hand was mentioned. This may suggest that with experience and knowledge of the person, their personality characteristics become less important with time, as one learns to know their strengths and limits.

When asked about trust in a newly implemented piece of technology, respondents distinguished between factors relevant before the introduction of the technology and during its introduction. Being able to learn to use the technology in a non-operational environment, as well as the quality of the material and manuals, the quality of manuals, the familiarity of the system and the user friendliness of the system, were considered important before the introduction of the technology. In the period in which it was being introduced, the impact of the change on the controller's working method, the smoothness of the transition as well as the quality of the manuals were important.

Respondents also talked about features of the actual technology, such as reliability and product provider, and the way the user felt when using the technology, in control and using something effective.

4.4.4. Section summary

This section described the format, administration and results of three questionnaires, which were completed by a total of 80 controllers. The questions in the three questionnaires resulted from the issues identified in the review of the literature on trust and from visits to operational centres.

The general objectives of the questionnaires was to understand how controllers define trust, in order to use their perspective in the study, whether trust was relevant to their work and, if so, what role it may play in their decision making. A number of questions were maintained in all versions, however the focus changed with questions becoming more specific, reflecting a clearer understanding of the domain.

Respondents' replies suggested that trust is considered important in the work of a controller, although paradoxically distrust seems to play a role as well. Trust was described in terms of a belief and expectation of another's ability and not having to monitor another's behaviour.

With regard to trust in technology it was described as confidence in the accuracy of the information provided by the equipment as well as its reliability.

In the literature trust and cooperation are considered to be related and trust is described as important in team work. When asked who was part of their team participants replied that controllers in their centre were and to a lesser extent controllers in other centres. Pilots however were seen as clients of a service. Technology was considered an aid more than a team member.

With regard to the characteristics of trustworthiness, for colleagues they were competence, personality (e.g. someone who knows their limits), experience, and self confidence. For pilots, competence, personality and airline. In relation to technology, features such as ease of use, feeling in control, tested, and reliable were provided as characteristics of a trustworthy piece of equipment.

Respondents were also asked to describe a competent controller, as competence had been identified in the literature as a salient characteristic for trust. Participants mentioned being a good team member, a calm, self-confident, fast decision maker who readily admits his/her mistakes.

Finally, the relevance of procedures in the decision making processes of controllers was highlighted in controllers' replies. The basis of trust was described differently in terms of the type of relationship, thus with colleagues and technology it was more often described by participants as ability and performance, with regard to pilots as dependent on necessity. Roles as well as procedures may frame the decision space of a controller and should be considered when modelling trust.

4.5. Structured Interviews

To acquire an understanding of the role of time and change in trust 30 short semi-structured interviews were carried out.
The aim of the interviews was to collect examples of the development of trust in new trainees and in new technology. These examples were to be used to highlight common themes in the development of trust in the work of a controller.
A new system was being introduced in three of the four centres where the interviews were carried out and thus it was assumed interviewees would find it relatively easy to provide an example of new technology. For the same reason however it was necessary to assure participants of the confidentiality of the information collected, on both trainees and their impressions of changes and the management of change. Thus, together with the interview protocol an information sheet and consent form were prepared to be given to the participant and signed before the interview (Appendix B).

4.5.1. Format and Administration

With regard to the format of the interviews, the interview on a trainee comprised seven questions. The interview on new technology consisted of eight questions. Although the questions were fixed, respondents were encouraged to set the agenda of the interview, and were free to choose whether to talk about one or more examples.
A critical incident approach was taken (cf. section 2.2.), according to which the assumption is made that events that are interesting, that include positive and negative experiences, will be those remembered by the operators as lessons learned.

All interviews were carried out in quiet room set aside by the supervisor of the centre and lasted about 20 minutes. Although the interviews were very short, this was necessary to ensure participation.
Participants were first briefed on the researcher's study, the reason of the consent form and its importance, as well as on how to contact the researcher to obtain the results of the exercise.
Notes were taken and no tape-recordings were made as most controllers did not feel comfortable being recorded.

4.5.2. Participants

In total 30 controllers were interviewed. No personal information was collected from the 16 controllers who replied to questions on a new trainee, and from the 14 controllers who answered questions on new technology.

The controllers interviewed worked in four different centres and were of two nationalities. Interviewees were recruited either by supervisors, by colleagues or by the researcher in the staff room. Although there was no control over the sampling of respondents, in order for controllers to be able to reply to questions on a new trainee controller the interviewee had to have experience as an On the Job Training Instructor (OJTI).

4.5.3. Results

The results relating to a new controller will be reported first, followed by those on new technology.

A new controller

The examples provided on a new controller varied from controllers whom the respondent had trained or worked with, trusted or not trusted. Some informants believed that trust was something immediate (42% of replies), based on "*first impressions*", whereas others argued it developed over time (48%).

Those who had trained the new controller varied substantially in their approaches towards training. A number (31%) described training as working double, having to keep a "*tight reign*" on the young and inexperienced student. Others (31%) explained that the difficulty in being a trainer was to learn to allow the student to learn alone, trusting them albeit their lack of experience. One controller explained that, based on his experience as a football trainer, he felt everyone should find the way of working best suited to themselves, and not be trained to work in one standard way. Another controller stressed how training effectively relies on *believing* in the student. One trainer illustrated the power of *reputation* in supporting the trust of colleagues in the student. Most students today in fact arrive from a training college, and thus often already have a 'reputation'. Common concerns were expressed (50% of respondents) regarding a general tendency for controllers to be trained far away from the control room. Unlike in the past, when a controller worked his or her way up to the controlling position, starting to work as an assistant in the control room, students today lack the implicit local knowledge a trainee would have had on their first day working at a control position.

With regard to the ideal student, he or she wants to learn, "listens to criticism and praise" (23% of replies), is committed (9%) and technically prepared (27%). They are calm (18%), humble (9%), but very curious (14%).

A nightmare controller on the other hand, is someone who does not learn from their mistakes (40%), is presumptuous (47%) and uncommitted (13%).

Overall, the differences in opinion of the controllers being interviewed did not appear to be related to their nationality as much as individual differences.

New technology

Most of the examples (78% of replies) provided on the introduction of new technology regarded the introduction of a new system. Other examples were the introduction of a new tool in the tower, the use of which was learned with practice, and an upgrade of the information provided on the radar screen.

A distinction was made by respondents between up-grades that "*help you to do your work*", and radical changes that involve learning new skills as they change the nature of the work.

When asked about the ideal way to introduce technology the understanding of the functionality of the new tool or system (21%), and rationale behind the design choices (7%) were deemed essential in order to learn to trust the technology. Many replied (11%) that ideally there would be three phases in an introduction: a theoretical introduction, a period of testing and use of the tool off-line, and a gradual and systematic introduction into the control room.

It was considered important that the new technology be specifically designed for the local context in which it is implemented (11%), tested (7%) and training provided to understand how it works (11%), without assuming everyone is at the same level of competence. Respondents felt that not only was the amount of information provided regarding the change and the functionality of the new technology (11%) important in influencing their trust, but also that there be a person to "*answer questions*" (7%), available to explain the system in detail and over time. Furthermore, the attitude of those introducing the system (7%) was influential, where they were "*doom or gloom merchants*" or informed and convinced of the benefits of the change.

Finally, it was considered that the development of trust in technology took time (7%), and "*even a wonderful technology can be introduced badly*". With experience one may learn to understand its potential and appreciate its benefits.

The experience of the controllers interviewed, in terms of the quality and sophistication of the system they use and their experience of changes strongly influenced their attitudes towards technology. Although age differences were expected to influence attitudes, with younger controllers being more favourable to change, no evidence of this was found to suggest this is indeed the case.

4.5.4. Section summary

This section described the format, administration and results of a series of interviews on new trainees and new technology carried out with 30 controllers.

The replies provided by the participants suggest that when training a new controller there is a tension between giving the inexperienced controller full control or very little control, however believing in him/her was considered by respondents as relevant to learning to trust them. The reputation of the young controller created expectations that were thought to influence their trust in them.

With regard to new technology a distinction was made by respondents between a support tool and technology that changed the way of working of a controller. In order to learn to trust new technology participants believed they had to understand the new functionalities and the rationale behind the design decisions, furthermore time was deemed important in order to learn to work with the new system.

The information collected from these interviews suggested that according to the participants their trust in new technology depended as much from the functionalities of the technology as the way in which it was introduced, the actual process.

4.6. Conclusions

On the basis of the information collected through observations, questionnaires, informal and structured interviews, it was concluded that the work of a controller is that of a decision-makers who takes decisions based on more or less certain information, and on a continually changing plan, that is up-dated according to the airspace, which is a dynamically changing environment.

Controllers described their work as teamwork, and considered their colleagues as the members of their team. Pilots are not part of a controller's team, but are provided a service.

Trust was described as believing in one's own abilities, self-confidence was reported as being essential to control, but also in the ability of others and in the accuracy of the information provided by technology. Trust is something learned with experience. The fact that a controller does not need to double-check the behaviour of others or the information presented by technology, was considered to operationalise trust. Competence was considered one of the most important characteristics in influencing trust in both colleagues and pilots. With regard to technology, experience, the understanding of how it works, its reliability and correct functioning were considered relevant. Trust between colleagues is mediated by implicit understandings, but also by procedures that dictate the degree to which one should rely on others and believe (i.e. not question) the information they provide.

Controllers perceived trust as having an important role in their work, were able to provide examples of the correct calibration of trust, its development in trainees and in new technology, illustrated with episodes in which they had trusted too little or too much. Furthermore, controllers were able to identify the characteristics that prompted or mediated their trust. Overall, competence resulted being one of the most relevant characteristics, although implicit and formal procedures were described as guiding their decisions to trust or not to trust others.

4.7. Chapter Summary

This chapter described the information collection phase of the research, which was aimed at the researcher's familiarisation of the domain and understanding of the role of trust in the work of a controller. This initial qualitative part of the research was carried out to scope the study and identify the salient characteristics of the work of a controller that could be hypothesised as being related to trust.

The information was collected through observations, three questionnaires, and structured interviews. The observations of controllers at work in operational centres were made in order to learn about the nature and organisation of work, as well as to gain an insight as to the type of technology available in present-day centres. The three questionnaires aimed at collecting information on controllers' definition of trust, its role in their work as well as their attitudes towards colleagues, pilots and technology. Finally, in order to understand how trust changes in time, 30 semi-structured interviews were carried out regarding the development of trust in trainee controllers and in new technology.

Each exercise allowed to focus on different aspects of a controller's work and the role of trust in a controller's decisions. Thus, an understanding of trust based on controllers' opinions was achieved, as well as a number of characteristics hypothesised as being relevant to a controllers trust in others and in technology. From observations and participants' replies the role of self-confidence, competence and procedures were suggested as being relevant in influencing a controllers' decision to trust others and the technology they use in their work.

Chapter Five: A Model of Trust in the Work of a Controller

5.1. Chapter Overview

The chapter summarises the approach taken in this study on trust in the work of a controller in four steps. The *first step* was the articulation of the assumptions made in the study, amongst which the choice on how to define trust (section 5.2.). The *second step* consisted in formulating a model proposing a way to understand trust (section 5.3.). This model was developed on the basis of literature reviewed in chapter two and the understanding of the work of an air traffic controller described in chapter four. The *third step* consisted in choosing a point of view (a trustor) for the study and the scope (the horizon) of the research (section 5.4.). On the basis of the horizon a number of 'important others' for the trustor (referents) were identified. These steps are summarised in this chapter. Section 5.5. describes the plan to validate the model. The *fourth step* encompassed testing the model proposed and this will be the subject of the following two chapters. The chapter closes with a summary in section 5.6..

5.2. First Step: Making Assumptions Clear

In the literature review summarised in chapter two it was mentioned that one of the main problems a researcher on trust encounters regards the use of previous studies, due to the variety in the definitions and approaches to the study of trust. For this reason it was considered essential to render explicit the assumptions made in this study. The rationale of this chapter is thus to allow future researchers to either compare studies that have made the same assumptions or to follow a similar approach to the study of trust.

This section summarises the assumptions made in this study on trust. The first step of the approach taken in this study of trust consisted in articulating the assumptions that were being made. The five assumptions are described below.

5.2.1. Trust implies a dyad

Trust implies a dyad, in other words a trustor and a trustee. The trustor and trustee can have a number of roles (e.g. a patient and a doctor, a doctor and a patient, a patient and the Health Board), which in part define the type of possible relations between the two.

The roles of interest in this study are those of a controller and technology, and the relation is a co-operation in order to achieve a common goal. Thus the assumption is that trust has a role in mediating the co-operation in a dyad (Deutsch 1958; Gambetta, 1988; Kramer, 2001), where the trustor is a controller and the trustee is another controller, a piece of equipment, or a tool.

5.2.2. A definition of trust

Following the literature reviewed in chapter two, and in particular Muir (1988), in this study trust has been defined as a willing yielding of control that a trustor gives to a trustee when, according to a set of expectations the trustor holds about the trustee, the trustor believes the trustee will carry out an action or behave in a certain way that will result in a positive outcome for the trustor.

The conceptualisation of trust as a belief and as a yielding of control was identified by controllers (cf. chapter four). The fact that trust influences interactions with others, in terms of the trustor deciding to trust another by maintaining or giving control to them, had also been identified in the literature (Sheridan, 1988; Muir, 1994).

Deutsch (1960a) states that trusting behaviour occurs when an individual perceives an ambiguous path, the result of which could be good or bad, and the occurrence of the good or bad result is contingent on the action of another person. Thus, when trusting we are deciding to run a risk by yielding control to another, on whose action the hoped for outcome becomes contingent (Luhmann, 1979).

The definition chosen for trust then was based on the literature reviewed in chapter two and in line with the understanding of trust by controllers, as described in chapter four. Muir (1989) described trust as yielding of control, an expectation (Rotter, 1980; Barber, 1983) of future behaviour of the other. In their replies to the three questionnaires summarised in chapter two, controllers described trust in terms of dependency and reliance on the other, as well as in terms of a belief of the other's ability or performance.

5.2.3. Trust is a consequence of a choice

A trustor has to have a choice whether or not to trust a trustee (Baier 1986; Rotter, 1967; Johnson-George & Swap, 1982; Lewicki & Bunker, 1996).

The implication of the fact that trust follows a choice is that decision points (i.e. moments in which a decision or a choice is taken) need to be identified and thus the researcher has to become knowledgeable in the activities of the trustor. These decision paths are equivalent to the 'decision rules' Kramer (2001) describes as part of the auditor's model (cf. chapter two).

In the psychology literature, Hutchins (1995a; 1995b) argues for the importance of learning about the representations used by expert decision-makers, before being able to understand how these representations mediate their decisions. In the trust literature reviewed, a number of researchers (e.g. Gabarro, 1978; Luhmann, 1979; Mc Knight & Chervany, 2001) argue for a grounded approach to the study of trust, in terms of using the understanding of the concept by the population studied. In order to achieve this understanding the researcher has to learn about the context within which the trustor takes decisions, including the assumptions shared with the trustees.

In this study of trust an ethnographical approach was favoured. Ethnography is "a set of methods that involve the researcher overtly or covertly participating in people's daily lives for an extended period of time, watching what happens, listening to what is said, asking questions – in fact, collecting whatever data is available to throw light on the issues that are the focus of the research" (Hammersley & Atkinson, 1995:1).

The way this was achieved in this study has been described in chapter four.

5.2.4. Measuring trust

Trust has been recognised as an important antecedent of co-operative behaviour (Kramer, 2001; Misztal 1996). The assumption is made that when a decision to trust is made it results in co-operation (Deutsch, 1960a). In order to measure trust it is necessary to understand when a decision has effectively been taken and when co-operation is institutionalised, in terms of a procedure, for example, that has to be followed.

Sanne (1999) demonstrates the importance of procedures, which structure co-operation and interaction, but also create a certain amount of redundancy that supports safety.

Once the context is known and understood by the researcher, and thus also the constraints imposed by the situation on the trustor's decisions, it is possible to observe when trust is absent or present.

In order to measure the presence of trust it is necessary to operationalise trust or make it "palpable" (Kelly 1955: 28). To ensure internal validity it is essential to match the conceptual definition with the operationalisation (Babbie, 1998). Depending on the nature of the trustee, trust was operationalised as a decision to delegate a task to the other, having decided that they are 'good enough' to carry out the task that we are delegating to them, or basing one's action on the information provided by the technology, or delegating a task to the technology.

5.2.5. The trustor is a decision-maker

In understanding the trustor as someone choosing to trust the trustee the trustor was conceived as a decision-maker. This is compatible with the conceptualisation of trust as a choice and with the understanding of the work of a controller as a decision-maker. A controller takes decisions, based on more or less certain information, and on a continually changing plan, that is updated according to a dynamic context.

In order to better understand how trust may result from a decision, the literature on decision-making, particularly in naturalistic settings was considered. Naturalistic settings are characterised by uncertainty, changing situation dynamics, time pressure, poorly defined procedures, cue learning, and team co-ordination (Orasanu & Connolly, 1993). The literature as presented below is summarised to highlight the processes that are considered in this thesis as necessary to understand the role of trust in the work of a controller.

Kelly's (1955) personal construct theory described people as 'personal scientists' who are driven by the need to cope with coming events, and successfully do so by anticipating them. According to Kelly objective reality is a myth, what is influential is the meanings one attaches to previous experience. Kelly thus focused on the way his patients interpreted their lives, giving meaning to their experiences, and argued that psychologists need to begin their work not with theories, but by understanding the life situation of those they have chosen to study.

In the same way that Hutchins (1995b) argues for a shift in paradigm in cognitive science in the way cognition is studied, towards an understanding of cognition as distributed both inside and outside the head, Kelly believed it was necessary to be involved in the context within which the person studied takes decisions. Kelly described people as creating transparent patterns, called 'constructs' and using them as filters "to fit over the realities of which the world is composed. The fit is not always very good. [but] Even a poor fit is more helpful to him then nothing at all" (1955:8-9).

Constructs are ways of interpreting the world, working hypothesis that are used to make judgements by supporting predictions. These predictions are verified with experience through 'validation', which "represents the compatibility (subjectively construed) between one's prediction and the outcome he observes. Invalidation represents incompatibility (subjectively construed) between one's prediction and the outcome he observes" (1955:158). It is suggested that in order to understand someone's experience it is necessary to comprehend how the person constructs meaningful events, the way these events are construed and validated, as well as identifying those constructs that with time have remained 'permeable and durable' (1955: 172).

Kelly's work illustrates that in order to understand someone's decisions it is necessary to understand the way they anticipate events and construct interpretation (Bannister & Fransella, 1971). Anticipation had been found to be amongst controllers' skills.

Craik (1943) first described people's ability to interpret events through "small-scale models" of reality that the mind uses to construct reality (Johnson-Laird & Byrne, 2000). Each mental model represents a possibility and reflects the way in which a situation or a system is understood, on which predictions and expectations of future behaviours are based (Rouse & Morris, 1986). Although the structure of mental models is considered to be analogous to that of the situation they represent, they do not have to be exact mappings of reality, as long as they are plausible (Moray, 1990). Moray (1987) writes that we create homomorphs of the original system, that is, many-to-one mappings that afford simplicity of use and a reduction of workload, because they are partial models of the original. In designing new systems it is necessary to map the 'system image' (i.e. the mental model of the designer) onto the mental model of the user to ensure the two are at least compatible (Norman, 1986). In this case the mental model is "knowledge of how the system works, what its components are, how they are related, what the internal processes are, and how they affect the components" (Carroll & Olson, 1987:6).

Another way of describing the way knowledge is represented is through schemas. Smith & Marshall (1997) quote Marshall's (1995) definition of a schema as a:

> "vehicle of memory, allowing organisation of an individual's similar experiences in such a way that the individual can recognise easily additional experiences that are also similar, discriminating between these and ones that are dissimilar; can access a general framework that contains the essential elements of all these similar experiences, including verbal and non verbal components; can draw inferences make estimates, create goals, and develop plans using the framework; can utilise skills, procedures or rules as needed when faced with a problem for which this particular framework is relevant " (1995:39).

Mental models then are ways of both anticipating situations but also storing and organising knowledge, which is then used to interact with both people and technology. Marshall (1955) describes four types of knowledge stored in schemas: identification, elaboration, planning and execution knowledge, and this brings us to the question of how one chooses a course of action.

On the basis of studies carried out with fire-fighters, nurses and pilots, on how experts take decisions, Klein (1999) developed a model that identifies how people use their experience to take rapid decisions under conditions of time pressure and uncertainty that preclude the use of analytical strategies. Klein et al. (1991; 1992 check) argued that the diagnosis of a situation was the result of feature matching, essentially pattern recognition, or story generation, used when the situation is not similar to previous experience thereby failing to activate an existing template or schema (Smith & Marshall, 1997).

Klein's (1999) recognition-primed decision (RPD) model explains how expert decision makers size-up a situation and make sense of it, and how they then choose the best course of action to take by imagining it. There are three variations on the model (Figure 5.1.), where the overall strategy can be described as perception, recognition and action.

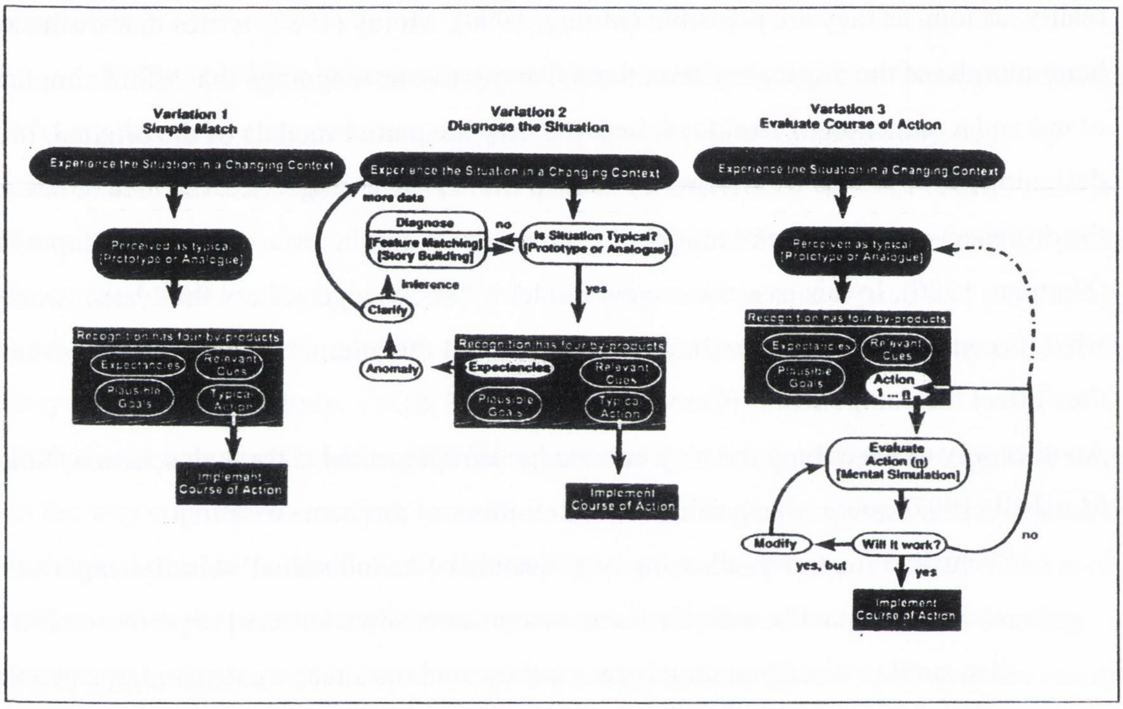

Figure 5.1. Three variations of Recognition Primed Decision Model. Reproduced from Klein (1999: 25).

According to the first variation, a decision maker recognises the situation as typical and familiar and then proceeds to act. Recognising a situation implies understanding what types of *goals* make sense, understanding which *cues* are important, knowing what to expect next in order to plan and prepare, and choosing the course of action most likely to succeed amongst the typical ways of responding to a given situation (1999:24). In other words, the decision maker recognises the pattern of cues in a problem as one that matches a template of typical cues in prior experience, and thereby categorises the situation.

The second and third variations refer to situations where the decision maker does not recognise the situation as typical or the course of action.

The focus in this model is on how experience, stored as patterns and salient cues and described in stories, enables decision makers to identify reasonable courses of action as the first ones considered (Klein, 1997).

What this work suggests is that decision makers user filters to perceive and interpret their context, and that with the benefit of experience not only are more filters collected, but also cues are learned that suggest the correct interpretation to use and a course of action to follow. In order to understand how experts take decisions Klein's work suggests that the researcher needs to identify the salient cues used; furthermore, many of these can be described implicitly by experts through the stories they use to share they experience with others.

To summarise what has been said so far, four theories of decision making were reviewed in order to understand how a controller makes decisions. From the literature on constructs (Kelly, 1955) a decision maker uses filters to interpret a situation. The literature on mental models (Norman, 19867; Moray, 1987; Johnson-Laird & Byrne, 2000) describes a decision maker's understanding of a situation in terms of a framework that guides their decisions. Marshall (1995) defines this understanding as schemas that guide actions through four steps: identify, elaborate, plan, and execute. Finally, Klein (1999) provides the RPD model that explains how expert decision makers use their experience to recognise situations as patterns by using salient cues. Together these models suggest how a trustor understands a situation in which they have to decide whether to trust another or not.

Wickens, Mavor, Parasuraman, & McGee (1997) presents a framework (Figure 5.2.) to illustrate the way a human operator interacts with a dynamic system and the relationship between trust, mental models and situational awareness (SA).

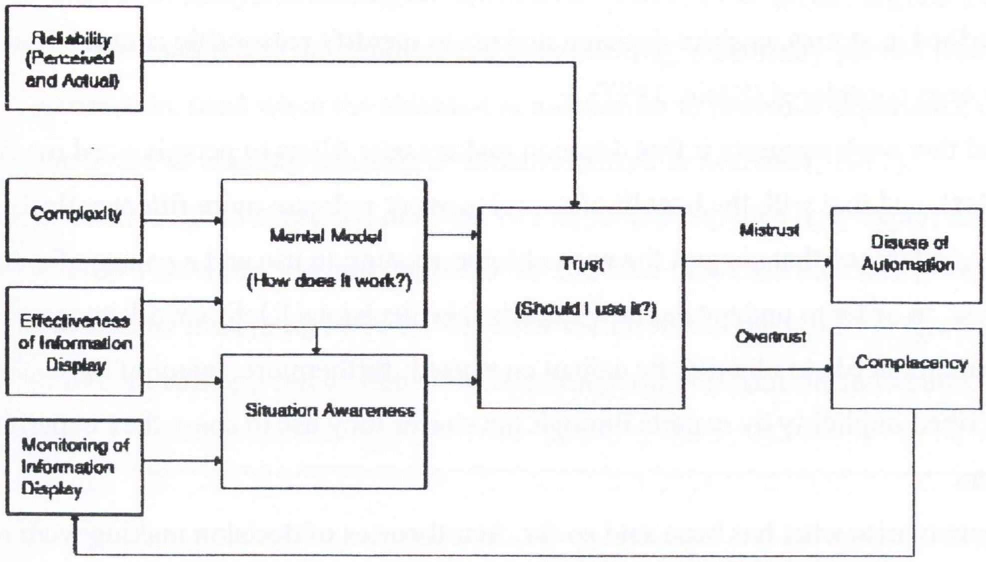

Figure 5.2. This figure presents a framework for examining human performance issues. Reproduced from Wickens et al., (1997:29).

Focusing on these three main elements, Wickens and his colleagues suggest that an operator's mental model, their understanding of the system, as well its anticipated behaviour, interacts with their SA, defined as the perception of the elements in the environment, the comprehension of their meaning, as well as the projection of their stature in the near future (Endsley, 1988). In other words, the interpretation and expectations interact with the dynamic perception of the situation and result in a decision to trust, operationalised here as *use*.

This model is not presented as a representation of the cognitive processes underlying the different elements. However it suggests reliability, complexity, effective information display and monitoring strategy as influencing a decision to trust. Although it does not represent in detail how these features contribute to an appropriate calibration of trust, it highlights the two outcomes of incorrect trust, mistrust and over trust, and the main characteristics of the technology considered to be relevant in this decision-making process.

This brief review summarises how experts use representations to interpret and anticipate events, store knowledge and the salient cues they use to identify the best course of action. Kelly and Moray illustrate how a decision maker can hold different representations for the same situation, even though it is suggested that there are some key elements that are either shared across situations or within communities, or with the system's model. In 'Cognition in the Wild', Hutchins (1995a) highlights that different cultures do not necessarily share the same representations, although the cognitive processes used to manipulate them are comparable, and it is necessary to adopt an ethnographic approach to understand the representations before understanding how decisions are taken.

The researcher, like an anthropologist needs to spend time observing and learning from experts to understand the domain from their perspective, in their terms, using their representations.

Klein (1999) describes how these representations change with time and experience, becoming in a way easier to use for the expert but harder to describe as well, because they are so contextualised and embedded in the way of understanding of the person. He writes that experts report 'just knowing' the correct course of action to take. In order to understand the salient cues and patterns an expert uses it is necessary to spend time observing experts and asking them to share their experience, collecting narratives and examples. Wickens provides a clear picture of how the interaction between representations or mental models, that precede perception, and the situation as perceived or situational awareness, influences the amount of trust given.

The literature reviewed, suggests that in assuming that the trustor is a decision-maker, it is necessary to understand the representations they use in terms of the patterns or mental models as well as salient cues. The focus in this thesis was on these last, and on determining what cues controllers to attribute competence used, as will be described in chapter six.

Regarding the assumptions made so far in this study, it was assumed that a controller (trustor) trusts another controller or a piece of equipment of a tool (trustees) when he/she willingly chooses to yield control to them. A trustor chooses to do so following a set of expectations of the trustee's behaviours. These expectations are stored in constructs or mental models that support the trustor in anticipating the behaviour of the trustee. A trustor uses salient cues to understand a situation, and the comparison between their perception and interpretation brings them to choose whether to trust or not.

In some cases, where the relation between the trustor and the trustee has been well defined through a contract, they will exhibit trusting behaviour even thought this is not considered trust, as trust implies a choice.

Trusting behaviour has been operationalised as delegating a task to the trustee or taking an action based on the information they provide without double-checking. A controller chooses to do this when, according to the expectations they hold about the trustee, they believe the trustee will behave in a certain way that will results in a positive outcome for them. The same behaviour, however, can be observed if a controller chooses to trust or co-operate according to procedures that are shared with the other. For this reason it is necessary not only to learn about the expectations and assumptions a controller uses to decide to trust, but also the procedures in place that, as scripts, guide his/her behaviour according to shared understandings within the working community.

5.3. Second Step: Developing a Model of Trust

The model of trust developed on the basis of the literature reviewed in chapter two and the understanding of the domain in chapters three and four contains three components. This model aims at providing a way of understanding trust in the work of a controller, under the assumptions described in the previous section.

The decision to structure the model in three components derived from Mc Knight & Chervany's (2001) classification of three types of trust, which focused, respectively, on the trustor, the trustee, and the context. The three components of the model are *Self*, *Belief* and *Control*. Their relationship is described below (Figure 5.3.), according to which the Self component is the first filter a decision-maker has in perceiving the world, followed by the way they judge others. The Self component encompasses the characteristics of the trustor that influence the decision to trust. The Belief component includes the characteristics of the trustee that affect a trustor's decision to trust them or not. These characteristics are not necessarily objective, but are as perceived or judged by the trustor. Control comprises features of the context that influence a decision to trust, and is represented as a space, but may also be understood as the line around self and belief, as the control element is made up of the rules and procedures that define acceptable and unacceptable, as well as possible, choices in an interaction, constraining decisions and structuring social behaviours. The three components that make up the model are hierarchical in that self is the first filter the trustor uses to judge others and the situation, then belief, which is a judgement of the other, and then control, which frames the situation and thus the decision space of the trustor.

With regard to the choice of the characteristics or features to include in each of the components, these were collected in the initial qualitative phase of the research. At this stage of definition, the model is conceptual and thus needs to be tested in order to ascertain whether the characteristics selected for each component are indeed relevant and valid.

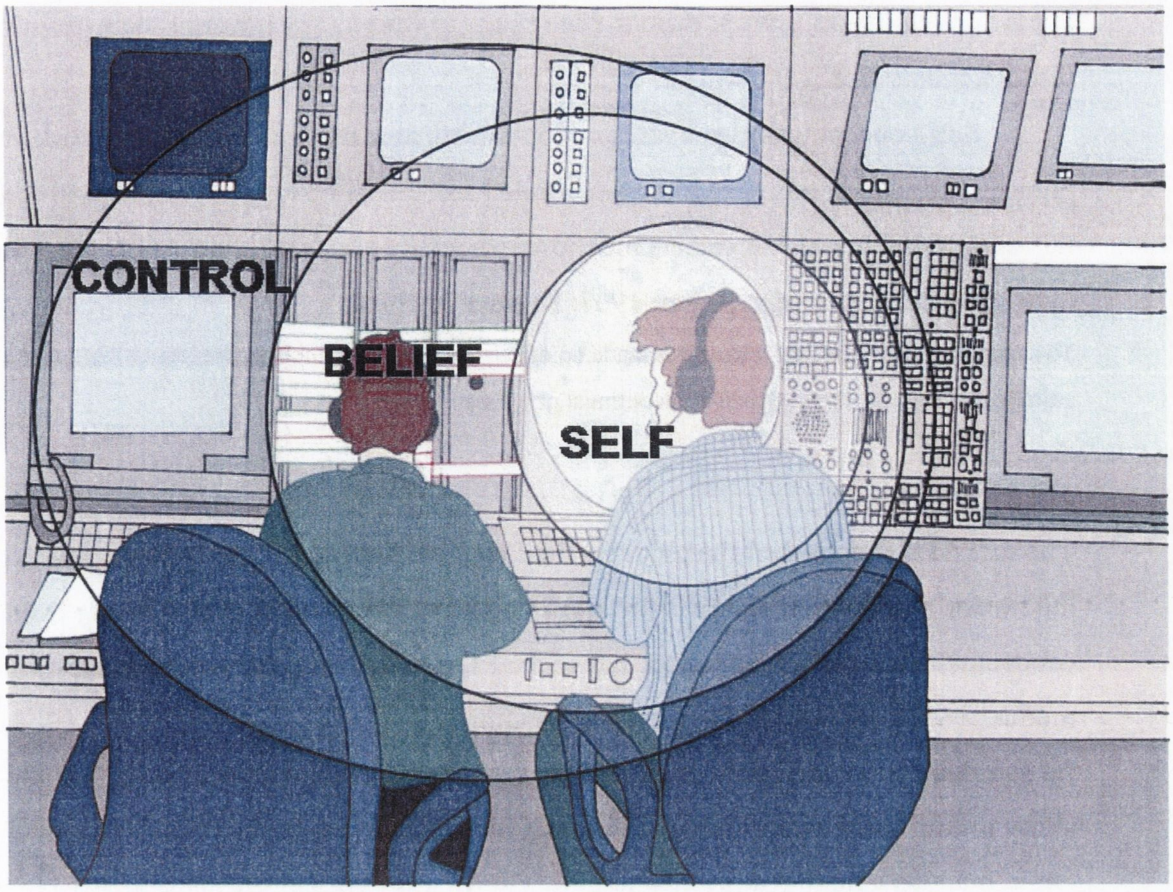

Figure 5.4. A representation of the three components of the model of trust: Self, Belief and Control. The focus of the model is the controller and thus his/her perception of self, followed by the perception of the other, followed by the perception of the context.

5.3.1. Self

The *Self* component pre-empts the way decision-makers interact with others and use technology, both in terms of whether they are confident in their ability to judge others and situations, but also in terms of their outlook onto the world, whether they are trusting towards others in general or not (e.g. Kramer's 2001 *optimists* and *pessimists*).

Zand (1972) shows that initial levels of trust colour the interpretation of the behaviour of others', as well as the way one reacts and chooses to collaborate with them. These initial levels can be understood as self concepts that are a person's first filter in interpreting the world (e.g. Kelly's constructs).

Lee & Moray (1994) illustrated the importance of self-confidence in influencing an operator's choice to delegate a task to a tool or carry it out manually. Their study showed that when the operator felt more confident in his own abilities than in those of the technology, he carried the operation out manually instead of delegating it to the tool.

Controllers confirmed the importance of self-confidence in their answers to the questionnaires described in chapter four, as it is considered what allows them to take fast decisions and expect prompt actions from pilots to whom they transmit their confidence through their voice.

Self-concept was also understood in the broader sense as being or not inclined or predisposed to trust others. Although a limited amount of research has been carried out in this area, a number of researchers mention personality and worldview as being a variable in trusting behaviour (e.g. Rotter, 1967; Kramer 2001).

To summarise then, the Self- concept is made up of self-confidence (which can be low or high) and a general attitude towards others, described as an optimist or pessimist.

5.3.2. Belief

The second component of the model is the *Belief* element and refers to that which guides the trustor's behaviour. Belief is the set of cognitive frameworks, which have been conceptualised in different ways, as described above in the review of decision-making models, which are used to interpret and anticipate.

As summarised in chapter two, controllers described trusting others as believing in their abiity to fulfil their expectations. Believing was chosen to express both a judgement of the other, but also a 'taking at face value' that allows us to act. Constructs are used to predict events and are revised on the basis of whether their predictions are found to be correct or misleading (Fransella & Bannister, 1977). This may explain how trust changes with time. The implication of this argument is that to study the belief component of trust it is necessary to understand the set of expectations, mental models or sets used by the trustor. In other words, the belief consists of the representations (Hutchins, 1995a) used in cognitive activity.

A controller has a set of expectations, organised into patterns that he or she use in their work to make accurate judgements. With experience, they are able to shift their expertise from speed to accuracy, optimising their resources. Patterns are taught to them during training but most of their expertise is gained on the job, during their OJT (On the Job Training) period and in their first years (C. Costello, 2001, personal communication). In the same way as Rempel et al.'s (1985) three-stage model (chapter two) can be understood as trust depending on stereotypical experiences and roles first, and, with time, on a richer understanding of the person's motivations, a controller's mental models become richer in terms of contingencies considered and cues to interpret situations with experience. Thus, it is possible to talk about the beliefs related to traffic patterns that a controller holds as changing in time, and becoming more efficient tools to manage their workload.

Trust has been described as an inherently situational phenomenon (Marsh & Meech, 2000). Thus, for example, someone may trust their brother to drive him to the airport but not to fly the plane (Marsh, 1994). Although initially trust was considered as something contextually determined (Bonini et al. 2001), closer consideration brought the realisation that when talking about trusting a person only in certain situations and not in others, what is effectively being said is not that the context influences whether the other is trusted or not, but that the judgement of their ability depends on the context in which they are placed. In other words, trust in them depends on how able they are judged to deal with the events in that context.

Thus, the Belief component was seen as a way to explain the fact that a person holds a number of constructs about the same person and mental models about the same system, that influence their trust in them under different circumstances. The belief then is a judgement made on the appropriateness of the trustee to carry out what is being delegated to them, "trust involves (…) a task of assessment of other people's capacity for the action" (Kramer 2001: 16).

The model developed from the literature and results of the initial qualitative phase was conceived as a general framework or description. In order for it to be relevant to the work of an air traffic controller it was necessary to clearly identify the characteristics in each component and test them. The belief component encompasses the mental models used by controllers to judge others and is vast in scope. For this reason a selection needed to be made regarding the components, and then validated. The results of the questionnaires described in chapter four suggested that competence was an important variable for controllers in deciding to trust others. Competence was then identified as a measure of the belief component.

Competence has been recognised at both interpersonal and organisational levels as a central element to understanding trusting behaviour (e.g. Barber, 1983; Butler, 1991; McAllister, 1995). A decision to trust a colleague and delegate a task to him/her, or to base an action on the information provided by technology, is effectively the choice of a control strategy. The assumption is made that when a controller chooses to trust another they are deciding if the other is "good enough" to carry out the task they want to delegate to them, or if the technology is "accurate enough" to give them the right information to make an informed and correct decision. Two examples should help clarify the relation between competence and trust. Both cases are taken from safety occurrence reports, and have thus been de-identified.

In the first case a trainee is working under the supervision of an OJTI (On the Job Training Instructor). The trainee receives a call from a pilot (AB123) whose call sign does not match that represented on the radar (AB125). The controller questions the pilot, who informs the trainee that there is another aircraft airborne, with a similar call sign. Based on previous experience, the trainee believes that the AB125 represented on the radar is the AB123 whose strip he holds. As Lee & Moray (1992; 1994) suggest the comparison between self-confidence and confidence in the technology's ability or 'competence' resulted in the controller trusting their experience rather than the information displayed. The controller trainee cleared (i.e. instructed) AB123 to climb. During this exchange a visitor distracted the OJTI. Visitors are more frequent in some control rooms than others. In busy times, they are usually ignored. This would suggest that not only the traffic was not high, but also that the OJTI believed that that student was competent enough to cope with the traffic unsupervised. The real AB123 was not shown on the trainee's radar, because it was flying outside the airspace shown on the screen. Complying with the instruction given to it, the aircraft lost separation with another aircraft, which took avoiding action under the instruction of the controller who was controlling the adjacent sector.

The inaccurate calibration of trust can be considered among the factors that contributed to this incident. The trainee did not trust the information on his or her radar screen, but was confident and relied on his or her experience and knowledge. The OJI, consciously or less, allowed her/himself to be distracted, as the traffic was reported as light and well within the capacities of the trainee to handle safely. The OJTI's task was to find a balance between keeping the situation under control, and giving the trainee enough freedom to become self-confident and learn to be a competent controller. It is only with experience that expertise is gained. The trainee was trusted as capable and hence delegated control of the situation. This interpretation of the events suggests that self-confidence; the judgement of the trainee's competence by the trainer and the judgement of the accuracy of the technology by the trainee all played a role in the occurrence.

The second example refers specifically to trust in technology and regards a judgement of the competence of a tool.

The traffic is medium to high and the controller puts three aircraft (A, B, and C) on parallel headings, roughly eastbound. The airway within which the aircraft are flying is restricted, due to the activation of a military zone. The intention of the controller is to climb C and A that are both outbound from the same airport, through the level of B, flying at 29,000 feet. Initially, B and C have about 3 Nautical miles (Nm), and B and A have about 5.7 Nm. The heading (i.e. direction flown) of A is 100, 6.5Nm away from B, which is on heading 095 (i.e. converging). C is on a heading of 101 degrees, 4Nm away from B (i.e. diverging) (Figure 5.4.).

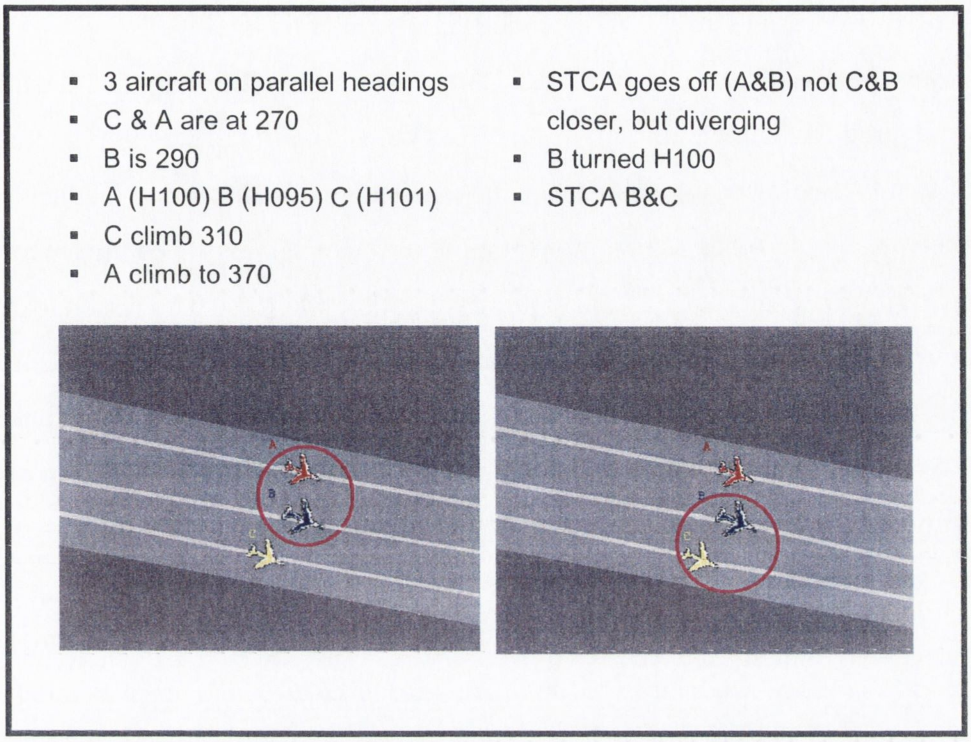

Figure 5.4. Two screen-shots of the occurrence described in the second example, in which a controller trusted the technology too much.

The controller instructs C to climb to 31,000 ft. At this moment the short-term conflict (STCA) alarm starts flashing. The STCA is an alarm that alerts a controller that two aircraft are on the same heading at the same altitude, or one aircraft is climbing/descending in the direction of another one. The distance between the aircraft that triggers this alarm varies from centre to centre, and is decided according to traffic density, complexity and airspace configuration, as well as local working methods. In this situation the STCA is triggered between A, climbing to FL370 and B because they are on converging tracks (B=094^0 and A=098^0). However, the distance between the two was well above that considered to be safe. Despite the fact that the distance between C (heading 098^0) and B was smaller than between A and B, although still within the safe limit, STCA was not triggered because they were diverging. The controller reacted to the STCA by turning B into heading 100. The tracks of B and C are now slightly converging (B=099^0 and C=097^0). This switches STCA from A to C, and reveals the actual separation between B and C is at the limit considered safe. As a reaction, C is turned onto heading 110^0, which quickly establishes horizontal separation, just before vertical separation is achieved as well.

The analysis of this episode suggested that the controller, who was busy at the time, saw the alarm and reacted on it, trusting the technology to be competent. During the debriefing following the occurrence, as described in the incident report, it was found that the controller was not aware of the underlying logic of the tool.
The controller had thus had not read the cues correctly, thinking that the alarm was triggered when the minimum distance between two aircraft was going to be infringed. Effectively, it was not the distance that had triggered, but simply the fact that they were converging. In other words, the judgment of the technology's competence was inappropriate, and led to an inappropriate decision to trust. The lesson learned from this event is that in order to support an appropriate calibration of trust in technology, it is essential that the user of the tool understands the logic underlying the functioning of the technology, so as to be able to distinguish the quality of the information provided, and thus how well the technology 'understands' the situation, based on the information it uses to suggest an action.

This judgement of appropriateness is then conceptualised in terms of an assessment of competency, where it is not so much the degree of competence as much as the *perceived competence* that is relevant. Although, as mentioned above, competence has been quoted as a relevant factor in trusting behaviour in order to understand controllers' trusting strategies, it was necessary to understand what a *competent other* means in a controller's terms. In other words, it was necessary to identify the characteristics that are relevant to a controller in order to attribute competence. Although a number of characteristics had been identified by the controllers who responded to the three questionnaires (chapter two) it was necessary to follow a quantitative approach to identify the most salient characteristics, which would then be used to test the relevance of the belief component in a controller's decision to trust in chapter seven. The way the information on competence was collected is described in the final section of this chapter and, in more detail, in chapter six.

To summarise then, the belief component is made up of beliefs on the other's ability to behave according to the trustor's expectations for the future. These beliefs are reinforced or disproved by experience. The most important belief for an air traffic controller was hypothesised as being competence.

It is important to reiterate that what is being suggested is not that competence is the only belief to influence trust. However, it is hypothesised as being the most relevant for a controller. Another belief identified from informal interviews and related to the trust of a controller in technology and its use, for example, was the way technology is introduced. In one control centre the same tool was used by one team of controllers and not used by another. This was due to the way the technology had been developed and introduced into the control centre, allowing controllers in the first team to participate in the process, but not the controllers in the second team, who consequently did not accept to use the tool. The controllers in the first team explained how they trusted the tool as being sound and how it provided reliable and useful information. The second team explained how they tried to use the technology but had found the information to be unreliable and did not trust it as a support tool.

5.3.3. Control

The *Control* component refers to the way the relation between the trustor and trustee is defined, mediated and constrained by implicit or explicit rules that are shared and assumed in their interaction and co-operative behaviour.

Trust assumes a choice. Deutsch (1960a) argued that if it were possible to control the behaviour of the other, there would be no need for trust, and Lewis & Weigert (1985) that trust begins where prediction ends. In other words, when trusting control (Baier 1986) or power (Zuboff 1988) is yielded to another, and with the action of yielding control (that can also be expressed by not taking any action) the trustor chooses to run the risk of making an incorrect judgement. This risk taking behaviour is justified by an expectation, a mix of hope and prediction, to be right.

The freedom to choose and willingly yield control is limited and constrained by the social structure that forms the context within which the trustor and trustee meet (Shapiro, 1987). This social structure is formed by rules, norms and mores that are shared by the social community, whether it is a cultural or national community. One way in which these structures have been understood is in terms of roles that people take or scripts that set up the relationships and patterns that inform a performance (Panteli, 2002). In the same way as actors in a play act a given role, that defines their behaviours, social actors' interactions are to an extent defined by the roles they choose to play or are given by society.
Another way in which these mediating mechanisms between social actors can be described is as contracts (Gambetta, 1988). There are two types of contracts. A contract is an agreement between two people concerning an exchange. This exchange goes beyond the simple giving *x* in order to receive *y*, to include the way information is disclosed and resources shared in interactions with others. In these terms the act or co-operating is an act of exchange, and thus a co-operation can be seen as the acting out of a contract.

A contract can be of a social or economical type, Zand (1972) makes the distinction between a collaborative and competitive contract. In sociology researchers talk about social contracts, based on agreed norms or habitus (Misztal, 1996), through which the social world is regulated. In this sense social contracts are mutual understandings whereby behaviours are stipulated for certain situations and these stipulations lead to the expectations that guide our everyday life and interactions. Thus, for example, someone knows what kind of behaviour to adopt when meeting another person for the first time, when driving a car, or when buying a house. The same person may be at loss in a different country to the one familiar to them, because they are not aware of the social contracts everyone else takes for granted.

The second kind of contact is an economic or financial one. These types of contracts are those that clearly stipulate what is exchanged and the way in which the exchange will happen, in order to both create expectations and avoid misunderstandings.

It is thus necessary to understand these relations because trust happens in a social context or exchange and interactions can often be explained by these structures that mediate their development. This had been first suggested in the interviews carried out with controllers on new technology, summarised in chapter four. Moreover, the particular type of relation of interest, co-operation, can be motivated by other factors than trust, as exemplified in Figure 5.5.. This figure is a conceptual representation and is not based on data. Trust then is expressed under conditions of freedom of choice and following a judgement by the trustor of the trustee.

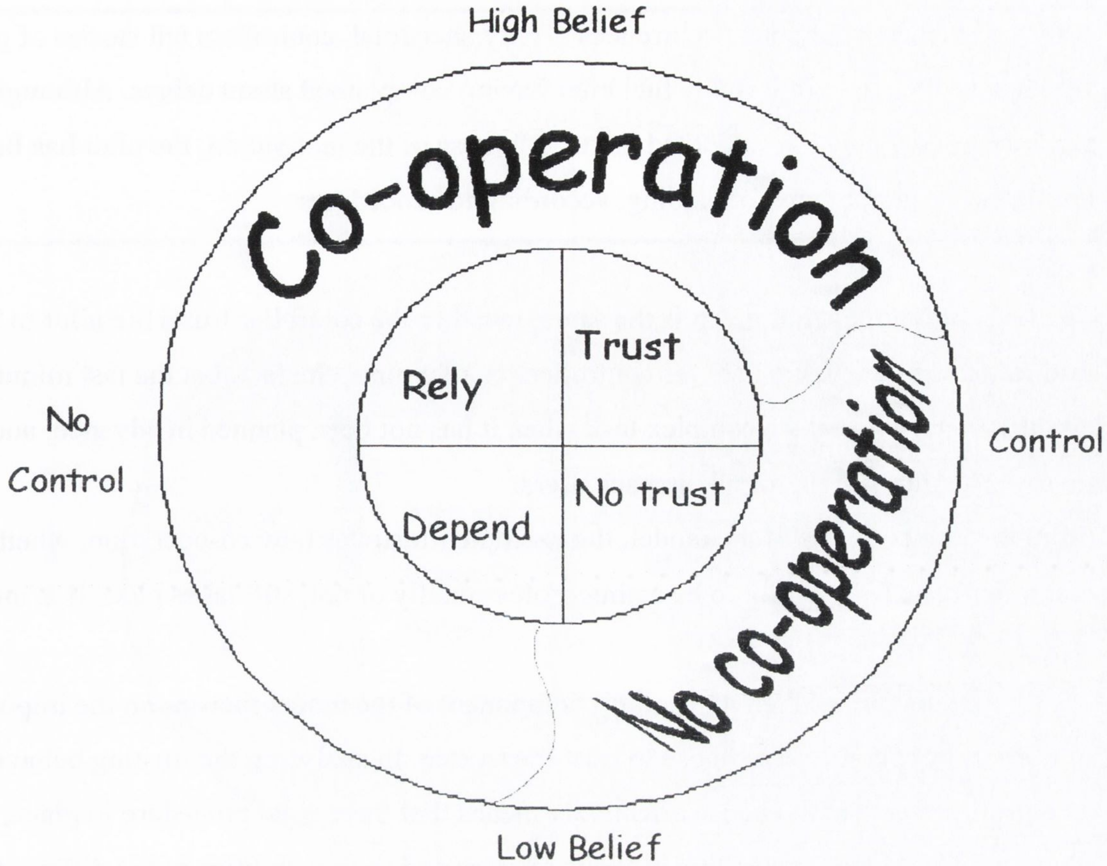

Figure 5.5. The relationship between control and belief, and co-operation and non-co-operation is represented in this figure.

Thus, when the trustor has no choice between trusting and not trusting, their relationship with the other can be described as reliance or dependence. In the first case, the trustor is considered to hold a high belief of the other, whereas in the second case, a low belief. This means that the trustor judges the other to be high or low in terms of their ability to co-operate with them. More specifically, in the case of dependence, the belief is not relevant to their motivation to co-operate.

In the case of control, the trustor has a choice to trust or less. Where the trustor chooses to trust, following an attribution of high belief, co-operation follows. In the case of a choice not to trust, following low belief, no co-operation results. An example collected through informal interviews may clarify this Figure.

Working at an approach position a controller occasionally may receive a call from a pilot in distress, who reports low fuel or a sick passenger on board. This sometimes happens in low traffic and other times in busy traffic. Under all circumstances, upon receiving such a call, the aircraft automatically becomes number one for landing, and the controller will co-ordinate with his/her colleagues to change the traffic configuration to ensure the pilot is able to land as soon as possible.

Although evidence for such occurrences is only anecdotal, controllers tell stories of pilots who have called in to report low fuel after having complained about delays. Although in some cases they may have doubted the truthfulness of the motivation, the pilot has become immediately number one for landing, according to procedures.

The level of co-operation given is the same, whether the controller trusts the pilot to be truthful or less. The issue here for controllers is, of course, the fact that the last minute re-organisation of traffic is a complex task when it has not been planned in advance, and involves additional risk for all airspace users.
From the point of view of the model, the example illustrates how co-operation, whether the controller believes the pilot to be acting professionally or not, still takes place (i.e. an aspect of competence).

To summarise, then, the control component of the model focuses on the importance of the trustor being free to choose to trust the trustee. In analysing the trusting behaviour of a controller, freedom to choose effectively means that there is no procedure in place, implicit or formal understanding in terms of roles and responsibilities of the different actors in the ATM system, that dictate the outcome of the choice to cooperate or not with the trustee. To be able to distinguish between situations in which controllers are free to choose and situations in which working methods or procedures guide their interactions with others and with technology, a good knowledge and understanding of the domain of their work is required.

Figure 5.6 below represents the model of trust that encompasses the three components, as described in the sections above.

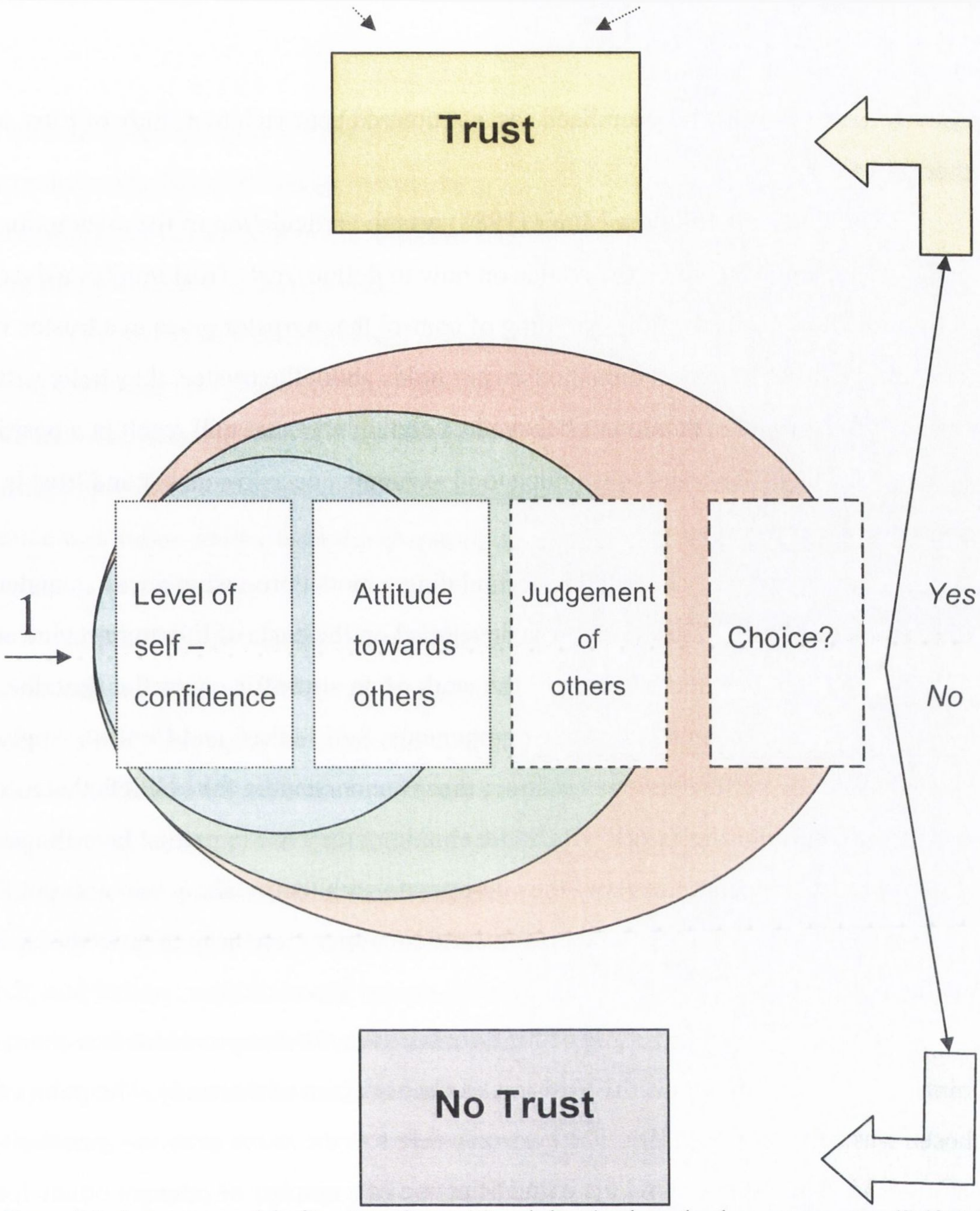

Figure 5.6. A process model of trust starting at (1) and showing how the three components (Self, Belief, and Control) lead to a decision to trust or not to trust.

The trustor begins by considering a situation through their self-confidence and attitude towards others. A judgement of the other is made and the decision to trust or less then depends on whether the trustor has a choice to freely choose or not. If the trustor considers the trustee to be able to meet their expectations, and there are no procedures, rules or norms that guide the decision of the trustor, the trustor will choose to trust the trustee. The decision to trust may be influenced by such things as workload and risk.

5.4. Third Step: The Approach Followed to Study Trust

As mentioned in the introduction to this chapter, a number of steps are suggested in a study of trust. Although these are the steps followed in the research described in this thesis, it is believed that they may be generalised as a structured approach to a study of trust, also in other domains.

The *first step*, following Muir (1988) was the articulation of the assumptions made in the study, amongst which the choice on how to define trust. Trust implies a dyad and the definition chosen was a willing yielding of control that a trustor gives to a trustee when, according to a set of expectations the trustor holds about the trustee, they believe the trustee will carry out an action or behave in a certain way that will result in a positive outcome for them. The trustor is understood as being a decision-maker and trust is the consequence of a choice.

The *second step* consisted in formulating a model proposing a way to understand the dynamics of trust. This model was developed on the basis of literature reviewed in Chapter two and the understanding of the work of an air traffic controller described in Chapter four, and encompasses three components: Self, Belief, and Control. Applying the model, as defined in the previous section, means understanding the beliefs that a controller has of the controller they work with and technology they use to predict how the presence or absence of trust mediates the way they co-operate with them, taking into account the control element that guides and constrains their co-operation through procedures, rules and culture.

Based on an understanding of the domain, the *third step* consisted in choosing a point of view, in other words the trustor, and the horizon of the study. The point of view chosen was that of a controller. The horizon refers to the scope or to the granularity of the study, and its definition allows the identification of a number of relevant others for the trustor. These relevant others, or *referents* (Bonini, 2000), are the others who may or may not be trusted by the trustor.

Trust has been described as being something that influences a person's interactions with others in terms of the decisions they take in maintaining or giving control to those with whom they can co-operate. In the case of an air traffic controller the others who have a role in their work vary according to the granularity of focus. Thus, they range from the decision support tool used in a tower to organise the sequence of arriving traffic, to the radar screen and the information it provides, from the controller sitting next to them who provides information and advice, to the controller in the next sector who agrees to make changes to the incoming traffic, from the watch manager or supervisor who ensures that the level of traffic attributed to the sector controlled is manageable, to the centre management who decides on working shifts, procedures and on how to introduce new technology into the centre.

In this study the horizon of the study was a controller working position, thus the others were the controller with whom the working position is shared (i.e. Executive or Planning controller), the controllers in the adjacent sector with whom he/she is in contact, and the technology available at the console.

The *fourth step* encompassed testing the model proposed, which will be the subject of the following two chapters. Trust was considered as depending on a judgement of how *able* the other (both human and technology) will be to fulfil a controller's expectations during their work, and thus competence was identified as a salient characteristic. This choice was supported by both the literature on trust and controllers' opinions, as described in chapter two and four.

In order to test whether a controller's trust in another controller and in the technology he/she uses effectively depends on a judgement of competence it was necessary to understand what competence meant to a controller. A tri-partite methodology was followed to first collect the characteristics used to recognise a competent controller and competent technology, and then to identify the most salient of these characteristics. The assumption was made that it is not the degree of competence that is relevant, but the perceived competence that is relevant to trust. The three exercises carried out by French, Irish, and Italian controllers and the results have been summarised in chapter six. Chapter seven describes the way in which the characteristics found to be relevant in a judgement of competence were used in a series of scenarios that tested the relationship between competence and trust.

5.5. Chapter Summary

This chapter summarised the assumptions made and the model of trust developed to describe an air traffic controller's trust in others and in the technology used in his/her work.

The assumptions made in this study of trust are described in the first section of this chapter. The first assumption is that trust implies a dyad, a trustor and a trustee. The second assumption is the definition of trust chosen, as a willing yielding of control that a trustor gives to a trustee when, according to a set of expectations the trustor holds about the trustee, the trustor believes the trustee will carry out an action or behaviour in a certain way that will result in a positive outcome for the trustor. The conceptualisation of trust as a belief in future actions of the other, as well as a yielding of control to another had been identified as relevant both in the literature and in questionnaires by controllers.

The third assumption is that trust is a consequence of a choice. Thus the nature of the decisions a controller makes in his/her work, as well as the choices available to them need to be understood. The results of the ethnographical approach followed, made up of observations and interviews, have been summarised in chapter four.

The fourth assumption is that trust is an antecendent of cooperation, as described by Deutsch (1960a), Mistzal (1996), and Kramer (2001). In order to measure whether trust and cooperation are present, these need to be operationalised. Trust as operationalised as a decision to delegate a task to another or base one's actions on the information provided by technology.

The fifth and final assumption made was that the trustor was conceived as a decision maker, which is compatible with the literature describing trust as a choice (chapter two), the understanding of an air traffic controller as a decision maker (chapter three), and the results of observations and questionnaires (chapter four).

The model of trust was developed based on the structure suggested by Mc Knight & Chervany (2001) who described three types of trust which focued on the trustor, on the trustee, and on the context. The three components of the model were called 'self', 'belief', and 'control'. The self component refers to the characteristics of the trustor that influence his or her decision to trust. The belief component refers to the characteristics of the trustee, understood in this thesis as another controller or technology, on the trustor's decision to trust. The control component refers to the characteristics of the context, defined in terms of the relation between trustor and trustee and the features of the situation which influence a trustor's decision to trust a trustee. It is believed that consideration needs to be given to all three components to achieve a complete understanding of trust. For each component the main characteristics or features were identified and described.

The chapter closes summarising the steps suggested as an approach to follow in a study of trust.

The next chapter describes in detail the study carried out to identify the salient characteristics of a competent controller. These characteristics will then be used to test the belief component of the model of trust in chapter seven.

Chapter Six: Competency in Air Traffic Control

6.1. Chapter Overview

This chapter and the following report the results from the quantitative phase of the research described in this this. The present chapter opens with a section explaining the rationale for the study the results of which are reported in detail. This study aimed at identifying the most salient characteristics of competency, for both controllers and technology, according to operational controllers. The study is presented as the first part of the validation study. Controllers from France, Ireland, and Italy took part in the study.

The methodology used was the same for all nationalities and encompassed three tasks. The results of each task served as the basis for the next two exercises.

The first task collected the characteristics participants thought described a competent colleague and technology. Controllers involved in the next task were asked to sort the list of characteristics resulting from the previous exercise into groups. The results of the third task are summarised in a series of 'scales of competence', where the two extreme markers are the least and most salient characteristics, according to the expert judgment of participants, and their relative distances represent attributed importance.

The results of this chapter were used in the second part of the validation study, described in chapters seven.

6.2. A First Step Towards the Validation of the Model

The research described in this thesis aimed at understanding the role of trust in the work of a controller by defining a model of trust in colleagues and in the technology a controller uses in his/her work. The initial phase of this research was qualitative in nature. The results of this phase have been reported in chapter four. Chapter five described the assumptions made in this study of trust and introduced the model developed on the basis of the literature on trust (chapter two), an understanding of the domain of Air Traffic Management (chapter three) and the qualitative information collected through observations, questionnaires, and interviews (chapter four). As described in the previous chapter, the model comprises three components: self, which refers to characteristics of the trustor, belief, which refers to characteristics of the trustee, and control, which refers to the characteristics of the context. To be able to test the model it was necessary to identify a number of characteristics believed to be relevant for each component in influencing a controller's trust of colleagues and technology. With regard to the self component, self-confidence and general attitude towards others were selected. Concerning belief, on the basis of the literature and the replies of the controllers who completed the questionnaires and were interviewed, competence was chosen as the most relevant characteristic of this component. Competence was then idenitifed as a measure of the belief component. Finally, the control component regards the relation between the trustor and the trustee, which needs to be characterised by freedom to choose and not constrained by predetermined choices such as those dictated by procedures.

The aim of the study described in this chapter was to identify descriptors of controller and technology competence for the belief component of the model, according to controllers from France, Ireland, and Italy. This study and the validation of the model described in the following chapter followed a quantitative approach, using statistical techniques rather than the analysis of verbal material.

In a way similar to the study of trust, researchers agree that the definition of competence is not straightforward (Holmes, 1994). Competence is in fact a complex combination of attitudes, values, knowledge and skill that allow for satisfactory performance in actual working situations (Gonczi & Athanasou, 1996). Satisfactory performance may be understood as an ability to perform according to standards required in an occupational area (Holmes, 1994), but also as being defined by the working culture of those in the domain (Hayward, 1997). Due to the implicit nature of competence, like trust, eliciting its definition from experts is not straightforward.

The model of competence found to be most often referred to is the component model (Sptizberg & Cupach, 1984), which includes knowledge, skill, and motivation, and describes the concept in terms of knowing what behaviour to carry out when, and being motivated to do so.

In the literature the concept of competence is reported as being treated either as an underlying characteristic of an individual, assessed by psychometrically derived tests, or as a socially situated ability to perform tasks and roles to an expected standard, which varies with experience and responsibility (Eraut, 1998). The latter understanding best suits an analysis of a competent controller, as someone able to apply the "appropriate knowledge, skills and experience to provide air traffic control services as notified in his air traffic controller licence" (Eurocontrol, 2000: 49).

Storey (2001) describes competence as a dynamic process that changes with experience. What changes with time is the repertoire of behaviours available, but also the ability to recognise salient characteristics more readily. This should also be true for the recognition of salient characteristics of competence and is in line with literature on expertise (e.g. Klein, 1999) as well as being confirmed in the way controllers describe learning to trust someone or technology in time, and with experience. These indicators can be attributes of a competent controller or features of an efficient and useful technology.

Holmes (1994) argues that social processes need to be considered in competency, as the concept of competence is culturally defined. This would suggest that controllers of different working cultures or nationalities may have different salient characteristics or indications of competence. Members of a social group who share assumptions that are culturally defined often cannot produce an organised description of their shared cognitive schemas that are well learned (Infield & Corker, 1997).

The possibility that competence may have different 'markers' in different countries or cultures is particularly important for Air Traffic Management (ATM), because it transgresses national boundaries, and the new technology or automation[1] that will be introduced in the future to support controllers will be implemented in different states. The importance of understanding the 'collective mental programming' of people's minds (Hofstede, 1997) is something that has been identified in the design of new technology in the nuclear industry (Meshkati, 1997). However, just as important is identifying the influence of national, corporate and professional cultures (Infield & Corker, 1997) on the definition and understanding of competence, as there is a general European goal of enabling future mobility of controllers throughout Europe (CFS, 2003; Eurocontrol, 2002)

6.3. Competence Rulers

The methodology used to collect controller and technology competence descriptors was the same for both nationalities and encompassed three exercises: an information collection task, a card sorting task and a paired comparisons task. The results of each exercise served as the basis for the next stage.

To reflect the process followed in the tri-partite study the structure of this chapters comprises three methodology sections, followed by the results of each methodology. The final section of the chapter is a general conclusion of all three tasks (section 6.7.).

Before describing the first task an overview is provided below of the three tasks: the information collection, card sort, and paired comparisons tasks. The final aim was to identify the *least* and *most* relevant characteristics for a controller in judging another controller and technology as competent.

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[1] The terms 'new technology' and 'automation' are used interchangeably throughout this thesis.

The information collection task aimed at collecting a representative list of characteristics that controllers use to describe competent colleagues and technology. Competent technology was defined as technology that works well and is considered helpful by a controller to accomplish their work.

To understand the relative saliency of each item in the lists that resulted from the survey it was decided to run a paired comparisons task (section 6.5.). Paired comparisons is a very effective technique in that it supports expert judgment in ranking a number of variables. The task fully exploits experts' implicit knowledge and at the same time achieves results supported by a theory. Each element to be compared is paired with each other element and the expert is asked to chose the most important between each pair. This technique is widely used in human reliability studies (Kirwan, 1994).

With one exception (i.e. Italian competent controller characteristics), the lists of characteristics of competency derived from the information collection task were too long for this exercise to be carried out. In order to reduce the lists of words into groups of items small enough to carry out a paired comparisons task, a group of controllers of each nationality were asked to carry out a card sort task to organise the words into groups, and in this way reduce the number of items to compare. The output of this exercise was a number (between four and five) of clusters of characteristics.

Card sorting is a variation on the Q-sort, "a time-honored [sic] method for dealing with disparate responses" (Neuendorf, 2002:213) and finding patterns of perceived similarity of elements between participants. Informants are asked to sort a number of elements, in this case characteristics of controller or technology competency, into groups, according to similarity or an underlying logic. The result of this exercise is a number of clusters of characteristics that were understood as being similar.

For the paired comparisons task each word was paired with all the characteristics with which it had been clustered. Controllers were then given the pairs of words and asked to choose which one they felt was more important in attributing competence. The results were summarised in scales or 'rulers' of competence, describing the least and most salient characteristics and their relative distance in terms of attributed importance.

6.4. Participants

Table 6.1. summarises the numbers of participant for each country and for each task, making the distinction between the collection of controller and technology descriptors.

Table 6.1.

Nationality	Number of Respondents					
	Info Collect	Word Sort	Paired Comp	Info Collect	Word Sort	Paired Comp
	CONTROLLER			TECHNOLOGY		
FRENCH	23	10	12	15	8	12
IRISH	22	10	12	14	10	12
ITALIAN	23	9	12	27	9	12
Total	*68*	*29*	*36*	*56*	*27*	*36*

Note. The number of participants in the study are shown by country (row) and according to the 3 tasks (columns) carried out to collect descriptors for competent controllers and technology.

Participants were operational controllers and all exercises were anonymous. It was not practicable to collect equal numbers of controllers for all tasks, or to have the same controllers complete the three exercises, although some of the controllers carried out more than one of the tasks. Where possible, an effort was made to achieve a representative group of participants in terms of age, experience and gender. Finally, having different participants in the tasks was found to be beneficial as their comments on the characteristics throughout the study supported their appropriateness. In others words, controllers in each task were questioned on whether they agreed with the characteristics being relevant to competence or if they thought some may be inappropriate. However, the numbers of controllers in each group were quite small, limiting the power of conclusions
The next three sections describe each of the tasks and the results found.

6.5. Task One: Information Collection

The first task was a word elicitation study that aimed at collecting a representative set of characteristics that describe competent colleagues and technology.
Although initially an approach that collected characteristics of both a competent and incompetent controller, it was soon realised that controllers do not accept to talk in terms of another controller as incompetent. Although mistakes are made and systems fail, controllers are expert decision-makers who are trained also to be flexible and to overcome mistakes (C. Costello, 2003, personal communication). Furthermore, all systems in the control room have back-ups and fail safe systems. The focus of the study was then exclusive to gain an understanding of competency and the characteristics that described a competent colleague and competent technology.

The characteristics collected from the replies made up a list from which only those that occurred more than once were retained. Very similar replies were regarded equivalent (e.g. "meets needs" and "responds to needs"). The resulting final list was considered to provide an indication of the constituent elements that guide the attribution of competency to another controller or to the technology used to work.
To understand the relative saliency of each item the next step was to run a paired comparisons task. However, with the exception of the Italian list of controller descriptors, the other five lists were too long to carry out this exercise. As mentioned above, a paired comparison involves comparing each item in a group with every other item in the group. The general rule of thumb used for the number of items that can be compared is usually limited to less than 12 (B. Kirwan, 2002, personal communication). In order to obtain groups of words small enough to carry out a paired comparisons task, a group of controllers of each nationality was asked to carry out a card sort task to organise the words, in order to reduce the number of items to compare.

6.5.1. Administration

The information was collected through a brief interview or through a questionnaire sent by email[2]. The questions are reported in table 6.2. and were administered in the respondents' mother-tongue (i.e. French, English, and Italian). Competent technology was defined as technology that works well and is considered helpful by a controller.

Table 6.2.

Controller Descriptors	
Question 1	Think of a controller whom you regard as competent. What characteristics does he/she have?
Technology Descriptors	
Question 2	Please list the characteristics that describe technology that works well..
Question 3	Please list the characteristics that describe technology that helps a controller work well.

Note. Questions asked to Irish and Italian controllers to collect characteristics describing competent controllers and technology.

[2] In addition to the French, Irish, and Italian respondents, 66 controllers from Australia, Brazil, Finland, Germany, Slovenia, Spain, Sweden, Switzerland, the UK and the US replied to the questions, as well as ten researchers working in the ATM domain. Due to the small numbers of participants within these groups, as well as logistic issues, it was not possible to carry out the following two tasks with them.

6.5.2. Participants

A total of 68 and 56 controllers replied to the questions on competent controller and competent technology, respectively (Table 6.1.). Approximately 10% of controllers contacted, replied.

Respondents were sent a summary of the results, containing the general conclusions from the replies received.

6.5.3. Results

The results are summarised below by nationality, first describing the characteristics of a competent controller and then competent technology.

A competent controller

The information collected from French controllers' replies resulted in 32 characteristics describing a competent controller and 20 characteristics describing competent technology (Appendix C). French respondents provided the highest number of items in their list of characteristics of a competent controller. They had a strong focus, like Irish controllers, on personal characteristics, but also on the attributes that make for a good controller specifically, as well as a team member.

Below and in the following paragraphs, the competent descriptors have been organised according to the researcher's interpretation.

A competent controller was described in terms of:

- *Attitude in their work* ('authority', 'cold blood', 'humble', 'knows own limits', 'likes his/her job', 'motivated', 'serious', 'tolerant')
- *Knowledge of rules and regulations* ('knowledgeable')
- *Personality characteristics* ('calm'; 'self confident')
- *Team skills* ('experienced', 'knows how to delegate', 'looks after others', 'team spirit')
- *recovery abilities* ('can manage unexpected events', 'can recover quickly from mistakes')
- *Way of working* ('anticipation', 'communication', 'concentration', 'efficient', 'flexibility', 'gets picture', 'keeps calm', 'radar technique', 'reactive', 'reads fast but acts carefully', 'rigorous', 'technically-oriented', 'uses phraseology')

French controllers described a competent controller as someone calm and flexible, but in control, who works well in a team and effectively manages unexpected problems.

The information collected from Irish controllers resulted in a list of 20 controller descriptors and 20 technology items (Appendix C).

The characteristics that Irish participants provided to describe a competent controller were not specific to an air traffic controller, but more generally those of a good colleague and team member. The focus in fact, was on personal and interpersonal skills.

A competent controller was described in terms of:

- *Attitude in their work* ('attitude to job'; 'cool head under pressure', 'hardworking'; 'not afraid to admit mistakes')
- *Knowledge of rules and regulations* ('knowledgeable')
- *Personality characteristics* ('calm', 'easygoing', 'friendly', 'self confident', 'sense of humour')
- *Team skills* ('able to share tasks', 'experienced', 'gets on with fellow controllers', 'helpful', 'reliable', 'team member')
- *Way of working* ('communicates clearly', 'fast', 'flexible', 'good decision maker').

A competent controller was thus described as a calm colleague, who has a number of skills and is a team member with whom it is enjoyable to work. Their description could be thought of as a general description that is not specific to ATM.

Italian controllers provided items that resulted in two lists of 12 controller descriptors and 32 technology descriptors (Appendix C). The responses of Italian participants describing a competent colleague stressed the preparation of a controller, their knowledge, use of English, and understanding of the technology they use, as well as calmness and self-control under stress. The Italian controllers' responses were less varied and more similar than those of Irish respondents, and thus resulted in a smaller list of characteristics.

A competent controller was described in terms of their:

- *Attitude in their work* ('calm even in emergencies', 'calm but can act and think fast', 'not presumptuous', 'never takes anything for granted')
- *Linguistic preparation and knowledge of rules and regulations* ('good knowledge of English', 'knowledgeable', 'knows procedures', 'keeps constantly up-to-date')
- *Understanding of the technology* ('knows strengths and limitations of technology at disposal')
- *Way of working* ('can manage unusual situations', 'good judgement').

The Italian participants described a calm decision maker, a flexible person, knowledgeable in procedures, in English and in the technology used, who takes decisions carefully, without precipitation. There was a stress on knowledge of procedures that was not mentioned by the other group.

Competent technology

French controllers were specific about the functions that the technology should have (e.g. 'allows precise measurements', 'conflict detection and resolution'), they focused on the simplicity and ease of use of the technology, as well as its intuitiveness.

The French respondents described competent technology in terms of:

- *Design features* ('conflict detection and resolution', 'fast', 'meets needs', 'provides relevant information', 'reliable', 'safe', 'simple')
- *Effect on the user's work* ('allows gain of time', 'allows precise measurements', 'assures safety', 'helps memorise', 'planning of future', 'reduces workload', 'simplifies work', 'supports user'
- *Use* ('easy to configure', 'intuitive', 'you forget about it', 'effective HMI', 'use friendly')

Irish controllers described competent technology as being simple to use and efficient. Its effect on a controller's work, in terms of simplifying work, improving performance and allowing to focus on the main controlling task, was stressed. Competent technology was described by its:

- *Design features* ('accurate'; 'efficient'; 'flexible', 'reliable', 'safe')
- *Display of information* ('bespoke solution', 'clearly displayed'; 'fast'; 'well maintained')
- *Effect on the user's work* ('decreases workload', 'does not distract you from primary task'; 'gives you more controlling time', 'simplifies job')
- *Use* ('accessible', 'confident in it', 'easy to set up', 'easy to understand'; 'simple to use', 'user friendly')
- *Way it is perceived* ('essential for my job').

Irish participants described competent technology as technology that is reliable, safe, and well maintained. They focused on its simplicity, ease of use and provision of good quality information.

In describing competent technology, Italian controllers stressed its usefulness and role as a support, the fact that it reduces workload and stress, and that it is free from malfunctions and can always be relied on. Technology considered competent was described in terms of its:

- *Design features* ('integrates with work', 'fast', 'flexible', 'immediate', 'not repetitive', 'responds to need', 'tested')
- *Display of information* ('clear display', 'easy access', 'provides useful information', 'well organised information')
- *Effect on user's work* ('acts as a support', 'gain time', 'helps work more', 'improves the quality of the information', 'increases efficiency', 'leave the controller in control', 'makes work easier', 'reduces stress', 'reduces workload')
- *Use* ('easy to understand', 'ergonomic', 'intuitive', 'simple to use')
- *Way it is perceived* ('integrates with work', 'of help', 'useful').

Italian controllers talked about ease of use, the fact the technology can be relied on, and the quality of the information it provides. Furthermore, the consequence it has on the work of a controller in terms of gain of time, reduction of stress, workload and increase in the quality of work were considered relevant. The focus then was on the quality of the information display, working more and more easily, as well as having more time.

6.5.4. Summary

To summarise, it can be said that all nationalities described a competent controller as someone who is calm and mature, who is a good decision maker and is knowledgeable. French controllers described a competent controller as someone very balanced, calm but flexible, with strong individual skills but able to effectively work in a team. Irish participants focused on a controller's personality and team skills, whereas Italian controllers stressed the importance of linguistic and procedural knowledge, as well as understanding of technology.

The controllers who participated in the information collection task were from control centres with similar traffic characteristics. It can be thus assumed that their working methods are to a certain degree similar or comparable. A large difference, for example, could have been found between a small airport and a high-level en-route centre. Differences in the focus and scope of items were identified. French participants focused on individual skills specific to a controller, and the ability to recover from mistakes. Irish controllers were most concerned with the way the controller worked and the skills that made them a good person to work with in a team. Italian respondents focused on knowledge, whether of procedures or linguistic. These results suggest that importance may be attributed to different values and meanings in describing competency.

With regard to competent technology characteristics, all three controller groups described technology that works well and is helpful, clearly displays information, is easy to understand and simple to use. The effect on their work is to reduce workload and increase time available to focus on controlling. Time and speed were characteristics stressed as well. French controllers were particular in that they mentioned technology as a means to support planning, gain time and reduce workload. They were very specific. Irish participants were mentioned the fact that technology had to be well maintained. Italian controllers described dependability, responding to needs, being ergonomic, being redundant and tested, as relevant to their judgment of competency.

To conclude then, with regard to a competent controller the information collected does suggest differences between nationalities, in terms of the salient characteristics used to judge competency. With regard to technology, on the other hand, replies appeared to be less varied. It is not possible, however, to determine whether the differences found were due to the working methods, to the organisational or national culture.

6.6. Task Two: Card Sort

A card-sorting task is a technique to find out about people's conceptual model of information, and explore how they classify items in terms of similarity.

Card sorting has been used for many purposes, from designing an interface to investigating the educational needs of patients (e.g. Lewis, 1991; Luniewski, Reigle, & White, 1999; Selltiz, Wrightsman, Cook, & Kidder, 1981). An example is designers involved in choosing the location of functions in different menus (Toms, Cummings-Hill, & Curry, 2001). Prospective users are given a number of words and asked to clarify them into logical groups based on their understanding of the concepts being investigated (Vogt, 1999). In the case of the example cited above, participants were given a list of functions and asked to group them under different menu titles, according to where they would expect to find them.

Usually, with the exception that all words have to be put in a group, there are no constraints to the way participants choose to group the words, nor to the number of groups they create.

6.6.1. Administration

The task was administered to participants either during breaks from their shift in their control centres or in between simulation exercises. Controllers were given a pack of randomly sorted cards containing either the controller or technology characteristics derived from the information collection task. Using standard instructions they were asked to organise them in a way that made sense to them.

6.6.2. Participants

A total of 56 controllers participated in the sorting tasks of controller and technology words (Table 6.1.). Informants were recruited by their supervisor, colleagues or the researcher. Participation was voluntary and no reward was given for taking part in the study. A conference paper summarised the results of the tri-partite study (Bonini & Kirwan, 2003). This paper was sent to the controllers who gave their contact details to the researcher in order to receive the results.

6.6.3. Results

The results of these exercises were analysed by carrying out a cluster analysis, which provides information on the groups of items that were correlated together by all respondents. A hierarchical agglomerate cluster analysis that sequentially merges all cases into one group was used (Aldenderfer & Blashfield, 1984). The output of this method can be represented in the form of a dendogram (i.e. a tree structure) that portrays the hierarchical organisation of the relation between items. An example of a dendogram is provided in Figure 6.1. below.

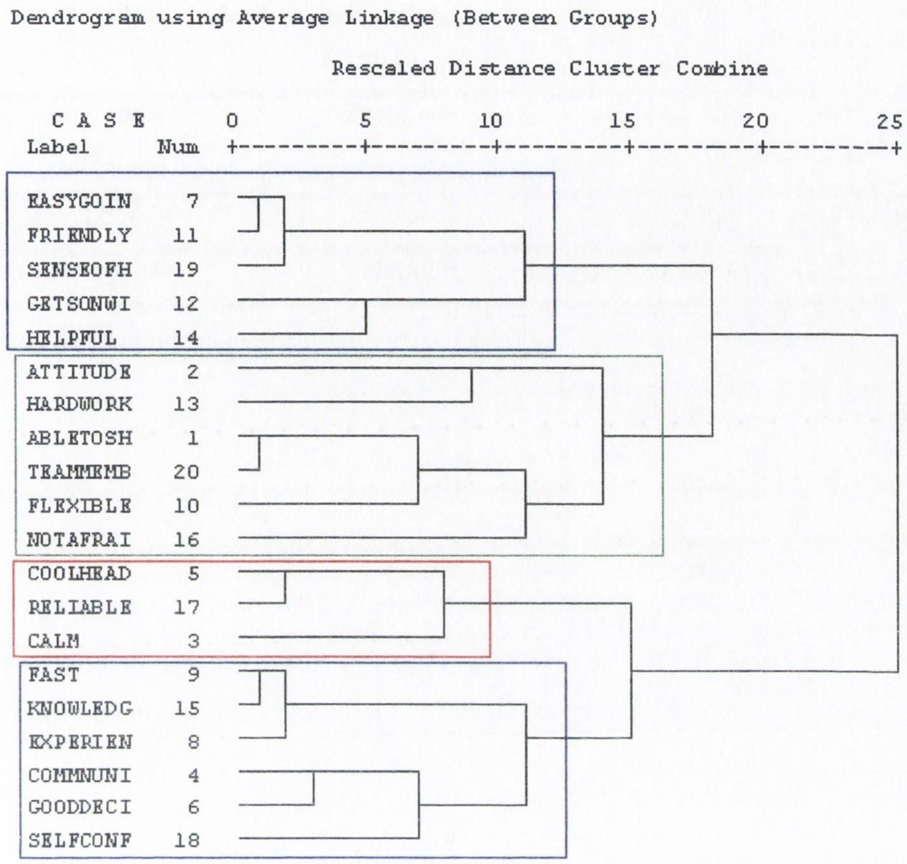

Figure 6.1. The dendogram of the results from the Card Sorting task carried out by Irish participants on items describing a competent controller.

French controllers clustered controller and technology descriptors into four clusters each. Irish respondents clustered controller and technology descriptors into five and four clusters respectively. The Italian respondents sorted technology items into five clusters. The tables of all clusters are provided in Appendix C, including the original characteristics provided by French and Italian controllers, and an example is provided in Figure 6.2.

Looking at the clusters into which controllers grouped items, it was possible to read an underlying strategy for most clusters. For example, Figure 6.2 represents the way Irish participants sorted competent controller characteristics. The first group relates to items on the personality or individual characteristics of a controller; the second group describes the calm demur of a controller who controls the traffic; the third group of characteristics describe attitude towards work; the fourth group contains characteristics of an experienced controller; and the last group is made of items that refer to team skills and sharing. The first two groups then identify *individual characteristics*, the third and fourth describe characteristics that make for a *controller who is respected*, and the fifth for a *team member*.

Easygoing	**Friendly**	**Gets on with fellow controllers**	**Helpful**
Sense of humour	**Calm**	**Cool head under pressure**	**Reliable**
Self confident	Attitude to job	Hardworking	Not afraid to admit mistakes
Communicates clearly	Experienced	Fast	Good decision maker
Knowledgeable	**Able to share tasks**	**Flexible**	**Team member**

Figure 6.2. Characteristics of a competent controller that were collected from the Co-operation questionnaire and grouped by Irish participants (listed in alphabetical order, within groups).

The same clusters can be understood differently however. For example the first and the last as characteristics of a *team-mate*, the second as *calmness*, the third as *personality characteristics* and the fourth as *skills of an experienced controller*. This exercise of interpretation is fruitful in as far as it allows to explore similarities and differences across groups of respondents, but does not necessarily lead to sound conclusions on the rationale behind the actual groupings made.

6.7. Task Three: Paired Comparisons

The paired comparisons task was used to understand the saliency of each characteristic in relation to the other items of the cluster it had been included in. The paired comparisons method is a psychological scaling technique (Thurstone, 1927; Torgenson, 1958; Seaver & Stillwell, 1983) and has been most often used in the human reliability domain to elicit expert judgements on likelihood of error. The technique is based on the idea that experts are better at comparing one item with another and then deciding which is higher or lower on a scale, rather than making absolute judgements for each item (Kirwan, 1994). The judgements made by experts are transformed into interval scales that represent a 'psychological continuum' of perceived characteristics. The results are represented graphically as 'rulers'.

Within-judge consistency is measured and the results of experts who were not consistent are not considered in the process to derive the rulers.

It is important to understand that the scaled ranking is a nominal scale of relative values, not absolute data. It represents relative spacing along some notional continuum, representing the spacing of the items in the 'communal minds' that produced the population of information sets (Hunns, 1982).

6.7.1. Administration

The task was administered to controllers in their control centres or during a simulation they took part in. During a break from their work, participants were given pairs of characteristics and asked to choose which of the two they felt would be most important in judging a colleague or technology as competent. These pairs were derived from matching each expression in a cluster, with every other item with which it had been grouped in the word sort task. Fifteen groups of words had been derived from the card sorting task.

6.7.2. Participants

Participation was voluntary. A total of 72 controllers carried out a paired comparisons task. Thirty-six controllers carried out tasks for controller and technology words respectively (Table 6.1.)

6.7.3. Results

As 23 clusters of characteristics had been derived from the card sorting task, the paired comparisons task resulted in 23 scales of competence describing the characteristics attributed to competent colleagues and technology according to French, Irish, and Italian controllers (Appendix C).

Differences were found in both controller and technology descriptors of competence, not only in terms of the characteristics provided (cfr. Section 6.3.) but also in the value that air traffic controllers attributed to common characteristics.

The paragraphs below describe competent controller 'rulers' and then competent technology 'rulers'.

Competent controller

The highest items ranked on the controller competency rulers by the French controllers were 'rigorous', 'anticipation', 'can recover quickly', and 'communication' (Figure 6.3.).

Lowest					(...)
0	18	82	95	124	151
Technically-Oriented	Uses Phraseology	Reads Fast but Acts Carefully	Serious	Radar Technique	Knowledgeable
	Highest				
191	208				
Experienced	Rigorous				

Ruler One

Lowest				Highest
0	116	139	191	350
Gets Picture	Knows how to Delegate	Concentration	Efficient	Anticipation

Ruler Two

Lowest					(...)
0	36	43	90	119	129
Authority	Reactive	Knows Own Limits	Keeps Calm	Cold Blood	Flexible
	Highest				
188	210				
Can Manage Unexpected Events	Can Recover Quickly from Mistakes				

Ruler Three

Lowest					(...)
0	21	81	170	183	187
Sense of Humour	Looks after Others	Friendly	Tolerant	Humble	Motivated
				Highest	
196	205	229	244	259	
Calm	Likes his/her Job	Team Spirit	Self Confidence	Communication	

Ruler Four

Figure 6.3 The four French rulers describing a competent controller.

The lowest items ranked were 'technically-oriented', 'gets picture', 'authority', and 'sense of humour' (Figure 6.3.). These rankings would suggest that the personality characteristics that influence the quality of a controller's work are attributed more importance than controller-specific characteristics, as well as a feeling of being in control, and being a colleague with whom working is enjoyable.

The highest items ranked on the controller competency rulers by the Irish respondents were: 'helpful', 'cool head under pressure', 'not afraid to admit mistakes', 'communicates clearly', 'team member' (Figure 6.4.).

Lowest				Highest
0	2	16	44	52
Easygoing	Friendly	Sense of humour	Gets on with fellow controllers	Helpful

Ruler five

Lowest		Highest
0	22	29
Calm	Reliable	Cool head under pressure

Ruler six

Lowest			Highest
0	42	49	61
Hardworkin g	Attitude to job	Self Confident	Not Afraid to Admit Mistakes

Ruler seven

Lowest				Highest
0	32	61	73	88
Fast	Experienced	Knowledgea ble	Good Decision Maker	Communicate s Clearly

Ruler eight

Lowest		Highest
0	23	29
Able to Share Tasks	Flexible	Team Member

Ruler nine

Figure 6.4. Five rulers representing characteristics of a competent controller, according to Irish respondents.

The items ranked lowest on the five rulers were: ‘easygoing’, ‘calm’, ‘hardworking’, ‘fast’, ‘able to share tasks’ (Figure 6.4). These results can be interpreted to suggest that although personality characteristics (e.g. ‘easygoing’, ‘friendly’, ‘calm’) are important, those related to the quality of work prevail: being helpful, rather than easygoing; keeping a cool head under difficulty, rather than simply being a calm person; admitting mistakes, rather than being hardworking; communicating clearly, rather than working fast; and that being a team member is more than just sharing tasks. The results from the Irish participants suggest that competence is related to personal characteristics that influence the way a colleague works.

Italian respondents were not asked to cluster the characteristics describing a competent controller, as the list was short enough to carry out a paired comparisons. The lowest characteristics on the scale were those related to ‘calmness’, and resourcefulness in emergencies, and the highest were ‘being knowledgeable’ in both English and procedures (Figure 6.5.). Technical skills were thus perceived as more important than personal ones.

Lowest					(...)
0	40	49	50	55	56
CALM BUT CAN ACT & THINK FAST	CALM EVEN IN EMERGENCIES	CAN MANAGE UNUSUAL SITUATIONS	NEVER TAKES ANYTHING FOR GRANTED	KNOWLEDGEAB LE	FLEXIBLE ACCORDING TO TRAFFIC CONDITIONS & SITUATIONS

					Highest
63	68	74	95	117	154
GOOD JUDGEMENT	KEEPS CONSTANTLY UP-TO-DATE	NOT PRESUMPTUOUS	KNOWS STRENGTHS & LIMITS OF TECHN.	KNOWS PROCEDURES	GOOD KNOWLEDGE OF ENGLISH

Ruler ten

Figure 6.5. The ruler representing the characteristics of a competent controller, according to Italian respondents.

Competent technology

The highest positions on the four technology rulers of French controllers were held by ‘gain of time’, ‘fast’, ‘simple’ and ‘effective HMI (Human Machine Interface)’ (Figure 6.6.). The fact that the technology helps in ‘planning the future’, is ‘intuitive’, ‘user friendly’ and ‘allows precise measurements’ was seen as less important. The first rulers rank items from the functionality of the technology to the ‘effect on the work’ and ‘ease of use’ and ‘gain of time’. The items can actually be read as following one from another. The second ruler moves from characteristics to effects too. Time, once again, is perceived as very important. The third ruler rates simple as more important than (both) ‘user friendly’ and ‘you forget about it’. The fourth ruler results from three clusters: ‘allows precise measurements’, ‘helps memorise’, ‘reliable’ and ‘supports work’, ‘provides relevant information’ and ‘effective HMI’. So, from what the technology allows the controller to do, to in effect the work, to the information it provides. The quality of the information is the most relevant.

Lowest						Highest
0	10	28	38	48	68	78
Planning of future	Conflict detection & resolution	Assures safety	Reduces workload	Simplifies work	Easy to configure	Gain of time

Ruler eleven

Lowest			Highest
0	40	50	60
Intuitive	Meets need	Safe	Fast

Ruler twelve

Lowest		Highest
0		26
User friendly	You forget about it	Simple

Ruler thirteen

Lowest					Highest
0	36	46		76	87
Allows precise measurements	Helps memorise	Reliable	Supports work	Provides relevant info	Effective HMI

Ruler fourteen

Figure 6.6. The four rulers describing competent technology according to French respondents.

With regard to technology, Irish controllers ranked 'accurate', 'safe', 'user friendly', and 'essential in my job' in the highest positions of their technology rulers (Figure 6.7.). The four characteristics 'fast', 'easy to understand', 'gives you more time', and 'well maintained', were less important (Figure 6.7.). Technology needs to be safe, user friendly and reliable (i.e. 'accurate' and 'essential in my job'). The speed of use is less important than certain characteristics, as well as the role of the technology in the controller's work.

Lowest							Highest
0	49	53	68	91	115	126	177
FAST	ACCESSIBLE	EASY TO SET UP	FLEXIBLE	BESPOKE SOLUTION	CLEARLY DISPLAYED	EFFICIENT	ACCURATE

Ruler thirteen

Lowest				Highest
0	33	51	57	85
EASY TO UNDERSTAND	SIMPLE TO USE	DECREASES WORKLOAD	SIMPLIFIES JOB	USER FRIENDLY

Ruler fourteen

Lowest			Highest
0	62	78	180
WELL MAINTAINED	CONFIDENT IN IT	RELIABLE	SAFE

Ruler fifteen

Lowest		Highest
0	57	98
GIVES YOU MORE CONTROLLING TIME	DOES NOT DISTRACT FROM PRIMARY TASK	ESSENTIAL FOR MY JOB

Ruler sixteen

Figure 6.7. Four rulers representing characteristics of competent technology, according to Irish respondents.

Looking at the rulers individually, in the first ruler it was found that the quality of the information may be more important than the ease with which it can be used. In the second, again, 'ease of use' is ranked lowest against the effects on a controller's job and user friendly. Perhaps ease of use is understood as the way the user utilises the technology, whereas user friendly is more focused on the perceived quality of the technology. The ranking of the characteristics of the fourth ruler suggest that safety is more important than reliability, presumably technology is safe both because of its reliability, but also because of the way in which it is used. In other words, the safety of a system is intrinsically linked to the person using the system. Finally, technology needs to be relied on, and is perceived as 'essential'. This is more important than 'gives more time' or not being a distraction to the user.

With regard to technology, respondents from Italy rated highest on their technology rulers 'reliable', 'free from malfunctions', had a 'clear display', 'improved the quality of work' together with 'increased efficiency', and 'not repetitive' (Figure 6.8.). The fact that technology is 'easy to use', 'improves the quality of information', 'fast', 'intuitive', and 'helps work more' resulted as being less important (Figure 6.8.).

Lowest						Highest
0	6	36	38	43	44	74
Easy to use	Redundant	Flexible	Easy access to information	Tested	Immediate	Dependable

Ruler nineteen

Lowest					Highest
0	36	38	52	61	66
Fast	Gain time	Of help	Simple to use	Useful	Clear display

Ruler twenty

Lowest					Highest
0	8	13	16	18	23
Improves quality of information	Well organised information	Always available	Provides useful information	Easy to understand	Free from malfunctions

Ruler twenty-one

Lowest							Highest
0	17	63	94	97	127	154	167
Intuitive	Leaves controller in control	Reduces stress	Integrates with work	Reduces workload	Responds to needs	Acts as support	Increases quality of work

Ruler twenty-two

Lowest		Highest
0		20
Helps work more	Not repetitive	Increases efficiency

Ruler twenty-three

Figure 6.8. Five rulers representing characteristics of competent technology, according to Italian respondents.

6.8. Discussion

With regard to a competent controller, all groups identified calmness and keeping cool. French controllers listed 'calm', 'keeps calm' and 'cold blood', which were all ranked in the middle position of their rulers. Irish controllers distinguished between the two, considering 'cool head under pressure' as higher. Italian respondents ranked 'calm' as lowest followed by 'calm even in emergencies'. Thus, both considered coolness as more important than calmness. Italian ranked 'managing difficulties' higher than these, whereas Irish controllers ranked self-confidence as more relevant.

The highest items on the Italian ruler were 'good knowledge of English' and of procedures. One explanation of this strong emphasis is Italian controllers are exposed to a higher number of non-English mother-tongue pilots, and thus adhering to procedures and reducing unusual instructions may be felt as strongly contributing to assure a shared understanding and safety. All groups identified 'flexible' as a characteristic of a competent controller. In the French ruler (ruler three) it was ranked after the two characteristics that referred to the ability to manage unusual situations or cope with mistakes. In the Irish ruler (ruler nine) it is less important than 'team member' and more important than 'being able to share tasks'. In other words, a team member has to be able to share tasks and be flexible. In the Italian ruler (ruler ten), 'flexible' was less important than knowledge, attitude and judgment, but more than 'calmness' and 'managing unusual situations'. Thus, flexibility is situated in between the way decisions are taken (i.e. 'calmness') and the source of good decisions (i.e. 'knowledge', 'attitude', and 'judgement').

Both Irish and Italian identified 'good judgement' or decision-making skills. French controllers did not list this characteristic. For Irish respondents it was more important than speed, experience or knowledge, but less than communication skills. For Italian informants it was more important than calmness, knowledge and flexibility, but less than knowledge of English, of procedures and of technology, as well as not being presumptuous. Thus the role of a good communicator prevailed over that of an effective decision-maker.

During the interviews it was apparent that it was not acceptable to talk about an incompetent controller.

With regard to competent technology rulers and the distribution of the contents, from least to most important, Irish and Italian controllers ranked common items more closely compared to French participants. For example, the item 'fast' was the lowest item in both Irish and Italian sets of rulers. For French respondents the contrary was found, fast ranked highest, with other time-related characteristics.

Clarity of display of information was ranked high on Irish and Italian rulers, but not mentioned by French controllers.

The unique characteristics are interesting. French controllers focused on the qualities of the information provided by the technology, the speed with which it was presented and simplicity of use. The effect on their work was less relevant to them. The Italian respondents valued a supportive technology that responds to needs, is reliable and dependable, providing clear information and increasing their efficiency. The Irish participants focused more on qualities (e.g. 'accurate', 'user friendly') and its role in their work, rather than the effect on their work. It is informative to know that the Irish controllers are in the process of having a system up-grade bringing more functionality. Italian controllers, on the other hand, changed over to a more sophisticated system a few years ago and may now take setting-up the added features as part of a routine. French controllers, whose focused on functionality, can be explained by the close working-relationship they have with the developers of their systems. It is possible that technology is already a team member for many Italian controllers. In other words, they have learned to trust technology more, through a positive experience. The replies of French controllers can be seen as situated in between, in that they focused on speed, simplicity and less on the effect on their work.

These comments highlight the necessity of reading the information collected in the study in the context of the system that is used at present by respondents. It also underlines the importance of a good general implementation programme for European ATM, as trust begets trust.

6.9. Conclusions

A general conclusion from this study is that the controller characteristics that resulted identify attributes that are important for a colleague and technology to be considered competent. It is important to remember that all the characteristics in the rulers were considered relevant by controllers when describing a competent controller or competent technology. Thus the resulting rulers suggest the least and most important amongst characteristics that are all valued.

Working well together is essential in ATM, and the results indicate that the groups of participants attributed importance to different characteristics.

Analysing the words in terms of the competence component model (Spitzberg and Cupach, 1984) it was found that French and Irish controllers focused more on characteristics describing skills and motivation, whereas Italian controllers focused less on motivation and more on knowledge. French controllers focused on the way a controller works in terms of rigour, good anticipation, and ability to cope with difficulties. Irish controllers felt that the most important characteristics were 'communicating clearly', 'being part of the team', 'helpful', 'not afraid to admit mistakes' and 'able to maintain a cool head under pressure'. Italian controllers focused on 'knowledge of English', of procedures and of the technology they use.

The technology attributes are interesting for the development and introduction of future technology. French controllers are concerned with the efficiency of the technology and quality of information. For the Irish and Italian controllers the technology characteristics identified stressed the importance of the way information displayed rather than the speed with which it is delivered, although there were particularities between the two groups. Their diversity emphasise the importance of considering the salient features of present systems before introducing change. The differences between cultures identified relate not only to the actual characteristics, but also to the value given to them.

Although the differences were more marked with respect to technology, overall the results then suggest that care needs to be taken in considering the mobility of controllers and introduction of common technology across borders. As described, there are similarities as well as particularities, success will depend on building on the shared characteristics, whilst respecting those that are valued differently.

The scales of competence derived from this study were used in the scenario-based questionnaire that aimed at testing the hypothesis that trust depends on a judgement of competence, as described in the next chapter.

6.10. Chapter Summary

This chapter reports the findings from the initial part of the validation study, concerning the identification of the salient characteristics of a competent controller and technology for the belief component of the model of trust described in chapter five.

The methodology used to collect controller and technology descriptors was the same for French, Italian, and Irish controllers, and encompassed three tasks: an information collection task, a card sorting task and a paired comparisons task. The results of each task served as the basis for the next stage. Ireland, Italy and France agreed to participate in the study.

The first task aimed at collecting a representative list of characteristics that controllers use to describe competent colleagues and technology. The information was collected through a brief interview or through a questionnaire sent by email. To understand the relative saliency of each item the next step was to run a paired comparisons task. However, with the exception of the Italian list of controller descriptors, the other lists were too long for this exercise. Thus, a group of controllers of each nationality were first asked to carry out a card sort task to organise the words, in order to reduce the number of items to compare.

The next task was a paired comparisons task. During a break from their work, participants were given pairs of characteristics and asked to choose which of the two was most important to be considered either a competent controller or technology. These pairs were derived from matching each expression in the lists, with every other item with which it had been grouped in the word sort task. The exercise resulted in 23 scales of competence describing the characteristics attributed to competent colleagues and technology according to French, Irish, and Italian controllers. Participants were found to attribute importance to different characteristics.

The information collected through this study was used in the validation study proper, as described in the next chapter.

Chapter Seven: Validating the Model

7.1. Chapter Overview

This chapter summarises the results of the study carried out to validate the trust model that was described in chapter five. The study had a between-subjects design and involved a control and an experimental group. A scenario-based questionnaire, containing ten scenarios, was administered to the Irish and Italian participants in the studies.
A brief introduction to the study is provided in the first section (section 7.2.) summarising the model and hypothesis explored. The second section (section 7.3.) explains the rationale behind the choice of scenarios as a methodology, and the way in which they were developed. The third section (section 7.4.) describes the design and administration of the questionnaire, as well as providing details on the participants in the studies. The fourth section (section 7.5.) summarises the analysis carried out and results found. Section 7.6. discusses the findings, highlighting strengths and weaknesses of the approach taken, and the implications of the results in terms of the model. The final section (7.7.) is a summary of the chapter.

7.2. The Scenario-based Questionnaire Study

As described in chapter five a number of assumptions were made in the research on trust described in this thesis and a model of trust was developed.
With regard to the assumptions made (cf. section 5.2.) the trustor was assumed to be a controller and the trustee another controller, a piece of equipment or a tool. Trust was assumed to have a role mediating their cooperation. It was also understood that the trustor had a choice as whether to trust or not, and would either delegate a task or act on the basis of the information provided by the trustee if they chose to trust them.
As summarised in Table 7.1., the model of trust developed was defined as being composed of three elements: self, belief, and control (cf. section 5.3.). The components were operationalised as self-confidence and general attitude towards others (self), an attribution of competence to the trustee (belief), and a relation between the trustor and the trustee that allows the trustor to freely choose to yield control to the trustee, unconstrained by procedures (control). These components were hypothesised as being related to a controller attributing trust to a trustee (i.e. another controller or technology) (Table 7.2.). Trust was operationalised as a decision to trust.

Table 7.1.

Self	Understood as self confidence[3] and general attitude towards others
Belief	Understood as an attribution of competence to the trustee
Control	Understood as a relation between trustor and trustee that allows the trustor to freely choose to yield control to the trustee

Note. The three components of the trust model (left column) and their operationalisation (right column).

Considering the literature on trust and the controllers' opinions collected in chapter four, it was hypothesised that for a controller the most important belief of the trustee is one of competence. Chapter six reported the results of the study carried out to understand what characteristics participant controllers used to attribute competence to a colleague and to technology. The findings were summarised in a series of scales of competence.

The findings summarised in the previous chapter suggested that there are differences between controllers working in different countries in the characteristics they consider to be salient in attributing competence to others and to technology. Hutchins (1995b) argued that although national cultures may use different representations to mediate their cognitive processes, the nature of the process can be generalised across cultures. This would suggest that although different nationalities participated in the study, no difference between their choices to trust others is expected as long as the cultural-specific belief representations are respected. A number of hypotheses follow from the model and are summarised in table 7.2. As was mentioned in chapter five, in this study of trust the assumption was made that trust implies a dyad, where the trustor is a controller and the trustee another controller, a piece of equipment or tool.

[3] Effectively self-confidence is an attribution of self-competence.

Table 7.2.

Hypothesis 1 (from *self*)	A respondent's high level of self-confidence will affect a decision to trust a trustee.
Hypothesis 2 (from *self*)	A respondent's positive general attitude towards others will affect their decision to trust a trustee.
Hypothesis 3 (from *belief*)	A respondent's judgement of high competence of the trustee will affect a decision to trust the trustee.
Hypothesis 4 (from *control*)	If there are no procedures in place that dictate a respondent's choice (assuming Hypotheses 1 to 3) a respondent will trust a trustee. Trust will result from a choice by the trustor.
Hypothesis 5 (from competency study)	High culturally-specific beliefs of competence will affect decisions to trust a trustee.

Note. The four main hypotheses deriving from the model and the fifth hypothesis derived from the study on the definition of competency across cultures.

The *first hypothesis* concerns the importance of the trustor's self confidence, which is expected to have an effect on his/her decision to trust the trustee. This relation was first demonstrated in the domain of human-machine interaction by Lee & Moray (1994) in their study. A high self confidence rating is expected to be positively correlated to a decision to trust. The *second hypothesis* has been addressed in terms of a distinction between low and high trust groups on a range of scales by researchers in interpersonal psychology (Rotter, 1967; McAllister, 1995) and organisational psychology (Zand, 1972). It has been demonstrated that it is possible to distinguish between participants in relation to their attitude towards others in terms of being more or less trusting towards them. According to this second hypothesis, a trustor's general attitude (i.e. generally trusting towards others or generally not trusting towards others) has an effect on the trustor choosing to trust a trustee. A positive general attitude is expected to be positively correlated to a decision to trust. The *third hypothesis* follows the identification of competence by a number of researchers in a variety of domains, such as Butler (1991) in interpersonal psychology, Barber (1983) in sociology, Kramer (2001) in organisational psychology, and Egger (2000) in electronic commerce. Studies have suggested that competence is relevant to a judgment of trust. According to this hypothesis a judgement of high competence by the trustor of the trustee will result in a decision to trust the trustee. A high judgement of competence is expected to be positively correlated to a decision to trust. The *fourth hypothesis* follows research carried out mainly by philosophers (e.g. Baier, 1986; Luhmann, 1979) that stresses the relevance of choice in trust. A trustor is expected to trust a trustee only when the trustor has a choice to trust. Thus, in cases in which decisions have been pre-determined by procedures, as is often the case in the control of traffic, it is not appropriate to talk about trust.

The *fifth hypothesis* regards cultural differences in trusting behaviours and predicts no differences between cultures in trusting strategies, so long as the beliefs participants use to judge the other are appropriately culturally-specific. In other words, in the same way as Hutchins (1995b) argues for cognitive processes that are culturally-independent and representations that are culturally-specific, here trusting behaviour is hypothesised as being culturally-independent and competence beliefs as culturally-specific. Thus, according to this hypothesis a trustor's choice to trust a trustee is not dependent on culture but is dependent on the culturally-specific beliefs, which are used to judge the competence of the trustee. A high judgement of competence is expected to be positively correlated to a decision to trust when appropriate (i.e. matching the culture of the trustor) culturally-specific beliefs are used to describe the trustee.

To summarise then, in order to test these five hypotheses it was necessary to find a methodology that measured the trustee's self-confidence and their attitudes towards others, as well as allowing the manipulation of belief, that respected cultural differences of participants. The method chosen also had to ensure that the trustor was free to choose whether or not to trust the trustee. Finally, the approach also needed to be contextually sound to ensure external validity.

With regard to the measurement of trust, in chapter two the debate on whether trust is a binary variable or a variable with a number of levels was mentioned. As described in chapter five, the decision was taken to operationalise trust as a decision and thus the way trust was measured in this study was in terms of a decision to trust or a decision not to trust the trustee, where the trustee was either a colleague or technology. For example, in testing the first hypothesis it is expected that respondents with a high self confidence rating with decide to trust the trustee more often than not to trust the trustee.

As described in chapter two, approaches to the study of trust have been varied, according to the academic background of the researcher, the domain of interest and the operationalisation of trust. Trust has been studied, for example, through questionnaires (e.g. Johnson-George & Swap, 1982; McAllister, 1995; Lazere & Huston, 1900; Rempel et al. 1985), interviews (e.g. Butler, 1991), participant observation (e.g. Henslin, 1990), problem solving games (e.g. Deutsch, 1958; Zand, 1972; Loomis, 1959), and simulations (Muir & Moray, 1996; Lee & Moray, 1994; Strand, 2001).

Considering the requirements outlined above, the methods that were initially considered were simulations, interviews and post-task cognitive walkthroughs. Simulations provide a controlled environment (Gottsdanker, 1978), in which self-confidence could be measured through questionnaires and competence manipulated in the design of the simulation. Furthermore, procedures could be well defined and freedom of choice supported in the design as well. However, not only was the expense of setting up a simulation of such a complex system as ATM prohibitive, but moreover the effect of the 'willing suspension of disbelief' that was required of participants in an unfamiliar environment needed to be considered. It can be argued in fact that due to the artificial nature of simulations (i.e. there are no passengers in the aircraft controlled), behaviour observed in simulations may not be comparable to that in operational centres.

Interviews were considered because their effectiveness in terms of the richness of information collected had been proven (cf. section 4.5.) and their main strength was the possibility to probe the participant for further detail and explanation of their answers. Self-confidence could be assessed by asking once again for a self-rating, whereas competence could be manipulated in terms of the way questions or a number of situations described to the respondent were phrased. The limitations of this approach, however, were in terms of the trade-off between the detail one could provide in questions and the amount of attention that could be assured by the respondents to the details provided. Furthermore, experimenter effects needed to be addressed (Hayes, 2000).

Finally, post-task cognitive walkthroughs (Dix, Finlay, Abowd, & Beale, 1998) were considered as they provide insight to the participant's reflections on their actions. This would ensure a high level of contextual validity but post-rationalisation of actions had to be considered. However, even if a recording of a controller working at a control position were feasible, not only would it not be possible to manipulate the competence or freedom of choice, but the confidentiality issues related to the filming of real time control would be very problematic. The main strength of this approach is its relation to context and the insight into the informant's experience that would be made explicit during the debriefing session.

Experience is often described in terms of stories or narratives (Klein, 1999) as salient cues can be described within a structure that is complemented by rich contextual detail. Researchers in aviation often use episodes, described in incident and accident reports (e.g. CHIRP, the UK Confidential Human Factors Incident Reporting Programme) or learned through ethnographical studies, to exemplify problems and illustrate concepts (e.g. Wiener 1977; Palmer, 1995; Cushings, 1994; Suchman, 1993; Sanne, 1999).

Considering the strengths and limitations of these three methods it became clear that a questionnaire that contained a number of narratives[4] would be the optimal solution. This approach provides the possibility to assess self confidence through a self-rating question, to control the manipulation of competence using the scales of competence in a number of scenarios, and to set up a strong sense of neutrality in the design of the narratives, that would ensure the respondent did not feel he/she were doing a test or meeting a challenge to find the correct answer, but considering an everyday, 'normal' situation.

Like simulations, scenarios limit the number and variety of variables, and support a control over variables allowing manipulation to be carried out in the storyline. Unlike simulations, if context is appropriately described, they do not suffer from external validity problems and can be related to by the respondent in a natural and intuitive way.

In the same way as carrying out an interview, if a questionnaire is administered on a one-to-one basis, it supports an exchange with the researcher and clarification of unclear issues or reinforcement of points of concern to participants, whilst maintaining a fixed structure to the question protocol. The fact that questionnaires needed to be supported by the opportunity of informants to question the researcher and explain their point of view had been found in carrying out the focus groups, as described in section 4.3.

Finally, if well designed, scenarios can support external validity through contextual detail. In a similar way to post-task cognitive walkthroughs, scenarios allow a vicarious appreciation of a context to the reader. This was important, as it was necessary to find a way that allowed participants to identify with the story, but at the same time to feel free to choose whether to trust or not trust. In other words, there was not to be a right or wrong answer to each narrative.

To conclude then, a scenario or narrative-based questionnaire was chosen as the most suited methodology. The way the scenarios were developed will be outlined in the next section.

7.3. Introduction to and development of the scenarios

Scenarios were first used in theatrical studies and became popular in research through military and strategic gaming (Jarke, Bui & Carroll, 1998). In cognitive psychology

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[4] The words *narrative*, *scenario*, and *story* are used interchangeably in this thesis.

narratives are commonly used in thinking and reasoning experiments (e.g. Byrne & McEleney, 2000; Walsh & Byrne, 2001), as they allow a strong control over variables and appropriately describe a situation from the reader's perspective. The participant is asked to make a judgement on the basis of the information provided.

Since the late 1980s researchers in HCI (Human Computer Interaction) have used scenarios to represent system requirements and improve the communication between developers and users (Jarke et al. 1998). To convey the design to users Carroll & Rosson (1992) created 'use scenarios', which describe tasks at a level at which they are meaningful to the people who engage in them. They define a scenario as "a description (in text, in a storyboard, etc.) of the activities a user might engage in while pursuing a particular concern" (Ibid.:185). In HCI scenarios are considered an ideal medium for participatory design as they allow the discussion between users and designers to be carried out in a common language.

In the trust literature narratives were used in a study carried out by Lerch & Prietula (1989) who compared participants' trust in humans with their trust in an expert system. The same information was provided to different groups of participants in the form of short narratives. Participants had to rate the trustworthiness of the information they were given. The source of the information was manipulated and thus participants were told the advice was either from a human novice, a human expert, or an expert system. Their findings indicated that expert systems were trusted as much as human novices, but less than human experts.

In the ATM domain scenarios have been used to study the factors that underlie the decisions that controllers take into account when solving conflicts (Eurocontrol, 2001) and to derive requirements for a future system from a number of different stakeholders (Smith, Woods, McCoy, Billings et al., 1998). In the first case controllers were given a series of screen shots of simplified radar screens and asked to describe how they would solve the traffic situation. In other words, what instructions they would give the aircraft represented on the screen, and why.

In the second case Smith et al. (1998) used a scenario to identify system requirements for new ATM concepts and technology. They presented a number of stakeholders (e.g. controllers, pilots, assistants, flow managers) with a scenario that was part of an incident report, asking them to carry out a conceptual walk-through analysing all that had gone wrong and deriving requirements for a future system that would ensure the incident did not reoccur. Smith and his colleagues (1998) argued that because many of the details of the design of a future system are unspecified, a scenario is the most effective way to help prototype how people and technology will coordinate in realistic operational scenarios and gain insight into issues and implications of proposed future designs. In other words, they concluded that scenarios provided an effective balance between realistic and specific detail. Furthermore, scenarios effectively capture external constraints of the context, as well as domain knowledge which, as is typical in the workplace, is often tacit (Carroll, Rosson, Chin & Koeneman, 1998:1167).

To be effective, scenarios have to be written with a good understanding of the users' context (Gaffney, 2000) and convince the reader, be believable (Carroll et al., 1998). The challenges to overcome in order to achieve this goal were caused on the one hand by the lack of the researcher's detailed operational knowledge of procedures and working methods, and on the other hand on the necessity to use the scenario in more than one centre, with participants of different nationalities. The narratives had to be general enough to be understood by a number of participants but a balance had to be achieved between realism and situations that did not suggest a correct or incorrect outcome or conclusion.

The strategy chosen to develop the scenarios was an iterative process of development between the structure described according to the experimental design and the details conceived from an operational point of view. This process was supported by a group of operational experts, as described next.

Carroll & Rosson (1992) argue that the most effective way to generate scenarios is to construe a theory or typology of the kind of scenario needed to generate scenarios but also to organise scenarios collected empirically, through observation or by asking people about their experience. The writers (Ibid.) suggest an analytical and empirical approach to the development of scenarios is optimal.

The analytical approach consists in defining a framework to use to build the stories. This structure was defined in terms of a series of requirements.

Each scenario had to describe a controller at work or a controller using technology to accomplish his/her work. Under the assumption that a controller takes decisions based on more or less certain information and on a continually changing plan that is updated according to a dynamic context, a situation had to be described in which something that is not unusual happens. Enough realism had to be achieved for the reader to relate to it, but the situation had not to be specific or an extreme one, rather as an everyday situation. In other words, the scenario had to be a description of a possible set of events that might reasonably take place (Jarke et al., 1998: 155). If limit situations had been chosen, participants would have probably understood the questionnaire as a test of their ability. Furthermore the stories did not have to be too long or complicated, for them to be administered in an operational environment, nor specific to a certain centre or country. Thus special situations or procedures had to be avoided.

Following Carroll & Rosson's (1992) method, the empirical approach consisted of collecting real stories, either through observation or interviews.

The initial idea was to create a safety occurrence report based on the critical incidents collected through questions and focus groups, describing a situation in detail and asking the reader to judge those described in the story. However, in piloting the scenario with an operational controller it was found that the story took too long to read (i.e. 45 minutes). Furthermore, it was found that using an incident report format not only suggested that the event was a non nominal situation, but also that the reader felt he/she could not relate to it as it was found to be too unusual. What was needed was a 'snapshot' of a normal, everyday, activity.

Effectively, a number of narratives had been collected in learning about the domain of interest through questionnaires, observations and interviews, as well as reviewing the publicly available sources of incident and accident reports (e.g. Canadian NSTB, Irish AIB, UK AIB). These stories were used as a repertoire of instances.

Five operational staff at EEC (from four different nationalities) accepted to initially create situations based on storylines taken from the repertoire of instances (e.g. a tower controller is using a sequence approach tool and does not agree with the solution it provides) and then evaluate the scenarios derived from their individual efforts and from the researcher's elaboration of instances from the repertoire, and assess them for their realism.

Although at the beginning the stories were conceived of as being written in the first person, this approach was felt to be problematic, suggesting once again the answers were testing the ability of the reader. It was thus decided to ask the reader to consider someone else's experience. The fact that the reader would be able to relate to the controller described in the story was still a necessary requirement.

Ten stories were derived in this way. In detail, one was derived from a visit, two from the safety occurrence literature, three from questionnaire results and four from the expert groups.

7.4. Design of the Study

The study was carried out with Irish and Italian participants with two samples of independent groups for each nationality. The reason for this choice should become clear in this section in describing the relation between the model and the design of the study.

According to the model three independent variables needed to be manipulated: Self, Belief, and Control. The way this manipulation was carried out and assessed is summarised in Table 7.3. The dependent variable was a decision to trust the trustee (controller or technology) or not.

Table 7.3

Component	Manipulation	Assessment
Self	None	Self rating by the participant of their self confidence
Belief	Lower or higher culturally-specific competence characteristics attributed to the controller and/or technology described in the narrative	Rating of the trustworthiness and of the competence of the controller and/or technology described in the narrative
Control	No right or wrong conclusion to the narrative	Ratings of realism of each story as well as to whether the reader could relate to each narrative.

Notes. The right column summarises the way in which the components in the left column were manipulated in the narratives. The belief component was only manipulated under the experimental condition.

The *Self* component was not manipulated in the stories. Thus information was not provided on the self-confidence of the actor or their outlook onto the world (i.e. trusting towards others in general or not trusting towards others). Information however was collected on the respondent's self-confidence and on their general outlook on trusting others.

The assumption was made that the reader would relate to the situation, at least to a certain extent. In order to ascertain whether this assumption was correct the reader was queried as to whether he/she related to each scenario. At the end of the questionnaire informants were asked to choose which statement they thought most suited them, for both other people and technology. The two statements described someone who trusts another until they have clear evidence that they could not be trusted, or did not trust another until they had clear evidence that they could be. It they chose the first statement, they were classified as *high trust* respondents; if they chose the second statement as *low trust* respondents. An equivalent pair of statements was written describing trust in technology.

The *Belief* component was manipulated using the highest and lowest characteristics on the competence rulers described in the previous chapter (chapter six) and are referred to here as *higher* and *lower* competence, respectively. Each nationality was provided with characteristics that were specific to their nationality, as described in chapter six. It is important to remember that in both cases the controller or technology was described as competent, more so with the higher characteristics and less so with the lower characteristics.

As mentioned in section 7.2. trust was operationalised as a decision, thus in the scenarios it was measured as a decision to trust or a decision not to trust the trustee.

The storylines and questions for both control and experimental group were the same. Under the experimental condition the nationality-specific characteristics (i.e. Italian characteristics for Italian participants and Irish characteristics for Irish participants) were included at the beginning of the story, the rationale being that they would be used as salient characteristics to judge the controller and/or technology described in the stories.

In the pilot study eight scenarios were used (Table 7.4.) and this resulted in a symmetric distribution of higher and lower permutations. The controller was attributed higher competence three times, and so was the technology. The controller was attributed lower competence three times, and the same was true for the technology. This symmetric distribution was however not maintained in the final version of the scenario-based questionnaire. Following the pilot study two scenarios that had not been used were included, as it was found that participants took considerably less time than expected to complete the task.

Although the number of coupled permutations was chosen so as to be balanced, the actual attribution of each permutation to a storyline was random (i.e. the decision to manipulate the competence of the controller and/or technology described in the story as lower or higher). Effectively, due to the addition of the two scenarios that had not been used in the pilot study there was a duplication of conditions in scenarios seven and nine and eight and ten (Table 7.4.), as they had the same attribution of lower competence.

This addition was considered acceptable for two reasons. The first was the fact that controller had taken less time to complete the scenarios than expected, thus the two extra scenarios did not create a problem in terms of the administration of the questionnaire. The second reason was the fact that there was a concern that respondents would not find the scenarios neutral. It was hoped that the inclusion of the two additional scenarios would allow the researcher to understand whether the belief characteristics or the control characteristics were more relevant in the way respondents read the situationsAt this point it may be appropriate to mention again the fact that it was considered inappropriate to describe an incompetent controller, as this was not something acceptable to controllers. For this reason, all characteristics were positively worded.

Table 7.4

	Controller	Technology
Scenario One	HIGHER	HIGHER
Scenario Two	LOWER	LOWER
Scenario Three	LOWER	HIGHER
Scenario Four	HIGHER	–
Scenario Five	HIGHER	LOWER
Scenario Six	-	HIGHER
Scenario Seven	LOWER	-
Scenario Eight	-	LOWER
Scenario Nine	LOWER	-
Scenario Ten	-	LOWER

Notes. The manipulations made of the competence of the controller and technology. The first eight scenarios were used in the pilot study. All ten scenarios were used in the two studies proper.

The treatment of the *Control* component was manipulated by ensuring that the situations described did not have right or wrong answers, suggesting whether the controller or technology should be trusted in the story. This assurance was provided by the review of the scenarios by five operational experts.

In the review the experts were asked to rate the realism of the scenarios and whether they could relate to them. The scenarios did not have to be an example of a right or wrong way of controlling. In assessing the scenarios they were asked to ensure the storylines were not dependent on particular local procedures and, if this was the case, to specify the relevant procedure and include it in the narrative.

In the study the realism of each scenario, as perceived by the respondent, was assessed in a question following each narrative. An overall realism rating was asked for at the end of the questionnaire.

As explained in the description of the belief component, it was decided to have two independent rather than related samples. First, it was believed that participants would notice the absence of characteristics in some scenarios. Second, the choice of a within-subject design implied the administration of 16 scenarios, which was not considered feasible.

In making such a choice it was understood that problems could arise in the sampling of respondents under the two conditions. As in previous studies (chapters four and six) it was not possible to control the sampling of the population. This did not imply a random sampling, on the contrary. It is possible that the selection of the participants by the control room supervisor or the researcher was biased towards certain types of participants (e.g. more open, less shy, members of trade unions).

7.5. Material and administration[5]

The scenario-based questionnaire consisted of:

- a cover letter introducing the study (that could be retained with contact details)
- a question on the respondent's years of operational experience
- a rating on the participant's self-confidence
- ten scenarios, followed by the same ten questions
- a question on the reader's general attitude towards others
- a question on the reader's general attitude towards technology
- a rating on the overall realism of the stories (Appendix D).

The questionnaire administered to Italian controllers was in Italian. The Italian translation was carried out by the researcher and checked by another bilingual Italian-English speaker for the translation, and by an Italian air traffic controller for the appropriate use of technical language.

The scenario-based questionnaire was administered in four control centres. The management of each ACC was send a brief introduction and rationale to the study, as well as the materials, and asked for permission to carry out the research. It was made clear that participation would be on a voluntary basis only, replies would be anonymous, and reference would be made to the nationality of the controllers without mentioning the centre in which they work.

The participants who volunteered were either informed by their supervisor or recruited during a break or staff debriefings. The researcher made every effort to ensure that controllers felt comfortable in refusing to participate if they did not wish to do so. All respondents were briefed with a standardised explanation on the rationale of the study and the format of the questionnaire. Where possible, controllers were also debriefed. However, in cases where other controllers were still completing the questionnaire, respondents were encouraged to contact the researcher for further details and for the results of the study, and many did. Once the study was completed the management and contact in the control room were send a copy of the report describing the results.

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[5] The English language version administered to the Irish participants can be found in Appendix D.

With regard to the selection of the condition under which the participants were placed, it was blind. The front page of the questionnaires was a cover letter that was the same for both conditions. As the experimental copy was longer, it was printed on double-sided sheets so as to make the two versions appear the same length. Thus, the researcher was unaware of the condition the participant was attributed. Although this approach implied no control over the sample, it was believed to contribute to reducing experimenter effects, together with the use of standardised instructions and replies to questions.

The participants' task was to read through the scenarios at their own pace, and answer all the questions after each scenario. The instructions given to the participants were standardised and included an overview of the questionnaire, an introduction to the doctoral work the study was part of, and an explanation on the format of the questionnaire. In the instructions emphasis was placed on the fact that there were no right or wrong answers, as the questionnaire was not a test of their ability but of a theoretical model. Furthermore, participants were informed that it was essential that all parts of the questionnaire be completed for their results to be used.

With very few exceptions all questionnaires were filled out with the researcher nearby, available to answer questions. Although this may have increased the likelihood of investigator effects (Rosenthal, 1966), it was believed that having the research available was useful and encouraged the completion of the questionnaire. Furthermore, answering participants' questions suggested information that was missing or unclear to respondents, and needed to be provided to other participants, balancing understanding.
In one centre an office was made available to the researcher to administer the questionnaires. However in most cases this was done at a closed working position or at a free assistant's desk in the control room.

The completion of the task took between 30 and 60 minutes in total. Some of the controllers began completing them, returned to their position and completed them during their next break.

7.6. Participants

A pilot study was carried out with eight Irish controllers, under the experimental condition (Table 7.5.). One scenario was changed as respondents found it to be unclear.

Table 7.5.

Study/ Nationality	Condition	Number of participants	Average yrs. operational experience	Standard deviation
Pilot study	*Experimental*	8	-	-
Irish	*Control* *Experimental*	11 15	11	10
Italian	*Control* *Experimental*	16 28	16	9

Note. The table summarises the number of participants in the study, under each condition, and their years of operational experience.

Twenty-six operational Irish controllers participated in the Irish study, 11 under the control condition and 15 under the experimental condition (Table 7.5.). Their average number of years as an operational controller was 11 years, with a standard deviation of 10 years. Forty-three Italian controllers participated in the Italian study, 16 under the control condition and 28 under the experimental condition. The average number of years as an operational controller was 16 years, with a standard deviation of nine years.

7.7. Results

The results are provided under the five headings following the hypothesis presented in section 7.2. The five sections regard the effects of self-confidence, overall attitude towards others and towards technology, competence, choice, and nationality group, on participants' choice to trust the controller and technology described in the scenarios.

Under each section general results that include both Irish and Italian studies will first be presented, followed by the results within each nationality and a comparison between the two, if relevant.

7.7.1. First hypothesis: trust and self confidence

Each participant was asked to rate their self confidence on a five-point scale at the beginning of the scenario-based questionnaire. A five-point scale was chosen following Lee & Moray (1994) who had used the same in their study relating process operators' trust and their self-confidence ratings. However as the numbers '2' and '4' were not used by respondents, the replies were coded as *low* (1 and 2), *average* (3) and *high* (4 and 5) (Table 7.6.).

The first analysis regarded calculating the frequency of low, average, and high self-confidence ratings for each nationality and under the two conditions. The variables were not in fact manipulated and thus descriptive statistics were considered appropriate. Overall, self confidence was reported as being high (86%) or average (14%). Eighty percent of Irish participants rated themselves high on self-confident and 20% as average. Seventy-nine percent of Italian controllers rated themselves as high and 21% as average. Both nationalities had the same average rating, with experimental being slightly higher (87%) than control (80%).

Table 7.6.

Condition/ Study	***Self-confident ratings***		
	Low	***Average***	***High***
Pilot	*0*	*11%*	*89%*
Control	0	20%	80%
Experimental	0	13%	87%

Note. Self-confidence ratings for Irish and Italian participants under two conditions.

All participants provided positive ratings of their self-confidence and it was thus not possible to analyse the effect of high versus low self-confidence on replies to the questions on trust. Due to the fact that all respondents were operational rated controllers, the fact that they rated themselves as self-confident was to be expected.

Considering the average and high self-confidence ratings overall of the control and experimental groups (Table 7.7.) a Chi-square test was carried out to measure whether there was a significant difference in self-confidence ratings according to condition. A significant difference at the level of 0.05 of significance was not found between the two groups ($X^2 = 0.32 < 3.84$; df = 1).

Table 7.7.

Condition/ Study	*Self-confident ratings*		
	Average	*High*	Total
Control	5 (3.85)*	20 (18.61)	*25*
Experimental	5 (6.15)	35 (33.85)	*40*
Total	*10*	*55*	*65*

* *expected frequencies within parenthesis*

According to the first hypothesis a positive relationship was to be found between a trustor's self confidence and a trustor's decision to trust. As mentioned above self-confidence was measured on a rating scale, whereas trust was measured as a decision to trust. Due to the fact that no manipulation was carried out on the variables measured it was only possible to look at their relation. In the case of a significant high positive correlation between self confidence ratings and decision to trust were found the hypothesis would be confirmed.

In order to measure whether the self-confidence ratings and the decision to trust or not to trust the trustee were related, a series of correlation tests were carried out (Appendix E 1.). A positive significant correlation at the 0.01 level was found in the replies of Irish controllers overall (i.e. participants under the control and experimental conditions) in their decisions to trust the controller in *scenario four* (Table 7.8.) and in *scenario three* (Table 7.9.) in their decision to trust the technology.

Table 7.8.

Correlations

		level of self confidence	4th scenario trust controller
level of self confidence	Pearson Correlation	1	,507**
	Sig. (2-tailed)	,	,010
	N	25	25
4th scenario trust controller	Pearson Correlation	,507**	1
	Sig. (2-tailed)	,010	,
	N	25	26

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7.9.

Correlations

		level of self confidence	3rd scenario trust technology
level of self confidence	Pearson Correlation	1	,556**
	Sig. (2-tailed)	,	,004
	N	25	25
3rd scenario trust technology	Pearson Correlation	,556**	1
	Sig. (2-tailed)	,004	,
	N	25	26

**. Correlation is significant at the 0.01 level (2-tailed).

With regard to Italian respondents overall there was a significant correlation at the 0.05 level between high self-confidence ratings and decision to trust (measured as 'trust' or 'not to trust') the controller described in *scenario one* (Table 7.10.) and *scenario six* (Table 7.11.).

Table 7.10.

Correlations

			level of self confidence	1st scenario trust controller
Kendall's tau_b	level of self confidence	Correlation Coefficient	1,000	,309*
		Sig. (2-tailed)	.	,049
		N	39	39
	1st scenario trust controller	Correlation Coefficient	,309*	1,000
		Sig. (2-tailed)	,049	.
		N	39	44
Spearman's rho	level of self confidence	Correlation Coefficient	1,000	,319*
		Sig. (2-tailed)	.	,048
		N	39	39
	1st scenario trust controller	Correlation Coefficient	,319*	1,000
		Sig. (2-tailed)	,048	.
		N	39	44

*. Correlation is significant at the .05 level (2-tailed).

Table 7.11.

Correlations

			level of self confidence	6th scenario trust controller
Kendall's tau_b	level of self confidence	Correlation Coefficient	1,000	,328*
		Sig. (2-tailed)	.	,034
		N	39	39
	6th scenario trust controller	Correlation Coefficient	,328*	1,000
		Sig. (2-tailed)	,034	.
		N	39	43
Spearman's rho	level of self confidence	Correlation Coefficient	1,000	,344*
		Sig. (2-tailed)	.	,032
		N	39	39
	6th scenario trust controller	Correlation Coefficient	,344*	1,000
		Sig. (2-tailed)	,032	.
		N	39	43

*. Correlation is significant at the .05 level (2-tailed).

For Italian controllers there was no significant correlation found between self-confidence and decision to trust the technology described in the narrative (Appendix E 1.)

7.7.2. Second hypothesis: trust and overall attitude towards others and technology

At the end of the scenario-based questionnaire each participant was asked to choose between two statements that described either trusting people or trusting technology. According to which of the two the participant selected, they were categorised as *high trust* (i.e. "I will trust someone/technology until I have clear evidence they cannot be trusted") or *low trust* (i.e. "I will not trust technology until there is clear evidence that it can be trusted").

With regard to being high or low in their overall trust towards others (Table 7.12.), under all conditions and for both nationalities most respondents rated themselves as high (69-86%).

Table 7.12.

	Trusting people		Trusting technology	
	Low	High	Low	High
Italian control	19%	81%	50%	50%
Italian experimental	31%	69%	64%	36%
Irish control	18%	82%	27%	73%
Irish experimental	14%	86%	57%	43%

Note. The percentages of respondents under low and high categories for trusting others and trusting technology.

With regard to trust in technology, however, percentages were more varied. Considering Irish respondents, most participants under the control condition rated themselves as high (73%). Under the experimental condition slightly more Irish controllers rated themselves as low (57%) than high (43%).

With regard to Italian ratings, there was a balance between low and high (50%) participants under the control condition. Under the experimental condition, most participants rated themselves as low (64%).

Considering the way the frequency of replies are distributed under the two conditions (Table 7.12.) a larger difference is observed for example between Italian control and experimental groups in their attitude towards others, in contrast to the Irish groups for whom the patterns of numbers of respondents in each cell is more similar. The difference between attitudes to both people and technology under the two conditions was measured through a series of chi square tests (Appendix E Tables E 2.15- E 2.18). The differences between attitudes under conditions were not found to be significant. Had this been the case an argument could have been made that the differences in attitudes towards others under the two conditions had biased the decisions to trust or not trust irrespective of the condition which they had been attributed. The next step consisted in examining whether there was a relation between the low or high attitude expressed by respondents and their decision to trust or not trust. If a significant high correlation were found between the two variables this second hypothesis would be confirmed. As for the previous hypothesis, no manipulation had been carried out on the two variables measured, thus the degree of relationship (from – 1 to + 1) was measured through a series of correlation tests (Appendix E 2.)

Considering the replies of both nationalities together, a significant correlation at the 0.01 level was found between trust ratings and overall attitude towards technology (Table 7.13.).

Table 7.13.

Correlations

		trusting technology	sum tec
trusting technology	Pearson Correlation	1	,348**
	Sig. (2-tailed)	,	,004
	N	65	65
sum tec	Pearson Correlation	,348**	1
	Sig. (2-tailed)	,004	,
	N	65	70

**. Correlation is significant at the 0.01 level (2-tailed).

Although the correlation was not significant within Irish respondents (rho = -0.008, N = 25, p = 0.971, two-tailed), it was with Italian respondents at the 0.05 level (Table 7.14.).

Table 7.14.

Correlations

			trusting technology	sum tec
Kendall's tau_b	trusting technology	Correlation Coefficient	1,000	,316*
		Sig. (2-tailed)	,	,023
		N	40	40
	sum tec	Correlation Coefficient	,316*	1,000
		Sig. (2-tailed)	,023	,
		N	40	44
Spearman's rho	trusting technology	Correlation Coefficient	1,000	,365*
		Sig. (2-tailed)	,	,021
		N	40	40
	sum tec	Correlation Coefficient	,365*	1,000
		Sig. (2-tailed)	,021	,
		N	40	44

*. Correlation is significant at the .05 level (2-tailed).

As this question appeared at the end of the questionnaire, it is possible that the narratives and the manipulation under the experimental condition influenced the replies. However, significance was found only with overall scores, not when considering the two conditions separately.

The differences that were found between participants with regard to their overall attitudes towards technology may suggest that it is possible to make a distinction between controllers who are more or less trusting towards technology. The fact that replies were more consistent in judging people may be due to the fact that trusting others is more dependent on the specific person, and less a general attitude.

7.7.3. Third hypothesis: trust and competence

The third hypothesis stated that when the competence of the controller and/or the technology was manipulated as higher, the respondent would trust the controller and/or the technology. This would be true more often than in the case in which the competence was manipulated as lower. Thus, high competence was hypothesised to result in a decision to trust. The confirmation of the hypothesis would follow from the finding of a significant high correlation between the two variables.

Respondents were asked whether they 'would trust', 'maybe trust' or 'not trust' the controller and the technology described in the story after each scenario. Ratings of competence and trustworthiness of the controller and the technology described were asked for after each scenario.

The analysis of the results was carried out in three steps. The first step considered the relation between the manipulation of the competence of the controller and/or the technology described in the scenarios, and the choice of respondents as whether to trust them or not. The second step looked at the manipulation of the competence of the controller and/or technology, as low or high, and the competence ratings given to them by respondents. In other words, this was a check of whether the manipulation had been perceived by respondents as it was intended. The third and final step (Appendix E 3.3.) of the analysis considered the relation between competence and trustworthiness ratings given by participants to the controller and/or the technology after each story.

Overall, considering replies regarding whether the participant would trust the controller or technology described in the scenario or not, it was found that with the exception of *scenario six*, participants under the control and experimental conditions chose most frequently the same answers (i.e. ‘trust’ or ‘not trust’) (Appendix E 3.1., Figure E 3.3.1. to Figure E. 3.3.20.). In other words, no difference was found between conditions.

As the experimental data consisted of frequencies in discrete categories the differences between the replies expected following the manipulation under the experimental condition and the answers collected were measured with a series of chi-squares. No significant differences were found (Appendix E 3.1.).

Participants’ replies were recoded from ‘no trust’, ‘maybe trust’, and ‘trust’, to ‘no trust’ and ‘trust’. This was in order to be able to carry out Fisher exact tests, that assume 2x2 tables (Siegel & Castellan, 1988), and can be used in cases where more than 20% of the cells in the contingency tables have expected frequency less than 5. These tests found no significant differences between the replies from participants under the control and under the experimental conditions.

It can be concluded that the manipulation of the competence of the controller and the technology described in the stories did not have a significant effect on participants’ choice to trust the controller and the technology.

Two explanations were considered. The first related to the fact that as both lower and higher characteristics were positive, this could have influenced replies. However, in this case a difference between control and experimental conditions should have still resulted, with more variance in replies under the control condition. This was not the case, as under both conditions replies given were the same. The second explanation for the lack of significant differences was the fact that the narratives had influenced the answers.

In reading through the answers given to questions asking for clarification of replies, (e.g. “what would change your answer?”), although most respondents did not reply (i.e. 98%), those that did showed to have interpreted the narratives quite differently. For example, for *scenario seven*, Italian participants under the experimental condition reported that their answer would have changed to 'trust' if the controller had "*double-checked*" or "*had been more professional*", as well as "*nothing would have changed my answer because he was perfect*". On the other hand, comments on replies to *scenario one* were similar in agreeing that the controller had taken the correct decision. In replying to participants' questions and discussing with them about the scenarios once they had completed the questionnaire, the researcher remarked that controllers focused on different aspects of the narratives as well. In *scenario four*, for example, many controllers asked for clarification on the quality of the radio transmission. The researcher expected the hand-over between shifts to be the focus of the story.

Competence ratings

The second step of the analysis consisted in assessing whether the manipulation under the experimental condition had been perceived as intended. The hypothesis was that in scenarios where the characteristics of higher competence were attributed to the controller and/or the technology described in the scenario their competence would be rated as 'high'. In scenarios where the characteristics of lower competence were attributed to the controller and/or to the technology, competence would be rated as 'average' to 'low'. In scenarios where the competences of either the controller or technology were not manipulated, no significant differences between ratings under the two conditions were expected.

Due to the fact that the data consisted of ordered variables a series of Wilcoxon-Mann-Whitney test were used to compare the ratings of competency between nationalities and under the two conditions. For Irish and Italian participants together, no significant difference found between control and experimental group ratings of competent controller and technology (Appendix E 3.2.).

The only case where a significant difference at the 0.05 level of significance was found was between control and experimental groups was for Italian participants' ratings of a competent controller in *scenario seven* ($U = 133{,}5$, $N_1 = 16$, $N_2 = 28$) (Table 7.15).

Table 7.15.

Test Statistics[a]

	7th scenario comptence controller
Mann-Whitney U	133,500
Wilcoxon W	269,500
Z	-2,348
Asymp. Sig. (2-tailed)	,019

a. Grouping Variable: control or experimental

Considering each scenario, in terms of competence ratings of both controller and technology made by Irish and Italian participants, the following considerations can be made.

Controllers' competence ratings

Irish controllers rating the competence of the controller described in the scenario had very similar replies in all scenarios except *scenario eight*, where respondents under the experimental condition replied most frequently 'high' (33%) and 'very high' (33%), and respondents under the control condition replied most frequently 'low' (36%). This scenario did not contain any manipulation of the controller described. The technology was manipulated as 'lower' in this scenario and it is possible that this manipulation influenced the judgement of the controller. This would be in line with Lee & Moray's (1994) argument that the comparison between the operator's self confidence (or competence in this case) and the technology's is salient, and not the judgement of the technology's competence alone.

With regard to the seven scenarios in which the controller's competence was manipulated under the experimental condition, in three scenarios (*scenario two, scenario three,* and *scenario nine*) both control and experimental participants replied most frequently with ratings that were not in accordance to those expected following the manipulation. In these three cases most participants rated the controller as high when lower competence characteristics had been assigned.

In *scenario two*, most controllers rated the controller as high (control = 40% and experimental = 45%) whereas the lower competence characteristics had been assigned to the controller described in the scenario.

In *scenario three* the lower controller characteristics had been assigned to the controller too, but respondents under both conditions rated the controller as high in competence (control = 54% and experimental = 47%).

With regard to *scenario nine*, the lower controller characteristics had been assigned to the controller described in the scenario here too, but the respondents under both conditions rated the controller as high (control = 54% and experimental = 50%) and very high (control = 46% and experimental = 50%).

In the four remaining scenarios (*scenario one*, *scenario four*, *scenario five*, and *scenario seven*) both control and experimental groups had a similar distribution of highest frequency replies, that followed the pattern of the manipulation under the experimental condition.

Italian controllers rating the competence of the controller described in the scenario had very similar replies in all scenarios except in two scenarios, *scenario three* and *scenario four*.

In *scenario three* the controller's competence had been manipulated as lower. The most frequent ratings of the participants under the experimental condition chose average (39%) and high (25%) as a rating. With regard to the ratings of participants under the control condition, most of them chose 'low' (31%) and 'average' (37%).

In *scenario four* under the experimental condition competence had been manipulated as higher. Most respondents under the experimental condition did indeed chose 'high' as a rating (46%), with 25% choosing 'average' and 21% choosing 'high', and 4% 'very low' and 'low'. Under the control condition on the other hand, the highest percentage of respondents chose low (31%).

In *scenario two* and *scenario nine* participants under both control and experimental conditions chose similar ratings which did not correspond to those expected following the manipulation. The same distribution had been found with the replies of Irish controllers.

In *scenario two* under the experimental condition the controller described in the scenario was described with lower competence characteristics. Under both conditions respondents chose high (experimental = 57%) and higher (control = 37%) most frequently.

In *scenario nine* controllers under both conditions chose high most frequently (control = 50% and experimental = 54%). The manipulation carried out under the experimental condition was to assign lower characteristics to the controller described in the scenario. This would suggest that both nationalities perceived the controller described in *scenario two* and *scenario nine* as competent, notwithstanding the condition they were under. In replies to *scenario three* the two nationalities differed.

Technology competence ratings

Irish respondents rating the competence of technology under both conditions had very similar replies, in terms of the frequency with which they attributed less or more competence. The ratings provided under the experimental and control conditions in *scenario two* were in line with those expected, in that under the experimental condition the technology's competence was rated as lower and the highest frequency for participants under the experimental condition was 'average' (40%) followed by 'low' (27%). Under the control condition the highest frequency of ratings was found under 'low' (36%), however 18% of ratings were also attributed respectively as 'very low', 'average' and 'high'.

With regard to the seven scenarios in which competence was manipulated, it was found that in two cases participants under both conditions did not score lower or higher as expected following the experimental manipulation.

In *scenario eight*, following the manipulation, it was expected that controllers under the experimental condition would rate the technology as being 'low'. The highest percentage of respondents under the experimental condition rated the technology as 'high', whereas under the control condition an equal percentage (30%) rated the technology as 'low', 'average', and 'high'.

The manipulation made in *scenario ten* to the technology was to describe it with the lower competence characteristics. The highest percentages of replies under both conditions fell under 'high' (experimental = 61% and control = 91%).

In terms of the frequency with which participants attributed less or more competence, Italian respondents rating the competence of technology under both conditions had very similar replies in all but two scenarios. In *scenario six*, under the experimental condition the technology had been described with the higher characteristics. Participants under the experimental condition replied with an equal frequency (26%) 'very low', 'average', and 'high'. The most frequent rating of participants under the control condition was a low rating.

In *scenario seven* there was no manipulation carried out on the description of the technology, most respondents under the experimental condition replied high (41%) and an equal number of respondents under the control condition (37%) replied low and high.

With regard to the other six scenarios where the description of the technology was manipulated, both conditions replied according to that expected under the manipulation, except in *scenario ten*. In *scenario ten* the manipulation carried out attributed a lower competence to the technology. Most replied fell under the high rating (control = 57% and experimental = 47%). This finding was true for Irish respondents as well.

Competence and trustworthiness

The third step regarded the association between competence ratings and trustworthiness ratings, the strength of which was measured through a series of Spearman's correlation tests (Appendix E 3.3.). Considering Irish results (both control and experimental) all correlations regarding the ratings of competence and trustworthiness of both controllers and technology were significant at the 0.01 level of significance. Considering Italian results, all correlations between the ratings of both controllers and technology were significant ($p = 0.01$).

With regard to Irish control all associations were significant at the 0.01 level of significance, with the exception of *scenario four* for controller ratings (rho=0,638 $N = 11$; $p = 0.05$; two-tailed) and *scenario eight* for technology ratings (rho = 0,745; $N = 10$; $p=0.05$; two-tailed). With regard to Irish experimental ratings for both controller and technology competence and trustworthy scales, they all resulted significant at the 0.01 level of significance.

With regard to Italian control ratings of competence and trustworthiness they all resulted significant at the 0.01 level of significance. With regard to the Italian experimental ratings of trustworthiness and competence, they all resulted significant at the 0.01 level of significance.

It can be concluded that a significant positive relation was found between competence and trustworthiness ratings for controllers and technology competence, under both conditions for Irish and Italian participants.

7.7.4. Fourth hypothesis: trust and choice

The fourth hypothesis stated that trust is the result of a choice by the trustor. The way choice was manipulated was by ensuring that the narratives were neutral and did not suggest a right or wrong answer. This was obtained through the expert review of five controllers.

Questions about whether the reader could relate to the scenario and a rating of realism were asked after each narrative. Furthermore, at the end of the scenario-based questionnaire, participants were asked for an overall rating of realism and to judge whether their local working practices were clearly defined or not. These questions all aimed at understanding whether the respondents felt that the stories were representative of experience and whether any biases (e.g. local working practices that included a very flexible way of working, perhaps without clearly defined procedures) could influence replies. The results are summarised below.

Overall, when asked if respondents could relate to the narratives, for all scenarios except *scenario ten*, and under both conditions, more then 60% of participants replied positively. Replies to *scenario ten* were slightly more positive (control = 54% and experimental = 56%) than negative (control = 46% and experimental = 44%). *Scenario two* (control = 93% and experimental = 96%) was the scenario most participants could relate to.

With regard to the replies from Irish participants under the control condition, replies were varied. Respondents considered they could relate to (70-91%) *scenario three*, *scenario six*, *scenario seven*, and *scenario eight*. Slightly more participants related to *scenario one* (54%) positively. The other five scenarios were rated negatively (60-73%). Under the experimental condition, *scenario five*, *scenario nine*, and *scenario ten*, as under the control condition were rated negatively (69-80%). All the other scenarios were rated positively (60-87%).

Italian controllers could relate to all scenarios under both the control (54-93%) and experimental (56-96%) conditions.

According to the realism ratings, under both conditions most Irish and Italian participants rated the scenarios from 'average' to 'very high'.

With regard to local working practices (Table 7.16.), overall most Italian respondents felt they were 'clearly defined' (60%). This was true under both conditions. There was less consensus among Irish controllers under the two conditions in describing their working practices. Slightly more (54.5%) respondents under the control condition felt them to be 'clearly defined'. More controllers under the experimental condition felt them to be 'not clearly defined' (71%).

Table 7.16.

Local working practices		
	Clearly	Not clearly defined
Italian control	60%	40%
Italian experimental	60%	40%
Irish control	54.5%	45.5%
Irish experimental	29%	71%
Totals		

Note. The table presents the distribution of replies to the question on the respondents' centres' local working practices being clearly or not clearly defined.

These results would suggest that Italians should have had a more homogeneous interpretation of the narratives, whereas Irish respondents felt more flexible about their working methods. There is no evidence of different interpretations according to nationality in terms of responses to the scenarios.

Although without a more in-depth analysis with respondents it is not possible to ascertain the extent to which participants felt the narratives were neutral, the fact that under both conditions respondents replied in a similar manner would suggest that the stories contained information that influenced participants' replies. The fact that the similar replies under both conditions were not the same for the two nationalities, however, would suggest that the two groups of participants interpreted the scenarios differently.

7.7.5. Fifth hypothesis: no difference in trusting choices will be found between nationalities

In considering whether differences between nationalities were found the most frequent responses to each scenario will be considered in turn (Appendix E 3.1. and Appendix E 3.5.), first within nationalities between conditions and then between nationalities. Scenarios will be considered first with regard to controllers and then with regard to technology.

Controller replies

With regard to *scenario one*, most Irish controllers under both conditions (91% under control, and 88% under experimental) replied that they trusted the controller. The same was found with Italian controllers' replies (75% under control, and 68% under experimental).

Most Irish controllers under the experimental condition (64%) replied that they trusted the controller described in *scenario two,* whereas under the control (45%) that they did not (i.e. replies were categorised in 'trust', 'maybe trust', and 'no trust'). For Italian participants, both conditions replied positively (Appendix E 3.5.).

Considering replies to *scenario three*, slightly more Irish controllers under both conditions replied positively (54% under control and 40% under experimental). With regard to Italian controllers, on the other hand, a third of participants chose 'maybe trust' (37% under control and 36% under experimental).

For *scenario four* and *scenario five*, most Irish and Italian controllers under both conditions chose to trust the controller described in the narrative (Appendix E 3.5.).

With regard to *scenario six*, under both conditions Irish participants replied most frequently they trusted the controller (72% under control and 56% under experimental), and half Italian respondents answered they did not trust the controller under the control condition and equally (41%) that they would trust or not trust the controller under the experimental condition.
Consensus on the other hand was found between the most frequent replies (between 72%-87%) to *scenario seven*, as under both conditions both nationalities chose not to trust the controller in the scenario.
Most participants chose to trust the controller in *scenario eight* (between 45% and 53%) and *scenario nine* (between 69% and 90%).
Finally, replies to *scenario ten* were similar between nationalities as they were positive (Appendix E 3.5.). In three scenarios out of ten then, replies between nationalities were different with regard choices to trust the controller described.

Technology replies
With regard to trusting technology in the ten scenarios, it was found that with the exception of *scenario six* (see below), most Irish and Italian controllers agreed on the choice as to whether to trust or less the technology described in the narrative.
Irish controllers under both conditions most frequently chose the same replies as to whether to trust or less the technology in the scenario. The same can be said of the replies of Italian controllers, with the exception of *scenario seven*, where controllers under the experimental condition tended to chose 'no trust' (48%) and under the control condition 'trust' (62%).
With regard to *scenario six*, under both conditions Irish participants replied most frequently they trusted the technology (32% and 36% under the control and experimental condition respectively), whereas most Italian respondents that they did not trust the technology (37% and 54% under the control and experimental condition respectively),.

Although these results would suggest that there were no differences between the two nationalities in their interpretation of the scenarios, the fact that respondents were categorised differently according to their general attitudes towards technology suggests that further research is needed to establish whether there are differences in trusting behaviour towards technology between nationalities or whether these differences are due to individual differences, independent from culture but perhaps influenced by working methods.

7.8. Conclusions

The controllers who participated in the study all rated themselves as average or high self confident. Thus, it was not possible to measure the variation of decisions to trust according to different levels of self confidence. The decision of participant Italian controllers to trust the controller or technology described in the narrative did however correlate with high self confidence.

With regard to participants' general attitudes towards others and towards technology, most controllers were rated high with respect to trusting others. Variations were found in terms of general attitudes towards technology, with Italians overall low and Irish overall high. This would suggest that not only are general trusting attitudes towards others and towards technology different, but that nationalities may have different attitudes as well. This conclusion is preliminary in view of the nature of the evidence, although the results from the competence 'rulers' had already suggested this. The fact that national differences were found in choices to trust the controller described in the scenario, but not in choices to trust the technology or less, suggests that further research is necessary in this area.

With regard to the main hypothesis, according to which competence is a salient feature used to decide whether or not to trust, the evidence supporting this hypothesis was not conclusive. The manipulation of lower and higher competence, carried out under the experimental condition, did not have a significant effect on participants' judgements on whether to trust the controller or technology described in the scenarios. However, strong positive correlations were found between competence ratings and trustworthiness ratings. The reason for the lack of significant results following the manipulation of competence may lie in the positively skewed manipulation of competence, which was described only in positive terms. However, stories in which a controller was described as incompetent would not have been acceptable. Controllers interpreted the narratives emphasising different aspects. Future research could include one-to-one sessions with controllers to talk through the scenarios and understand the rationale for their decisions to trust the controllers and technology described in the narratives. Furthermore, more attention should be given to the relationship between the manipulations of the controller together with that of the technology, to understand whether the relationship may be more important than the individual ratings of the two agents alone.

To conclude, although the results of this study were not significantly conclusive, a correlation was found between competence and trustworthiness and the use of narratives, as a methodology to communicate with controllers and talk about trust, was found to be effective. The use of scenarios provided both a common picture and a baseline that allowed comparisons to be made between individual controllers and controllers from different nationalities and organisational cultures. Further research is needed to establish clearly whether individual differences or variance due to nationality and culture are stronger in influencing controllers' choices to trust colleagues and the technology they use in their work.

7.9. Chapter Summary

This chapter summarised the validation study carried out to validate the model of trust developed in this thesis and described in chapter five.

Following from the model five hypotheses were articulated, that regarded the role of self-confidence, general attitude towards others and technology, a judgement of competence, and the freedom to choose, in a controller's decision as whether to trust or not to trust another or technology. The fifth hypothesis regarded the role of culture, which was hypothesised not to influence trusting behaviour. In order to test these hypotheses it was necessary to find a methodology that measured the trustee's self-confidence and their attitudes towards others, as well as allowing the manipulation of belief, and that respected cultural differences of participants. The method chosen also had to ensure that the trustor was free to choose whether or not to trust the trustee. Finally, the approach also needed to be contextually sound to ensure external validity.

The methods considered are described together with the rationale for choosing scenarios. A scenario-based questionnaire was developed with the support of operational experts and administered to seventy controllers in Irish and Italian air traffic control centres. Replies were analysed in terms of their frequency, the statistical difference between conditions (with chi-square tests), and strength of relation (with correlation tests). Although the results of the study were not significantly conclusive, a correlation was found between competence and trustworthiness suggesting that the two variables are related. Furthermore, from this experience it can be concluded that using narratives as a methodology to communicate with controllers and talk about trust was acceptable to participants and effective. The use of scenarios provided both a common picture and a baseline that allowed comparisons to be made between individual controllers and controllers from different nationalities and organisational cultures. Further research is needed to establish clearly whether individual differences or variance due to nationality and culture are stronger in influencing controllers' choices to trust colleagues and the technology they use in their work.

The following chapter discusses the results of this study in relation to the model of trust developed and the need for future research.

Chapter Eight: Conclusion and Future Research

8.1. This Thesis

This thesis was concerned with understanding the role of trust in the work of an air traffic controller and with identifying the salient characteristics used by controllers in choosing whether to trust colleagues and technology.

The study of trust in the work of an air traffic controller was considered necessary because the literature on trust considers it to be a precursor of cooperation. A controller' work is based on cooperating with others and with technology, albeit today to a limited extent. Understanding how to best optimise these cooperative behaviours is important today for two reasons. On the one hand, there is a trend for controllers to become more mobile. Consequently, training is becoming more standardised and there is a risk that culturally- or national-specific enablers of cooperation be omitted. Thus, it is important to identify the enablers of cooperation between cooperation. On the other hand, due to traffic growth technology is expected to become more of a team member and less of a tool. Thus, it is necessary to identify ways to optimise the interaction between controllers and the technology they use in their work.

The way this thesis has been written reflects the development of the research it summarises. The study of the role of trust in the work of a controller was first qualitative and then quantitative.

The scope and variety in approaches to studying trust highlight the necessity not only to define the term trust, but also to describe the context within which trust is being studied and the scope of the enquiry. For this reason it is believed that an initial qualitative approach is necessary for a study of trust in order to define the scope and the relevant context.

The qualitative research is summarised in the first half of the thesis, and was concerned with specifying the problem, defining trust and understanding the domain. On the basis of this work, a model which follows the framework defined by Mc Knight & Chervany (2001) according to which it is possible to talk about three types of trust. To understand trust it was argued that one needs to consider three elements, which were called 'self', 'belief' and 'control'. According to this tri-partite model, trust was understood as depending on characteristics of the trustor (i.e. the person that chooses to trust), on characteristics of the trustee (i.e. the person, organisation, structure, or technology) as perceived by the trustee, and on the characteristics of the context. Once the framework has been understood in these terms it is necessary to identify the characteristics that make up these three components. This was done on the bases of the literature review summarised in chapter two, an understanding of the domain (chapter three), and the information collected on the work of a controller described in chapter four. The two main characteristics of the self component were identified as self-confidence and general attitude towards others, where the trustee is understood as another controller or technology. The main characteristics of the belief component was considered to be competence. Finally, the main characteristic of the control component was the fact that the trustor was free to decide whether to choose to trust or not to trust the trustee.

The second part of the thesis summarises the quantitative research carried out to validate the model of trust. Two main studies were carried out to accomplish this and are described in chapters six and seven. The first study focused specifically on identifying salient characters of competency. The second study was the validation study proper and was concerned with five hypotheses. The hypotheses regarded each aspect of the model and the role of culture, which was hypothesised as not influencing the choice to trust on condition that culturally-appropriate characteristics were used for the belief component. The other four hypotheses regarded the role of self-confidence, a general attitude towards others and technology, a judgement of competence, and of the freedom to choose in a controller's decision as whether to trust or not to trust another controller or technology.

This chapter summarises the main conclusions from these studies and highlights issues for future research.

8.2. A Structured Approach to the Study of Trust

The research described in this thesis followed a structured approach to trust that can be summarised in four steps. Although trust has been studied across disciplines, researchers have not succeeded in agreeing upon a working definition of trust, in part due to the fundamental differences in approach used by each discipline. It is important then to render as explicit as possible the assumptions made in a study of trust, as this will support a necessary multi-disciplinary dialogue and, to an extent, the comparison of results in different domains.

The *first step* was the articulation of the assumptions made in this study, amongst which the choice on how to define trust. Trust was considered to imply a dyad, where the trustor is a controller and the trustee a colleague or technology. On the basis of the literature review summarised in chapter two, following Muir (1994), trust was defined as a willing yielding of control that a trustor gives to a trustee when, according to a set of expectations the trustor holds about the trustee, they believe the trustee will carry out an action or behave in a certain way that will result in a positive outcome for them. The trustor was understood as being a decision-maker and trust is the consequence of a choice.

The *second step* consisted in formulating a model proposing a way to understand the dynamics of trust. This model was developed on the basis of literature reviewed in chapter two and the understanding of the work of an air traffic controller described in chapter four, and encompasses three components, referred to as Self, Belief, and Control. According to the model, to predict the trusting behaviour of a controller it is necessary to understand their general attitude towards others or technology, their self-confidence, the beliefs they have of their colleagues and of the technology they use, in terms of competence. It is also necessary to take into account the elements that guide and constrain their decision to co-operate (e.g. procedures, rules and cultural norms).

A single model to describe trust in others and in technology was developed following the conclusions from a number of studies in which Reeves & Nass (1996) showed that users interact with technology in a fundamentally social manner, using common strategies to those in interpersonal relations (e.g. politeness, responding to praise, using stereotypes). This approach is consistent with Muir's (1987; 1994) view of trust in technology, that follows from research in interpersonal trust development, and a common understanding of human-human and human-technology trust has been supported by recent studies in the trust literature (e.g. Jian et al. 1998).

The *third step* implies having a good understanding of the domain of interest. In order to achieve this, the approach favoured in this thesis was an ethnomethodological one that combined informal and structured interviews with questionnaires and observations, which aimed at learning about the work of a controller from the point of view of controllers. From the work summarised in chapter an understanding of the domain of ATM was acquired, as well as an appreciation of the meaning and role attributed by controllers to trust in their work.

Controllers described the importance of trust in learning to work with a trainee or a new colleague, in teamwork, and in using the technology on which controlling depends. Trust was also understood as being relevant when discussing their interactions with pilots and with management.

Controllers related trust to the building of self-confidence, which is essential to expert decision makers, and was described as being dependent on a judgement of competence and experience. Trust was defined as believing, relying on others, and being able to take for granted the correct and safe actions of others, and the accuracy of the information provided by technology. On the one hand, controllers asserted that trust was essential to be able to work with others because it meant not having to double-check colleagues' actions or the information displayed by the technology. On the other hand, double-checking different sources of information is part of a controller's job. Colleagues are relied upon to be a "second pair of eyes and ears" and to check upon their work to notice any inconsistencies or mistakes. To an extent it is possible for controllers to rely on technology for this too, in the case of safety nets (e.g. STCA), to highlight a situation that the controller does not notice or that resulted from a misjudgement. In other words, albeit a paradoxical one, trust would seem to have an important role in the work of an air traffic controller.

Based on an understanding of the domain, this *third step* consisted in choosing a point of view, in other words the trustor, and the horizon of the study. The *point of view* chosen was that of a controller. The horizon refers to the scope or to the granularity of the study, and its definition allows the identification of a number of relevant others for the trustor or referents. In this study the *horizon* of the study was a working position, and thus the *referents* were the controller sharing the position (i.e. tactical or planning controller), the colleagues in the adjacent sector with whom he/she is in contact, and the technology available at the console. The model was conceived of as describing a controller's trust in both other controllers and technology.

The *fourth step* encompassed testing the model proposed. The model was tested as has been described in chapter seven and the conclusions and future research are described in the next section.

8.3. A Model of Trust in the Work of an Air Traffic Controller

As described in detail in chapter five, a model of trust comprising three components was developed to describe an air traffic controller's trust in others and in the technology used in his/her work. The Self component refers to the characteristics of the trustor that influence his or her decision to trust. The Belief component refers to the characteristics of the trustee, understood in this thesis as another controller or technology, on the trustor's decision to trust. The Control component refers to the characteristics of the context, defined in terms of the relation between trustor and trustee and the features of the situation which influence a trustor's decision to trust a trustee.

According to the Belief component of the model, trust was considered to be dependent on a judgement of how able the other (both human and technology) would be in fulfilling the trustee's expectations. It was considered that this judgement of appropriateness could effectively be conceptualised in terms of an assessment of competency. This choice was corroborated both by the literature on trust and by controllers' opinions on what influences their decisions to trust.

However, to test whether a controller's trust in another controller and in the technology he/she uses effectively depends on a judgement of competence, it was necessary to understand what competence means to a controller. The assumption was made that it is not the degree of competence of the trustee that is relevant, but their perceived competence.

French, Irish and Italian controllers participated in a tri-partite study that first collected the characteristics used to describe a competent controller and competent technology, and then identified the most salient of these characteristics.

The first set of results were summarised in chapter six and suggest that different national groups attributed relevance to different characteristics, especially in judging the competence of technology. Although it was not possible to ascertain whether the differences between national cultures were due to nationality, the working environment or organisational culture, the findings highlight the need for further research to investigate the effect of culture, in general terms, on judgements of competence and trustworthiness. In ATM these issues are particularly relevant now, with increasing controller mobility and industrial standardisation of technological support.

The second set of results of the scenario-based questionnaire study, which aimed at validating the model of trust, were summarised in chapter seven. With regard to the Self component of the model, although no differences in overall attitudes towards others were found, individual differences resulted with regard to views of technology, suggesting a distinction between 'low' and 'high' trustors. The fact that initial positive or negative attitudes exist when judging technology should be investigated in more detail, and addressed when introducing new technology.

With regard to the Belief component, the manipulation of the competence of the controllers did not have an effect on the choice to trust under the experimental condition. However, a significant positive correlation was found between ratings of competence and ratings of trustworthiness, for both controller and technology. Further research needs to be carried out to understand the Belief component of the model. This confirms that competence is indeed a key component of trust.

Differences in characteristics identified by national groups were found in the tri-partite study carried out with French, Italian and Irish controllers, although they were not as varied as those describing a competent technology. It is possible that the lack of effect in the scenario-based questionnaire study was due to the fact that all characteristics were not at the same level of description. Furthermore, the way words were divided into the groups identified in the card sort task, and then transformed into rulers, may have influenced the effectiveness of the actual rulers.

With regard to the third component of the model, the Control component, this was not manipulated in the scenario-based questionnaire, but held neutral. Participants responded positively in terms of realism ratings and being able to relate to the narratives, which suggests the narratives were considered realistic and possible by respondents. However, from the results it appears that different cultures responded differently to the same stories. In fact, under both conditions most respondents made the same choices as whether to choose to trust or less the controller or the technology described in the narratives. Nonetheless, the choices were different according to nationality. This would suggest that the variation in interpretation of the scenarios was culturally-related.
Future research should involve an in-depth analysis of the scenarios, carrying out one-to-one interviews with controllers of both nationalities to understand in detail how the stories were interpreted, the aspects readers focused on and gave more importance to.
With a clearer appreciation of how controllers interpret each scenario, it should be possible to distinguish between differences due to culture and individual differences within cultures. After such an exercise, the manipulation of the competence of the controller and technology described in the story should provide results that are 'less noisy', and that allow to differentiate between the influence of individual differences and of culture on the participant's decision to trust the controller and the technology described in the narrative.

Another issue to be considered is the interaction between the competence of the controller and the competence of the technology. Lee's work (Lee, 1992; Lee & Moray, 1994) showed how the comparison between the operator's ability and the perceived ability of the automation by the operator was relevant to the control strategy chosen, and the operator's ratings of trust. Thus, further studies, also using the scenario-based questionnaire approach, should investigate this aspect.

One limitation of the three component model that needs further consideration is the influence of time and experience. Although implicitly, experience may improve, or at least change, the Self and Belief elements, the exact process whereby this happens has to be described.

This thesis has contributed to an understanding of the role and development of trust in ATM by suggesting a structured approach to study trust, which, if followed, will support the sharing and comparison of findings, and by proposing a model of trust that combines finding from the multidisciplinary trust literature with an appreciation of the domain.

The model proposed is a first step in understanding how a controller decides to trust others and the technology he/she uses in their work.

The results of the scenario-based questionnaire study did not support a conclusive validation of the three components. However, with regard to the Self component individual differences were found that suggest it is possible to make a distinction between 'low' and 'high' trustors in relation to attitudes towards technology.

With regard to the Belief component, although the manipulation under the experimental condition was not effective in predicting choices to trust, a significant correlation was found between competence and trustworthy ratings. This supports the hypothesis that competence is a key factor in controllers' decisions to trust.

The competence rulers developed and described in chapter six can be used in future studies measuring the interaction between competence and trust. Moreover, from the tri-partite study differences between cultures were found in the attribution of importance to characteristics of both competent controllers and technology. These differences advocate the need for further research in the effect of culture on controllers' judgments of competence and trustworthiness for both people and technology.

This need is also supported by the conclusions drawn regarding the third component of the model, the Control component. Although this component was not manipulated in the scenario-based questionnaire study, and hypothesised to be neutral, under both conditions the two nationalities interpreted the narratives differently. It follows that further research is necessary to clearly establish the nature of the effect of culture on the Control component.

To conclude, the research described in this thesis found a degree of support for the Self and Belief components and identified the need to further explore the third component Control. Moreover, the influence of culture on controllers' decisions to trust should be further investigated. It is essential to understand the development of trust in a professional population that is becoming increasingly mobile, and thus cross-cultural, and the way trust mediates controllers' use of technology across cultures in order to inform an appropriate and safe design of future decision-support tools. .

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Appendices

Appendix A: Questionnaires

Appendix B: Interviews

Appendix C: Competence Rulers

Appendix D: The Scenario-based Questionnaire

Appendix E: Statistical Results of the Scenario-based Questionnaire Study

Appendix A: Questionnaires

This Appendix contains the question protocol of the three questionnaires, the results of which are reported in chapter four.

The three parts of the *first questionnaire* may be found under section A 1 in three sub-sections (A 1.1., A 1.2., and A 1.3.).

The three parts that made up the *second questionnaire* can be found under section A 2, under three sub-sections (A 2.1., A 2.2., and A 2.3).

The question protocol of the *third questionnaire* is to be found under section A 3.

For clarity of presentation the original format has been modified.

A 1. The First Questionnaire

A 1.1. Part One.

Throughout the questionnaire there are a number of questions on your attitude towards technology.

To ensure that we share an understanding of the word *technology* please select (✓) which of the following you consider *technology* in air traffic management:

[ ] Conflict alert

[ ] Data-link

[ ] Flight processing data display

[ ] Flight strips

[ ] Keyboard

[ ] Radar display

[ ] Radio/telephone

[ ] Tracker ball

[ ] Weather display

[ ] Other. (please specify):

The following statements are about how you work with other agents in the air traffic management system and your attitude towards technology.

Please read then in their order and select (✓) the option which expresses how strongly you agree or disagree with the statement.

Feel free to add comments (suggestions or criticism) at any point of the questionnaire.

1. I collaborate with others in doing my work.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

2. I sometimes forget that those I speak to on the r/t are other people who are working towards achieving the same goal as me.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

3. I need the help of others to carry out my job.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

4. I think it is important for a controller to be self-confident

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

5. I work on my own.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

6. I trust those with whom I work.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

7. I rely on other controllers in my job.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

8. I rely on pilots to do my job.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

9. To control aircraft effectively I need the support of pilots.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

10. I work in a team formed by both controllers and pilots.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

11. I rely on the information provided by pilots to do my job.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

12. To control aircraft effectively I need the support of technology.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

13. I rely on the information provided by other controllers to do my job.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

14. I work in a team.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

15. To control aircraft effectively I need the support of other controllers.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

16. I rely on the support of others to do my job well.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

17. I have to trust others to accomplish my job.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

18. I need technology to do my work.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

19. There is too much technology in my work.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

20. I think there should be more technology to support me in my work.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

21. Having self-confident colleagues is important for me to do my work well.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

22. In my work confidence in pilots is important.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

23. I sometimes double-check the information fellow controllers give me.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

24. I don't always believe the information pilots give me.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

25. Feeling confidant in my fellow controllers is essential for me to do my work well.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

26. Feeling confidant in pilots is essential for me to do my job effectively.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

27. Controllers are important in supporting me do my job.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

28. Self-confidence is a critical element in supporting me make decisions when I am controlling traffic.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

29. I always agree with the decisions taken by fellow controllers.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

30. Controllers always understand the same situation in the same way.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

31. I don't always believe the information fellow controllers give me.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

32. In my work confidence in those around me is important.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

33. I sometimes double-check the information a pilot gives me.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

34. I think that one adjusts to minor system errors without loosing faith in the system as a whole.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

35. In my work confidence in fellow controllers is important.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

36. Sometimes I do not understand the technology I use in my job.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

37. Sometimes I have misunderstood the information provided by the technology.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

38. I regularly double-check the information pilots give me.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

39. I rely on the information presented on the radar screen to do my job.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

40. I regularly double-check the information fellow controllers give me.

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

A 1.2. Part Two

Please read the following questions and select (✓) your answer.

After some of the questions if this is relevant you are asked to refer to your **operational** experience to exemplify your answer. You may go into as much or as little detail as you wish.

Please remember that the information gathered through this survey is solely for my research and will be treated as CONFIDENTIAL.

41. Do you think self-confidence is important for a controller?

Yes [ ] No [ ]

Why?

42. Which aspects of your job (if any) do you think have to and will always be carried out by a controller and never by technology?

43. What/who do you think is the most reliable source of information in your job?

44. What does team work mean to you? Please give an example.

45. Do you think air traffic management is teamwork?

Yes [ ] No [ ]

If yes, whom do you consider as a member of your team?

[ ] Controllers in your centre

[ ] Controllers in other centres

[ ] Pilots

[ ] Technology

[ ] Other (please specify)

46. Have you ever found yourself in a situation where you did not feel confident of a decision made by a fellow controller?

Yes [ ] No [ ]

If yes, did your overall confidence in your fellow controller diminish as a result of this episode?

Yes [ ] No [ ]

47. Are fellow controllers important in supporting you in doing your job?

Yes [ ] No [ ]

48. Have you ever had the feeling a fellow controller did not believe the information you gave him/her?

Yes [ ] No [ ]

If yes, give an example.

49. Has a fellow controller ever misunderstood what you said to him/her?

Yes [ ] No [ ]

If yes, do you think that their overall feeling of trust in you changed?

Yes [ ] No [ ]

50. Have you ever misunderstood the intention of a fellow controller?

Yes [ ] No [ ]

If yes, do you think this influenced your perception of their competence?

Yes [ ] No [ ]

51. Think of a controller whom you regard as competent. What characteristics does he/she have?

Think of air traffic management as a system in which controllers, pilots and technology work together.

52. What do you think influences how much you co-operate with a fellow controller?

[ ] Controller's personality

[ ] Controller's competence

[ ] Controller's age

[ ] Controller's experience

[ ] Controller's sex

[ ] Other (please specify)

53. What do you think may influence how much you co-operate with a pilot you have on frequency?

[ ] Pilot's personality (as inferred from their voice)

[ ] Pilot's competence (as inferred from their use of terminology)

[ ] Pilot's airline

[ ] Pilot's sex

[ ] Other (please specify)

54. What do you think may influence how much you co-operate with technology (an example of technology is a new tool that is introduced into your system)?

[ ] Interface characteristics

[ ] Ease of use

[ ] Your perceived need for this tool

[ ] Manufacturer of tool

[ ] Fact that it is certified

[ ] Other (please specify)

Think of the role of trust in the air traffic management system (ATM system is defined as the system in which controllers, pilots and technology work together).

55. How would you define *trust*.

56. What do you think influences how much you trust a fellow controller?

[ ] Controller's personality

[ ] Controller's competence

[ ] Controller's age

[ ] Controller's experience

[ ] Controller's sex

[ ] Other (please specify)

57. What do you think influences how much you trust a pilot you have on frequency?

[ ] Pilot's personality (as inferred from their voice)

[ ] Pilot's competence (as inferred from their use of terminology)

[ ] Pilot's airline

[ ] Pilot's sex

[ ] Other (please specify)

58. What do you think influences how much you trust technology (for example, a new tool which is introduced into your system)?

[ ] Interface characteristics

[ ] Ease of use

[ ] Your perceived need for this tool

[ ] Provider of the tool

[ ] Fact that it is certified

[ ] Other (please specify)

59. What part of your job would you never want to give up? In other words, what is the aspect of your job that you like most?

60. Do you think that one of the skills of a good controller is to be able to anticipate the intentions of pilots and other controllers?

Yes [ ]   No [ ]

Why?

A 1.3. Part Three of the First Questionnaire

Please answer the following questions in their order. Remember that there are no right or wrong answers as what I am interested in is your opinion.

Please feel free to add comments (suggestions or criticism).

61. Consider whether controllers, pilots and technology help you do your work.

Put them in order from 1 to 3, where 1 is the most important in supporting you do your job and 3 is least important in supporting you do your job.

___ Controllers

___ Pilots

___ Technology

62. Imagine this scenario: you watch an aircraft with label ABC123 enter your sector on your radar and a pilot on your frequency calls you as ABC125.

From your experience do you think it is more likely that your first thought is that the correct information is that provided by the pilot or that visible on the radar screen?

Pilot[ ]

Radar screen [ ]

How do you understand whether the correct call-sign is that given by the pilot or that represented on the radar?

63. Do you normally believe the information given to you by:

Controllers Yes [ ]No [ ]

Pilots Yes [ ]No [ ]

Technology Yes [ ]No [ ]

What does the fact that you believe or do not believe controllers, pilots, technology depend on?

Please read the following 10 questions on your attitude towards the technology you use in your work and select (✓) your answer.

After some of the questions you are asked to refer to your operational experience to exemplify your answer. If you do have experience relevant to your answer you can chose one or more episodes, and go into as much or as little detail as you wish.

Please remember that the information gathered through this survey is only for my research.

64. Do you feel that the support of technology is essential to your work?

Yes [ ] No [ ]

If yes, why?

If no, why not?

65. Consider the system as made up of controllers interacting with technology.

Did the occurrence of an inconsistency in the system change your level of trust in the system?

Yes [ ] No [ ]

If yes, did it change the level of trust you had in:

[ ] the whole system

[ ] only in the element that did not behave as you expected

[ ] other (please specify)

66. Do you think that technology is important in your work?

Yes [ ] No [ ]

67. Has the system ever responded to an input of yours in a way you did not expect?

Yes [ ] No [ ]

If yes, please give an example.

68. Can you understand how a controller may misinterpret the information on the radar screen?

Yes [ ] No [ ]

If yes, describe the circumstances under which this might happen.

69. Do you feel that controllers are important in supporting you in doing your job?

Yes [ ] No [ ]

Why?

70. Have you ever had the feeling a pilot did not believe the information you gave them?

Yes [ ]   No [ ]

If yes, please describe the circumstances under which this happened.

71. In the same way that people misunderstand the intentions of their colleague, I sometimes do not understand the system I work with. Do you agree with this idea?

Yes   [ ]   No [ ]

If yes, please describe the circumstances under which this may occur.

If no, can you think of a better metaphor for the way in which you interact with the system?

72. Has the technology you use ever worked in a way you did not expect?

Yes [ ]   No [ ]

73. Are there any aspects of your work that you think should be automated?

Yes [ ]   No [ ]

What are these aspects?

Thank you for your time.

If you wish to discuss any of the questions please contact me at dbonini@tcd.ie

A 2. The Second Questionnaire

A 2.1. The first part of the second questionnaire: Trust and Teamwork.

Trust is considered an important element in enhancing teamwork, especially in supporting teams communicate well. This may be because trust is based on a shared agreement or understanding. Below are a number of questions on common understanding and effective communication with those you work with. Please read them and select (✓) your answer.

After some of the questions, if this is relevant, you are asked to refer to your **operational** experience to exemplify your answer. You may go into as much or as little detail as you wish.

Please remember that the information gathered through this survey is solely for my research and will be treated as CONFIDENTIAL.

1. How would you define trust?

2. Do you think trust is important in your job?

Yes [ ] No [ ]

Why?

3. Do you think trust means? [Please select as appropriate]

[ ] Believing someone

[ ] Relying on someone

[ ] Needing someone

[ ] Having confidence in someone

[ ] Having faith in someone

[ ] Other [please specify]..

4. Do you think there is any difference between the trust you have in a colleague and one in a friend?

Yes [ ] No [ ]

If yes, please describe what this difference is.

5. Trust is considered an important element in effective teams. Do you feel part of a team?

Yes [ ] No [ ]

If yes, who are the members of your team? [Please select as appropriate]

[ ] airlines

[ ] airport management

[ ] center assistants

[ ] center's management

[ ] center's technical support

[ ] Controllers in other centers

[ ] Controllers in your center

[ ] Pilots

[ ] regulatory authority

[ ] Technical equipment

[ ] Others [please specify]

6. Do you think trust has a role in the way you interact with any of those listed below? If yes, please select them.

[ ] airlines

[ ] airport management

[ ] center assistants

[ ] center's management

[ ] center's technical support

[ ] controllers in other centers

[ ] controllers in your center

[ ] pilots

[ ] regulatory authority

[ ] technical equipment

[ ] others [please specify]

7. What do you think helps you and your fellow controllers share a common understanding [e.g. the *picture*]?

8. Do you think speaking the same language is important in helping you share the *picture*?

Yes [ ]   No [ ]

9. Do you think knowing your colleague is important in helping you share the *picture*?

Yes [ ]   No [ ]

10. Do you think that pilots and controllers share a common perspective?

Yes [ ] No [ ]

If yes, do you think that speaking the same language helps you share the same perspective?

Yes [ ] No [ ]

If no, why do pilots and controllers not share the same perspective?

11. Do you feel you share the same perspective as management?

Yes [ ] No [ ]

12. Would you describe the organization in which you work as a trustworthy one? [i.e. characterized by openness, shared understanding, good communication, reliability and equity]

Yes [ ] No [ ]

Why?

THANK YOU FOR YOUR TIME!!

A 2.2. Second part of the second questionnaire: Trust and Co-operation.

Below are a few questions on your trust in those you work with. Please read them and select (✓) your answer.

After some of the questions, if this is relevant, you are asked to refer to your operational experience to exemplify your answer. You may go into as much or as little detail as you wish.

Please remember that the information gathered through this survey is solely for my research and will be treated as CONFIDENTIAL.

13. What do you think influences your trust in a new controller (e.g. a trainee)?

14. What do you think influences how much you trust a controller you work with? [Please select as appropriate]

[ ] Age

[ ] Competence

[ ] Experience

[ ] Personality characteristics

[ ] Use of phraseology/language

[ ] Other [please specify]

15. What do you think influences how much you trust a controller you talk to on the radio/telephone? [Please select as appropriate]

[ ] Age

[ ] Competence

[ ] Experience

[ ] Personality characteristics

[ ] Use of phraseology/language

[ ] Other [please specify]

16. What does your trust in a pilot that you have on frequency depend on? [Please select as appropriate]

[ ] Airline

[ ] Competence [as inferred from their response to instructions]

[ ] Competence [as inferred from their use of phraseology/language]

[ ] Personality characteristics [as inferred from their voice]

[ ] Other [please specify]

17. What does your trust in a manager in your control center depend on? [Please select as appropriate]

[ ] Age

[ ] Background (e.g. ex-controller or not)

[ ] Competence

[ ] Experience

[ ] Personality characteristics

[ ] Other [please specify]

18. Does your trust in another controller change with time?

Yes [ ] No [ ]

19. Can you think of an episode in which you trusted another controller too little or too much?

[what happened – what did you do – what did you learn – how did you share your experience with fellow controllers]

20. What happens if a controller you work with makes a mistake or has an incident. Does your trust in him/her change?

Yes [ ] No [ ]

If yes, what influences whether you trust them again or not?

21. Do you think you work better with a controller whom you trust?

Yes [ ] No [ ]

22. I adjust to minor errors in the system I use without losing faith in the system as a whole

[ ] strongly agree

[ ] agree

[ ] uncertain or neutral

[ ] disagree

[ ] strongly disagree

23. What characteristics should a controller have in order for you to trust him/her?

Please select the appropriate ones out of this list.

[ ] Always follows procedures

[ ] Cautious

[ ] Dependable

[ ] Experienced

[ ] Fast decision maker

[ ] Good team-mate

[ ] Intuitive

[ ] Knows their limits

[ ] Motivated

[ ] Planning skills

[ ] Predictable

[ ] Proactive to problems

[ ] Quiet

[ ] Reactive

[ ] Reliable

[ ] Self-confident

[ ] Serious

[ ] Uses correct phraseology

[ ] Other [please specify]

24. In the same way that people can misunderstand each other's intentions, I sometimes do not understand the system I work with. Do you agree with this statement?

Yes [ ] No [ ]

Why?

THANK YOU FOR YOUR TIME!!

A 2.3. Third part of the second questionnaire: Technology and change

Below are a few questions on your work, your interaction with technology and your attitude towards change. Please read them and select (✓) your answer.

After some of the questions, if this is relevant, you are asked to refer to your operational experience to exemplify your answer. You may go into as much or as little detail as you wish.

Please remember that the information gathered through this survey is solely for my research and will be treated as CONFIDENTIAL.

25. To ensure that we share an understanding of the word *technology* please select (✓) which of the following you consider *technology*?

[ ] Conflict alert

[ ] Data-link

[ ] Flight processing data display

[ ] Flight strips

[ ] Keyboard

[ ] Radar display

[ ] Radio/telephone

[ ] Tracker ball

[ ] Weather display

[ ] Other [Please specify] ....

26. What aspect of your work would you never give up? Please choose one of the following.

[ ] Contact with pilots

[ ] Decision making

[ ] Responsibility

[ ] The real time aspect of my work

[ ] Working in a team

[ ] Other [Please specify] ....

27. Consider the system as made up of controllers interacting with technology. Did the occurrence of one inconsistency in the system change your level of trust in the system?

Yes [ ] No [ ]

If yes, did it change the level of trust you had in

[ ] The whole system

[ ] Only in the element that did not behave as expected

[ ] Other [please specify]

If yes, what happened to make you regain trust?

28. Think of the technical equipment you use in your work. Chose the best metaphor to describe how you think of this technology.

[ ] Boss

[ ] Friend

[ ] Partner

[ ] Subordinate

[ ] Team mate

[ ] Other [Please specify] ....

29. Do you think your answer to the previous question will change in the future?

Yes [ ] No [ ]

If yes, what metaphor do you expect will be appropriate in the future?

[ ] Boss

[ ] Friend

[ ] Partner

[ ] Subordinate

[ ] Team mate

[ ] Other [please specify] ....

30. What do you think influences your trust in a newly implemented piece of technology?

31. Imagine this scenario: on your radar you watch aircraft with label AB123 enter your sector. A pilot then calls you and identifies himself/herself as AB125.

From your experience, do you think that your first thought is that the correct information is that provided by the pilot or that visible on your computer screen?

Pilot [ ]

Radar [ ]

Why would you believe one source rather than another?

32. What do you think influences how much you trust the technical equipment you use? [please select as appropriate]

[ ] Amount of training

[ ] Certified

[ ] Consistency

[ ] Ease of use

[ ] Interfaces characteristics [e.g. how information is presented]

[ ] Provider of the tool

[ ] Reliability

[ ] Your perceived need for this tool

[ ] Other [please specify] ....

33. What characteristics do you think make a piece of equipment trustworthy?

34. Are you in favor of changes in procedures or in technology?

Yes [ ] No [ ]

35. Are there any aspects of your work that you think should be automated?

Yes [ ] No [ ]

What are these aspects?

THANK YOU FOR YOUR TIME!!

A 3. The third questionnaire: a questionnaire on trust

Below are 10 questions on trust in general, and your trust in those you work with. Please read them and select (✓) your answer.

Some of the questions ask you to refer to episodes from your operational experience to exemplify your answer. You may go into as much or as little detail as you wish. Please remember that the information gathered through this survey is solely for my research and will be treated as CONFIDENTIAL.

Feel free to add comments (suggestions or criticism) at any point of the questionnaire.

1. How would you define trust?

2. Do you think trust is important in your job?

Yes [ ] No [ ]

Why?

3. Please list the characteristics of a trustworthy controller.

4. What do you think influences your trust in a new controller (e.g. a trainee)?

5. What do you think influences how much you trust a controller you work with? [Please select as appropriate]

[ ] Age

[ ] Competence

[ ] Experience

[ ] Personality characteristics

[ ] Use of phraseology/language

[ ] Other [please specify] ....

Please clarify what you mean by the characteristic/s you selected.

6. What does your trust in a pilot that you have on frequency depend on? [Please select as appropriate]

[ ] Airline

[ ] Competence [as inferred from their response to instructions]

[ ] Competence [as inferred from their use of phraseology/language]

[ ] Personality characteristics [as inferred from their voice]

[ ] Other [please specify]

Please clarify what you mean by the characteristic/s you selected.

7. Can you think of an episode in which you trusted another controller too little or too much?

[For example, what happened – what did you do – what did you learn]

8. Please list the characteristics of trustworthy technology and equipment you use in your work.

9. What do you think influences your trust in a newly implemented piece of technology?

10. Imagine this scenario: on your radar you watch aircraft with label AB123 enter your sector. A pilot then calls you and identifies himself/herself as AB125.

From your experience, do you think that your first thought is that the correct information is that provided by the pilot or that visible on your computer screen?

Pilot [ ]

Radar [ ]

Describe a scenario where the correct information is that provided by the pilot.

Describe a scenario where the correct information is that provided by the radar.

THANK YOU FOR YOUR TIME!!

Appendix B: Interviews

This appendix contains the question protocol from the interviews carried out to collect information on trust in new trainees and new technology summarised in chapter four (section 4.4.).

Section B 1. contains the question protocol used for the interview on a new controller. Section B 2. contains the question protocol used for the interview on new technology. Section B 3. contains the consent form and the information sheet provided to the English speaking participants.

B 1. An interview on a New Controller

1) Description of the trainee

2) Did you train him/her ?   Yes / No

3) What was your first impression of them?

4) Did they change?   Yes / No   Why?

5) Did you trust them immediately or did it take time?

6) Describe the perfect student

7) Describe the nightmare student

B 2. An Interview on New Technology

1) Describe the technology to me

2) Were you involved in the development of the technology   Yes / No

3) Were you involved in the introduction of the technology   Yes / No

4) What were your first impressions

5) Did they change with time?   Yes / No   Why?

6) If it was necessary, what kind of training did you receive?

7) Describe to me the ideal way to introduce technology in the control room

8) Describe to me the wrong way to introduce technology in the control room

B 3. Consent Form and Information Sheet for English-speaking Participants

DEPARTMENT OF PSYCHOLOGY
TRINITY COLLEGE
DUBLIN 2, IRELAND

Phone: +353-1-608 1623
Fax: +353-1-608 2006
E-mail: dbonini@tcd.ie

Please read the Consent form (A) and Information Sheet (B) carefully. Make sure that all your questions have been answered to your satisfaction before signing.

(A) Participant's Consent to Voluntary Participation in a Research Project

I, ________________________, understand that Deirdre Bonini is a PhD student in the department of Psychology at Trinity College Dublin (Ireland) and that her work is sponsored by EUROCONTROL (France).

The study I am being invited to participate in is being carried out as part of her doctoral research which is on the role of trust in the work of an air traffic controller.

I agree to participate in an interview about my experiences with new controllers or on the introduction of new technology and change in an air traffic control centre. The purpose of the interview is to collect information to inform a number of case studies.

I understand that my participation will not cause me any risk or discomfort.

I understand that records of this interview are strictly confidential, and I will not be identifiable by name or description in any reports or publications about this study. The names of people I may mention in my account will only be quoted with their general job title (e.g. watch manager; controller; assistant). Any of the information that may identify cannot be used for purposes other than those stated without my written permission.

I grant Deirdre Bonini with permission to reproduce and publish all records, notes or data collected from my participation, provided there is no association of my name with the collected data and confidentiality is maintained.

I understand that although participation does not hold a prospect of direct benefit, sharing my person experience will provide concrete examples that may benefit the ATC (air traffic control) community in the form of lessons learned. I will not receive any payment for my time but if I so wish I will receive a copy of the report[1].

During the interview it will be my responsibility to provide an accurate account of the events I describe, and to answer any questions asked during the interview to the best of my abilities.

---

[1] If you so wish, please include contact details below signature at the end of the letter of consent.

I agree/do not agree [please circle your choice] for the interview to be tape-recorded. I understand that audio recordings will be used in the analysis to complement notes taken during the study. I also agree that extracts from the recording be used in reports, provided confidentiality is respected.

My consent to participate in this study has been freely given. I may withdraw my consent, and thereby withdraw from the study at any time without penalty.

I have had an opportunity to ask questions and have received satisfactory answers to all my questions.

If I have any further questions about this study I will contact Deirdre Bonini at +33 1 69887503 or her academic supervisor Dr Nick McDonald at +353 1 608 1471.

I have read this consent document and understand its contents. I have received a copy of this consent form.

Principal Investigator: ______________________________

Date: _________________

Research Participant: ______________________________

Date: _________________

Contact details for receiving final report:

Space where photocopy of TCD ID card will appear.

(B) Information sheet

The research I am carrying out as part of my doctorate is concerned with the role of trust in the domain of Air Traffic Control. I have developed a model that describes the development of trust between controllers and between controllers and the technology they use in their work. As this model is conceptual in nature, it is necessary for me to validate it with data collected from the field. At present I am in the initial phase of my validation plan which aims at testing whether my model effectively and appropriately represents the way in which controllers trust others and technology.

My doctorate is on the role of trust in the work of an air traffic controller. I am interested in understanding what role trust has in the way a controller works with other controllers and in the way he/she uses the technology available in their centre to carry out their work.

I would like to carry out a series of interviews to collect information on the introduction of a new piece of equipment, a change in a feature of the technology, and the arrival of a new controller.

Aim

The objective of these interviews is to collect information on the role of experience in trust. Thus, whether for a new arrival or new technology, there is an initial learning period. This period is interesting from my point of view because it is when the basis of trust is created.

The result will be a series of examples or very short case studies. All the information collected will be reported in such a way as to make it general in nature and not allow specific individual or centre identification.

Format and Content of Interview

The interview will be an open-structure interview with a number of open- and closed-ended questions (i.e. some where you write free text, others where you chose from a selection of possible answers). The interview will be either about a trainee or about new technology. You are free to chose the topic, however if you have not done OJTI I would prefer you to answer questions on new technology. Each interview should last no more than 20 minutes. Some people do not like their interviews to be tape-recorded, you are free to choose whether you agree to your interview being recorded or not.

I will give you my visitor's card with my contact details and you may contact me if you are interested in receiving the results. You will also have my supervisor's contact details on your copy of the consent form.

Do you have any questions?

Appendix C: Competence Rulers

This appendix contains the results from the tri-partite study carried out with French, Italian and Irish controllers and summarized in chapter six.

Section C 1. contains ten tables and five figures. The ten tables summarize the controller and technology descriptors provided by French, Irish and Italian participants in the information collection task (section 6.3.). The characteristics provided in French and Italian are also provided. The five figures summarise the results of the word sort tasks (section 6.4.) carried out on the technology characteristics by the French, Irish, and Italian participants.

Section C 2. contains the final phase of the statistical analysis of the paired comparisons results that are then represented as 'rulers' of competence.

C 1. Descriptors of a Competent Controller and Technology

The ten tables below represent the characteristics provided by respondents describing a competent controller and competent technology. They are listed by nationality: French, Irish and Italian.

French

Table C 1.

Anticipation	Authority	Calm	Can manage unexpected events
Can recover quickly from mistakes	Cold blood	Communication	Concentration
Efficient	Experienced	Flexible	Friendly
Gets picture	Humble	Keeps calm	Knowledgeable
Knows how to delegate	Knows own limits	Likes his/her job	Looks after others
Motivated	Radar technique	Reactive	Reads fast but acts carefully
Rigorous	Self confidence	Sense of humour	Serious
Team spirit	Technically-oriented	Tolerant	Uses phraseology

Note. Characteristics provided by French respondents describing a competent controller, listed in alphabetical order.

Table C 2.

Anticipation (4)	Autorité (5)	Calme (7)	Sait faire face a l'imprévu (25)
Etre capable de gérer les erreurs (14)	Sang-froid (26)	Communication (8)	Concentration (9)
Efficace (13)	Expérimenter (15)	Adaptabilité (1)	Affable (2)
Garde une image (17)	Humilie (18)	Garde son calme (16)	Connaissance (11)
Sait délégué (24)	Connaît ses limites (12)	Aime son travail (3)	Prend soin des autres (21)
Motive (20)	Technique radar (30)	Réactionnel (22)	Lit rapidement mais agit soigneusement (19)
Rigoureux (23)	Confiance en soi (10)	Sens de l'humour (27)	Sérieux (28)
Avoir l'esprit d'équipe (6)	Technicien (29)	Tolérance (31)	Utilise la phraséologie (32)

Note. Characteristics provided by French respondents in French describing a competent controller, listed to mirror Table C 1. (the numbers in brackets refer to the results provided in section C 2.)

Table C 3.

Allows gain of time	Allows precise measurements	Assures safety	Conflict detection & resolution
Easy to configure	Effective HMI	Fast	Helps memorise
Intuitive	Meets need	Planning of future	Provides relevant information
Reduces workload	Reliable	Safe	Simple
Simplifies work	Supports user	User friendly	You forget about It

Note. Characteristics provided by French respondents to describe competent technology, listed in alphabetical order.

Table C 4.

Fait gagner du temps (8)	Faire des mesures précises (7)	Assure sécurité (4)	Aide a la détection et résolution (1)
Configuration facile a faire (5)	I.H.M. efficace (10)	Rapide (13)	Aide a la mémorisation (2)
Intuitive (11)	Répond a un besoin (15)	Prévision de futur (12)	Donne informations pertinents (6)
Réduit la charge de travail (14)	Fiable (9)	Sur (19)	Simple (17)
Simplifie le travail (18)	Apporte un confort de travail (3)	Usage convivial (20)	Se fait oublier (16)

Note. Characteristics provided by French respondents in French to describe competent technology, listed to mirror Table C. 3. (the numbers in brackets refer to the results provided in section C 2.)

Irish

Table C 5.

Able to share tasks	Attitude to job	Calm	Communicates clearly
Cool head under pressure	Easygoing	Experienced	Fast
Flexible	Friendly	Gets on with fellow controllers	Good decision maker
Hardworking	Helpful	Knowledgeable	Not afraid to admit mistakes
Reliable	Self confident	Sense of humour	Team member

Note. Irish competent controller descriptors listed in alphabetical order.

Table C 6.

Accessible	Accurate	Bespoke solution	Clearly displayed
Easy to set up	Efficient	Fast	Flexible
Decreases workload	Easy to understand	Simple to use	Simplifies job
User friendly	Confident in it	Reliable	Well maintained
Does not distract you from primary task	Essential for my job	Gives you more controlling time	Safe

Note. Irish competent technology descriptors listed in alphabetical order.

Italian

Table C 7.

Calm but can act & think fast	Calm even in emergencies	Can manage unusual situations	Flexible according to traffic conditions & situations
Good judgement	Good knowledge of English	Keeps constantly up-to-date	Knowledgeable
Knows procedures	Knows strengths & limits of technology at disposal	Never takes anything for granted	Not presumptuous

Note. Italian competent controller descriptors listed in alphabetical order.

Table C 8.

Calmo ma sa pensare e agire in maniera veloce	Calmo anche nelle emergenze	Sa gestire situazioni inusuali	Flessibile in funzione di circostanze ambientali o di traffico
Buona capacita' di giudizio	Buona conoscenza della lingua inglese	Si mantiene aggiornato costantemente	preparato
Conosce la normativa	Conosce potenzialita' e limiti delle tecnologie a disposizione	Non da' mai nulla per scontato	Non e' presuntuoso

Note. Italian competent controller descriptors in Italian, listed to mirror Table C 7.

Table C 9.

Acts as support	Always available	Clear display	Dependable
Easy access to information	Easy to understand	Ergonomic	Fast
Flexible	Free from malfunctions	Gain time	Helps work more
Immediate	Improves the quality of information	Increases efficiency	Integrates with work
Intuitive	Leaves the controller in control	Makes work easier	Not repetitive
Of help	Provides useful information	Reduces stress	Reduces workload
Redundant	Responds to needs	Simple to use	Tested
Useful	Well organised information		

Note: Italian competent technology descriptors listed in alphabetical order.

Table C 10.

Di supporto	Sempre disponibile	Visualizzazione chiara	Affidabile
Facile accesso a informazioni	Facile da comprendere	Ergonomica	Veloce
Flessibile	Esente da malfunzioni	Risparmio di tempo	Aiuta a lavorare di piu'
Immediata	Migliora la qualita' delle informazioni	Aumenta l'efficacia	Si integra con il lavoro
Istintiva	Lascia il controllore in controllo	Facilita il lavoro	Non ripetitiva
Di aiuto	Apporta informazioni utili	Riduce lo stress	Riduce il carico di lavoro
Ridondante	Risponde alle esigenze	Semplice da usare	E' stata testate
Utile	Informazioni ben organizzate		

Note: Italian competent technology descriptors in Italian, listed to mirror Table C 9.

C 2. The Card Sorting Groupings

The figures represented below represent the groups of characteristics resulting from participant's card sorting task for controllers and for technology, according to nationality: French, Italian and Irish.

French

Friendly	**Likes his/her job**	**Team spirit**	**Calm**
Communication	**Self confidence**	**Humble**	**Motivated**
Looks after others	**Sense of humour**	**Tolerant**	Flexible
Authority	Knows own limits	Can recover quickly from mistakes	Keeps calm
Reactive	Can manage unexpected events	Cold blood	Anticipation
Concentration	Efficient	Gets picture	Knows how to delegate
Knowledgeable	**Experienced**	**Reads fast but acts carefully**	**Rigorous**
Serious	**Technically-oriented**	**Radar technique**	**Uses phraseology**

*Figure C 1.*Groupings of characteristics carried out by French controllers on characteristics describing a competent controller.

Conflict detection & resolution	**Assures safety**	**Configuration easy to do**	**Allows gain of time**
Planning of future	**Reduces workload**	**Simplifies work**	Helps memorise
Simple	**User friendly**	Simplifies work	Provides relevant information
You forget about it	Intuitive	Effective HMI	Reliable
Fast	Meets need	Safe	Allows precise measurements

*Figure C 2.*Groupings of characteristics carried out by French controllers on characteristics describing competent technology.

Irish

Easygoing	**Friendly**	**Gets on with fellow controllers**	**Helpful**
Sense of humour	**Calm**	**Cool head under pressure**	**Reliable**
Self confident	Attitude to job	Hardworking	Not afraid to admit mistakes
Communicates clearly	Experienced	Fast	Good decision maker
Knowledgeable	**Able to share tasks**	**Flexible**	**Team member**

Figure C 3. Characteristics of a competent controller that were sorted into groups by Irish participants (listed in alphabetical order, within groups

Accessible	**Accurate**	**Bespoke solution**	**Clearly displayed**
Easy to set up	**Efficient**	**Fast**	**Flexible**
Decreases workload	Easy to understand	Simple to use	Simplifies job
User friendly	**Confident in it**	**Reliable**	**Well maintained**
Does not distract you from primary task	Essential for my job	Gives you more controlling time	**Safe**

Figure C 4. Characteristics of competent technology that were sorted into groups by Irish participants (listed in alphabetical order, within groups).

Italian

Dependable	**Tested**	**Easy to use**	**Easy access to information**
Flexible	**Immediate**	**Redundant**	**Of help**
Gain time	**Simple to use**	**Useful**	**Fast**
Clear display	**Provides useful information**	Free from malfunctions	Easy to understand
Well organised information	Improves the quality of information	Always available	Acts as support
Increase quality of work	Intuitive	Leaves the controller in control	Reduces workload
Reduces stress	Responds to needs	Integrates with work	**Helps work more**
		Increases efficiency	**Not repetitive**

Figure C 5. Characteristics of technology sorted by Italian controllers (listed in alphabetical order, within groups). The bold line defines groups into which words were sorted in the next task.

C 3. The paired comparisons results

The tables below provide the final statistical analysis carried out in the paired comparisons.

In order, they are:

- French controller rulers (Figure C 6.)
- French technology rulers (Figure C 7.)
- Irish controller rulers (Figure C 8.)
- Irish technology rulers (Figure C 9.)
- Italian controller rulers (Figure C 10.)
- Italian technology rulers (Figure C 11.)

	27	21	2	31	18	20	7	3	6	10	8
2. affable	0.85	0.58		1.18	1.18	0.85	1.18	0.58	1.75	0.85	1.75
3. aime son travail	-1.41	-0.99	-0.71	-0.47	-0.26	-0.47	-0.26		0.15	0.58	0.85
6. avoir l'esprit d'équipe	-0.99	-0.99	?	-0.47	-0.47	-0.26	-0.47	-0.26		-0.05	0.58
7. calme	-0.71	-0.47	-1.41	-0.26	-0.05	-0.47		0.15	0.36	0.58	0.15
8. communication	-1.41	-1.41	?	-1.41	-0.99	-0.05	-0.26	-0.99	-0.71	-0.05	
10. confiance en soi	-1.41	-0.71	-0.99	-0.99	-1.41	-0.99	-0.71	-0.71	-0.05		-0.05
18. humilité	-0.71	-0.47	?	-0.26		-0.26	-0.26	-0.05	0.36	0.85	0.85
20. motivé	-0.99	-0.47	-0.99	-0.26	0.15		0.36	0.36	0.15	0.58	-0.05
21. prend soin d'autres	-0.26		-0.71	0.36	0.36	0.36	0.15	0.85	0.85	0.58	0.85
27. sens de l'humour		0.15	-0.99	0.36	0.58	0.85	0.58	1.18	0.85	1.18	1.18
31. tolérance	-0.47	-0.47	-1.41		0.15	0.15	0.15	0.36	0.36	0.58	1.18
	-7.51	-5.25	-4.1	-2.22	-0.76	-0.29	0.46	1.47	4.07	5.68	7.29

27	21		21	2		2	31		31	18		18	20		20	7		7	3		3	6		6	10		10	8	
0.85	0.58	0.27	0.58		0.58		1.18	-1.18	1.18	1.18	0	1.18	0.85	0.33	0.85	1.18	-0.33	1.18	0.58	0.6	0.58	1.75	-1.17	1.75	0.85	0.9	0.85	1.75	-0.9
-1.41	-0.99	-0.42	-0.99	-0.71	-0.28	-0.71	-0.47	-0.24	-0.47	-0.26	-0.21	-0.26	-0.47	0.21	-0.47	-0.26	-0.21	-0.26		-0.26		0.15	-0.15	0.15	0.58	-0.43	0.58	0.85	-0.27
-0.99	-0.99	0	-0.99	?	#####	?	-0.47	#####	-0.47	-0.47	0	-0.47	-0.26	-0.21	-0.26	-0.47	0.21	-0.47	-0.26	-0.21	-0.26		-0.26		-0.05	0.05	-0.05	0.58	-0.63
-0.71	-0.47	-0.24	-0.47	-1.41	0.94	-1.41	-0.26	-1.15	-0.26	-0.05	-0.21	-0.05	-0.47	0.42	-0.47		-0.47		0.15	-0.15	0.15	0.36	-0.21	0.36	0.58	-0.22	0.58	0.15	0.43
-1.41	-1.41	0	-1.41	?	#####	?	-1.41	#####	-1.41	-0.99	-0.42	-0.99	-0.05	-0.94	-0.05	-0.26	0.21	-0.26	-0.99	0.73	-0.99	-0.71	-0.28	-0.71	-0.05	-0.66	-0.05		-0.05
-1.41	-0.71	-0.7	-0.71	-0.99	0.28	-0.99	-0.99	0	-0.99	-1.41	0.42	-1.41	-0.99	-0.42	-0.99	-0.71	-0.28	-0.71	-0.71	0	-0.71	-0.05	-0.66	-0.05		-0.05		-0.05	0.05
-0.71	-0.47	-0.24	-0.47	?	#####	?	-0.26	#####	-0.26		-0.26		-0.26	0.26	-0.26	-0.26	0	-0.26	-0.05	-0.21	-0.05	0.36	-0.41	0.36	0.85	-0.49	0.85	0.85	0
-0.99	-0.47	-0.52	-0.47	-0.99	0.52	-0.99	-0.26	-0.73	-0.26	0.15	-0.41	0.15		0.15		0.36	-0.36	0.36	0.36	0	0.36	0.15	0.21	0.15	0.58	-0.43	0.58	-0.05	0.63
-0.26		-0.26		-0.71	0.71	-0.71	0.36	-1.07	0.36	0.36	0	0.36	0.36	0	0.36	0.15	0.21	0.15	0.85	-0.7	0.85	0.85	0	0.85	0.58	0.27	0.58	0.85	-0.27
	0.15	-0.15	0.15	-0.99	1.14	-0.99	0.36	-1.35	0.36	0.58	-0.22	0.58	0.85	-0.27	0.85	0.58	0.27	0.58	1.18	-0.6	1.18	0.85	0.33	0.85	1.18	-0.33	1.18	1.18	0
-0.47	-0.47	0	-0.47	-1.41	0.94	-1.41		-1.41		0.15	-0.15	0.15	0.15	0	0.15	0.15	0	0.15	0.36	-0.21	0.36	0.36	0	0.36	0.58	-0.22	0.58	1.18	-0.6
		-0.21			0.604			-0.89			-0.13			-0.04			-0.07			-0.09			-0.24			-0.15			-0.15

	5	22	12	16	26	1	25	14
1. adaptabilité	-1.34	-1.34	-0.92	-0.36	-0.13		0.33	0.88
5. autorité		0.33	0.33	0.88	1.29	1.29	2.33	2.33
12. Connaît	-0.36	-0.13		0.33	0.88	0.88	2.33	2.33
14. être capable de	?	?	?	-0.61	-0.36	-0.92	-0.13	
16. garde son calme	-0.92	-0.13	-0.36		-0.13	0.33	0.88	0.58
22. réactionnel	-0.36		0.1	0.1	0.88	1.29	1.29	2.33
25. sait faire face..	?	-1.34	?	-0.92	-0.61	-0.36		0.33
26. sang-froid	-1.34	-0.92	-0.92	0.1		0.1	0.33	0.33
	-4.32	-3.53	-1.77	-0.48	1.82	2.61	7.36	9.11

5	22		22	12		12	16		16	26		26	1		1	25		25	14	
-1.34	-1.34	0	-1.34	-0.92	-0.42	-0.92	-0.36	-0.56	-0.36	-0.13	-0.23	-0.13		-0.13		0.33	-0.33	0.33	0.88	-0.55
	0.33	-0.33	0.33	0.33	0	0.33	0.88	-0.55	0.88	1.29	-0.41	1.29	1.29	0	1.29	2.33	-1.04	2.33	2.33	0
-0.36	-0.13	-0.23	-0.13		-0.13		0.33	-0.33	0.33	0.88	-0.55	0.88	0.88	0	0.88	2.33	-1.45	2.33	2.33	0
?	?	#####	?	?	#####	?	-0.61	#####	-0.61	-0.36	-0.25	-0.36	-0.92	0.56	-0.92	-0.13	-0.79	-0.13		-0.13
-0.92	-0.13	-0.79	-0.13	-0.36	0.23	-0.36		-0.36		-0.13	0.13	-0.13	0.33	-0.46	0.33	0.88	-0.55	0.88	0.58	0.3
-0.36		-0.36		0.1	-0.1	0.1	0.1	0	0.1	0.88	-0.78	0.88	1.29	-0.41	1.29	1.29	0	1.29	2.33	-1.04
?	-1.34	#####	-1.34	?	#####	?	-0.92	#####	-0.92	-0.61	-0.31	-0.61	-0.36	-0.25	-0.36		-0.36		0.33	-0.33
-1.34	-0.92	-0.42	-0.92	-0.92	0	-0.92	0.1	-1.02	0.1		0.1		0.1	-0.1	0.1	0.33	-0.23	0.33	0.33	0
		-0.36			-0.07			-0.47			-0.29			-0.1			-0.59			-0.22

	17	24	9	13	4
4. anticipation	?	?	-0.44	0.13	
9. concentration	-1.23	-0.15		0.13	0.41
13. efficace	?	-0.77	-0.15		-0.15
17. garde une image		1.18	1.18	2.33	2.33
24. sait déléguer	-1.23		0.13	0.74	2.33
	-2.46	0.26	0.72	3.33	4.92

17	24		24	9		9	13		13	4	
?	?	#####	?	-0.44	#####	-0.44	0.13	-0.57	0.13		0.13
-1.23	-0.15	-1.08	-0.15		-0.15		0.13	-0.13	0.13	0.41	-0.28
?	-0.77	#####	-0.77	-0.15	-0.62	-0.15		-0.15		-0.15	0.15
	1.18	-1.18	1.18	1.18	0	1.18	2.33	-1.15	2.33	2.33	0
-1.23		-1.23		0.13	-0.13	0.13	0.74	-0.61	0.74	2.33	-1.59
		-1.16			-0.23			-0.52			-1.59

	29	32	19	28	30	11	15	23
11. connaissance	-0.77	?	-0.44	-0.77	0.41		0.41	0.41
15. expérimenté	?	-1.23	-0.44	?	0.13	-0.44		0.41
19. "Lit rapidement mais	-1.23	-0.44		-0.44	-0.15	0.41	0.41	0.74
23. rigoureux	-1.23	-1.23	-0.77	?	-1.23	-0.44	-0.44	
28. sérieux	-0.77	-0.77	0.41		0.13	0.74	2.33	2.33
29. technicien		0.13	0.41	0.74	0.74	0.74	2.33	1.18
30. technique radar	-0.77	-0.77	0.13	-0.15		-0.44	-0.15	1.18
32. utilise la phraséologie	-0.15		0.41	0.74	0.74	2.33	1.18	1.18
	-4.92	-4.31	-0.29	0.12	0.77	2.9	6.07	7.43

29	32		32	19		19	28		28	30		30	11		11	15		15	23	
-0.77	?	#####	?	-0.44	#####	-0.44	-0.77	0.33	-0.77	0.41	-1.18	0.41		0.41		0.41	-0.41	0.41	0.41	0
?	-1.23	#####	-1.23	-0.44	-0.79	-0.44	?	#####	?	0.13	#####	0.13	-0.44	0.57	-0.44		-0.44		0.41	-0.41
-1.23	-0.44	-0.79	-0.44		-0.44		-0.44	0.44	-0.44	-0.15	-0.29	-0.15	0.41	-0.56	0.41	0.41	0	0.41	0.74	-0.33
-1.23	-1.23	0	-1.23	-0.77	-0.46	-0.77	?	#####	?	-1.23	#####	-1.23	-0.44	-0.79	-0.44	-0.44	0	-0.44		-0.44
-0.77	-0.77	0	-0.77	0.41	-1.18	0.41		0.41		0.13	-0.13	0.13	0.74	-0.61	0.74	2.33	-1.59	2.33	2.33	0
	0.13	-0.13	0.13	0.41	-0.28	0.41	0.74	-0.33	0.74	0.74	0	0.74	0.74	0	0.74	2.33	-1.59	2.33	1.18	1.15
-0.77	-0.77	0	-0.77	0.13	-0.9	0.13	-0.15	0.28	-0.15		-0.15		-0.44	0.44	-0.44	-0.15	-0.29	-0.15	1.18	-1.33
-0.15		-0.15		0.41	-0.41	0.41	0.74	-0.33	0.74	0.74	0	0.74	2.33	-1.59	2.33	1.18	1.15	1.18	1.18	0
		-0.18			-0.64			0.133			-0.29			-0.27			-0.4			-0.17

Figure C 6. French controller rulers

	12. prévision de futur	1. aide à la détection et résolution		1. aide à la détection et résolution	4. assure sécurité		4. assure sécurité	14. réduit la charge de travail		14. réduit la charge de travail	18. simplifie le travail		18. simplifie le travail	5. configuration facile à faire		5. configuration facile à faire	8. fait gagner du temps	
1. aide à la détection et résolution	-0.2	?	###	?	0.44	###	0.44	0.15	0.29	0.15	-0.4	0.59	-0.4	0.77	-1.2	0.77	0.44	0.33
4. assure sécurité	-0.2	-0.4	0.29	-0.4	?	###	?	0.44	###	0.44	0.44	0	0.44	0.15	0.29	0.15	0.15	0
5. configuration facile à faire	-0.4	-0.4	0	-0.4	-0.2	-0.3	-0.2	-0.2	0	-0.2	0.15	-0.3	0.15	?	###	?	0.44	###
8. fait gagner du temps	-0.4	-0.4	0	-0.4	-0.4	0	-0.4	-0.8	0.33	-0.8	0.15	-0.9	0.15	-0.4	0.59	-0.4	?	###
12. prévision de futur	?	0.15	###	0.15	0.15	0	0.15	0.44	-0.3	0.44	0.15	0.29	0.15	0.44	-0.3	0.44	0.44	0
14. réduit la charge de travail	-0.4	-0.2	-0.3	-0.2	-0.4	0.29	-0.4	?	###	?	-0.2	###	-0.2	0.15	-0.3	0.15	0.77	-0.6
18. simplifie le travail	-0.2	0.44	-0.6	0.44	-0.4	0.88	-0.4	0.15	-0.6	0.15	?	###	?	-0.2	###	-0.2	-0.2	0
			-0.9			0.18			0.04			-0.1			0			-0.6
			0.29						-0.6						-0.9			0.33
			-0.1						0.29						-0.2			-0.1
									-0.1									

	11. intuitive	15. répond à un besoin		15. répond à un besoin	19. sûre		19. sûre	13. rapide	=
11. intuitive	?	0.36	###	0.36	0.61	-0.3	0.61	0.61	0
13. rapide	-0.6	-0.4	-0.3	-0.4	-0.4	0	-0.4	?	###
15. répond à un besoin	-0.4	?	###	?	0.13	###	0.13	0.36	-0.2
19. sûre	-0.6	-0.1	-0.5	-0.1	?	###	?	0.36	###
			-0.4			-0.1			-0.1

	16. se fait oublier	20. usage convivial		20. usage convivial	17. simple	
16. se fait oublier	?	0.67	###	0.67	0.41	0.26
17. simple	-0.4	-0.4	0	-0.4	?	###
20. usage convivial	-0.7	?	###	?	0.41	###
			0			0.26

	7. faire des mesures précises	2. aide à la mémorisation		2. aide à la mémorisation	3. apporte un confort de travail		3. apporte un confort de travail	9. fiable		9. fiable	6. donne informations pertinentes		6. donne informations pertinentes	10. IHM efficace	
2. aide à la mémorisation	-0.7	?	###	?	?	###	0	0.67	-0.7	0.67	1.18	-0.5	1.18	0.67	0.51
3. apporte un confort de travail	-0.3	?	###	0	?	###	?	?	###	?	?	###	?	0.33	###
6. donne informations pertinentes	-0.3	-0.7	0.36	-0.7	?	###	?	?	###	?	?	###	?	?	###
7. faire des mesures précises	?	0.67	###	0.67	0.33	0.34	0.33	0.33	0	0.33	0.33	0	0.33	0.67	-0.3
9. fiable	-0.3	-0.7	0.36	-0.7	?	###	?	?	###	?	?	###	?	0.67	###
10. IHM efficace	-0.7	-0.7	0	-0.7	-0.3	-0.4	-0.3	-0.7	0.36	-0.7	?	###	?	?	###
			0.36			-0			-0.1			-0.3			0.11

Figure C 7. French technology rulers.

	easygoing	friendly		friendly	sense of humour		sense of humour	gets on with fellow controllers		gets on with fellow controllers	helpful	
easygoing		-1.08	**1.08**	-1.08	-1.18	**0.1**	-1.18	-0.77	**-0.41**	-0.77	-0.85	**0.08**
friendly	-1.29		**-1.29**		-1.08	**1.08**	-1.08	-0.92	**-0.16**	-0.92	-0.85	**-0.07**
gets on with fellow controllers	-1.75	-1.75	**0**	-1.75	-1.55	**-0.2**	-1.55		**-1.55**		-0.99	**0.99**
helpful	-2.05	-2.05	**0**	-2.05	-1.55	**-0.5**	-1.55	-1.41	**-0.14**	-1.41		**-1.41**
sense of humour	-1.08	-1.18	**0.1**	-1.18		**-1.18**		-0.85	**0.85**	-0.85	-0.85	**0**
	1	2	**-0.11**	2	3	**-0.7**	3	4	**-1.41**	4	5	**-0.41**
			-0.022			**-0.14**			**-0.282**			**-0.082**

	hardworking	attitude to job		attitude to job	self confidence		self confidence	not afraid to admit	
attitude to job	-1.04		**-1.04**		-1.04	**1.04**	-1.04	-0.85	**-0.19**
hardworking		-1.04	**1.04**	-1.04	-0.85	**-0.19**	-0.85	-0.77	**-0.08**
not afraid to admit	0.67	-1.29	**1.96**	-1.29	-1.18	**-0.11**	-1.18		**-1.18**
self confidence	-1.29	-1.04	**-0.25**	-1.04		**-1.04**		-0.95	**0.95**
	1	2	**1.71**	2	3	**-0.3**	3	4	**-0.5**
			0.4275			**-0.075**			**-0.125**

	calm	reliable		reliable	cool head under pressure	
calm		-0.74	**0.74**	-0.74	-0.53	**-0.21**
cool head under pressure	-1.29	-0.85	**-0.44**	-0.85		**-0.85**
reliable	-0.95		**-0.95**		-0.85	**0.85**
	1	2	**-0.65**	2	3	**-0.21**
			-0.21667			**-0.07**

	fast	knowledgeable		knowledgeable	experienced		experienced	communicates clearly		communicates clearly	good decision maker	
communicates clearly	-2.05	-1.18	**-0.87**	-1.18	-1.75	**0.57**	-1.75		**-1.75**		-0.92	**0.92**
experienced	-1.75	-1.18	**-0.57**	-1.18		**-1.18**		-0.85	**0.85**	-0.85	-1.18	**0.33**
fast		-1.08	**1.08**	-1.08	-0.85	**-0.23**	-0.85	-0.77	**-0.08**	-0.77	-0.77	**0**
good decision maker	-2.05	?	**#VALUE!**	?	-1.18	**#VALUE!**	-1.18	-1.55	**0.37**	-1.55		**-1.55**
knowledgeable	-1.29		**-1.29**		-1.18	**1.18**	-1.18	-1.18	**0**	-1.18	-0.71	**-0.47**
	1	2	**-1.29**	2	3	**1.18**	3	4	**-0.61**	4	5	**-0.77**
			-0.3225			**0.295**			**-0.122**			**-0.154**

	able to share tasks	flexible		flexible	team member	
able to share tasks		-0.61	**0.61**	-0.61	-0.61	**0**
flexible	-1.13		**-1.13**		-1.13	**1.13**
team member	-1.13	-0.95	**-0.18**	-0.95		**-0.95**
			-0.7			**0.18**
	1	2	**-0.23333**	2	3	**0.06**

Figure C 8. Irish controller rulers.

		12 fast	1 accessible		1 accessible	8 easytoset up		8 easytoset up	13 flexible		13 flexible	3 bespokesolutio		3 bespokesolutio	4 clearlydisplaye		4 clearlydisplaye	10 efficient		10 efficient	2 accurate	
1.	accessible	?		######		-0.44	0.44	-0.44	0.77	-1.21	0.77	0.15	0.62	0.15	0.44	-0.29	0.44	0.77	-0.33	0.77	1.23	-0.46
2.	accurate	?	-1.23	######	-1.23	-1.23	0	-1.23	?	######	?	-0.15	######	-0.15	-0.44	0.29	-0.44	-0.77	0.33	-0.77		-0.77
3.	bespoke solution	-0.77	-0.15	-0.62	-0.15	-0.44	0.29	-0.44	-0.15	-0.29	-0.15		-0.15		0.15	-0.15	0.15	0.15	0	0.15	0.15	0
4.	clearly displayed	?	-0.44	######	-0.44	-0.44	0	-0.44	-1.23	0.79	-1.23	-0.15	-1.08	-0.15		-0.15		-0.15	0.15	-0.15	0.44	-0.59
8.	easy to set up	-0.44	0.44	-0.88	0.44		0.44		-0.15	0.15	-0.15	0.44	-0.59	0.44	0.44	0	0.44	0.77	-0.33	0.77	1.23	-0.46
10.	efficient	-1.23	-0.77	-0.46	-0.77	-0.77	0	-0.77	-0.44	-0.33	-0.44	-0.15	-0.29	-0.15	0.15	-0.3	0.15		0.15		0.77	-0.77
12.	fast		?	######	?	0.44	######	0.44	0.77	-0.33	0.77	0.77	0	0.77	?	######	?	1.23	######	1.23	?	######
13.	flexible	-0.77	-0.77	0	-0.77	0.15	-0.92	0.15		0.15		0.15	-0.15	0.15	1.23	-1.08	1.23	0.44	0.79	0.44	?	######
				-0.49			0.04			-0.15			-0.23			-0.24						-0.51

		9 easytounderstand	17. simpletouse		17. simpletouse	6 decreasesworkload		6 decreasesworkload	18 simplifiesjob		18 simplifiesjob	19 userfriendly	
6.	decreases workload	-0.44	-0.15	-0.29	-0.15		-0.15		-0.15	0.15	-0.15	0.44	-0.59
9.	easy to understand		0.15	-0.15	0.15	0.44	-0.29	0.44	0.44	0	0.44	1.23	-0.79
17.	simple to use	-0.15		-0.15		0.15	-0.15	0.15	0.44	-0.29	0.44	0.15	0.29
18.	simplifies job	-0.44	-0.44	0	-0.44	0.15	-0.59	0.15		0.15		0.15	-0.15
19.	user friendly	-1.23	-0.15	-1.08	-0.15	-0.44	0.29	-0.44	-0.15	-0.29	-0.15		-0.15
				-0.33			-0.18			-0.06			-0.28

		20 well maintained	5 confident in it		5 confident in it	15 reliable		15 reliable	16 safe	
5.	confident in it	-0.44		-0.44		0.44	-0.44	0.44	0.67	-0.23
15.	reliable	-1.41	-0.44	-0.97	-0.44		-0.44		1.41	-1.41
16.	safe	?	-0.67	######	-0.67	-1.41	0.74	-1.41		-1.41
20.	well maintained		0.44	-0.44	0.44	0.95	-0.51	0.95	?	######
				-0.62			-0.16			-1.02

		14 givesyoumoretime	7. doesnotdistract		7. doesnotdistract	11. essentialinmyjob	
7.	does not distract	-0.61		-0.61		-0.36	0.36
11.	essential in my job	-0.13	0.36	-0.49	0.36		0.36
14.	gives you more time		0.61	-0.61	0.61	0.1	0.51
				-0.57			0.41

Figure C 9. Irish technology rulers.

	calmo ma sa anche pensare..	sa gestire situazioni inusuali		sa gestire situazioni inusuali	calmo anche nelle emergenze		calmo anche nelle emergenze	flessibile in funzione delle circostanze		flessibile in funzione delle circostanze	non da mai nulla per scontato	
Buona capacita' di giudizio	0.7	0.7	0	0.7	0.4	0.23	0.4	1	-0.5	1	0	0.95
buona conoscenza della lingua inglese	1.4	1	0.41	1	1.4	-0.4	1.4	1	0.46	1	1	0
calmo anche nelle emergenze	0.4	0.2	0.24	0.2		?		0.2	?	0.2	-0	0.64
calmo ma sa anche pensare..		-1	?	-1	-0	-0.5	-0	-1	0.51	-1	0	-0.95
conosce la normativa	1	0.7	0.28	0.7	0.4	0.23	0.4	0.2	0.24	0.2	0.7	-0.47
conosce le potenzialita'	0.7	0.7	0	0.7	0.7	0	0.7	0.4	0.23	0.4	0.4	0
flessibile in funzione delle circostanze	1	0.7	0.28	0.7	-0	0.9	-0		?		-0	?
non da mai nulla per scontato	0	0	0	0	0.4	-0.4	0.4	0.4	0	0.4		?
non e' presuntuoso	0.7	0.2	0.47	0.2	0.7	-0.5	0.7	0.4	0.23	0.4	0	0.44
preparato	1	0.4	0.51	0.4	0	0.44	0	0	0	0	0.2	-0.2
sa gestire situazioni inusuali	1		?		-0	?	-0	-1	0.44	-1	0	-0.67
si mantiene costantemente aggiornato	0.7	1	-0.3	1	0.7	0.28	0.7	0.7	0	0.7	0.4	0.23
	8.3	4.5	1.91	4.5	3.8	0.25	3.8	2.7	1.6	2.7	1.8	-0.003
			10			10			10			10
	1	2		2	3		3	4		4	5	
			0.19			0.03			0.16			-0.0003
			19			3			16			0

	non da mai nulla per scontato	preparato		preparato	Buona capacita' di giudizio		Buona capacita' di giudizio	si mantiene costantemente aggiornato		si mantiene costantemente aggiornato	non e' presuntuoso	
Buona capacita' di giudizio	0	0.4	-0.4	0.4		?		-0	?	-0	-1	0.23
buona conoscenza della lingua inglese	1	0.7	0.28	0.7	1	-0.3	1	0	0.95	0	0.4	-0.44
calmo anche nelle emergenze	-0	0	-0.4	0	-0	0.44	-0	-1	0.23	-1	-1	0
calmo ma sa anche pensare..	0	-1	0.95	-1	-1	-0.3	-1	-1	0	-1	-1	0
conosce la normativa	0.7	1	-0.3	1	0.2	0.75	0.2	1	-0.8	1	-0	1.18
conosce le potenzialita'	0.4	0.4	0	0.4	-0	0.88	-0	-0	-0.2	-0	0.2	-0.43
flessibile in funzione delle circostanze	-0	0	-0.4	0	-1	0.95	-1	-1	-0.3	-1	-0	-0.23
non da mai nulla per scontato		-0	?	-0	0	-0.2	0	-0	0.44	-0	0	-0.44
non e' presuntuoso	0	0.2	-0.2	0.2	0.7	-0.5	0.7	0.4	0.23	0.4		?
preparato	0.2		?		-0	?	-0	0.4	-0.7	0.4	-0	0.67
sa gestire situazioni inusuali	0	-0	0.44	-0	-1	0.23	-1	-1	0.28	-1	-0	-0.72
si mantiene costantemente aggiornato	0.4	-0	0.88	-0	0.4	-0.9	0.4		?		-0	?
	1.8	0.6	0.75	0.6	-2	1.11	-2	-2	0.22	-2	-3	-0.18
			10			10			10			10
	5	6		6	7		7	8		8	9	
			0.08			0.11			0.02			-0.018
			8			11			2			0

	non e' presuntuoso	conosce le potenzialita'		conosce le potenzialita'	conosce la normativa		conosce la normativa	buona conoscenza della lingua inglese	
Buona capacita' di giudizio	-1	0.4	-1.11	0.4	-0	0.67	-0	-1	0.72
buona conoscenza della lingua inglese	0.4	0.2	0.24	0.2	1	-0.8	1		?
calmo anche nelle emergenze	-1	-1	0	-1	-0	-0.2	-0	-1	0.97
calmo ma sa anche pensare..	-1	-1	0	-1	-1	0.28	-1	-1	0.46
conosce la normativa	-0	-0	0	-0		?		-1	?
conosce le potenzialita'	0.2		?		0.2	?	0.2	-0	0.43
flessibile in funzione delle circostanze	-0	-0	0	-0	-0	-0.2	-0	-1	0.72
non da mai nulla per scontato	0	-0	0.44	-0	-1	0.23	-1	-1	0.28
non e' presuntuoso		-0	?	-0	0.2	-0.4	0.2	-0	0.64
preparato	-0	-0	0.21	-0	-1	0.51	-1	-1	-0.3
sa gestire situazioni inusuali	-0	-1	0.44	-1	-1	0	-1	0	-0.7
si mantiene costantemente aggiornato	-0	0.2	-0.64	0.2	-1	1.15	-1	0	-1
	-3	-3	-0.42	-3	-4	1.22	-4	-8	2.32
			10			10			10
	9	10		10	11		11	12	
			-0.042			0.12			0.23
			0			12			23

Figure C 10. Italian controller ruler.

	istintiva	lascia al controllore il controllo	
di aiuto	-2.05	-1.75	-0.3
facilita il lavoro	-2.33	-1.88	-0.45
istintiva		-1.41	1.41
lascia il controllore in controllo	-2.05		-2.05
riduce il carico di lavoro	-2.05	-1.88	-0.17
riduce lo stress	?	-1.88	####
risponde alle sue esigenze	-1.88	-1.88	0
si integra con il lavoro	-1.41	-1.75	0.34
			-0.17

	lascia al controllore il controllo	riduce lo stress	
di aiuto	-1.75	-1.55	-0.2
facilita il lavoro	-1.88	-1.88	0
istintiva	-1.41	?	####
lascia il controllore in controllo		-1.48	1.48
riduce il carico di lavoro	-1.88	-1.41	-0.47
riduce lo stress	-1.88		-1.88
risponde alle sue esigenze	-1.88		-1.88
si integra con il lavoro	-1.75	-1.48	-0.27
			-0.46

	riduce lo stress	si integra con il lavoro	
di aiuto	-1.55	-1.64	0.09
facilita il lavoro	-1.88	-1.64	-0.24
istintiva	?	-2.05	####
lascia il controllore in controllo	-1.48	-1.55	0.07
riduce il carico di lavoro	-1.41	-1.55	0.14
riduce lo stress		-1.88	1.88
risponde alle sue esigenze		-1.75	1.75
si integra con il lavoro	-1.48		-1.48
			0.31

	si integra con il lavoro	riduce il carico di lavoro	
di aiuto	-1.64	-1.75	0.11
facilita il lavoro	-1.64	-1.75	0.11
istintiva	-2.05	-1.41	-0.64
lascia il controllore in controllo	-1.55	-1.48	-0.07
riduce il carico di lavoro	-1.55		-1.55
riduce lo stress	-1.88	-2.05	0.17
risponde alle sue esigenze	-1.75	-1.64	-0.11
si integra con il lavoro		-1.75	1.75
			-0.03

	riduce il carico di lavoro	risponde alle sue esigenze	
di aiuto	-1.75	-1.64	-0.11
facilita il lavoro	-1.75	-1.64	-0.11
istintiva	-1.41	-1.48	0.07
lascia il controllore in controllo	-1.48	-1.48	0
riduce il carico di lavoro		-1.64	1.64
riduce lo stress	-2.05		-2.05
risponde alle sue esigenze	-1.64		-1.64
si integra con il lavoro	-1.75	-1.55	-0.2
			-0.3

	risponde alle sue esigenze	di aiuto	
di aiuto	-1.64		-1.64
facilita il lavoro	-1.64	-2.05	0.41
istintiva	-1.48	-1.41	-0.07
lascia il controllore in controllo	-1.48	-1.55	0.07
riduce il carico di lavoro	-1.64	-1.55	-0.09
riduce lo stress		-1.75	1.75
risponde alle sue esigenze		-1.64	1.64
si integra con il lavoro	-1.55	-1.64	0.09
			0.27

	di aiuto	facilita il lavoro	
di aiuto		-1.41	1.41
facilita il lavoro	-2.05		-2.05
istintiva	-1.41	-1.34	-0.07
lascia il controllore in controllo	-1.55	-1.48	-0.07
riduce il carico di lavoro	-1.55	-1.55	0
riduce lo stress	-1.75	-1.48	-0.27
risponde alle sue esigenze	-1.64	-1.64	0
si integra con il lavoro	-1.64	-1.64	0
			-0.13

Figure C 11. Italian technology rulers.

Appendix D: The Scenario-based Questionnaire

Appendix D contains the contents of the scenario-based questionnaire which was used in the study reported in chapter seven. The format has been changed for clarity.

This Appendix contains:

- the introduction to the Scenario-based questionnaire (section D 1.)
- two questions (A & B) asked at the beginning of the questionnaire (section D 2.)
- ten questions (1 to 10) asked after each scenario (section D 3.)
- four questions asked at the end of the questionnaire (C to F) (section D 4.)
- the English full-text of the scenarios (section D 5.)

D.1. First section – Introduction

Below you find a series of stories. They have been collected through interviews and have been changed to create situations that are simple in structure, but at the same time reasonably realistic. I would like you to read them and to answer a few questions after. Whatever information is missing, introduce whatever facts and experiences seem reasonable under the circumstances. If something is not clear at any time, just ask. Before starting please answer the following two questions.

D. 2. Second section – First Questions

<u>For each respondent</u>

A. From 1 to 5 rate your self-confidence as a controller.

1 2 3 4 5

B. How many years of operational experience do you have?

D. 3. Third section – Questions after each Scenario

1. Would you...

[ ] Definitely not trust this Controller

[ ] Definitely trust this Controller

[ ] Trust this Controller only if …

2. What would change your answer to the previous question?

3. Please rate the Controller's trustworthiness from 1 (lowest) to 5 (highest).

1 2 3 4 5

4. Please rate the Controller's competence from 1 (lowest) to 5 (highest).

1 2 3 4 5

5. Would you...

[ ] Definitely not trust this technology

[ ] Definitely trust this technology

[ ] Trust this technology only if …

6. What would change your answer to the previous question?

7. Please rate the technology's trustworthiness from 1 (lowest) to 5 (highest).

1 2 3 4 5

8. Please rate the technology's performance from 1 (lowest) to 5 (highest).

1 2 3 4 5

9. Can you relate to this situation?

[ ] Yes

[ ] No

Why?

10. Please rate the story for realism from 1 (lowest) to 5 (highest).

1 2 3 4 5

D.4. Fourth section– Final Questions

Please select which of the statements below best describe you.

C. For other people

I will trust someone until I have clear evidence that s/he cannot be trusted.

OR

I will not trust someone until there is clear evidence that he or she can be trusted.

D. For technology

I will trust technology until I have clear evidence that it cannot be trusted.

OR

I will not trust technology until there is clear evidence that it can be trusted.

E. In my centre the roles and responsibilities of EXE and PL are clearly defined and separate.

OR

In my centre the roles and responsibilities of EXE and PL are shared.

F. Please rate the 10 stories for realism from 1 (lowest) to 5 (highest).

1 2 3 4 5

D.5. Fifth section – the Scenarios

(<u>underlined</u> are the sections added under the experimental condition for Irish participants)

Story 1

We are in an approach environment and two runways are in use, 27R and 22. The Controller at work is a team mate, a helpful Controller, who keeps a cool head under pressure, is not afraid to admit mistakes and communicates clearly. The technology the Controller is using is user friendly, accurate, safe, and considered essential for their job by Controllers.

The Controller has just cleared an aircraft for landing and it called in to report very strong crosswinds. There are 2 flows for landing from north and from south, and the work of the Controller consists of integrating these two flows. The traffic is building up to peak time.

The Controller calls the first aircraft approaching from the north and instructs it to turn for ILS. The Pilot confirms. The Controller does not see any change on the radar screen. When called, the Pilot confirms he is indeed turning. The Controller knows that with the strong winds, the turn should show up by the time the fourth trail dot appears. This is indeed what happens.

Story 2

We are in an approach environment and one runway is in use, 27R. The Controller at work is easygoing, calm, hardworking, fast and able to share tasks. The technology the Controller is using is easy to understand, fast, well maintained and perceived by Controllers as giving them more controlling time.

The Controller is integrating traffic flows from the north, south and southeast. An aircraft from the southeast flow is making good time, better than expected. The Controller calls Tower to change the sequence, putting this aircraft in ahead of the sequence previously agreed. Tower confirms. The Controller calls the aircraft in the south flow and instructs turn for ILS approach. The Pilot confirms. The Controller watches the radar and sees no change. He calls the Pilot, who confirms he is indeed turning. The aircraft continues not to turn. The Controller is just about to call the aircraft approaching in the north flow to reduce speed, when the radar flickers and the aircraft in the south flow now appears on track for the ILS. The Controller instructs the Pilot to contact Tower, and calls the aircraft from the north to prepare for approach.

Story 3

We are in an en-route ACC. Pilots are calling in to report strong winds. The Controller at work is easygoing, calm, hardworking, fast and able to share tasks. The technology the Controller is user-friendly, accurate, safe and considered by Controllers as essential for their job.

An aircraft calls in and asks for descent. The Controller had planned to descend it, as it was traffic for another aircraft. The Controller instructs the aircraft to descend. The Controller then focuses on a crossing near the sector boundary and deconflicts 4 aircraft. The STCA goes off. The Controller looks at the aircraft that had been instructed to descend; it has not changed level. The Controller instructs the Pilot to expedite descent. The STCA stops flashing as the aircraft begins to descend.

Story 4

We are in an approach sector and the weather is creating delays for landing and take-off. One runway is in use. The major flows of traffic are from south and south-east, turning onto runway 27R. The Controller at work is helpful, keeps a cool head under pressure, is not afraid to admit mistakes, communicates clearly, and is a team member.

The weather is having an impact on the Controller's workload. The tower calls for release of an aircraft (he had called earlier asking to open runway 22 for this take-off, but the Controller on the previous shift forgot to mention it in his brief). There is radio interference. Tower repeats the request without mentioning runway. It is approved. The Controller then clears an aircraft approaching from east to descend to FL60. He then sees the aircraft that has just taken off from runway 22 on his radar. According to the airport's regulations, he knows that it is cleared to FL60 before making contact with him. He calls back the aircraft cleared for descent and stops its descent at FL70, just in time.

Story 5

We are at a regional airport which caters for high performance military aircraft, locally based airlines to serve rural communities, regional traffic and Atlantic traffic. It is also a primary diversion airport for traffic coming off the Atlantic for emergencies. Only one of the two runways has ILS, the nearest suitable alternative for jet aircraft is at 500nM away.

The Controller at work is helpful, keeps a cool head under pressure, is not afraid to admit mistakes, communicates clearly, and is a team member. The technology the Controller is using is easy to understand, fast, well maintained and Controllers feel it gives them more controlling time.

We are in an approach environment and an approach sequencing tool is available. The sequences it gives are not very good, so the Controller is kept busy by changing them. As the traffic level gets higher though, it is becoming harder to make changes. A Pilot calls in to notify intent to go-around, due to a landing gear problem. The Controller looks the stream of traffic thinking of how to re-insert aircraft into flow. He sees that one heavy weight and light weight aircraft are lined up in an incorrect sequence and their speed differential does not look right. He manages to insert the go-around into the flow and corrects the sequence.

Story 6

We are in an en-route environment. The technology the Controller is using is user-friendly, accurate, safe, and perceived by Controllers as essential for their job.

Today there has been a higher rate of STCA false alarms than usual. The last one the Controller had was indeed false. He has 2 aircraft vertically separated by 1000ft. One of the two aircraft asks for FL 370 (he is at FL 350), the Controller says he will get the level requested but will call back. The Pilot confirms that he has to wait for the climb. The

Controller is busy deconflicting 2 other aircraft in order to provide horizontal separation. The STCA goes off for the first 2 aircraft but the labels are garbled and the Controller cannot read the flight levels. The two aircraft call into with traffic information from their TCAS systems. The Controller instructs the two aircraft to climb and descend, respectively. He un-garbles the labels and sees that the two aircraft have just achieved a separation of 1000ft.

Story 7

We are in an en-route sector. <u>The Controller at work is easygoing, calm, hardworking, fast, and able to share tasks.</u>

AB552 is issued a frequency change before being handed over to the en-route sector we are looking at. The crew of AB552 did not hear the frequency change. AB556 heard the frequency change instruction instead, and the first officer of AB556 responded to the instruction and requested to be cleared to FL390. The Controller on the sector saw AB552 on the radar when AB556 established contact. The Controller asked AB556 to confirm 556 and not 552. AB556 confirmed, and reported that there was an AB552 airborne (the Controller could not see it because of the range selected on the radar). The Controller believed that the AB552 displayed on the radar was in reality the AB556 to which s/he was talking. It had happened once before that data had been displayed on the radar incorrectly. The Controller thus cleared AB556 to climb. The Controller from the first sector watched AB556 climb and realised it was in conflict with another aircraft. The STCA went off. The Controller tried to contact the AB556, but he was unsuccessful because the aircraft was on the other sector's frequency. The conflicting aircraft was instructed to climb to resolve the conflict, but separation was lost.

Story 8

We are in an en-route ACC with traffic entering and leaving Oceanic airspace. <u>The technology the Controller is using is easy to understand, fast, well maintained, and perceived by Controllers as giving them more controlling time.</u>

A Pilot calls in to give the time, height and speed at which they are estimated to be at their entry track: "centre centre this is ABC requesting clearance to..." On the radar screen the Controller has an ABD flight, but has the ABC strip. The Controller calls the Pilot and asks him to squawk. The radar label remains unvaried. The Controller then inputs the correct call sign into his system and after 4 seconds it appears correctly on this radar. The Controller then checks that there is no flight due at the level requested in the aircraft's time frame. He calls the aircraft to confirm its track entry time and level.

Story 9

We are in a Tower, observing the Arrivals Controller. The Controller's work is facilitated by an approach tool, that suggests the landing order.

<u>The Controller is easygoing, hardworking, calm, fast and able to share tasks.</u>

An aircraft is cleared an aircraft to land. The Pilot reports not getting the lights until 200 feet. The next aircraft on the landing list to be cleared is an AFR567. The Pilot acknowledges clearance and advises a 'go around' might be a possibility. The Controller passes on this information to the Departures Controller, who is extremely busy but nods to gesture he has understood.

BAW123 is cleared for descent and vectored to ILS when AFR567 reaches its decision height and initiates a missed approach. The Pilot complies with standard procedures and climbs straight ahead to 3000 ft. The Controller instructs the Pilot to climb runway heading and wait for further instructions. The BAW123 calls in with engine problems. Although local procedures necessitate a transfer of AFR567 to the Departures Controller, the Controller feels the choice is between running the risk of becoming overloaded and increasing the workload of a colleague who already seems overloaded. He informs the Departure Controller of his decision to maintain control of the AFR567. The Controller calls Tower to open a second runway, requests the assistance of a Coordinator, calls emergency services and clears the BAW123 for landing. The Coordinator reorganises the flow of traffic to land on the second runway.

Story 10

We are in a Tower. A new tool has been installed to support Controllers with their work. The more experienced Controllers are impressed with it, as not only it provides good sequences, but it also has an alarm to avert of inappropriate speed differentials. This has been found to be a problem especially with younger Controllers in bad weather conditions. <u>The technology is fast, easy to understand, well maintained and Controllers consider it to give them more controlling time.</u>

The Controller is having a busy morning and is starting to feel quite tired. The Controller has just made a couple of changes in the sequence. The alarm flashes showing that 2 aircraft are getting too close. The Controller had miscalculated their speeds and has to change heading of the second aircraft to build in spacing. The following aircraft are kept in the hold for an extra turn. If the Controller had followed the tool this would not have been necessary.

Appendix E: Statistical Results of the Scenario-based Questionnaire Study

Appendix E contains the main statistical results from the scenario-based questionnaire study summarised in chapter seven. This Appendix contains three sections, corresponding to the results regarding the first hypothesis (trust and self-confidence) (section E 1.); the second hypothesis (trust and attitudes towards others and towards technology) (section E 2.); and the third hypothesis (trust and competence) (section E 3.).

E 1. First Hypothesis: Trust and Self confidence

Irish respondents' self confidence ratings and choice to trust others ('trust' or 'no trust').

Table E.1.1.

Correlations

		level of self confidence	1st scenario trust controller
level of self confidence	Pearson Correlation	1	,007
	Sig. (2-tailed)	,	,972
	N	25	25
1st scenario trust controller	Pearson Correlation	,007	1
	Sig. (2-tailed)	,972	,
	N	25	26

Table E.1.2.

Correlations

		level of self confidence	2nd scenario trust controller
level of self confidence	Pearson Correlation	1	,084
	Sig. (2-tailed)	,	,690
	N	25	25
2nd scenario trust controller	Pearson Correlation	,084	1
	Sig. (2-tailed)	,690	,
	N	25	26

Table E.1.3.

Correlations

		level of self confidence	3rd scenario trust controller
level of self confidence	Pearson Correlation	1	,119
	Sig. (2-tailed)	,	,571
	N	25	25
3rd scenario trust controller	Pearson Correlation	,119	1
	Sig. (2-tailed)	,571	,
	N	25	26

Table E.1.4.

Correlations

		level of self confidence	4th scenario trust controller
level of self confidence	Pearson Correlation	1	,507**
	Sig. (2-tailed)	,	,010
	N	25	25
4th scenario trust controller	Pearson Correlation	,507**	1
	Sig. (2-tailed)	,010	,
	N	25	26

**. Correlation is significant at the 0.01 level (2-tailed).

Table E.1.5.

Correlations

		level of self confidence	5th scenario trust controller
level of self confidence	Pearson Correlation	1	,144
	Sig. (2-tailed)	,	,491
	N	25	25
5th scenario trust controller	Pearson Correlation	,144	1
	Sig. (2-tailed)	,491	,
	N	25	26

Table E.1.6.

Correlations

		level of self confidence	6th scenario trust controller
level of self confidence	Pearson Correlation	1	,057
	Sig. (2-tailed)	,	,787
	N	25	25
6th scenario trust controller	Pearson Correlation	,057	1
	Sig. (2-tailed)	,787	,
	N	25	26

Table E.1.7.

Correlations

		level of self confidence	7th scenario trust controller
level of self confidence	Pearson Correlation	1	,179
	Sig. (2-tailed)	,	,392
	N	25	25
7th scenario trust controller	Pearson Correlation	,179	1
	Sig. (2-tailed)	,392	,
	N	25	26

Table E.1.8.

Correlations

		level of self confidence	8th scenario trust controller
level of self confidence	Pearson Correlation	1	-,293
	Sig. (2-tailed)	,	,156
	N	25	25
8th scenario trust controller	Pearson Correlation	-,293	1
	Sig. (2-tailed)	,156	,
	N	25	26

Table E.1.9.

Correlations

		level of self confidence	9th scenario trust controller
level of self confidence	Pearson Correlation	1	-,215
	Sig. (2-tailed)	,	,335
	N	25	22
9th scenario trust controller	Pearson Correlation	-,215	1
	Sig. (2-tailed)	,335	,
	N	22	23

Table E.1.10.

Correlations

		level of self confidence	10th scenario trust controller
level of self confidence	Pearson Correlation	1	-,046
	Sig. (2-tailed)	,	,835
	N	25	23
10th scenario trust controller	Pearson Correlation	-,046	1
	Sig. (2-tailed)	,835	,
	N	23	24

Irish respondents' self confidence ratings and choice to trust technology ('trust' or 'no trust').

Table E.1.11.

Correlations

		level of self confidence	1st scenario trust technology
level of self confidence	Pearson Correlation	1	,000
	Sig. (2-tailed)	,	1,000
	N	25	24
1st scenario trust technology	Pearson Correlation	,000	1
	Sig. (2-tailed)	1,000	,
	N	24	25

Table E.1.12.

Correlations

		level of self confidence	2nd scenario trust technology
level of self confidence	Pearson Correlation	1	,027
	Sig. (2-tailed)	,	,897
	N	25	25
2nd scenario trust technology	Pearson Correlation	,027	1
	Sig. (2-tailed)	,897	,
	N	25	26

Table E.1.13.

Correlations

		level of self confidence	3rd scenario trust technology
level of self confidence	Pearson Correlation	1	,556**
	Sig. (2-tailed)	,	,004
	N	25	25
3rd scenario trust technology	Pearson Correlation	,556**	1
	Sig. (2-tailed)	,004	,
	N	25	26

**. Correlation is significant at the 0.01 level (2-tailed).

Table E.1.14.

Correlations

		level of self confidence	4th scenario trust technology
level of self confidence	Pearson Correlation	1	-,056
	Sig. (2-tailed)	,	,790
	N	25	25
4th scenario trust technology	Pearson Correlation	-,056	1
	Sig. (2-tailed)	,790	,
	N	25	26

Table E.1.15.

Correlations

		level of self confidence	5th scenario trust technology
level of self confidence	Pearson Correlation	1	-,033
	Sig. (2-tailed)	,	,877
	N	25	25
5th scenario trust technology	Pearson Correlation	-,033	1
	Sig. (2-tailed)	,877	,
	N	25	26

Table E.1.16.

Correlations

		level of self confidence	6th scenairo trust technology
level of self confidence	Pearson Correlation	1	-,038
	Sig. (2-tailed)	,	,859
	N	25	25
6th scenairo trust technology	Pearson Correlation	-,038	1
	Sig. (2-tailed)	,859	,
	N	25	26

Table E.1.17.

Correlations

		level of self confidence	7th scenario trust technology
level of self confidence	Pearson Correlation	1	-,164
	Sig. (2-tailed)	,	,434
	N	25	25
7th scenario trust technology	Pearson Correlation	-,164	1
	Sig. (2-tailed)	,434	,
	N	25	26

Table E.1.18.

Correlations

		level of self confidence	8th scenario trust technology
level of self confidence	Pearson Correlation	1	-,053
	Sig. (2-tailed)	,	,805
	N	25	24
8th scenario trust technology	Pearson Correlation	-,053	1
	Sig. (2-tailed)	,805	,
	N	24	24

Table E.1.19.

Correlations

		level of self confidence	9th scenario trust technology
level of self confidence	Pearson Correlation	1	,250
	Sig. (2-tailed)	,	,263
	N	25	22
9th scenario trust technology	Pearson Correlation	,250	1
	Sig. (2-tailed)	,263	,
	N	22	23

Table E.1.20.

Correlations

		level of self confidence	10th scenario trust technology
level of self confidence	Pearson Correlation	1	-,009
	Sig. (2-tailed)	,	,966
	N	25	23
10th scenario trust technology	Pearson Correlation	-,009	1
	Sig. (2-tailed)	,966	,
	N	23	24

Italian respondents' self confidence ratings and choice to trust others ('trust' or 'no trust').

Table E.1.21.

Correlations

		level of self confidence	1st scenario trust controller
level of self confidence	Pearson Correlation	1	,298
	Sig. (2-tailed)	,	,065
	N	39	39
1st scenario trust controller	Pearson Correlation	,298	1
	Sig. (2-tailed)	,065	,
	N	39	44

Table E.1.22.

Correlations

			level of self confidence	1st scenario trust controller
Kendall's tau_b	level of self confidence	Correlation Coefficient	1,000	,309*
		Sig. (2-tailed)	,	,049
		N	39	39
	1st scenario trust controller	Correlation Coefficient	,309*	1,000
		Sig. (2-tailed)	,049	,
		N	39	44
Spearman's rho	level of self confidence	Correlation Coefficient	1,000	,319*
		Sig. (2-tailed)	,	,048
		N	39	39
	1st scenario trust controller	Correlation Coefficient	,319*	1,000
		Sig. (2-tailed)	,048	,
		N	39	44

*. Correlation is significant at the .05 level (2-tailed).

Table E.1.23.

Correlations

		level of self confidence	2nd scenario trust controller
level of self confidence	Pearson Correlation	1	,116
	Sig. (2-tailed)	,	,483
	N	39	39
2nd scenario trust controller	Pearson Correlation	,116	1
	Sig. (2-tailed)	,483	,
	N	39	44

Table E.1.24.

Correlations

		level of self confidence	3rd scenario trust controller
level of self confidence	Pearson Correlation	1	-,064
	Sig. (2-tailed)	,	,698
	N	39	39
3rd scenario trust controller	Pearson Correlation	-,064	1
	Sig. (2-tailed)	,698	,
	N	39	44

Table E.1.25.

Correlations

		level of self confidence	4th scenario trust controller
level of self confidence	Pearson Correlation	1	-,154
	Sig. (2-tailed)	,	,351
	N	39	39
4th scenario trust controller	Pearson Correlation	-,154	1
	Sig. (2-tailed)	,351	,
	N	39	44

Table E.1.26.

Correlations

		level of self confidence	5th scenario trust controller
level of self confidence	Pearson Correlation	1	,053
	Sig. (2-tailed)	,	,746
	N	39	39
5th scenario trust controller	Pearson Correlation	,053	1
	Sig. (2-tailed)	,746	,
	N	39	44

Table E.1.27.

Correlations

		level of self confidence	6th scenario trust controller
level of self confidence	Pearson Correlation	1	,340*
	Sig. (2-tailed)	,	,034
	N	39	39
6th scenario trust controller	Pearson Correlation	,340*	1
	Sig. (2-tailed)	,034	,
	N	39	43

*. Correlation is significant at the 0.05 level (2-tailed).

Table E.1.28.

Correlations

			level of self confidence	6th scenario trust controller
Kendall's tau_b	level of self confidence	Correlation Coefficient	1,000	,328*
		Sig. (2-tailed)	,	,034
		N	39	39
	6th scenario trust controller	Correlation Coefficient	,328*	1,000
		Sig. (2-tailed)	,034	,
		N	39	43
Spearman's rho	level of self confidence	Correlation Coefficient	1,000	,344*
		Sig. (2-tailed)	,	,032
		N	39	39
	6th scenario trust controller	Correlation Coefficient	,344*	1,000
		Sig. (2-tailed)	,032	,
		N	39	43

*. Correlation is significant at the .05 level (2-tailed).

Table E.1.29.

Correlations

		level of self confidence	7th scenario trust controller
level of self confidence	Pearson Correlation	1	,172
	Sig. (2-tailed)	,	,294
	N	39	39
7th scenario trust controller	Pearson Correlation	,172	1
	Sig. (2-tailed)	,294	,
	N	39	44

Table E.1.30.

Correlations

		level of self confidence	8th scenario trust controller
level of self confidence	Pearson Correlation	1	-,164
	Sig. (2-tailed)	,	,331
	N	39	37
8th scenario trust controller	Pearson Correlation	-,164	1
	Sig. (2-tailed)	,331	,
	N	37	42

Table E.1.31.

Correlations

		level of self confidence	9th scenario trust controller
level of self confidence	Pearson Correlation	1	-,172
	Sig. (2-tailed)	,	,296
	N	39	39
9th scenario trust controller	Pearson Correlation	-,172	1
	Sig. (2-tailed)	,296	,
	N	39	44

Table E.1.32.

Correlations

		level of self confidence	10th scenario trust controller
level of self confidence	Pearson Correlation	1	,029
	Sig. (2-tailed)	,	,865
	N	39	38
10th scenario trust controller	Pearson Correlation	,029	1
	Sig. (2-tailed)	,865	,
	N	38	43

Italian respondents' self confidence ratings and choice to trust technology ('trust' or 'no trust').

Table E.1.33.

Correlations

		level of self confidence	1st scenario trust technology
level of self confidence	Pearson Correlation	1	,173
	Sig. (2-tailed)	,	,305
	N	39	37
1st scenario trust technology	Pearson Correlation	,173	1
	Sig. (2-tailed)	,305	,
	N	37	42

Table E.1.34.

Correlations

		level of self confidence	2nd scenario trust technology
level of self confidence	Pearson Correlation	1	-,137
	Sig. (2-tailed)	,	,406
	N	39	39
2nd scenario trust technology	Pearson Correlation	-,137	1
	Sig. (2-tailed)	,406	,
	N	39	44

Table E.1.35.

Correlations

		level of self confidence	3rd scenario trust technology
level of self confidence	Pearson Correlation	1	,190
	Sig. (2-tailed)	,	,248
	N	39	39
3rd scenario trust technology	Pearson Correlation	,190	1
	Sig. (2-tailed)	,248	,
	N	39	44

Table E.1.36.

Correlations

		level of self confidence	4th scenario trust technology
level of self confidence	Pearson Correlation	1	-,008
	Sig. (2-tailed)	,	,964
	N	39	37
4th scenario trust technology	Pearson Correlation	-,008	1
	Sig. (2-tailed)	,964	,
	N	37	42

Table E.1.37.

Correlations

		level of self confidence	5th scenario trust technology
level of self confidence	Pearson Correlation	1	,231
	Sig. (2-tailed)	,	,158
	N	39	39
5th scenario trust technology	Pearson Correlation	,231	1
	Sig. (2-tailed)	,158	,
	N	39	44

Table E.1.38.

Correlations

		level of self confidence	6th scenairo trust technology
level of self confidence	Pearson Correlation	1	-,199
	Sig. (2-tailed)	,	,232
	N	39	38
6th scenairo trust technology	Pearson Correlation	-,199	1
	Sig. (2-tailed)	,232	,
	N	38	42

Table E.1.39.

Correlations

		level of self confidence	7th scenario trust technology
level of self confidence	Pearson Correlation	1	,201
	Sig. (2-tailed)	,	,239
	N	39	36
7th scenario trust technology	Pearson Correlation	,201	1
	Sig. (2-tailed)	,239	,
	N	36	41

Table E.1.40.

Correlations

		level of self confidence	8th scenario trust technology
level of self confidence	Pearson Correlation	1	,269
	Sig. (2-tailed)	,	,119
	N	39	35
8th scenario trust technology	Pearson Correlation	,269	1
	Sig. (2-tailed)	,119	,
	N	35	40

Table E.1.41.

Correlations

		level of self confidence	9th scenario trust technology
level of self confidence	Pearson Correlation	1	-,071
	Sig. (2-tailed)	,	,677
	N	39	37
9th scenario trust technology	Pearson Correlation	-,071	1
	Sig. (2-tailed)	,677	,
	N	37	42

Table E.1.42.

Correlations

		level of self confidence	10th scenario trust technology
level of self confidence	Pearson Correlation	1	-,020
	Sig. (2-tailed)	,	,910
	N	39	35
10th scenario trust technology	Pearson Correlation	-,020	1
	Sig. (2-tailed)	,910	,
	N	35	40

E 2. Second Hypothesis: Trust and Attitude Towards Others and Towards Technology

The sum of Irish and Italian frequency to choose to trust considered together and correlated with their general attitudes towards technology in Tables E 2.1. to E 2.14..

The Tables E 2.15 to E 1.18 represent the cross-tabulations to calculate the chi square to measure the difference between conditions in attitudes towards others and towards technology.

Table E.2.1.

Correlations

		trusting technology	sum tec
trusting technology	Pearson Correlation	1	,348**
	Sig. (2-tailed)	,	,004
	N	65	65
sum tec	Pearson Correlation	,348**	1
	Sig. (2-tailed)	,004	,
	N	65	70

**. Correlation is significant at the 0.01 level (2-tailed).

Table E.2.2.

Correlations

			trusting technology	sum tec
Kendall's tau_b	trusting technology	Correlation Coefficient	1,000	,309**
		Sig. (2-tailed)	,	,004
		N	65	65
	sum tec	Correlation Coefficient	,309**	1,000
		Sig. (2-tailed)	,004	,
		N	65	70
Spearman's rho	trusting technology	Correlation Coefficient	1,000	,357**
		Sig. (2-tailed)	,	,003
		N	65	65
	sum tec	Correlation Coefficient	,357**	1,000
		Sig. (2-tailed)	,003	,
		N	65	70

**. Correlation is significant at the .01 level (2-tailed).

The frequency of choices to trust technology of Irish participants alone correlated with their general attitudes towards technology.

Table E.2.3.

Correlations

		trusting other people	sum atco trust
trusting other people	Pearson Correlation	1	-,058
	Sig. (2-tailed)	,	,785
	N	25	25
sum atco trust	Pearson Correlation	-,058	1
	Sig. (2-tailed)	,785	,
	N	25	26

Table E.2.4.

Correlations

			trusting other people	sum atco trust
Kendall's tau_b	trusting other people	Correlation Coefficient	1,000	-,007
		Sig. (2-tailed)	,	,970
		N	25	25
	sum atco trust	Correlation Coefficient	-,007	1,000
		Sig. (2-tailed)	,970	,
		N	25	26
Spearman's rho	trusting other people	Correlation Coefficient	1,000	-,008
		Sig. (2-tailed)	,	,971
		N	25	25
	sum atco trust	Correlation Coefficient	-,008	1,000
		Sig. (2-tailed)	,971	,
		N	25	26

The frequency of choices to trust technology of Italian participants alone correlated with their general attitudes towards technology.

Table E.2.5.

Correlations

		trusting technology	sum tec
trusting technology	Pearson Correlation	1	,369*
	Sig. (2-tailed)	,	,019
	N	40	40
sum tec	Pearson Correlation	,369*	1
	Sig. (2-tailed)	,019	,
	N	40	44

*. Correlation is significant at the 0.05 level (2-tailed).

Table E.2.6.

Correlations

			trusting technology	sum tec
Kendall's tau_b	trusting technology	Correlation Coefficient	1,000	,316*
		Sig. (2-tailed)	,	,023
		N	40	40
	sum tec	Correlation Coefficient	,316*	1,000
		Sig. (2-tailed)	,023	,
		N	40	44
Spearman's rho	trusting technology	Correlation Coefficient	1,000	,365*
		Sig. (2-tailed)	,	,021
		N	40	40
	sum tec	Correlation Coefficient	,365*	1,000
		Sig. (2-tailed)	,021	,
		N	40	44

*. Correlation is significant at the .05 level (2-tailed).

Tables of frequency regarding general attitudes towards others and towards technology of Irish control and experimental groups and Italian control and experimental groups.

Irish control

Table E.2.7.

trusting other people

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	2	18,2	18,2	18,2
	high	9	81,8	81,8	100,0
	Total	11	100,0	100,0	

Table E.2.8.

trusting technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	3	27,3	27,3	27,3
	high	8	72,7	72,7	100,0
	Total	11	100,0	100,0	

Irish experimental

Table E.2.9.

trusting other people

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	2	13,3	14,3	14,3
	high	12	80,0	85,7	100,0
	Total	14	93,3	100,0	
Missing	System	1	6,7		
Total		15	100,0		

Table E.2.10.

trusting technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	8	53,3	57,1	57,1
	high	6	40,0	42,9	100,0
	Total	14	93,3	100,0	
Missing	System	1	6,7		
Total		15	100,0		

Italian control

Table E.2.11.

trusting other people

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	2	12,5	13,3	13,3
	high	13	81,3	86,7	100,0
	Total	15	93,8	100,0	
Missing	System	1	6,3		
Total		16	100,0		

Table E.2.12.

trusting technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	7	43,8	46,7	46,7
	high	8	50,0	53,3	100,0
	Total	15	93,8	100,0	
Missing	System	1	6,3		
Total		16	100,0		

Italian experimental

Table E.2.13.

trusting other people

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	8	28,6	30,8	30,8
	high	18	64,3	69,2	100,0
	Total	26	92,9	100,0	
Missing	System	2	7,1		
Total		28	100,0		

Table E.2.14.

trusting technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	16	57,1	64,0	64,0
	high	9	32,1	36,0	100,0
	Total	25	89,3	100,0	
Missing	System	3	10,7		
Total		28	100,0		

Italian respondents attitude towards others and technology

Table E.2.15.

	Trusting people		
	Low	High	Tot
Italian control	3 (4.024)	12 (10.97)	15
Italian experimental	8 (6.97)	18 (19.02)	26
	11	30	41

X_2 = 0.56 , 3.84, df = 1

At the level of significance of 0.05 the difference was not significant.

Table E.2.16.

	Trusting technology		
	Low	High	Tot
Italian control	7 (8.625)	8 (6.375)	15
Italian experimental	16 (14.375)	9 (10.625)	25
	23	17	40

$X_2 = 1.041 < 3.84$, df = 1
At the level of significance of 0.05 the difference was not significant.

Irish respondents attitude towards others and technology

Table E.2.17.

	Trusting people		
	Low	High	Tot
Irish control	2 (1.76)	9 (9.24)	11
Irish experimental	2 (2.24)	12 (11.76)	14
	4	21	25

$X_2 = 0.067 < 3.84$, df = 1
At the level of significance of 0.05 the difference was not significant.

Table E.2.18.

	Trusting technology		
	Low	High	Tot
Irish control	3 (4.84)	8 (6.16)	11
Irish experimental	8 (6.16)	6 (7.84)	14
	11	14	25

$X_2 = 2.21 < 3.84$, df = 1
At the level of significance of 0.05 the difference was not significant.

E 3. Third Hypothesis: Trust and Competence

This section provides the print-outs from the chi-square tests carried out on Irish and Italian replies together to find significant relations between competence manipulation and decision to trust.

E 3.1. Chi-square results

1st scenario trust controller

Table E 3.1.1.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2,454[a]	2	,293
Likelihood Ratio	2,664	2	,264
Linear-by-Linear Association	,115	1	,734
N of Valid Cases	70		

a. 3 cells (50,0%) have expected count less than 5. The minimum expected count is 2,31.

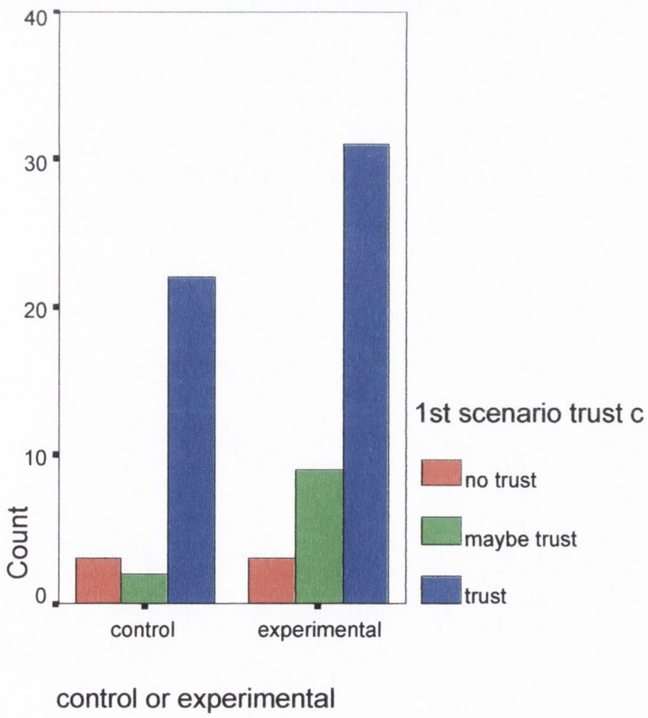

Figure E 3.1.1.

1st scenario trust technology

Table E 3.1.2.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,370[a]	2	,831
Likelihood Ratio	,385	2	,825
Linear-by-Linear Association	,019	1	,890
N of Valid Cases	67		

a. 2 cells (33,3%) have expected count less than 5. The minimum expected count is 1,49.

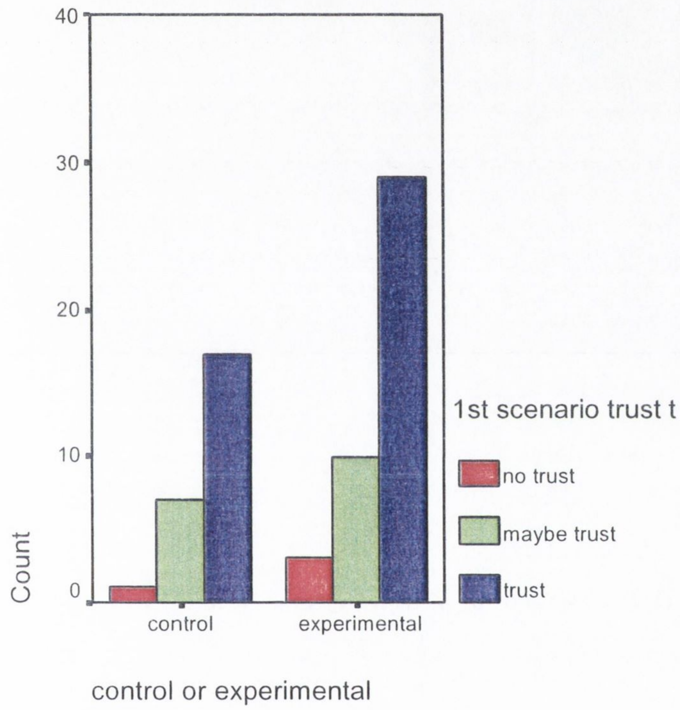

Figure E 3.1.2.

2^{nd} scenario trust controller

Table E 3.1.3.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5,023[a]	2	,081
Likelihood Ratio	4,920	2	,085
Linear-by-Linear Association	4,149	1	,042
N of Valid Cases	70		

a. 1 cells (16,7%) have expected count less than 5. The minimum expected count is 3,86.

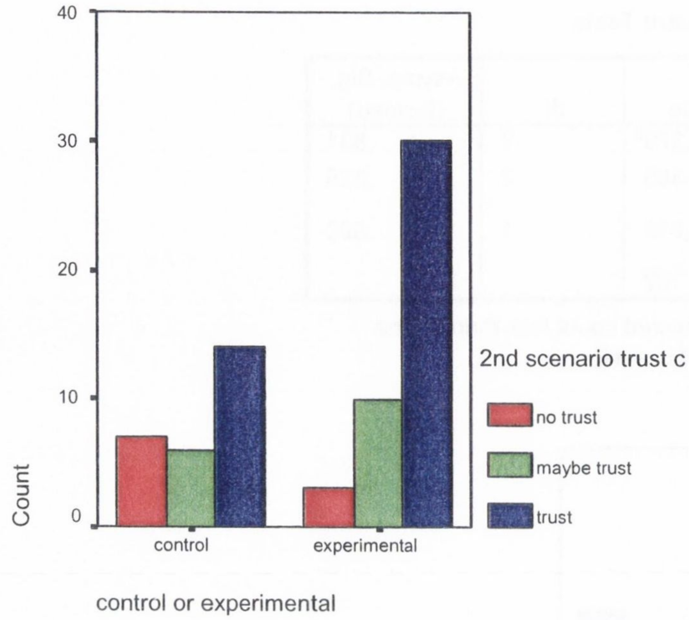

Figure E 3.1.3.

2nd scenario trust technology

Table E 3.1.4.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,072[a]	2	,965
Likelihood Ratio	,072	2	,965
Linear-by-Linear Association	,068	1	,794
N of Valid Cases	70		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,94.

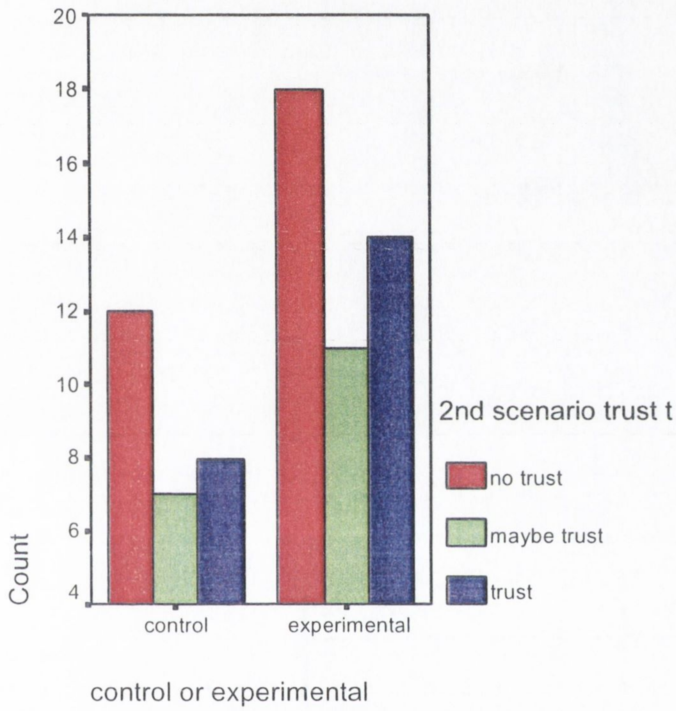

Figure E 3.1.4.

3rd scenario trust controller

Table E 3.1.5.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1,651[a]	2	,438
Likelihood Ratio	1,724	2	,422
Linear-by-Linear Association	,871	1	,351
N of Valid Cases	70		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,17.

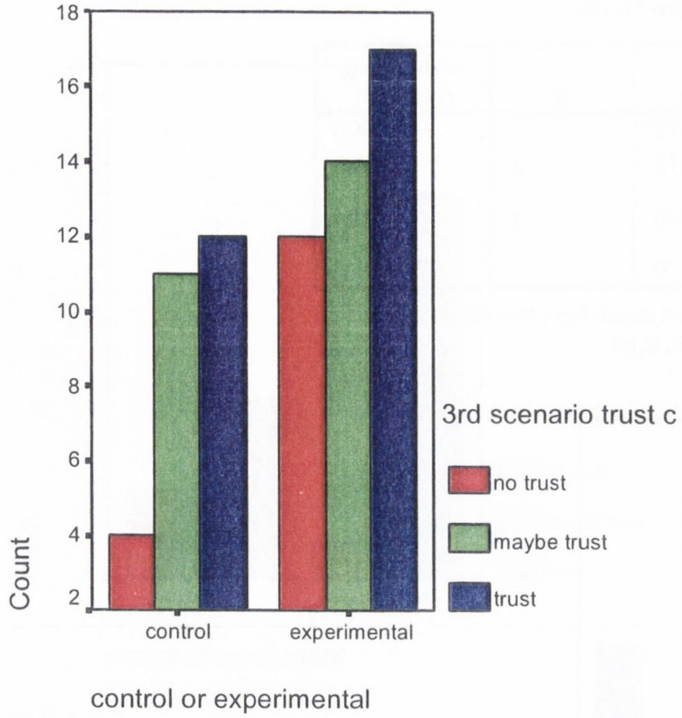

Figure E 3.1.5.

3rd scenario trust technology

Table E 3.1.6.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1,478[a]	2	,478
Likelihood Ratio	1,634	2	,442
Linear-by-Linear Association	,619	1	,431
N of Valid Cases	70		

a. 4 cells (66,7%) have expected count less than 5. The minimum expected count is 2,31.

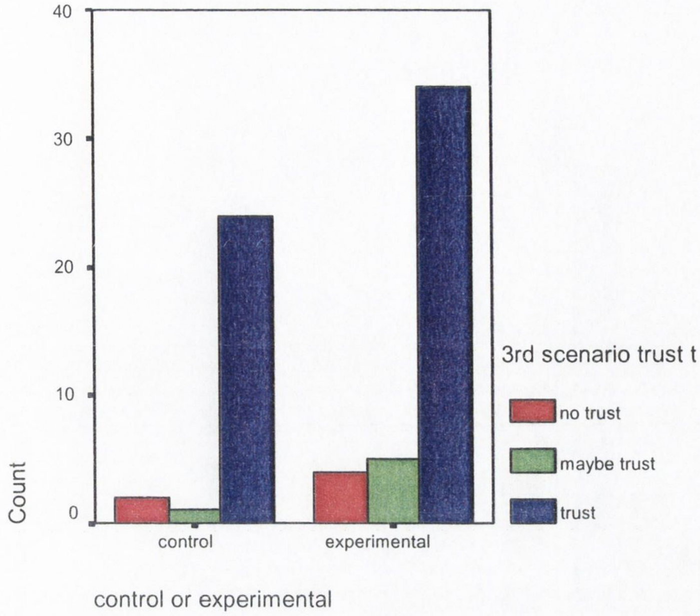

Figure E 3.1.6.

4^{th} scenario trust controller

Table E 3.1.7.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1,814[a]	2	,404
Likelihood Ratio	1,785	2	,410
Linear-by-Linear Association	1,783	1	,182
N of Valid Cases	70		

a. 1 cells (16,7%) have expected count less than 5. The minimum expected count is 4,24.

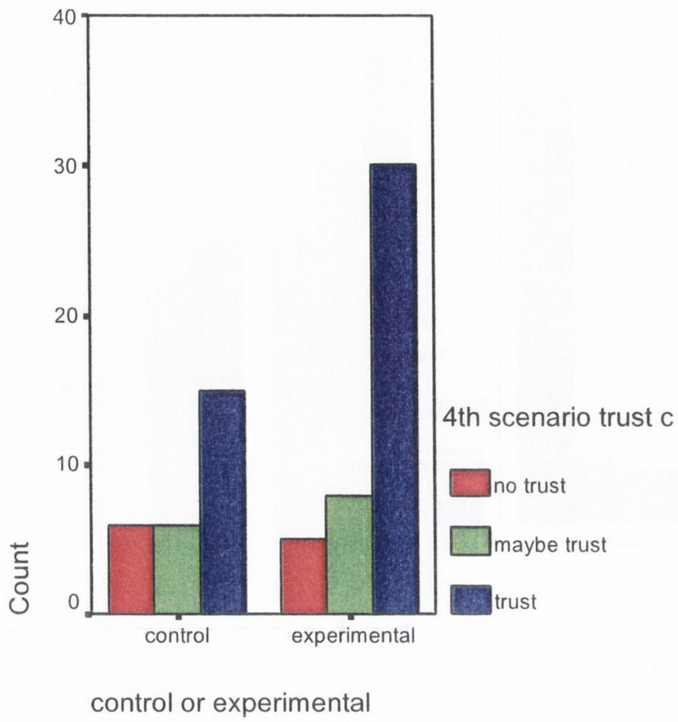

Figure E 3.1.7.

4th scenario trust technology

Table E 3.1.8.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2,604[a]	2	,272
Likelihood Ratio	2,771	2	,250
Linear-by-Linear Association	1,736	1	,188
N of Valid Cases	68		

a. 3 cells (50,0%) have expected count less than 5. The minimum expected count is 2,78.

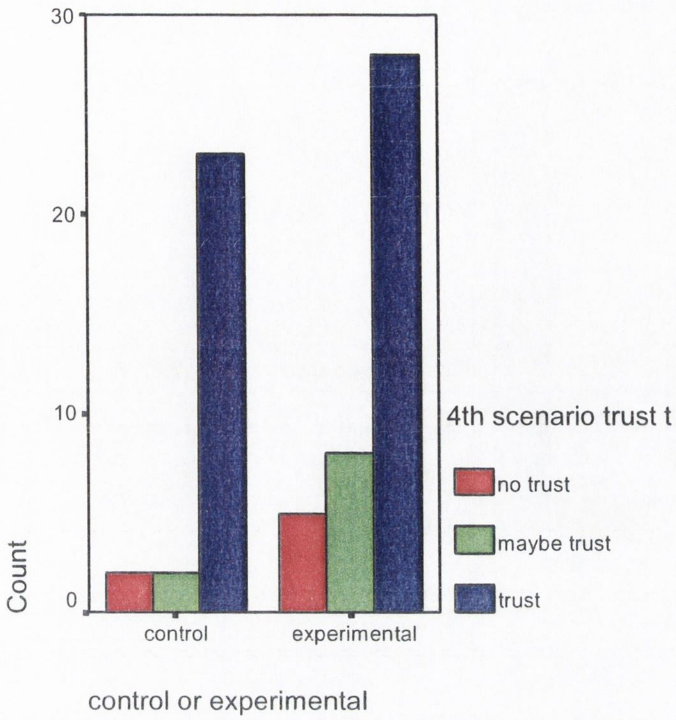

Figure E 3.1.8.

5th scenario trust controller

Table E 3.1.9.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,328[a]	2	,849
Likelihood Ratio	,341	2	,843
Linear-by-Linear Association	,056	1	,812
N of Valid Cases	70		

a. 4 cells (66,7%) have expected count less than 5. The minimum expected count is 1,93.

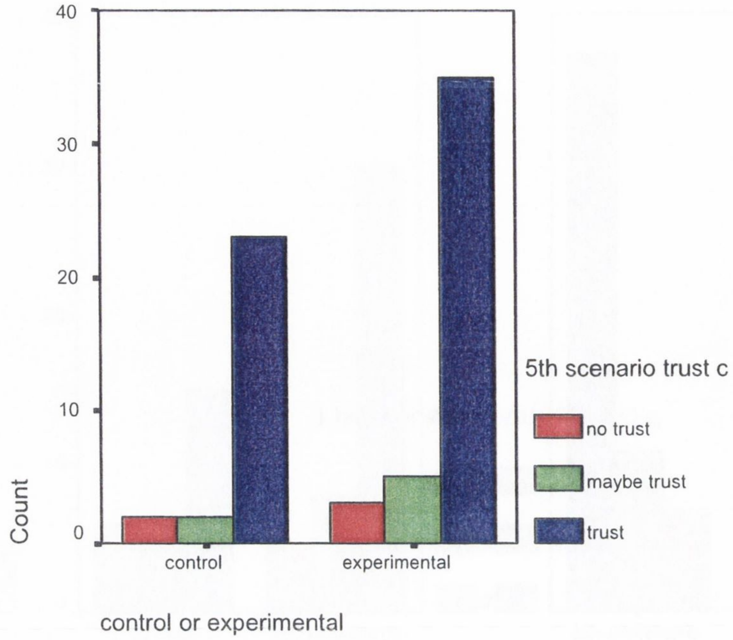

Figure E 3.1.9.

5^{th} scenario trust technology

Table E 3.1.10.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,362[a]	2	,835
Likelihood Ratio	,361	2	,835
Linear-by-Linear Association	,324	1	,569
N of Valid Cases	70		

a. 2 cells (33,3%) have expected count less than 5. The minimum expected count is 2,70.

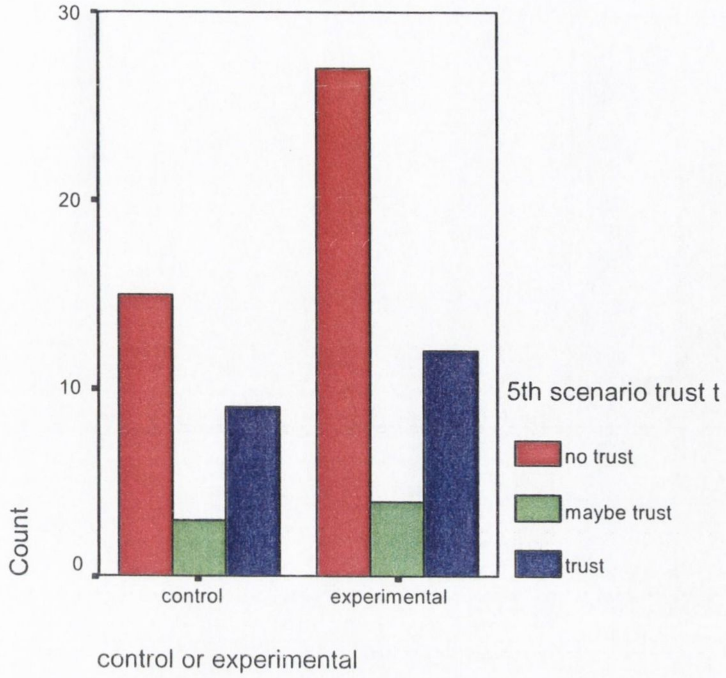

Figure E 3.1.10.

6th scenario trust controller

Table E 3.1.11

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,808[a]	2	,668
Likelihood Ratio	,839	2	,658
Linear-by-Linear Association	,055	1	,815
N of Valid Cases	69		

a. 1 cells (16,7%) have expected count less than 5. The minimum expected count is 4,30.

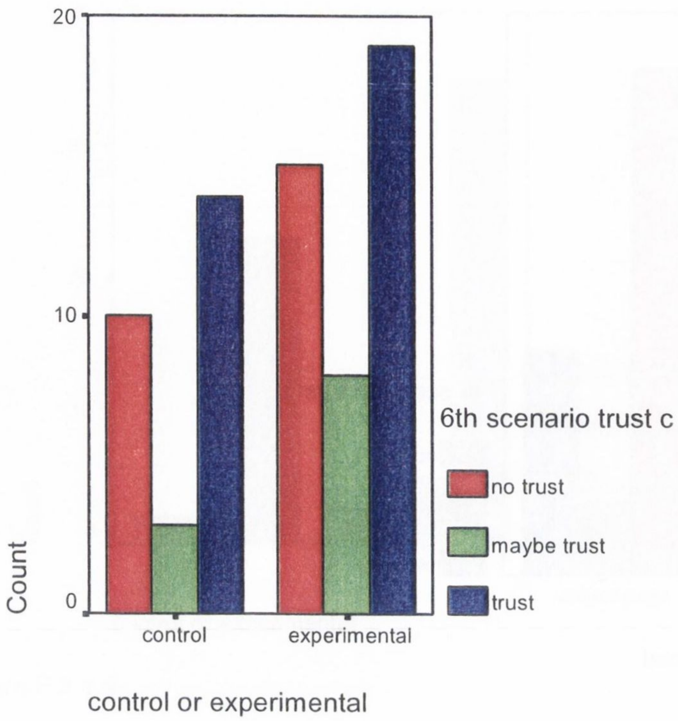

Figure E 3.1.11

6th scenario trust technology

Table E 3.1.12

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,749[a]	2	,687
Likelihood Ratio	,747	2	,688
Linear-by-Linear Association	,664	1	,415
N of Valid Cases	68		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 7,54.

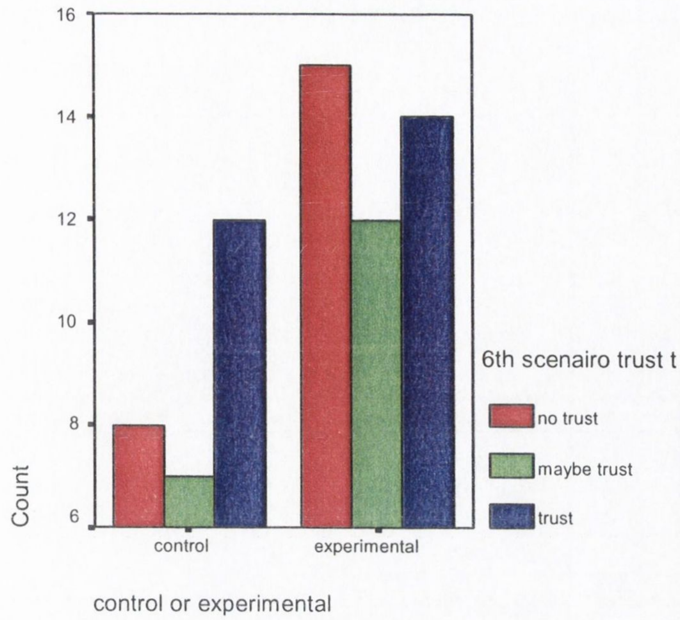

Figure E 3.1.12

7th scenario trust controller

Table E 3.1.13

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,965[a]	2	,617
Likelihood Ratio	,995	2	,608
Linear-by-Linear Association	,013	1	,910
N of Valid Cases	70		

a. 4 cells (66,7%) have expected count less than 5. The minimum expected count is 2,31.

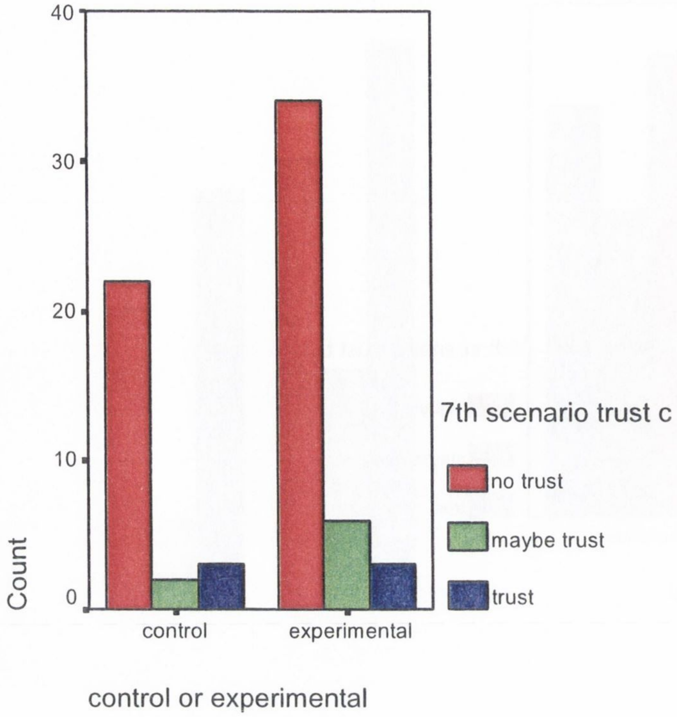

Figure E 3.1.13

7th scenario trust technology

Table E 3.1.14

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3,543[a]	2	,170
Likelihood Ratio	3,635	2	,162
Linear-by-Linear Association	1,761	1	,185
N of Valid Cases	67		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 5,24.

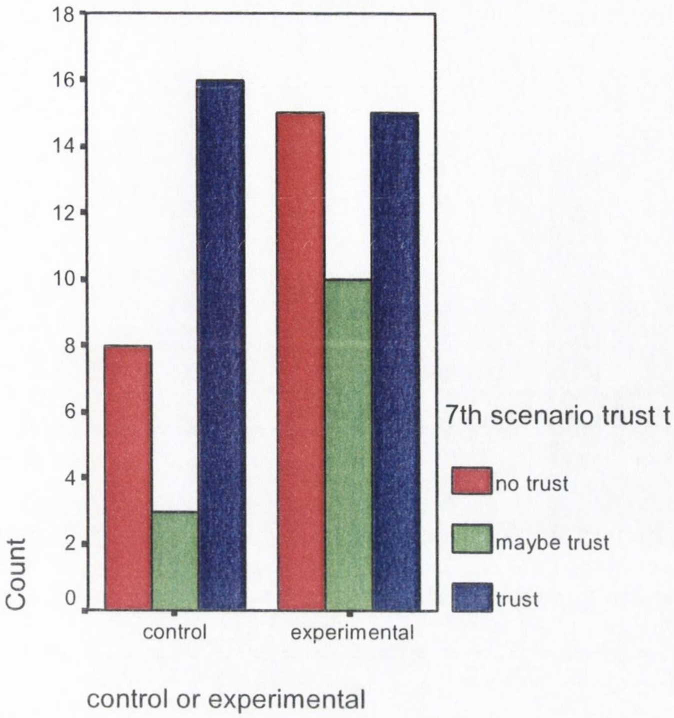

Figure E 3.1.14

8^{th} scenario trust controller

Table E 3.1.15

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3,180[a]	2	,204
Likelihood Ratio	3,358	2	,187
Linear-by-Linear Association	,675	1	,411
N of Valid Cases	68		

a. 1 cells (16,7%) have expected count less than 5. The minimum expected count is 4,21.

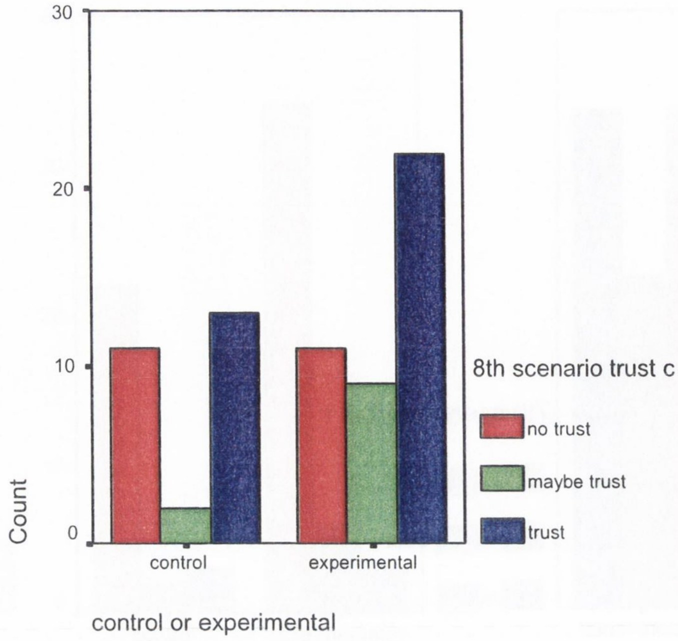

Figure E 3.1.15

8th scenario trust technology

Table E 3.1.16

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2,534[a]	2	,282
Likelihood Ratio	2,757	2	,252
Linear-by-Linear Association	2,180	1	,140
N of Valid Cases	64		

a. 1 cells (16,7%) have expected count less than 5. The minimum expected count is 4,30.

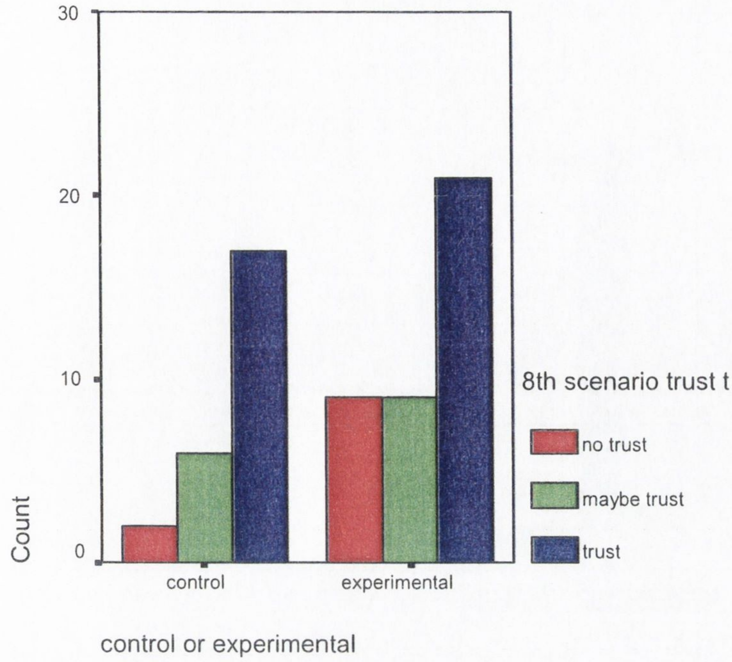

Figure E 3.1.16

9^{th} scenario trust controller

Table E 3.1.17

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,244[a]	2	,885
Likelihood Ratio	,247	2	,884
Linear-by-Linear Association	,210	1	,647
N of Valid Cases	67		

a. 3 cells (50,0%) have expected count less than 5. The minimum expected count is 1,16.

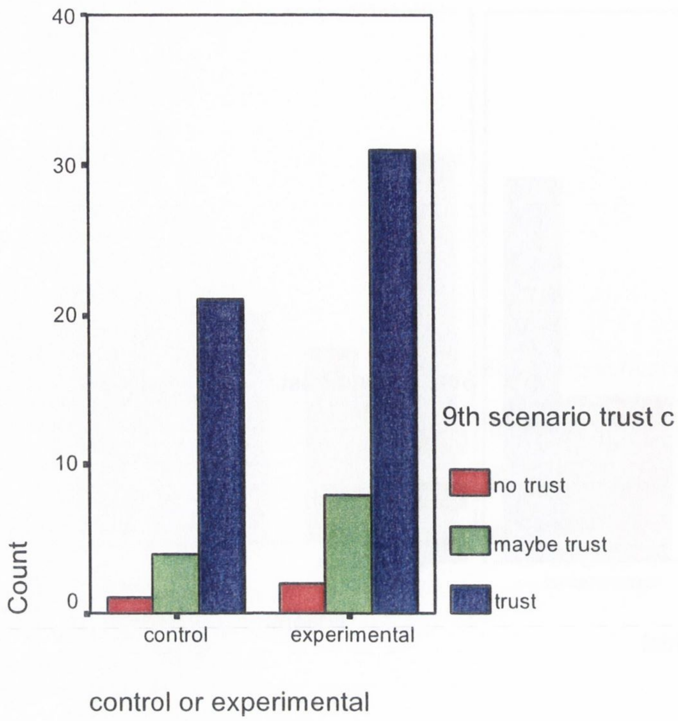

Figure E 3.1.17

9^{th} scenario trust technology

Table E 3.1.18

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,183[a]	2	,913
Likelihood Ratio	,180	2	,914
Linear-by-Linear Association	,066	1	,797
N of Valid Cases	65		

a. 2 cells (33,3%) have expected count less than 5. The minimum expected count is 1,60.

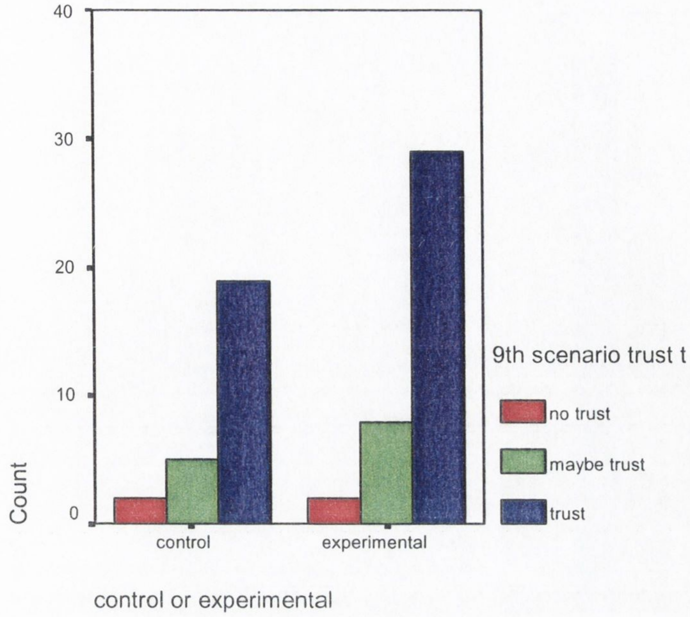

Figure E 3.1.18

10^{th} scenario trust controller

Table E 3.1.19

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,660[a]	2	,719
Likelihood Ratio	,663	2	,718
Linear-by-Linear Association	,259	1	,611
N of Valid Cases	67		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,85.

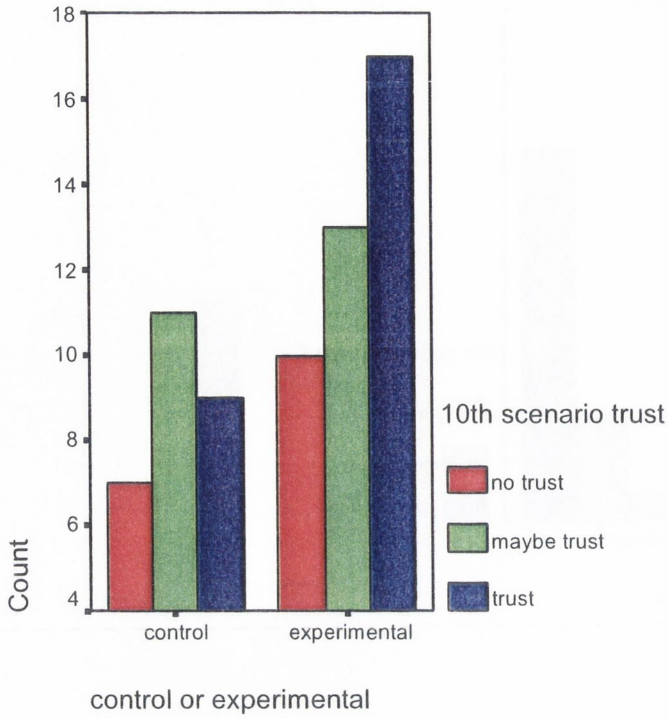

Figure E 3.1.19

10^{th} scenario trust technology

Table E 3.1.20

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,416[a]	2	,812
Likelihood Ratio	,412	2	,814
Linear-by-Linear Association	,398	1	,528
N of Valid Cases	64		

a. 2 cells (33,3%) have expected count less than 5. The minimum expected count is 1,63.

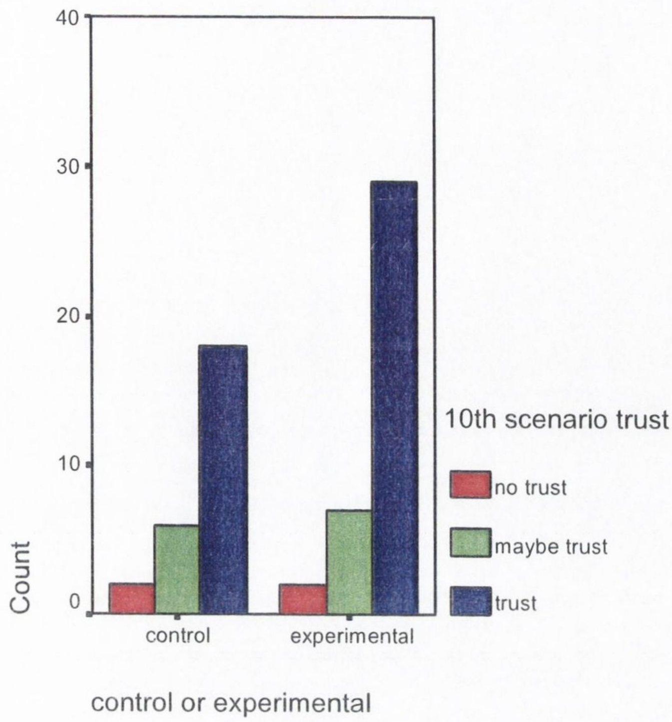

Figure E 3.1.20

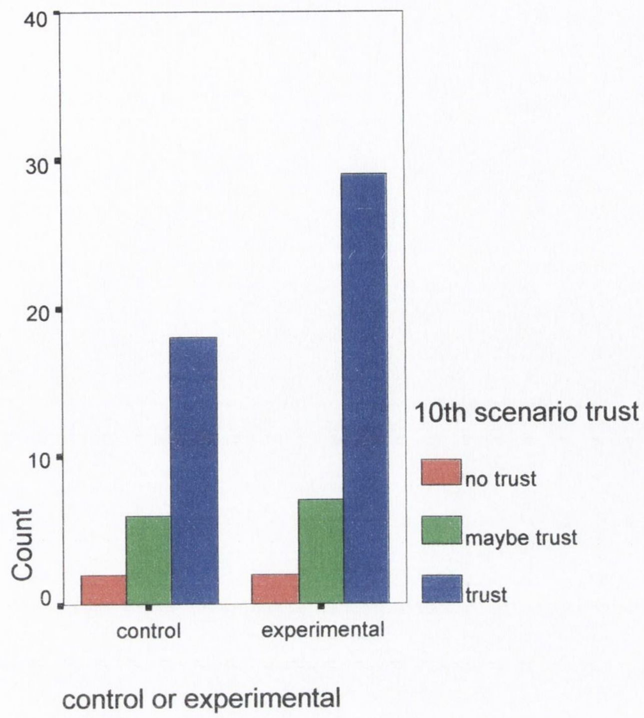

Figure E 3.1.20

E 3.2. Competence ratings of Irish and Italian respondents of the controller and the technology described in the ten scenarios.

Irish

Controller
1st scenario

control or experimental * 1st scenario comptence Crosstabulation

			1st scenario comptence			Total
			average	high	very high	
control or experimental	control	Count		8	3	11
		% within control or experimental		72,7%	27,3%	100,0%
	experimental	Count	3	6	5	14
		% within control or experimental	21,4%	42,9%	35,7%	100,0%
Total		Count	3	14	8	25
		% within control or experimental	12,0%	56,0%	32,0%	100,0%

2nd scenario

control or experimental * 2nd scenario competence controller Crosstabulation

			2nd scenario competence controller				
			low	average	high	very high	Total
control or experimental	control	Count	4	1	5	1	11
		% within control or experimental	36,4%	9,1%	45,5%	9,1%	100,0%
	experimental	Count	2	2	6	5	15
		% within control or experimental	13,3%	13,3%	40,0%	33,3%	100,0%
Total		Count	6	3	11	6	26
		% within control or experimental	23,1%	11,5%	42,3%	23,1%	100,0%

3rd scenario

control or experimental * 3rd scenario competence controller Crosstabulation

			3rd scenario competence controller					
			very low	low	average	high	very high	Total
control or experimental	control	Count		1	4	6		11
		% within control or experimental		9,1%	36,4%	54,5%		100,0%
	experimental	Count	1	1	4	7	2	15
		% within control or experimental	6,7%	6,7%	26,7%	46,7%	13,3%	100,0%
Total		Count	1	2	8	13	2	26
		% within control or experimental	3,8%	7,7%	30,8%	50,0%	7,7%	100,0%

4th scenario

control or experimental * 4th scenario comptence controller Crosstabulation

			4th scenario comptence controller				Total
			low	average	high	very high	
control or experimental	control	Count	1	2	8		11
		% within control or experimental	9,1%	18,2%	72,7%		100,0%
	experimental	Count	1	4	6	4	15
		% within control or experimental	6,7%	26,7%	40,0%	26,7%	100,0%
Total		Count	2	6	14	4	26
		% within control or experimental	7,7%	23,1%	53,8%	15,4%	100,0%

5th scenario

control or experimental * 5th scenario competence controller Crosstabulation

			5th scenario competence controller				Total
			low	average	high	very high	
control or experimental	control	Count		1	7	3	11
		% within control or experimental		9,1%	63,6%	27,3%	100,0%
	experimental	Count	2		7	6	15
		% within control or experimental	13,3%		46,7%	40,0%	100,0%
Total		Count	2	1	14	9	26
		% within control or experimental	7,7%	3,8%	53,8%	34,6%	100,0%

6th scenario

control or experimental * 6th scenario competence controller Crosstabulation

			6th scenario competence controller					Total
			very low	low	average	high	very high	
control or experimental	control	Count	1	2		8		11
		% within control or experimental	9,1%	18,2%		72,7%		100,0%
	experimental	Count		3	4	5	3	15
		% within control or experimental		20,0%	26,7%	33,3%	20,0%	100,0%
Total		Count	1	5	4	13	3	26
		% within control or experimental	3,8%	19,2%	15,4%	50,0%	11,5%	100,0%

7th scenario

control or experimental * 7th scenario comptence controller Crosstabulation

			7th scenario comptence controller				Total
			very low	low	average	high	
control or experimental	control	Count	3	5	2	1	11
		% within control or experimental	27,3%	45,5%	18,2%	9,1%	100,0%
	experimental	Count	5	8	2		15
		% within control or experimental	33,3%	53,3%	13,3%		100,0%
Total		Count	8	13	4	1	26
		% within control or experimental	30,8%	50,0%	15,4%	3,8%	100,0%

8th scenario

control or experimental * 8th scenario competence controller Crosstabulation

			8th scenario competence controller					
			very low	low	average	high	very high	Total
control or experimental	control	Count		4	2	3	2	11
		% within control or experimental		36,4%	18,2%	27,3%	18,2%	100,0%
	experimental	Count	1	3	1	5	5	15
		% within control or experimental	6,7%	20,0%	6,7%	33,3%	33,3%	100,0%
Total		Count	1	7	3	8	7	26
		% within control or experimental	3,8%	26,9%	11,5%	30,8%	26,9%	100,0%

9th scenario

control or experimental * 9th scenario competence controller Crosstabulation

			9th scenario competence controller		
			high	very high	Total
control or experimental	control	Count	5	5	10
		% within control or experimental	50,0%	50,0%	100,0%
	experimental	Count	7	6	13
		% within control or experimental	53,8%	46,2%	100,0%
Total		Count	12	11	23
		% within control or experimental	52,2%	47,8%	100,0%

10^{th} scenario

control or experimental * 10th scenario competence controller Crosstabulation

			10th scenario competence controller					Total
			very low	low	average	high	very high	
control or experimental	control	Count		1	5	4	1	11
		% within control or experimental		9,1%	45,5%	36,4%	9,1%	100,0%
	experimental	Count	1		7	5		13
		% within control or experimental	7,7%		53,8%	38,5%		100,0%
Total		Count	1	1	12	9	1	24
		% within control or experimental	4,2%	4,2%	50,0%	37,5%	4,2%	100,0%

Technology

1^{st} scenario

control or experimental * 1st scenario competence tech Crosstabulation

			1st scenario competence tech				Total
			low	average	high	very high	
control or experimental	control	Count		1	8	2	11
		% within control or experimental		9,1%	72,7%	18,2%	100,0%
	experimental	Count	1	2	7	4	14
		% within control or experimental	7,1%	14,3%	50,0%	28,6%	100,0%
Total		Count	1	3	15	6	25
		% within control or experimental	4,0%	12,0%	60,0%	24,0%	100,0%

2nd scenario

control or experimental * 2nd scenario competence tech Crosstabulation

			2nd scenario competence tech					Total
			very low	low	average	high	very high	
control or experimental	control	Count	2	4	2	2	1	11
		% within control or experimental	18,2%	36,4%	18,2%	18,2%	9,1%	100,0%
	experimental	Count		4	6	3	2	15
		% within control or experimental		26,7%	40,0%	20,0%	13,3%	100,0%
Total		Count	2	8	8	5	3	26
		% within control or experimental	7,7%	30,8%	30,8%	19,2%	11,5%	100,0%

3rd scenario

control or experimental * 3rd scenario comptence technology Crosstabulation

			3rd scenario comptence technology			Total
			average	high	very high	
control or experimental	control	Count	1	8	2	11
		% within control or experimental	9,1%	72,7%	18,2%	100,0%
	experimental	Count	1	6	8	15
		% within control or experimental	6,7%	40,0%	53,3%	100,0%
Total		Count	2	14	10	26
		% within control or experimental	7,7%	53,8%	38,5%	100,0%

4th scenario

control or experimental * 4th scenario comptence technology Crosstabulation

			4th scenario comptence technology				
			low	average	high	very high	Total
control or experimental	control	Count	1	2	5	3	11
		% within control or experimental	9,1%	18,2%	45,5%	27,3%	100,0%
	experimental	Count		6	3	6	15
		% within control or experimental		40,0%	20,0%	40,0%	100,0%
Total		Count	1	8	8	9	26
		% within control or experimental	3,8%	30,8%	30,8%	34,6%	100,0%

5th scenario

control or experimental * 5th scenario competence technology Crosstabulation

			5th scenario competence technology					
			very low	low	average	high	very high	Total
control or experimental	control	Count	5	3		1	2	11
		% within control or experimental	45,5%	27,3%		9,1%	18,2%	100,0%
	experimental	Count	2	8	3		2	15
		% within control or experimental	13,3%	53,3%	20,0%		13,3%	100,0%
Total		Count	7	11	3	1	4	26
		% within control or experimental	26,9%	42,3%	11,5%	3,8%	15,4%	100,0%

6th scenario

control or experimental * 6th scenario competence technology Crosstabulation

			6th scenario competence technology				
			low	average	high	very high	Total
control or experimental	control	Count	2	2	7		11
		% within control or experimental	18,2%	18,2%	63,6%		100,0%
	experimental	Count	1	5	6	3	15
		% within control or experimental	6,7%	33,3%	40,0%	20,0%	100,0%
Total		Count	3	7	13	3	26
		% within control or experimental	11,5%	26,9%	50,0%	11,5%	100,0%

7th scenario

control or experimental * 7th scenario competence technology Crosstabulation

			7th scenario competence technology				
			low	average	high	very high	Total
control or experimental	control	Count	4		6	1	11
		% within control or experimental	36,4%		54,5%	9,1%	100,0%
	experimental	Count	2	2	7	4	15
		% within control or experimental	13,3%	13,3%	46,7%	26,7%	100,0%
Total		Count	6	2	13	5	26
		% within control or experimental	23,1%	7,7%	50,0%	19,2%	100,0%

8th scenario

control or experimental * 8th scenario competence technology Crosstabulation

			8th scenario competence technology					
			very low	low	average	high	very high	Total
control or experimental	control	Count		3	3	3	1	10
		% within control or experimental		30,0%	30,0%	30,0%	10,0%	100,0%
	experimental	Count	2	2	3	6	1	14
		% within control or experimental	14,3%	14,3%	21,4%	42,9%	7,1%	100,0%
Total		Count	2	5	6	9	2	24
		% within control or experimental	8,3%	20,8%	25,0%	37,5%	8,3%	100,0%

9th scenario

control or experimental * 9th scenario competence technology Crosstabulation

			9th scenario competence technology			
			average	high	very high	Total
control or experimental	control	Count	1	7	1	9
		% within control or experimental	11,1%	77,8%	11,1%	100,0%
	experimental	Count	2	8	3	13
		% within control or experimental	15,4%	61,5%	23,1%	100,0%
Total		Count	3	15	4	22
		% within control or experimental	13,6%	68,2%	18,2%	100,0%

10th scenario

control or experimental * 10th scenario competence technology Crosstabulation

			10th scenario competence technology		Total
			high	very high	
control or experimental	control	Count	10	1	11
		% within control or experimental	90,9%	9,1%	100,0%
	experimental	Count	8	5	13
		% within control or experimental	61,5%	38,5%	100,0%
Total		Count	18	6	24
		% within control or experimental	75,0%	25,0%	100,0%

Italian

Controller

1st scenario

control or experimental * 1st scenario comptence Crosstabulation

Count

		1st scenario comptence				Total
		very low	average	high	very high	
control or experimental	control	2	2	7	4	15
	experimental		4	18	6	28
Total		2	6	25	10	43

2^{nd} scenario

control or experimental * 2nd scenario competence controller Crosstabulation

Count

		2nd scenario competence controller					Total
		very low	low	average	high	very high	
control or experimental	control	1	2	2	5	6	16
	experimental		3	3	16	6	28
Total		1	5	5	21	12	44

3^{rd} scenario

control or experimental * 3rd scenario competence controller Crosstabulation

Count

		3rd scenario competence controller					Total
		very low	low	average	high	very high	
control or experimental	control	1	5	6	2	2	16
	experimental	2	4	11	7	4	28
Total		3	9	17	9	6	44

4th scenario

control or experimental * 4th scenario comptence controller Crosstabulation

Count

		4th scenario comptence controller					Total
		very low	low	average	high	very high	
control or experimental	control	1	5	3	3	4	16
	experimental	1	1	7	13	6	28
Total		2	6	10	16	10	44

5th scenario

control or experimental * 5th scenario competence controller Crosstabulation

Count

		5th scenario competence controller					Total
		very low	low	average	high	very high	
control or experimental	control	1		1	7	7	16
	experimental		1	4	11	12	28
Total		1	1	5	18	19	44

6th scenario

control or experimental * 6th scenario competence controller Crosstabulation

			6th scenario competence controller					
			very low	low	average	high	very high	Total
control or experimental	control	Count	3	3	4	5	1	16
		% within 6th scenario competence controller	60,0%	25,0%	36,4%	38,5%	50,0%	37,2%
		% of Total	7,0%	7,0%	9,3%	11,6%	2,3%	37,2%
	experimental	Count	2	9	7	8	1	27
		% within 6th scenario competence controller	40,0%	75,0%	63,6%	61,5%	50,0%	62,8%
		% of Total	4,7%	20,9%	16,3%	18,6%	2,3%	62,8%
Total		Count	5	12	11	13	2	43
		% within 6th scenario competence controller	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	11,6%	27,9%	25,6%	30,2%	4,7%	100,0%

7^{th} scenario

control or experimental * 7th scenario comptence controller Crosstabulation

			7th scenario comptence controller					Total
			very low	low	average	high	very high	
control or experimental	control	Count	8	7		1		16
		% within 7th scenario comptence controller	57,1%	36,8%		25,0%		36,4%
		% of Total	18,2%	15,9%		2,3%		36,4%
	experimental	Count	6	12	6	3	1	28
		% within 7th scenario comptence controller	42,9%	63,2%	100,0%	75,0%	100,0%	63,6%
		% of Total	13,6%	27,3%	13,6%	6,8%	2,3%	63,6%
Total		Count	14	19	6	4	1	44
		% within 7th scenario comptence controller	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	31,8%	43,2%	13,6%	9,1%	2,3%	100,0%

8th scenario

control or experimental * 8th scenario competence controller Crosstabulation

			8th scenario competence controller					
			very low	low	average	high	very high	Total
control or experimental	control	Count	2	4	1	6	2	15
		% within 8th scenario competence controller	40,0%	50,0%	16,7%	33,3%	33,3%	34,9%
		% of Total	4,7%	9,3%	2,3%	14,0%	4,7%	34,9%
	experimental	Count	3	4	5	12	4	28
		% within 8th scenario competence controller	60,0%	50,0%	83,3%	66,7%	66,7%	65,1%
		% of Total	7,0%	9,3%	11,6%	27,9%	9,3%	65,1%
Total		Count	5	8	6	18	6	43
		% within 8th scenario competence controller	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	11,6%	18,6%	14,0%	41,9%	14,0%	100,0%

9^{th} scenario

control or experimental * 9th scenario competence controller Crosstabulation

			9th scenario competence controller				Total
			low	average	high	very high	
control or experimental	control	Count	2	2	8	4	16
		% within 9th scenario competence controller	40,0%	50,0%	34,8%	33,3%	36,4%
		% of Total	4,5%	4,5%	18,2%	9,1%	36,4%
	experimental	Count	3	2	15	8	28
		% within 9th scenario competence controller	60,0%	50,0%	65,2%	66,7%	63,6%
		% of Total	6,8%	4,5%	34,1%	18,2%	63,6%
Total		Count	5	4	23	12	44
		% within 9th scenario competence controller	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	11,4%	9,1%	52,3%	27,3%	100,0%

10^{th} scenario

control or experimental * 10th scenario competence controller Crosstabulation

			10th scenario competence controller					Total
			very low	low	average	high	very high	
control or experimental	control	Count	1	3	6	4	1	15
		% within 10th scenario competence controller	100,0%	30,0%	35,3%	36,4%	25,0%	34,9%
		% of Total	2,3%	7,0%	14,0%	9,3%	2,3%	34,9%
	experimental	Count		7	11	7	3	28
		% within 10th scenario competence controller		70,0%	64,7%	63,6%	75,0%	65,1%
		% of Total		16,3%	25,6%	16,3%	7,0%	65,1%
Total		Count	1	10	17	11	4	43
		% within 10th scenario competence controller	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
		% of Total	2,3%	23,3%	39,5%	25,6%	9,3%	100,0%

Technology

1st scenario

control or experimental * 1st scenario competence tech Crosstabulation

			1st scenario competence tech					Total
			very low	low	average	high	very high	
control or experimental	control	Count	1	2	5	6	2	16
		% within control or experimental	6,3%	12,5%	31,3%	37,5%	12,5%	100,0%
	experimental	Count	1	2	7	12	6	28
		% within control or experimental	3,6%	7,1%	25,0%	42,9%	21,4%	100,0%
Total		Count	2	4	12	18	8	44
		% within control or experimental	4,5%	9,1%	27,3%	40,9%	18,2%	100,0%

2nd scenario

control or experimental * 2nd scenario competence tech Crosstabulation

			2nd scenario competence tech					Total
			very low	low	average	high	very high	
control or experimental	control	Count	4	5	2	4	1	16
		% within control or experimental	25,0%	31,3%	12,5%	25,0%	6,3%	100,0%
	experimental	Count	3	12	5	6	2	28
		% within control or experimental	10,7%	42,9%	17,9%	21,4%	7,1%	100,0%
Total		Count	7	17	7	10	3	44
		% within control or experimental	15,9%	38,6%	15,9%	22,7%	6,8%	100,0%

3rd scenario

control or experimental * 3rd scenario comptence technology Crosstabulation

			3rd scenario comptence technology				
			low	average	high	very high	Total
control or experimental	control	Count	2	2	8	4	16
		% within control or experimental	12,5%	12,5%	50,0%	25,0%	100,0%
	experimental	Count	2	5	10	11	28
		% within control or experimental	7,1%	17,9%	35,7%	39,3%	100,0%
Total		Count	4	7	18	15	44
		% within control or experimental	9,1%	15,9%	40,9%	34,1%	100,0%

4th scenario

control or experimental * 4th scenario comptence technology Crosstabulation

			4th scenario comptence technology					
			very low	low	average	high	very high	Total
control or experimental	control	Count	1	1	5	6	3	16
		% within control or experimental	6,3%	6,3%	31,3%	37,5%	18,8%	100,0%
	experimental	Count	2	4	6	8	7	27
		% within control or experimental	7,4%	14,8%	22,2%	29,6%	25,9%	100,0%
Total		Count	3	5	11	14	10	43
		% within control or experimental	7,0%	11,6%	25,6%	32,6%	23,3%	100,0%

5th scenario

control or experimental * 5th scenario competence technology Crosstabulation

			5th scenario competence technology					Total
			very low	low	average	high	very high	
control or experimental	control	Count	6	4	1	5		16
		% within control or experimental	37,5%	25,0%	6,3%	31,3%		100,0%
	experimental	Count	4	12	4	5	3	28
		% within control or experimental	14,3%	42,9%	14,3%	17,9%	10,7%	100,0%
Total		Count	10	16	5	10	3	44
		% within control or experimental	22,7%	36,4%	11,4%	22,7%	6,8%	100,0%

6th scenario

control or experimental * 6th scenario competence technology Crosstabulation

			6th scenario competence technology					Total
			very low	low	average	high	very high	
control or experimental	control	Count	3	6	3	3	1	16
		% within control or experimental	18,8%	37,5%	18,8%	18,8%	6,3%	100,0%
	experimental	Count	7	6	7	7		27
		% within control or experimental	25,9%	22,2%	25,9%	25,9%		100,0%
Total		Count	10	12	10	10	1	43
		% within control or experimental	23,3%	27,9%	23,3%	23,3%	2,3%	100,0%

7th scenario

control or experimental * 7th scenario competence technology Crosstabulation

			7th scenario competence technology					Total
			very low	low	average	high	very high	
control or experimental	control	Count		6	1	6	3	16
		% within control or experimental		37,5%	6,3%	37,5%	18,8%	100,0%
	experimental	Count	6	5	4	11	1	27
		% within control or experimental	22,2%	18,5%	14,8%	40,7%	3,7%	100,0%
Total		Count	6	11	5	17	4	43
		% within control or experimental	14,0%	25,6%	11,6%	39,5%	9,3%	100,0%

8th scenario

control or experimental * 8th scenario competence technology Crosstabulation

			8th scenario competence technology					Total
			very low	low	average	high	very high	
control or experimental	control	Count	1	3	3	5	3	15
		% within control or experimental	6,7%	20,0%	20,0%	33,3%	20,0%	100,0%
	experimental	Count	2	5	9	10	2	28
		% within control or experimental	7,1%	17,9%	32,1%	35,7%	7,1%	100,0%
Total		Count	3	8	12	15	5	43
		% within control or experimental	7,0%	18,6%	27,9%	34,9%	11,6%	100,0%

9th scenario

control or experimental * 9th scenario competence technology Crosstabulation

			9th scenario competence technology					
			very low	low	average	high	very high	Total
control or experimental	control	Count		1	4	9	2	16
		% within control or experimental		6,3%	25,0%	56,3%	12,5%	100,0%
	experimental	Count	1	2	4	14	4	25
		% within control or experimental	4,0%	8,0%	16,0%	56,0%	16,0%	100,0%
Total		Count	1	3	8	23	6	41
		% within control or experimental	2,4%	7,3%	19,5%	56,1%	14,6%	100,0%

10th scenario

control or experimental * 10th scenario competence technology Crosstabulation

			10th scenario competence technology				
			low	average	high	very high	Total
control or experimental	control	Count		5	7	3	15
		% within control or experimental		33,3%	46,7%	20,0%	100,0%
	experimental	Count	1	3	16	8	28
		% within control or experimental	3,6%	10,7%	57,1%	28,6%	100,0%
Total		Count	1	8	23	11	43
		% within control or experimental	2,3%	18,6%	53,5%	25,6%	100,0%

E 3. 3. The relation between competence ratings and trustworthiness ratings.

This section provides the results of the correlation tests carried out between the ratings of competence and of trustworthiness. Italian and Irish results were considered separately.

Irish

Controller

1st scenario

Correlations

			1st scenario trustworthiness	1st scenario comptence
Spearman's rho	1st scenario trustworthiness	Correlation Coefficient	1,000	,901**
		Sig. (2-tailed)	.	,000
		N	26	25
	1st scenario comptence	Correlation Coefficient	,901**	1,000
		Sig. (2-tailed)	,000	.
		N	25	25

**. Correlation is significant at the .01 level (2-tailed).

2nd scenario

Correlations

			2nd scenario trustworthiness controller	2nd scenario competence controller
Spearman's rho	2nd scenario trustworthiness controller	Correlation Coefficient	1,000	,963**
		Sig. (2-tailed)	.	,000
		N	26	26
	2nd scenario competence controller	Correlation Coefficient	,963**	1,000
		Sig. (2-tailed)	,000	.
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

3rd scenario

Correlations

			3rd scenario trustworthiness controller	3rd scenario competence controller
Spearman's rho	3rd scenario trustworthiness controller	Correlation Coefficient	1,000	,905**
		Sig. (2-tailed)	.	,000
		N	26	26
	3rd scenario competence controller	Correlation Coefficient	,905**	1,000
		Sig. (2-tailed)	,000	.
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

4^{th} scenario

Correlations

			4th scenario trustworthiness controller	4th scenario comptence controller
Spearman's rho	4th scenario trustworthiness controller	Correlation Coefficient	1,000	,792**
		Sig. (2-tailed)	,	,000
		N	26	26
	4th scenario comptence controller	Correlation Coefficient	,792**	1,000
		Sig. (2-tailed)	,000	,
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

5^{th} scenario

Correlations

			5th scenario trustworthiness controller	5th scenario competence controller
Spearman's rho	5th scenario trustworthiness controller	Correlation Coefficient	1,000	,999**
		Sig. (2-tailed)	,	,000
		N	26	26
	5th scenario competence controller	Correlation Coefficient	,999**	1,000
		Sig. (2-tailed)	,000	,
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

6^{th} scenario

Correlations

			6th scenario trustworthiness controller	6th scenario competence controller
Spearman's rho	6th scenario trustworthiness controller	Correlation Coefficient	1,000	,909**
		Sig. (2-tailed)	,	,000
		N	26	26
	6th scenario competence controller	Correlation Coefficient	,909**	1,000
		Sig. (2-tailed)	,000	,
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

7^{th} scenario

Correlations

			7th scenario trustworthiness controller	7th scenario comptence controller
Spearman's rho	7th scenario trustworthiness controller	Correlation Coefficient	1,000	,804**
		Sig. (2-tailed)	,	,000
		N	26	26
	7th scenario comptence controller	Correlation Coefficient	,804**	1,000
		Sig. (2-tailed)	,000	,
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

8^{th} scenario

Correlations

			8th scenario trustworthiness controller	8th scenario competence controller
Spearman's rho	8th scenario trustworthiness controller	Correlation Coefficient	1,000	,976**
		Sig. (2-tailed)	.	,000
		N	26	26
	8th scenario competence controller	Correlation Coefficient	,976**	1,000
		Sig. (2-tailed)	,000	.
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

9^{th} scenario

Correlations

			9th scenario trustworthiness controller	9th scenario competence controller
Spearman's rho	9th scenario trustworthiness controller	Correlation Coefficient	1,000	,740**
		Sig. (2-tailed)	.	,000
		N	23	23
	9th scenario competence controller	Correlation Coefficient	,740**	1,000
		Sig. (2-tailed)	,000	.
		N	23	23

**. Correlation is significant at the .01 level (2-tailed).

10th scenario

Correlations

			10th scenario trustworhtiness controller	10th scenario competence controller
Spearman's rho	10th scenario trustworhtiness controller	Correlation Coefficient	1,000	,814**
		Sig. (2-tailed)	.	,000
		N	24	24
	10th scenario competence controller	Correlation Coefficient	,814**	1,000
		Sig. (2-tailed)	,000	.
		N	24	24

**. Correlation is significant at the .01 level (2-tailed).

Technology

1st scenario

Correlations

			1st scenario trustworthiness tech	1st scenario competence tech
Spearman's rho	1st scenario trustworthiness tech	Correlation Coefficient	1,000	,507**
		Sig. (2-tailed)	.	,010
		N	25	25
	1st scenario competence tech	Correlation Coefficient	,507**	1,000
		Sig. (2-tailed)	,010	.
		N	25	25

**. Correlation is significant at the .01 level (2-tailed).

2nd scenario

Correlations

			2nd scenario trustworthiness technology	2nd scenario competence tech
Spearman's rho	2nd scenario trustworthiness technology	Correlation Coefficient	1,000	,906**
		Sig. (2-tailed)	.	,000
		N	26	26
	2nd scenario competence tech	Correlation Coefficient	,906**	1,000
		Sig. (2-tailed)	,000	.
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

3rd scenario

Correlations

			3rd scenario trustworthiness controller	3rd scenario comptence technology
Spearman's rho	3rd scenario trustworthiness controller	Correlation Coefficient	1,000	,939**
		Sig. (2-tailed)	.	,000
		N	26	26
	3rd scenario comptence technology	Correlation Coefficient	,939**	1,000
		Sig. (2-tailed)	,000	.
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

4^{th} scenario

Correlations

			4th scenario trustworthiness technology	4th scenario comptence technology
Spearman's rho	4th scenario trustworthiness technology	Correlation Coefficient	1,000	,922**
		Sig. (2-tailed)	,	,000
		N	26	26
	4th scenario comptence technology	Correlation Coefficient	,922**	1,000
		Sig. (2-tailed)	,000	,
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

5^{th} scenario

Correlations

			5th scenario trustworthiness technology	5th scenario competence technology
Spearman's rho	5th scenario trustworthiness technology	Correlation Coefficient	1,000	,909**
		Sig. (2-tailed)	,	,000
		N	26	26
	5th scenario competence technology	Correlation Coefficient	,909**	1,000
		Sig. (2-tailed)	,000	,
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

6th scenario

Correlations

			6th scenario trustworthiness technology	6th scenario competence technology
Spearman's rho	6th scenario trustworthiness technology	Correlation Coefficient	1,000	,840**
		Sig. (2-tailed)	.	,000
		N	26	26
	6th scenario competence technology	Correlation Coefficient	,840**	1,000
		Sig. (2-tailed)	,000	.
		N	26	26

**. Correlation is significant at the .01 level (2-tailed).

7th scenario

Correlations

			7th scenario trustworthiness technology	7th scenario competence technology	control or experimental
Spearman's rho	7th scenario trustworthiness technology	Correlation Coefficient	1,000	,857**	,141
		Sig. (2-tailed)	.	,000	,492
		N	26	26	26
	7th scenario competence technology	Correlation Coefficient	,857**	1,000	,230
		Sig. (2-tailed)	,000	.	,258
		N	26	26	26
	control or experimental	Correlation Coefficient	,141	,230	1,000
		Sig. (2-tailed)	,492	,258	.
		N	26	26	26

**. Correlation is significant at the .01 level (2-tailed).

8th scenario

Correlations

			8th scenario trustworthiness technology	8th scenario competence technology
Spearman's rho	8th scenario trustworthiness technology	Correlation Coefficient	1,000	,627**
		Sig. (2-tailed)	.	,001
		N	24	24
	8th scenario competence technology	Correlation Coefficient	,627**	1,000
		Sig. (2-tailed)	,001	.
		N	24	24

**. Correlation is significant at the .01 level (2-tailed).

9^{th} scenario

Correlations

			9th scenario trustworthiness	9th scenario competence technology
Spearman's rho	9th scenario trustworthiness	Correlation Coefficient	1,000	,882**
		Sig. (2-tailed)	.	,000
		N	22	22
	9th scenario competence technology	Correlation Coefficient	,882**	1,000
		Sig. (2-tailed)	,000	.
		N	22	22

**. Correlation is significant at the .01 level (2-tailed).

10^{th} scenario

Correlations

			10th scenario trustworthiness technology	10th scenario competence technology
Spearman's rho	10th scenario trustworthiness technology	Correlation Coefficient	1,000	,588**
		Sig. (2-tailed)	.	,002
		N	24	24
	10th scenario competence technology	Correlation Coefficient	,588**	1,000
		Sig. (2-tailed)	,002	.
		N	24	24

**. Correlation is significant at the .01 level (2-tailed).

Italian

Controller

1st scenario

Correlations

			1st scenario trustworthiness	1st scenario comptence
Spearman's rho	1st scenario trustworthiness	Correlation Coefficient	1,000	,659**
		Sig. (2-tailed)	.	,000
		N	44	43
	1st scenario comptence	Correlation Coefficient	,659**	1,000
		Sig. (2-tailed)	,000	.
		N	43	43

**. Correlation is significant at the .01 level (2-tailed).

2nd scenario

Correlations

			2nd scenario trustworthiness controller	2nd scenario competence controller
Spearman's rho	2nd scenario trustworthiness controller	Correlation Coefficient	1,000	,886**
		Sig. (2-tailed)	.	,000
		N	44	44
	2nd scenario competence controller	Correlation Coefficient	,886**	1,000
		Sig. (2-tailed)	,000	.
		N	44	44

**. Correlation is significant at the .01 level (2-tailed).

3rd scenario

Correlations

			3rd scenario trustworthiness controller	3rd scenario competence controller
Spearman's rho	3rd scenario trustworthiness controller	Correlation Coefficient	1,000	,833**
		Sig. (2-tailed)	,	,000
		N	44	44
	3rd scenario competence controller	Correlation Coefficient	,833**	1,000
		Sig. (2-tailed)	,000	,
		N	44	44

**. Correlation is significant at the .01 level (2-tailed).

4th scenario

Correlations

			4th scenario trustworthiness controller	4th scenario comptence controller
Spearman's rho	4th scenario trustworthiness controller	Correlation Coefficient	1,000	,897**
		Sig. (2-tailed)	,	,000
		N	44	44
	4th scenario comptence controller	Correlation Coefficient	,897**	1,000
		Sig. (2-tailed)	,000	,
		N	44	44

**. Correlation is significant at the .01 level (2-tailed).

5th scenario

Correlations

			5th scenario trustworthiness controller	5th scenario competence controller
Spearman's rho	5th scenario trustworthiness controller	Correlation Coefficient	1,000	,916**
		Sig. (2-tailed)	.	,000
		N	44	44
	5th scenario competence controller	Correlation Coefficient	,916**	1,000
		Sig. (2-tailed)	,000	.
		N	44	44

**. Correlation is significant at the .01 level (2-tailed).

6th scenario

Correlations

			6th scenario trustworthiness controller	6th scenario competence controller
Spearman's rho	6th scenario trustworthiness controller	Correlation Coefficient	1,000	,963**
		Sig. (2-tailed)	.	,000
		N	43	43
	6th scenario competence controller	Correlation Coefficient	,963**	1,000
		Sig. (2-tailed)	,000	.
		N	43	43

**. Correlation is significant at the .01 level (2-tailed).

7^{th} scenario

Correlations

			7th scenario trustworthiness controller	7th scenario comptence controller
Spearman's rho	7th scenario trustworthiness controller	Correlation Coefficient	1,000	,761**
		Sig. (2-tailed)	.	,000
		N	44	44
	7th scenario comptence controller	Correlation Coefficient	,761**	1,000
		Sig. (2-tailed)	,000	.
		N	44	44

**. Correlation is significant at the .01 level (2-tailed).

8^{th} scenario

Correlations

			8th scenario trustworthiness controller	8th scenario competence controller
Spearman's rho	8th scenario trustworthiness controller	Correlation Coefficient	1,000	,971**
		Sig. (2-tailed)	.	,000
		N	43	43
	8th scenario competence controller	Correlation Coefficient	,971**	1,000
		Sig. (2-tailed)	,000	.
		N	43	43

**. Correlation is significant at the .01 level (2-tailed).

9^{th} scenario

Correlations

			9th scenario trustworthiness controller	9th scenario competence controller
Spearman's rho	9th scenario trustworthiness controller	Correlation Coefficient	1,000	1,000**
		Sig. (2-tailed)	.	.
		N	44	44
	9th scenario competence controller	Correlation Coefficient	1,000**	1,000
		Sig. (2-tailed)	.	.
		N	44	44

**. Correlation is significant at the .01 level (2-tailed).

10^{th} scenario

Correlations

			10th scenario trustworhtiness controller	10th scenario competence controller
Spearman's rho	10th scenario trustworhtiness controller	Correlation Coefficient	1,000	,867**
		Sig. (2-tailed)	.	,000
		N	44	43
	10th scenario competence controller	Correlation Coefficient	,867**	1,000
		Sig. (2-tailed)	,000	.
		N	43	43

**. Correlation is significant at the .01 level (2-tailed).

Technology

1st scenario

Correlations

			1st scenario trustworthiness tech	1st scenario competence tech
Spearman's rho	1st scenario trustworthiness tech	Correlation Coefficient	1,000	,892**
		Sig. (2-tailed)	.	,000
		N	44	44
	1st scenario competence tech	Correlation Coefficient	,892**	1,000
		Sig. (2-tailed)	,000	.
		N	44	44

**. Correlation is significant at the .01 level (2-tailed).

2nd scenario

Correlations

			2nd scenario trustworthiness technology	2nd scenario competence tech
Spearman's rho	2nd scenario trustworthiness technology	Correlation Coefficient	1,000	,857**
		Sig. (2-tailed)	.	,000
		N	43	43
	2nd scenario competence tech	Correlation Coefficient	,857**	1,000
		Sig. (2-tailed)	,000	.
		N	43	44

**. Correlation is significant at the .01 level (2-tailed).

3rd scenario

Correlations

			3rd scenario trustworthiness controller	3rd scenario comptence technology
Spearman's rho	3rd scenario trustworthiness controller	Correlation Coefficient	1,000	,917**
		Sig. (2-tailed)	,	,000
		N	44	44
	3rd scenario comptence technology	Correlation Coefficient	,917**	1,000
		Sig. (2-tailed)	,000	,
		N	44	44

**. Correlation is significant at the .01 level (2-tailed).

4th scenario

Correlations

			4th scenario trustworthiness technology	4th scenario comptence technology
Spearman's rho	4th scenario trustworthiness technology	Correlation Coefficient	1,000	,956**
		Sig. (2-tailed)	,	,000
		N	43	43
	4th scenario comptence technology	Correlation Coefficient	,956**	1,000
		Sig. (2-tailed)	,000	,
		N	43	43

**. Correlation is significant at the .01 level (2-tailed).

5th scenario

Correlations

			5th scenario trustworthiness technology	5th scenario competence technology
Spearman's rho	5th scenario trustworthiness technology	Correlation Coefficient	1,000	,919**
		Sig. (2-tailed)	.	,000
		N	44	44
	5th scenario competence technology	Correlation Coefficient	,919**	1,000
		Sig. (2-tailed)	,000	.
		N	44	44

**. Correlation is significant at the .01 level (2-tailed).

6th scenario

Correlations

			6th scenario trustworthiness technology	6th scenario competence technology
Spearman's rho	6th scenario trustworthiness technology	Correlation Coefficient	1,000	,805**
		Sig. (2-tailed)	.	,000
		N	43	43
	6th scenario competence technology	Correlation Coefficient	,805**	1,000
		Sig. (2-tailed)	,000	.
		N	43	43

**. Correlation is significant at the .01 level (2-tailed).

7th scenario

Correlations

			7th scenario trustworthiness technology	7th scenario competence technology
Spearman's rho	7th scenario trustworthiness technology	Correlation Coefficient	1,000	,871**
		Sig. (2-tailed)	.	,000
		N	43	43
	7th scenario competence technology	Correlation Coefficient	,871**	1,000
		Sig. (2-tailed)	,000	.
		N	43	43

**. Correlation is significant at the .01 level (2-tailed).

8th scenario

Correlations

			8th scenario trustworthiness technology	8th scenario competence technology
Spearman's rho	8th scenario trustworthiness technology	Correlation Coefficient	1,000	,860**
		Sig. (2-tailed)	.	,000
		N	43	43
	8th scenario competence technology	Correlation Coefficient	,860**	1,000
		Sig. (2-tailed)	,000	.
		N	43	43

**. Correlation is significant at the .01 level (2-tailed).

9th scenario

Correlations

			9th scenario trustworthiness	9th scenario competence technology
Spearman's rho	9th scenario trustworthiness	Correlation Coefficient	1,000	1,000**
		Sig. (2-tailed)	,	,
		N	41	41
	9th scenario competence technology	Correlation Coefficient	1,000**	1,000
		Sig. (2-tailed)	,	,
		N	41	41

**. Correlation is significant at the .01 level (2-tailed).

10th scenario

Correlations

			10th scenario trustworthiness technology	10th scenario competence technology
Spearman's rho	10th scenario trustworthiness technology	Correlation Coefficient	1,000	,678**
		Sig. (2-tailed)	,	,000
		N	43	43
	10th scenario competence technology	Correlation Coefficient	,678**	1,000
		Sig. (2-tailed)	,000	,
		N	43	43

**. Correlation is significant at the .01 level (2-tailed).

E 3. 4. General attitudes towards others and technology.

This section provides the tables containing the frequencies of replies concerning the attitudes towards others and toward technology for each group: Irish control, Irish experimental, Italian control, and Italian experimental.

Irish control

Table E 3.4.1.

trusting other people

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	2	18,2	18,2	18,2
	high	9	81,8	81,8	100,0
	Total	11	100,0	100,0	

Table E 3.4.2.

trusting technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	3	27,3	27,3	27,3
	high	8	72,7	72,7	100,0
	Total	11	100,0	100,0	

Irish experimental

Table E 3.4.3.

trusting other people

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	2	13,3	14,3	14,3
	high	12	80,0	85,7	100,0
	Total	14	93,3	100,0	
Missing	System	1	6,7		
Total		15	100,0		

Table E 3.4.4.

trusting technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	8	53,3	57,1	57,1
	high	6	40,0	42,9	100,0
	Total	14	93,3	100,0	
Missing	System	1	6,7		
Total		15	100,0		

Italian control

Table E.3.4.5.

trusting other people

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	2	12,5	13,3	13,3
	high	13	81,3	86,7	100,0
	Total	15	93,8	100,0	
Missing	System	1	6,3		
Total		16	100,0		

Table E 3.4.6.

trusting technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	7	43,8	46,7	46,7
	high	8	50,0	53,3	100,0
	Total	15	93,8	100,0	
Missing	System	1	6,3		
Total		16	100,0		

Italian experimental

Table E.3.4.7.

trusting other people

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	8	28,6	30,8	30,8
	high	18	64,3	69,2	100,0
	Total	26	92,9	100,0	
Missing	System	2	7,1		
Total		28	100,0		

Table E 3.4.8.

trusting technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	low	16	57,1	64,0	64,0
	high	9	32,1	36,0	100,0
	Total	25	89,3	100,0	
Missing	System	3	10,7		
Total		28	100,0		

E 3. 5. The choice to trust or not to trust.

This section provides the tables containing information on the replies concerning the choice of respondents to trust or not to trust. This information has been provided in E 3.1. in graphical form. Percentages of replies are provided first for Irish control and experimental groups. Italian control and experimental results are provided in tables of frequencies.

Irish control

Table 3.5.1.1

1st scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	1	9,1	9,1	9,1
	trust	10	90,9	90,9	100,0
	Total	11	100,0	100,0	

Table 3.5.1.2

1st scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	3	27,3	27,3	27,3
	trust	8	72,7	72,7	100,0
	Total	11	100,0	100,0	

Table 3.5.1.3

2nd scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	5	45,5	45,5	45,5
	maybe trust	3	27,3	27,3	72,7
	trust	3	27,3	27,3	100,0
	Total	11	100,0	100,0	

Table 3.5.1.4

2nd scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	5	45,5	45,5	45,5
	maybe trust	3	27,3	27,3	72,7
	trust	3	27,3	27,3	100,0
	Total	11	100,0	100,0	

Table 3.5.1.5

3rd scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	5	45,5	45,5	45,5
	trust	6	54,5	54,5	100,0
	Total	11	100,0	100,0	

Table 3.5.1.6

3rd scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	1	9,1	9,1	9,1
	trust	10	90,9	90,9	100,0
	Total	11	100,0	100,0	

Table 3.5.1.7

4th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	1	9,1	9,1	9,1
	maybe trust	2	18,2	18,2	27,3
	trust	8	72,7	72,7	100,0
	Total	11	100,0	100,0	

Table 3.5.1.8

4th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	1	9,1	9,1	9,1
	trust	10	90,9	90,9	100,0
	Total	11	100,0	100,0	

Table 3.5.1.9

5th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	1	9,1	9,1	9,1
	maybe trust	1	9,1	9,1	18,2
	trust	9	81,8	81,8	100,0
	Total	11	100,0	100,0	

Table 3.5.1.10

5th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	8	72,7	72,7	72,7
	trust	3	27,3	27,3	100,0
	Total	11	100,0	100,0	

Table 3.5.1.11

6th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	2	18,2	18,2	18,2
	maybe trust	1	9,1	9,1	27,3
	trust	8	72,7	72,7	100,0
	Total	11	100,0	100,0	

Table 3.5.1.12

6th scenairo trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	2	18,2	18,2	18,2
	maybe trust	2	18,2	18,2	36,4
	trust	7	63,6	63,6	100,0
	Total	11	100,0	100,0	

Table 3.5.1.13

7th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	8	72,7	72,7	72,7
	maybe trust	1	9,1	9,1	81,8
	trust	2	18,2	18,2	100,0
	Total	11	100,0	100,0	

Table 3.5.1.14

7th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	3	27,3	27,3	27,3
	maybe trust	2	18,2	18,2	45,5
	trust	6	54,5	54,5	100,0
	Total	11	100,0	100,0	

Table 3.5.1.15

8th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	4	36,4	36,4	36,4
	maybe trust	2	18,2	18,2	54,5
	trust	5	45,5	45,5	100,0
	Total	11	100,0	100,0	

Table 3.5.1.16

8th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	4	36,4	40,0	40,0
	trust	6	54,5	60,0	100,0
	Total	10	90,9	100,0	
Missing	System	1	9,1		
Total		11	100,0		

Table 3.5.1.17

9th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	1	9,1	10,0	10,0
	trust	9	81,8	90,0	100,0
	Total	10	90,9	100,0	
Missing	System	1	9,1		
Total		11	100,0		

Table 3.5.1.18

9th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	1	9,1	10,0	10,0
	maybe trust	2	18,2	20,0	30,0
	trust	7	63,6	70,0	100,0
	Total	10	90,9	100,0	
Missing	System	1	9,1		
Total		11	100,0		

Table 3.5.1.19

10th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	2	18,2	18,2	18,2
	maybe trust	5	45,5	45,5	63,6
	trust	4	36,4	36,4	100,0
	Total	11	100,0	100,0	

Table 3.5.1.20

10th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	1	9,1	9,1	9,1
	maybe trust	2	18,2	18,2	27,3
	trust	8	72,7	72,7	100,0
	Total	11	100,0	100,0	

Irish experimental

Table 3.5.1.21

1st scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	2	8,0	8,0	8,0
	maybe trust	1	4,0	4,0	12,0
	trust	22	88,0	88,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.22

1st scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	6	24,0	25,0	25,0
	trust	18	72,0	75,0	100,0
	Total	24	96,0	100,0	
Missing	System	1	4,0		
Total		25	100,0		

Table 3.5.1.23

2nd scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	3	12,0	12,0	12,0
	maybe trust	6	24,0	24,0	36,0
	trust	16	64,0	64,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.24

2nd scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	10	40,0	40,0	40,0
	maybe trust	10	40,0	40,0	80,0
	trust	5	20,0	20,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.25

3rd scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	4	16,0	16,0	16,0
	maybe trust	11	44,0	44,0	60,0
	trust	10	40,0	40,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.26

3rd scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	1	4,0	4,0	4,0
	maybe trust	2	8,0	8,0	12,0
	trust	22	88,0	88,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.27

4th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	3	12,0	12,0	12,0
	maybe trust	5	20,0	20,0	32,0
	trust	17	68,0	68,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.28

4th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	1	4,0	4,0	4,0
	maybe trust	7	28,0	28,0	32,0
	trust	17	68,0	68,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.29

5th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	2	8,0	8,0	8,0
	maybe trust	1	4,0	4,0	12,0
	trust	22	88,0	88,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.30

5th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	17	68,0	68,0	68,0
	maybe trust	4	16,0	16,0	84,0
	trust	4	16,0	16,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.31

6th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	7	28,0	28,0	28,0
	maybe trust	4	16,0	16,0	44,0
	trust	14	56,0	56,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.32

6th scenairo trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	4	16,0	16,0	16,0
	maybe trust	13	52,0	52,0	68,0
	trust	8	32,0	32,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.33

7th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	21	84,0	84,0	84,0
	maybe trust	3	12,0	12,0	96,0
	trust	1	4,0	4,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.34

7th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	4	16,0	16,0	16,0
	maybe trust	10	40,0	40,0	56,0
	trust	11	44,0	44,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.35

8th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	8	32,0	32,0	32,0
	maybe trust	5	20,0	20,0	52,0
	trust	12	48,0	48,0	100,0
	Total	25	100,0	100,0	

Table 3.5.1.36

8th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	4	16,0	16,7	16,7
	maybe trust	9	36,0	37,5	54,2
	trust	11	44,0	45,8	100,0
	Total	24	96,0	100,0	
Missing	System	1	4,0		
Total		25	100,0		

Table 3.5.1.37

9th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	4	16,0	30,8	30,8
	trust	9	36,0	69,2	100,0
	Total	13	52,0	100,0	
Missing	System	12	48,0		
Total		25	100,0		

Table 3.5.1.38

9th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	3	12,0	23,1	23,1
	trust	10	40,0	76,9	100,0
	Total	13	52,0	100,0	
Missing	System	12	48,0		
Total		25	100,0		

Table 3.5.1.39

10th scenario trust controller

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no trust	3	12,0	23,1	23,1
	maybe trust	4	16,0	30,8	53,8
	trust	6	24,0	46,2	100,0
	Total	13	52,0	100,0	
Missing	System	12	48,0		
Total		25	100,0		

Table 3.5.1.40

10th scenario trust technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	maybe trust	2	8,0	15,4	15,4
	trust	11	44,0	84,6	100,0
	Total	13	52,0	100,0	
Missing	System	12	48,0		
Total		25	100,0		

Italian control and experimental

Table 3.5.1.41

control or experimental * 1st scenario trust controller Crosstabulation

Count

		1st scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	3	1	12	16
	experimental	1	8	19	28
Total		4	9	31	44

Table 3.5.1.42

control or experimental * 1st scenario trust technology Crosstabulation

Count

		1st scenario trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	1	4	9	14
	experimental	3	7	18	28
Total		4	11	27	42

Table 3.5.1.43

control or experimental * 2nd scenario trust controller Crosstabulation

Count

		2nd scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	2	3	11	16
	experimental	1	6	21	28
Total		3	9	32	44

Table 3.5.1.44

control or experimental * 2nd scenario trust technology Crosstabulation

Count

		2nd scenario trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	7	4	5	16
	experimental	12	6	10	28
Total		19	10	15	44

Table 3.5.1.45

control or experimental * 3rd scenario trust controller Crosstabulation

Count

		3rd scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	4	6	6	16
	experimental	9	10	9	28
Total		13	16	15	44

Table 3.5.1.46

control or experimental * 3rd scenario trust technology Crosstabulation

Count

		3rd scenario trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	2		14	16
	experimental	3	4	21	28
Total		5	4	35	44

Table 3.5.1.47

control or experimental * 4th scenario trust controller Crosstabulation

Count

		4th scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	5	4	7	16
	experimental	3	5	20	28
Total		8	9	27	44

Table 3.5.1.48

control or experimental * 4th scenario trust technology Crosstabulation

Count

		4th scenario trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	2	1	13	16
	experimental	4	3	19	26
Total		6	4	32	42

Table 3.5.1.49

control or experimental * 5th scenario trust controller Crosstabulation

Count

		5th scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	1	1	14	16
	experimental	1	5	22	28
Total		2	6	36	44

Table 3.5.1.50

control or experimental * 5th scenario trust technology Crosstabulation

Count

		5th scenario trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	7	3	6	16
	experimental	16	3	9	28
Total		23	6	15	44

Table 3.5.1.51

control or experimental * 6th scenario trust controller Crosstabulation

Count

		6th scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	8	2	6	16
	experimental	11	5	11	27
Total		19	7	17	43

Table 3.5.1.52

control or experimental * 6th scenairo trust technology Crosstabulation

Count

		6th scenairo trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	6	5	5	16
	experimental	14	5	7	26
Total		20	10	12	42

Table 3.5.1.53

control or experimental * 7th scenario trust controller Crosstabulation

Count

		7th scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	14	1	1	16
	experimental	21	4	3	28
Total		35	5	4	44

Table 3.5.1.54

control or experimental * 7th scenario trust technology Crosstabulation

Count

		7th scenario trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	5	1	10	16
	experimental	12	4	9	25
Total		17	5	19	41

Table 3.5.1.55

control or experimental * 8th scenario trust controller Crosstabulation

Count

		8th scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	7		8	15
	experimental	6	6	15	27
Total		13	6	23	42

Table 3.5.1.56

control or experimental * 8th scenario trust technology Crosstabulation

Count

		8th scenario trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	2	2	11	15
	experimental	6	5	14	25
Total		8	7	25	40

Table 3.5.1.57

control or experimental * 9th scenario trust controller Crosstabulation

Count

		9th scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	1	3	12	16
	experimental	2	4	22	28
Total		3	7	34	44

Table 3.5.1.58

control or experimental * 9th scenario trust technology Crosstabulation

Count

		9th scenario trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	1	3	12	16
	experimental	2	5	19	26
Total		3	8	31	42

Table 3.5.1.59

control or experimental * 10th scenario trust controller Crosstabulation

Count

		10th scenario trust controller			Total
		no trust	maybe trust	trust	
control or experimental	control	5	6	5	16
	experimental	7	9	11	27
Total		12	15	16	43

Table 3.5.1.60

control or experimental * 10th scenario trust technology Crosstabulation

Count

		10th scenario trust technology			Total
		no trust	maybe trust	trust	
control or experimental	control	1	4	10	15
	experimental	2	5	18	25
Total		3	9	28	40