CRANFIELD UNIVERSITY

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DEVELOPMENT OF AN OBJECTIVE EVALUATION FRAMEWORK WITH SUBJECTIVE IMPACT

SCHOOL OF INDUSTRIAL AND MANUFACTURING SCIENCE

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Development of an objective evaluation framework with subjective impact

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ABSTRACT

Multimedia technologies are finding new and advanced uses within the modern organisation. From a strategic perspective, these organisations realise technology contributes to enhance productivity and operational success. However, to embrace technology without recourse to those who ultimately utilise such facilities, could effectively jeopardize the up-take of new improved working practices.

Sir Paul Condon: Commissioner of Police for the Metropolis has been noted within MetView (1999) for the following statements:

- *"Technology is playing an ever increasing role in modern policing methods and has been responsible for many of our current successes"*
- *"Good and innovative policing, and good and innovative technology cannot be separated".*

To continue this success there is a need within a modern policing organisation to develop an objective framework for evaluating multimedia technologies. This framework will give recognition to subjective user issues that are necessary to contribute towards the partnership that exists between innovative policing and innovative technology.

This research presents a framework that achieves specific business requirements outlined by a technology aware department within a police organisation. Three research objectives were completed. These objectives are:

- Provide a business process for evaluating multimedia technologies in a way that is repeatable and unbiased
- Provide a sound foundation that accounts for the typical user of multimedia technologies
- Aid towards increased user satisfaction and confidence.

Conclusions detail the objective evaluation framework with subjective impact, reference to a business process and considerations for a modern policing organisation on a way forward.

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Finally, I would like to express my special thanks to all my family members. Crazy as it may sound, but awareness of family thoughts towards such matters as education provides great support.

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NOTATIONS

MPS	Metropolitan Police Service
DoT	Department of Technology
CARAT	Centre of Applied Research and Technology
QFD	Quality Function Deployment
QoS	Quality of Service
OSI	Open System Interconnection
WWW	World Wide Web
PC	Personal Computers
MPEG	Moving Picture Expert Group
Mbps	Megabits per second
KHz	Kilohertz
CD	Compact Disk
CD-ROM	Compact Disk – Read Only Memory
ISDN	Integrated Services Digital Network
CRC	Cyclic Redundancy Check
DCT	Discrete Cosine Transform
DPCM	Differential Pulse Code Modulation

CHAPTER 1: INTRODUCTION

1.1 GENERAL INTRODUCTION

To a limited extent in the past, there has been a need within the Metropolitan Police Service (MPS) to objectively assess a technology that is typically judged subjectively by the user; for example speech codec developments in the early 1980s. Now there is an increasing demand to objectively evaluate and compare technologies that are judged by users in a subjective manner. This demand is driven by the explosion in multimedia technology and its relative cheap availability to mass markets via the World Wide Web (WWW) and Personal Computers (PC) technologies.

1.2 BACKGROUND

Demand within the MPS for an objective evaluation framework with subjective recognition has accumulated in the current requirement to develop an appropriate business process.

Before such a framework can be thoroughly researched and defined within a business process an understanding of the organisation where the framework will be utilised needs to be obtained. To gain this understanding a general examination of the purpose and values of the MPS makes a necessary first step. Examining in more detail the Department of Technology (DoT) within the MPS allows for a contextual understanding, within which technological needs can be related to policing requirements.

1.2.1 Metropolitan Police Service

The 'Statement of our Common Purpose and Values' best describes the Metropolitan Police Service. It states (Policing Plan 1998/99):

"The purpose of the Metropolitan Police Service is to uphold the law fairly and firmly; to prevent crime; to pursue and bring to justice those who break the law; to

keep the Queen's Peace; to protect, help and reassure people in London; and to be seen to do all this with integrity, common sense and sound judgement.

We must be compassionate, courteous and patient, acting without fear or favour or prejudice to the rights of others. We need to be professional, calm and restrained in the face of violence and apply only that force which is necessary to accomplish our lawful duty.

We must strive to reduce the fears of the public and, so far as we can, to reflect their priorities in the action we take. We must respond to well-founded criticism with a willingness to change."

1.2.2 Department Of Technology

The MPS Department of Technology (DoT) is an organisation of professional engineers, technologists and procurement experts which supplies the MPS with all its transport, communication and information technology requirements (MetVIEW, 1999).

Working closely with police officers to identify requirements and define accurate technical specifications and services needs to combat crime, the DoT plays an important role in MPS success. Having specified specifications or service requirements, the DoT through its associated project groups deals closely with commercial organisations, initiating procurement procedures. Undertaking implementation and ensuring that MPS representatives are properly trained and satisfied with the new technology forms the final stages within this procurement process.

The importance of technology for the effective operations of the MPS can be best expressed by a comment made by Sir Paul Condon; Commissioner of Police for the Metropolis. Sir Paul Condon states (MetVIEW, 1999):

"Technology is playing an ever increasing role in modern policing methods and has been responsible for many of our current successes. We are investing heavily in expertise. Good and innovative policing and good and innovative technology cannot be separated."

1.2.3 Multimedia Technology Within MPS

The importance of technology has been stressed by an example of Sir Condon's comments regarding the role of technology in policing (see section 1.2.2). Multimedia technology falls into Sir Condon's technology comments, and to a large degree, could be identified as one of the most important ongoing technological developments.

Current multimedia technologies within the MPS include the following Applications:

- Dynamic Link Libraries (DLLs)
- Bumblebee Imaging System
- Video Conferencing
- Custody Suite
- Video and Audio Forensic Laboratories
- Shoe-print
- Remote Capture
- Geographic Information System (GIS) Link.

An extremely important factor, and one that cannot afford to be over looked, is the role of people in the operational usefulness of technology. These people represent the crucial factor in the success of technology. Therefore, MPS personnel need to be considered in the appraisal of technology requirements. For this reason subjective user issues are to be given full consideration within the business process for objectively evaluating multimedia technology.

1.4 BUSINESS PROCESS: EVALUATION FRAMEWORK

From the development of an Objective Evaluation Framework with Subjective Impact a business process is identified. This business process involves operational stages that are necessary to objectively evaluate any multimedia technology in relation to subjective user requirements.

Comparing framework and business process objectives, it can be noted that the framework aims to present specific techniques and tools to facilitate its function. However, the business process aims to identify operational stages that must be undertaken to provide the basic foundation of any evaluation methodology for multimedia technology. Therefore, the business process provides a focus on fundamentals while the framework presents in detail procedures.

Two framework techniques that are utilised because of their ability to recognise subjective and objective evaluation requirements are cognitive mapping and quality function deployment (QFD). These techniques are introduced separately below.

1.4.1 Cognitive Mapping Introduction

Cognitive mapping may be utilised for a variety of purposes although it is generally a problem that forms the bases of its application. It is a technique used to structure, analyse and make sense of accounts of problems. These accounts can be verbal or documentary. Thus, the application of cognitive mapping is suitable during an interview as a note-taking procedure, or following an interview in conjunction with interview transcripts (Ackermann, 1990).

The technique is founded upon George Kelly's theory of personal constructs (Kelly, 1955) which focuses on human beings as problem solvers. In essence the theory which has resulted in various adapted modelling techniques seeks to portray the way in which problems owners make sense of their situation. Aiming to ascertain problem owners' explanations of the way the situation is, as they

construe it, and why it matters, places focus upon a qualitative understanding. This qualitative understanding of each situation is presented by a directed graph through linkages between bi-polar constructs (Eden, 1994).

1.4.2 Quality Function Deployment Introduction

Quality function deployment (QFD) is a management technique that takes customers' needs and prioritises them within an objective matrix. The basis of QFD is *"the belief that products should be designed to reflect customers' desires and tastes..."* (Hauser and Clausing, 1988). QFD consists of a set of planning and communication techniques. Case studies have shown that since the development of QFD in Japan in 1972, it has lead to products that closely meet customers' expectations.

The central analysis mechanism in the QFD planning process is the correlation matrix. This matrix allows customers requirements (or user WANTs) to be entered along one axis and compared against various technical specification (or design HOWs) on the other axis. Used as an objective analysis tool the matrix helps in decision making regarding customers' requirements. That is, the correlation matrix facilitates identification of technical options that can best satisfied users.

Operational steps for undertaking QFD are provided in appendix B. Detailed information on this technique has not been provided as many excellent textbooks are available. For the interested reader see: Shillito, 1994 or Guinta and Praizler, 1993.

1.5 STRUCTURE OF THE THESIS

This thesis is divided into nine chapters. Chapter one of this thesis provides an introduction to the research by examining the need for a multimedia technology evaluation process within the Metropolitan Police Service.

It will become apparent that extensive literature is available on the separate subjects that encompass the final objective evaluation framework with subjective impact. These subject areas are reviewed within chapter two from the perspective of how they contribute to the development of a business process founded on the fore mentioned evaluation framework for multimedia technologies.

The aim of the research is made explicit accompanied by research objectives within chapter three. Deliverables and the research methodology followed are also presented. To ensure a thorough understanding of why this research has been carried out a section of chapter three details research rationale.

Chapter four details the development of a proposed framework structure with specific focus placed upon two important phases. Phase one offers the choice of two possible cognitive mapping techniques to elicit subjective user issues. While phase two of the framework utilises Qualify Function Deployment (QFD) as an objective evaluation process.

Cognitive mapping as a technique to elicit user requirements is presented in chapter five. Two specific mapping techniques: causal maps and repertory grids are discussed in detail. This discussion begins by examining the Interpretivist approach to data collection and finishes by reviewing application of both causal maps and repertory grids.

Validation of the proposed framework requires MPS based case studies. Before these case studies are carried out an understanding of multimedia technology is compulsory. Chapter six provides a discussion on multimedia considerations. What is multimedia? Is there a known definition for multimedia? What are the implications of multimedia within the MPS? These questions are analysed in the chapter's discussion before some practical points are identified from a user perspective.

Concentrating on users, chapter seven examines perceived value associated with a user's experience of technology. The need to segment users into behaviourally oriented groups is presented. These groups allow for similar user needs to be identified. By presenting user needs ready to be utilised within phase two of the framework (or QFD) a matrix of users' subjective requirements can also be constructed. This needs matrix finds usefulness when phase one of the overall framework utilises the causal map technique.

Chapter 8 case studies provide an extensive review of the stages undertaken during the use of the objective evaluation framework with subjective impact. Each case study, of which there were three, is discussed in moderate detail. Extensive details regarding data elicited and analysed is provided in appendix D and E. Demonstration of the framework is provided by example; specific results obtained from two respondents are presented. One respondent is taken from a video conferencing case study. The other respondent from the video and audio laboratory case studies.

The final chapter, chapter nine, documents conclusions from the overall thesis. Included in this concluding section are lessons learnt during the duration of the research project with the MPS. The Research Findings section presents the objective evaluation framework with subject impact. This chapter includes remarks specific to the tools and techniques utilised within the different business process stages. Implications and limitations are also identified as awareness of these issues may aid in the successful continuation of other research projects within the fascinating area.

CHAPTER 2: LITERATURE RESEARCH

2.1 INTRODUCTION

This chapter discusses in some detail, literature relevant for the development of an evaluation methodology applicable for multimedia technologies. Additionally, to enable follow on research within this research area an initial section has been provided regarding available resources and sources utilised.

2.2 SOURCES

For the literature research undertaken various sources of information have been examined and exploited. It is through this process of study and investigation that knowledge of several interrelated domains has been utilised.

The diversity of information mediums and hence sources continue to grow with the emergence of new electronic distribution devices. These technological alternatives allow for the access and use of modern information sources. Such modern technology based sources include World Wide Web, Internet, computer databases and news-groups. These sources allowed for quick access to publicly available information. However, the quality of information cannot be assumed to follow those standards achieved through rigorous examination associated with other traditional information formats.

Traditional information sources continue to find favour with university based research programmes. However, electronic alternatives are also being encouraged. Both options can greatly complement each other. Compromising one for the sake of the other is not a necessity.

2.2.1 Sources Utilised

Both modern and traditional information sources proved extremely beneficial to the accumulation of knowledge relevant to the research programme. When conducting research on issues associated with multimedia technologies

and users of those technologies, both the Internet and scholarly journals proved rich source of information. Gathering information regarding cognitive science and requirements capture techniques required extensive use of library resources, especially working papers from numerous universities. Quality Function Deployment (QFD), considered an older methodology utilised by the manufacturing industry, allowed reference to an extensive number of books and journals. However, within a service environment, QFD as a useful concept is relatively unpublished. Thus, the far reaching World Wide Web provided the perfect resource to search a larger selection of information repositories.

As a final point concerning literature sources, quality of work remains a fundamental issue that must be considered. When conducting literature research an understanding of the relevance of theoretical underpinnings and methodological issues is a necessity. Literature that follows on from historical assumptions without awareness of context or re-assessing fundamental concerns should be considered questionable in terms of appropriate forms of reference. It is the search for effective information in an efficient manner that underpins a successful research programme.

2.3 MULTIMEDIA TECHNOLOGY: QUALITY OF SERVICE

The notion of Quality of Service (QoS) originally emerged in telecommunications to describe certain technical characteristic of data transmission. For example, the Open System Interconnection (OSI) Reference Model has a number of QoS parameters describing speed and reliability of transmission, such as throughput, transit delay error rate, and connection established failure probability. QoS is however increasingly gaining importance for all components within distributed multimedia technology. Therefore, QoS parameters can now be found in operating systems, multimedia databases and file servers as well as the user (human) interface (Vogel *et al*, 1995).

In a QoS survey conducted during 1995, Vogel *et al* (1995) concluded that people are the starting point for QoS considerations. Thus, the primary source of QoS requirements has to be the user. Vogel *et al* (1995) states: *"until recently, this view has not been sufficiently emphasises in the literature".*

Quality of service may represent a relatively new term. However, service quality issues have been under considerations within several industries for numerous years. To date, the methods for examining service quality have focused mainly upon techniques for monitoring operations, that is, ensuring conformance to specifications (see Crosby, 1996 or Taguchi, 1986) and methods for measuring customer satisfaction (see Deming, 1986 or Juran, 1988). Conformance to specifications presents an operations perspective, while customer satisfaction has a marketing perspective. Extensive literature has been produced, including textbooks (for example Taguchi, 1986) that addresses issues of variation from specific conformance standards. However, for those service organisations that offer customisation (i.e. personalised serviced) such classic studies may detract from contemporary opportunities.

Methods for measuring customer satisfaction are typically subjective as such approaches rely on customers' perception of service. Satisfying customers' requirements or fitness for purpose relies on the ability of the service provider to determine customers' requirements and then meet those requirements. This approach is often referred to as 'customer-led' or 'customer focused' (Ghobadian, 1995).

Parasuraman, Zeithaml and Berry (1986) have developed a questionnaire-based methodology for evaluating customers' perceptions of service quality called SERVQUAL. The SERVQUAL tool requires that customers complete a survey that deals with the following service quality attributes (Watson *et al*, 1998): tangibles, reliability, responsiveness, assurance and empathy.

For each attribute, SERVQUAL measures the service expectations of consumers and their perceptions of that service. The difference between the two measures is then evaluated and used as an indication of service quality. SERVQUAL does not evaluate the service delivery process. Other marketing based studies however, considered delivery related criteria. Bolton and Drew (1991) developed linear structured models to allow assessment of service performance, quality and value by consumers.

Another issue identified within service quality literature is the use of aggregated data management or averages developed from determining average customer's perception. The problem with aggregated data management is that it is based on the assumption that there is one best answer towards a service attribute (Havener, 1993). A further assumption is that average customer perceptions exist within a market place and are best addressed by that one answer. To gain an improved understanding of the linkage between service quality and perceptions, an examination of attitudinally homogeneous customer groups (or segments) must be matched with data describing their service experience.

2.4 UNDERSTANDING PERCEPTIONS THROUGH COGNITIVE MAPPING

The application of cognitive mapping techniques is apparent from the wide variety of literature available within this subject domain. Reflecting the cognitive schema of various organisational representatives has been extensively researched, providing understanding of subjective data in a meaningful manner (Cossette, 1992).

Utilising cognitive mapping as a research tool, maps for what are thought to be key decision-makers in organisations are produced. Swan (1997) offers the following examples: corporate-level managers (Ginsberg, 1989); political elite's (Axelrod, 1976); company executives (Narayanan and Faney, 1990), or any top manager involved in making decisions. It is assumed that a better

understanding of top managers' cognition will lead to an improved understanding of overall organisational performance.

Swan and Clark (1992) have conducted research that identified other factors, especially intra-firm politics, which effect the relationship between individual decision-makers' cognition and organisation outcomes. This research gives consideration to middle managers' cognition and their exerted influence over decision outcomes. While key individuals can provide an understanding of organisational outcomes, the level of understanding may prove to be limited. Thus, other organisational representatives may provide useful perspectives more influential to specific organisational phenomena.

Research available has also addressed issues associated with the validity of some cognitive mapping techniques. Eden (1992) and Eden *et al* (1993) have written extensively on underlining principles and methodological considerations of causal maps. Both Kelly and Reger (see Kelly, 1955 and Reger, 1990) are often cited authors whom have well-established literature validating repertory grid technique. Swan (1997) makes the following observation regarding the validity of mapping techniques:

"There are still relatively few empirical studies that include an assessment of the validity of different mapping techniques (though for an exception see Daniels et al, 1994)."

Swan's comments continue to highlight the usefulness of cognitive mapping in conjunction with process-orientated research in order to validate connections between subjective beliefs and behavioural outcomes, which are typically assumed. A further observation by Swan that builds on the possible application of cognitive mapping techniques states:

"Mapping techniques could be used at different points in the decision process and for different units of analysis (e.g. groups and individuals) to examine the links between revealed subjective beliefs and decision outcomes over time."

2.5 QFD: MULTIMEDIA TECHNOLOGY APPLICATIONS

A number of authors have published literature on the theory, application and relevance of Quality Function Deployment (QFD) (see Minzuno, 1988; Hauser and Clausing, 1988; and Akao, 1990).

Shigru Mizuno and Yoji Akao developed the QFD technique in Japan during the late 1960s (Bergman and Klefsjo, 1994). QFD is reported as providing a systematic method for transferring customers' needs and expectations into product / service characteristics that have been identified. The sequence of work involved in a QFD study can be divided into the following four stages:

- Analysis to determine needs and expectations of customers, referred to as customers' wants
- Examination of competing (alternatives) to objectively ascertain the ability of a particular product / service to satisfy the wants of the customers
- Identification of key factors for developing a product / service to better fulfil the known wants of the marketplace
- Translation of key factors into product / service characteristics, through design, development and production activities (manufacturing orientated), or specification, configuration and tendering (service orientated).

The majority of QFD literature found in journals and textbooks has strong links with manufacturing industries. This characteristic can however be associated with older sources of information. Originally adopted by manufacturers in the west, QFD found its greatest use in product development. Thus, manufacturers embraced QFD as a 'design for quality' tool for tangible products.

As western businesses have evolved and an increased awareness of service opportunities has been realised, QFD has become popular as a Total Quality Management (TQM) tool within the service sector. Extensive research is continually undertaken within service sector businesses, utilising QFD as a system to focus on customer needs and expectations (Oakland, 1993). Ghobadian and Terry (1995) demonstrated the application of QFD in improving service quality (service process and delivery) within Itlalina, an Italian air transport service business. Yoshizawa *et al* (1993) provides an application example of using QFD to improve customer service in telecommunication call centres of a US based utility business. This research sets out to determine, understand and validate the following customer (external) issues: expectations, satisfaction, segmentation and perceptions.

No research found demonstrated the application of QFD for ascertaining wants and objectives associated with multimedia technology. Limited literature also seems to exist, demonstrating the application of QFD for improving a product or service utilised by internal customers. Within the most up-to-date quality literature, QFD is finding less and less publication space. This is not because QFD is no longer relevant within modern business or because customers' expectations are under control. Rather, such powerful and systematic techniques gain rapid publication during their early periods of dissemination, before being inappropriately left behind for modern techniques that have yet to pass the test of time. In today's society it sometimes seems that association with modern possibilities, no matter how vague, is more beneficial than working with and disseminating older well proved techniques.

2.6 OBJECTIVE-SUBJECTIVE EVALUATION

A review of literature associated with objective and subjective evaluation leads to the discovery of an extensive range of quantitative and qualitative publications. This strong connection exists as quantitative studies imply an objective assessment founded upon Positive research methodologies. While

qualitative techniques follow an Interpretive approach, allowing inductive research formed by subjects' perspective.

Objective evaluation has been utilised to a very large degree in numerous fields of research. Reviewing technical proceedings and other scientific publications demonstrates the extent of objective methodologies that have been developed for specific situations. Soars *et al* (1995) employs an objective analysis to assess computational image quality. Palanque *et al* (1997), Anbar (1991), and Kot and Bondarenko (1998) develop specific objective evaluation methodologies to assess specification relative to human operations of technologies.

This Positivist approach to evaluation involves deductive logic, and from an Interpretivists' perspective, requires priori constructions which subjects react to. For example, objective evaluations facilitate reaction by the researcher to such issues as definitional clarity, interpretability and actionable results. Thus, through the use of a Positive approach (objective) there is a need to find data to match theory. Interpretive (subjective) evaluation however, helps create theory that explains data (Despres, 1998).

Subjective evaluation, again, has been covered within a diverse range of publications, especially within Social Sciences and management based research. There is however, generally a need within these research domains to combine objective and subjective considerations for assessment purposes. This may result in a lesser emphasis of the benefits possible from subjective based analysis. Shrivastava (1987) provides a context for this understanding identified by Despres (1998). Regarding objective and subjective consideration for management issues Shrivastava states:

"While subjectively oriented methods can be and indeed are rigorous, the sociological forces that shape knowledge creation in this field favour objectively oriented methods."

2.7 SUMMARY

Literature research showed that quality concerns associated with multimedia technology continue to persist. Large proportions of these concerns arise from users, a primary driver in the evolution of technology. Cognitive mapping and quality function deployment literature were examined to determine their impact on evaluation methodologies. Literature findings help enforce the usefulness of these two techniques within an objective evaluation which recognises subjective user needs. The next chapter details the research aim, objectives and deliverables, with additional information regarding research methodology and rationale.

CHAPTER 3: RESEARCH OBJECTIVES AND METHODOLOGY

3.1 INTRODUCTION

This chapter details the aim of the research, objectives and deliverables. The scope and boundaries of the research are made explicit. Information is also provided regarding the research methodology. A project plan presented in Gantt chart format is acknowledged allowing reference to a related appendix.

3.2 RESEARCH AIM AND OBJECTIVES

The aim of this research is to develop an objective evaluation framework for assessing multimedia technology. This framework must take into consideration those subjective issues deemed important by the users of technology. Such a framework would facilitate the Metropolitan Police Service in its need to compare and contrast competing technologies.

The objective evaluation framework that is to contribute to the success of technology appraisal and usage through subjective user recognition will meet with the following objectives:

- Provide a business process for evaluating multimedia technologies in a way that is repeatable and unbiased
- Provide a sound foundation that accounts for the typical user of multimedia technologies
- Aid towards increased user satisfaction and confidence.

3.2.1 Deliverables

Two deliverables of this research are:

1. Document an objective evaluation framework with subjective impact applicable for multimedia technologies utilised within the MPS.
2. Case studies, preferably two; one video and one audio, providing practical examples of the objective evaluation methodology in use within the MPS.

3.3 RESEARCH SCOPE

From the onset it was known that this project is in fact part of a much larger 'area of interest' to the Metropolitan Police Service. This project is however considered a very important part of the work needing to be undertaken throughout the whole organisation. The scope of this project will include the following considerations:

- Objective evaluation of multimedia technology
- Comparing and contrasting competing technologies
- Subjective meaning as understood by technology users
- Distinction between subjective quality and aesthetic values.

3.4 RESEARCH BOUNDARIES

As the project was limited in its scope certain boundaries were identifiable. These boundaries may be perceived as limitations to the research. However, such boundaries provide a beneficial means to ensuring that the suggested research was completed given the constraints of time. Such boundaries also allow for other aspects of the larger 'area of interest' to be undertaken concurrently by other researchers or sequentially at a later date.

Reviewing the scope of the project provides information as to the main areas that this particular project addresses. This information does not however make explicit those areas that were not considered. It is necessary to make this distinction, as it was realised, implicit assumptions are often formed by interested third parties leading to conversations and debates which go beyond the work which was considered. Such conversations and debated address interesting areas of work however, this initial project needed be completed for progress to be made in those other areas identified by third parties.

Therefore, it is not the aim of this particular project to undertake the following areas of research:

- Determine how people perceive
- Understand determinates of perception and influence those determinates

- Alter perception through education, training or other forms of learning and communication
- Develop improved intuitive based multimedia technologies
- Undertake empirical based analysis to quantify objective and subjective issues associated with multimedia technologies.

3.5 RESEARCH RATIONALE

A predominate driver for the undertaking of this particular project lies in its in attention to consider the human aspect of improving integration of multimedia technologies into an organisation's working philosophy.

All to often technology is appraised based on technological specifications or worse due to commercial pressures. This approach has however, over time, demonstrated that a mechanism is needed to ensure that those subjective user considerations are reflective in any decisions associated with technology requirements.

Recognition of users' subjective considerations must be included in an objective evaluation framework to compliment the technology assessment process. To do this, technology users must become part of that process and feel comfortable with voicing their opinions' regarding tools that facilitate productivity.

3.6 PROJECT METHODOLOGY

The undertaking of this thesis required an Action Research approach. As a result of this requirement, the research combined active participation from practitioners, that is, MPS representatives in addition to the library based postgraduate researcher.

Practitioners provided the opportunity for the researcher to elicit implicit knowledge utilised within a working environment and determine perceptual or empathic needs. To enhance the work conducted within the participating public

sector organisation the researcher also proactively research using such information sources as:

- Library material; working papers, journals, reports and other publications
- Conference participation and papers
- University professionals
- Institutions (i.e. Institute of Electrical Engineers)
- World Wide Web / Internet resources
- Commercial organisations.

The main methods of investigation, when located at the participation organisation included semi-structured interviews, workshops, group discussion, and brain storming sessions. The use of the organisation's Intranet provided interesting reference material for current internal developments. The researcher interacted with company personnel to develop perceptual meaning of multimedia quality issues as perceived by various users. The understanding gained through this process was used to develop an objective evaluation framework of technology with subject impact. This evaluation process was documented and validated with case studies.

Provided in appendix A is the schedule utilised during the research project. This Gantt chart based schedule allowed for forward planning and successful completion of the research within the limited time frame of three months.

3.7 SUMMARY

Details of the research objectives and methodology have been presented. The understanding gained from this chapter enables research progress by examining the development of the proposed framework and business process.

CHAPTER 4: OBJECTIVE EVALUATION FRAMEWORK WITH SUBJECTIVE IMPACT

4.1 INTRODUCTION

This chapter of the thesis details information regarding the development of an Objective Evaluation Framework with Subjective Impact. The framework's development has resulted from investigation into techniques and tools used to elicit subjective user issues and qualify these qualitative requirements in an objective manner.

4.2 PROPOSED EVALUATION FRAMEWORK

Framework objectives stipulated by representatives from the Department of Technology (DoT) within the MPS presented particular challenges. These requirements were identified as framework objectives in section 3.2: Research Aim and Objectives. The proposed framework had to achieve these requirements in addition to satisfying both objective and subjective issues associated with evaluation procedures.

Literature researched allowed for the realisation that subjective and objective issues would have to be considered separately. This realisation was made apparent by the trend within analysis methodologies to separate qualitative and quantitative issues. Qualitative issues are then presented in a manner that enables objective measures with quantifiable results.

Thus, the proposed framework consisted of two phases. The first phase provided a methodology to ascertain and analyse subjective issues. These subjective issues represented qualitative considerations. The second phase provides objective analysis of subjective issues, using quantitative measurements. Figure 4.0 below graphically depicts an initial proposed objective evaluation framework with subjective impact developed for multimedia technology assessment within the MPS.

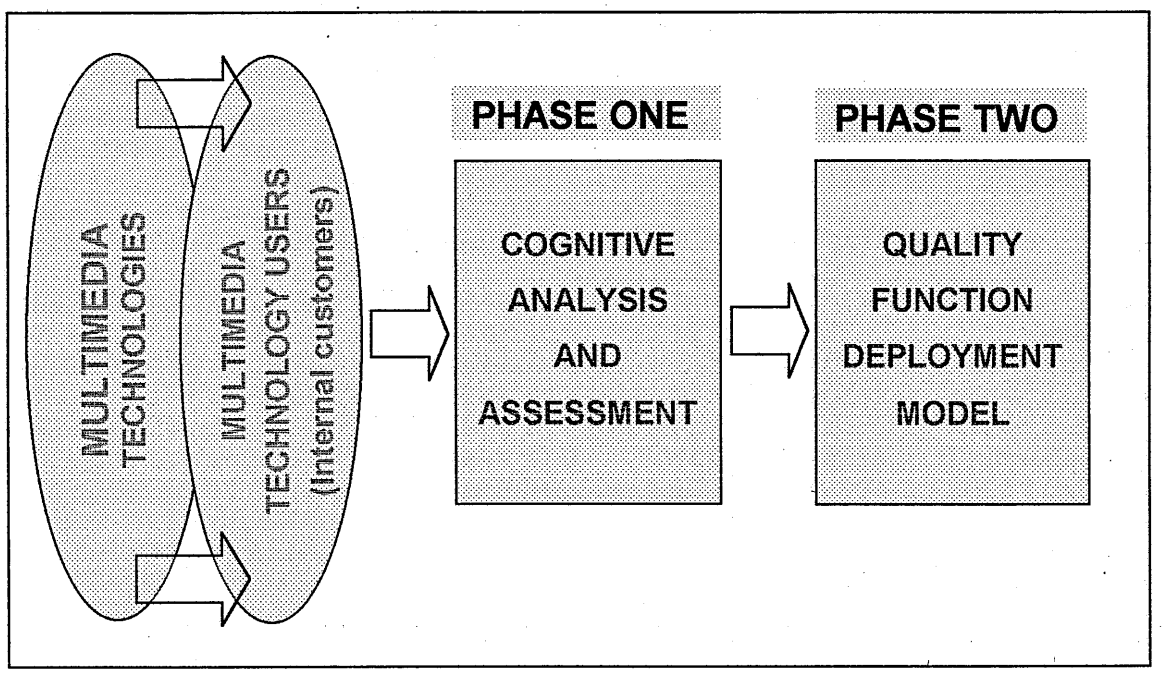


Figure 4.0: Initial Graphical Illustration of Proposed Framework

4.2.1 Structure

The basic structure of the framework is provided in figure 4.0 (above). This figure deliberately leaves out several details pertaining to the framework's internal stages of operation. This is because phase one of the framework can utilise one of two possible cognitive mapping techniques to elicit users' perceptions. Therefore, depending upon the type of multimedia technology to be analysed, phase one will vary between two cognitive analysis and assessment possibilities. Two generic multimedia technology groups have been identified within the MPS and are presented in some detail in section 5.3. Figure 4.1 below illustrates the alternative procedures available within phase one of the overall framework. Factors influencing the choice of alternative cognitive analysis and assessment procedure are provided in sections 5.4.2 and 5.4.3.

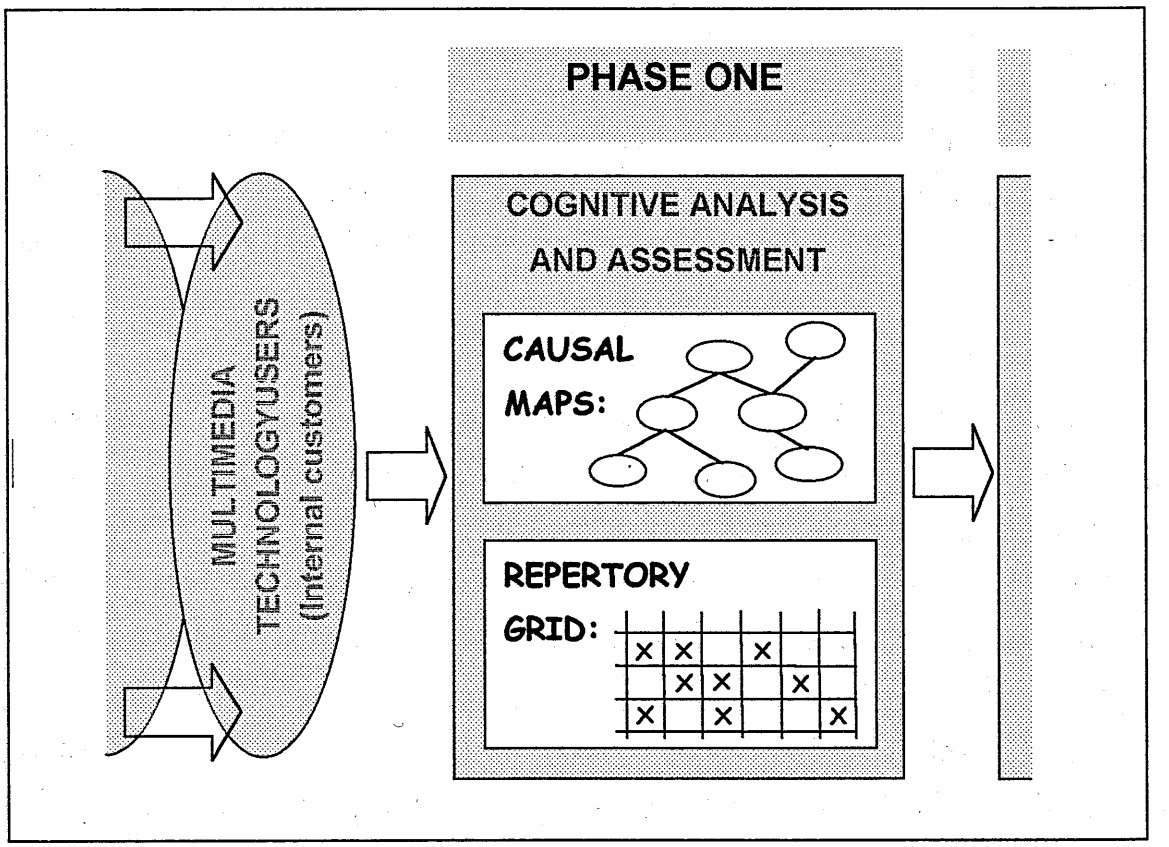


Figure 4.1: Different Alternatives in Phase One

Before providing more details specific to phase one and two of the proposed framework, further development of the basic framework structure is possible.

There is an obvious need to include intermediate checking procedures by those whom the framework is to be utilised by; DoT representatives within the MPS. Such intermediate procedures aim to provide an opportunity to ensure correct evaluation requirements are being achieved, and that information obtained in preceding stages is adequate for subsequent stages. Thus, between phase one and phase two a Requirement check is included to facilitate a review of data collected by cognitive mapping. It is also possible at this stage to contemplate assigning a priority value to the various users (or user groups) if user's requirements are to be dealt with in a sequential or hierarchical manner. Furthermore, a second check called Considerations is included after phase two.

This secondary check facility provides the opportunity to:

1. Present and discuss results from the QFD process clarifying objective evaluation of user needs and necessary next steps to realise those needs.
2. If necessary, make alterations to better reflect MPS / DoT objectives whilst ensuring user needs remain central to final outcomes.

To ascertain the quality of results achieved from adhering to framework procedures, a final evaluation stage is also included. This necessary stage aims to ensure progress through conducting two evaluation tasks:

1. Carrying out an immediate evaluation of the results obtained from the QFD process by discussing these results with both users of multimedia technology and appropriate DoT professionals.
2. Make explicit all known outcomes; good, bad and / or other. Outcomes or findings should be discussed with, as a minimum, DoT professionals.

Including the facility to check Requirements and Considerations followed by an Evaluation stage, the framework can now be represented as shown in figure 4.2 (over leaf).

4.2.2 Phase One

Phase one facilitates cognitive analysis and assessment of subjective issues. Two possible cognitive mapping techniques have been suggested for the purpose of obtaining, analysing and conducting an assessment of subjective issues. These subjective issues are user specific. Thus depending on the users of the multimedia technology under investigation, either causal maps or the repertory grid will be utilised as a first phase technique. The aim of this first phase remains the same whichever cognitive mapping technique is selected. That is, phase one must elicit subjective user issues.

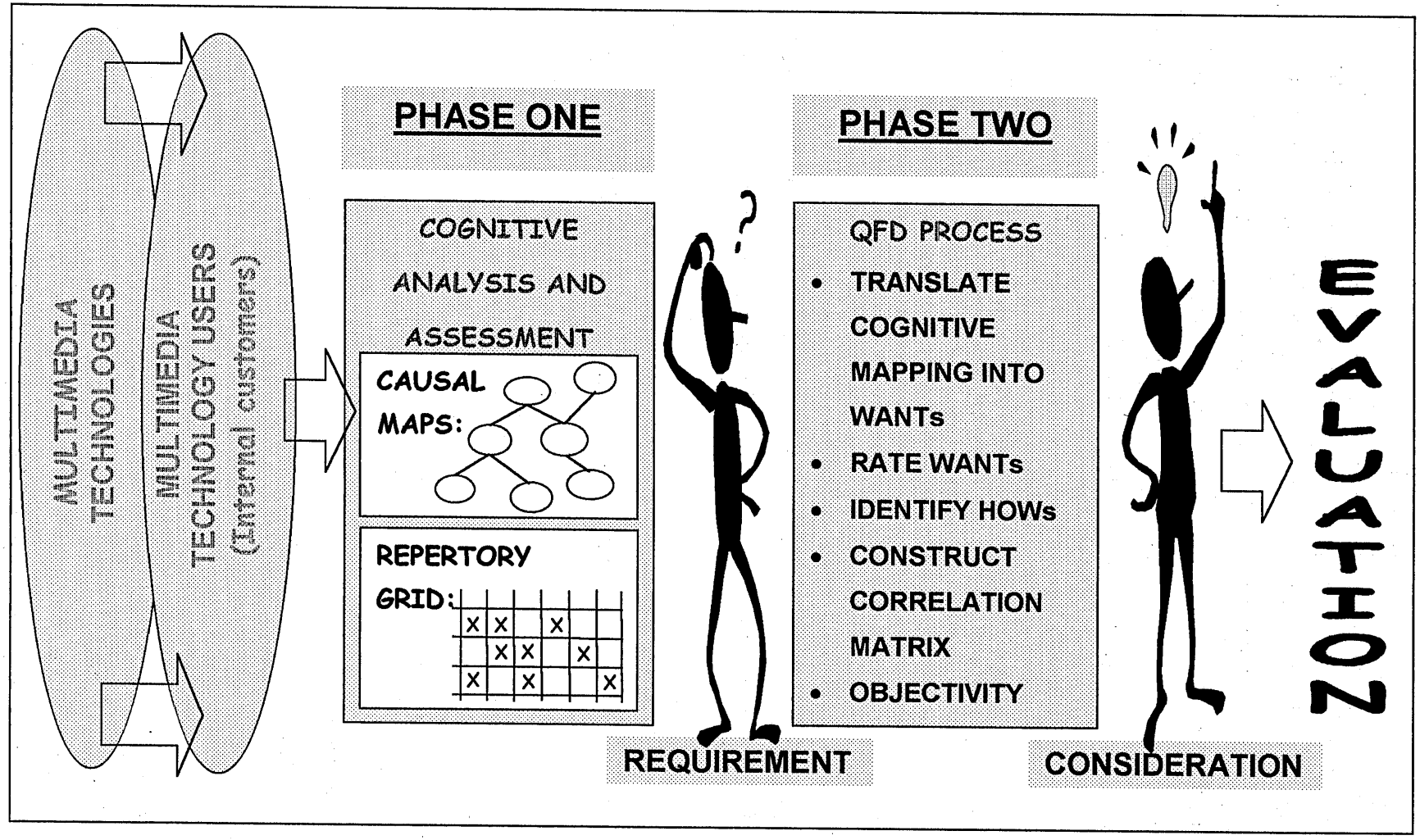


Figure 4.2: Multimedia Technology Evaluation Framework Illustration

4.2.3 Phase Two

Phase two facilitates quality function deployment (QFD) analysis, providing objectivity. Subjective issues gathered from phase one become the WANTs within a QFD process. Technical specifications as known by experts or available as features on products within the marketplace become HOWs for successfully achieving users' WANTs. Possible multimedia technologies are also compared within phase two of the framework as an objective means to relate their ability to meet the various subjective requirements of users. The purpose of this secondary phase is to objectively evaluate possible multimedia specifications and technologies in the light of known subjective user requirements.

4.3 BUSINESS PROCESS

The proposed framework in its completed form can also be presented as a simplified business process in text format (see section 9.3). This business process provides accurate reference to all stages of operation in a sequential manner.

From examination of business process operational stages are identifiable. These stages are:

1. Identification
2. Recognition
3. Analysis (subjective)
4. Requirements Check
5. Selection (objective)
6. Consideration Check
7. Review.

Fundamentally, these stages form the bases for analysing any multimedia technology whilst providing recognition of user requirements. The Identification stage provides attention to a specific type of technology that continues to grow in usage within the MPS. The next stage, Recognition, focuses on those users'

perceptions of that technology, and informs users of their role in improving multimedia technology user satisfaction. Analysis, involves the collection and assessment of subjective user requirements. To ensure that the outputs from proceeding stages are suitable for progression a Requirements stage is passed through. Following this checking mechanism Selection is undertaken using an objective evaluation process, before a Consideration check is enforced. To ensure the business process achieves what it originally set out to achieve a Review stage is finally enacted.

4.4 SUMMARY

Chapter 4.0 has presented extensive details on the development of an objective evaluation framework that recognises subjective impact. Business process information has also been provided. It is now possible to examine cognitive requirement capture, a fundamental consideration for possible techniques and tools in gaining an understanding of subjective user needs.

CHAPTER 5: COGNITIVE REQUIREMENTS CAPTURE

5.1 INTRODUCTION

This chapter explains the logic behind the decision to employ cognitive mapping techniques for the purpose of eliciting users' subjective issues associated with the operation of multimedia technologies. Details are also presented regarding the identification of two generic multimedia user classifications within the MPS. Both generic groups provide slightly different challenges regarding the elicitation of user requirements. These two user classifications affect the selection of suitable cognitive mapping techniques. However, two cognitive mapping techniques are selected and detailed for the purpose of explaining their application.

5.2 INTERPRETIVISM

In order to investigate subjective issues or user perceptions associated with the operation of multimedia technologies within an organisational environment an interprevist view was utilised.

Organisational phenomena are both elusive and ephemeral. It is therefore beneficial to follow an interpretive approach that allows for an inductive research strategy, employing general and guiding research questions, suspended preconceptions and a focus on everyday actions in naturally-occurring contexts (Despres, 1998). Through appropriate data gathering techniques, the aim of capturing meaning, attribution and other subjective phenomena indigenous to a particular situation was achieved.

5.3 TECHNOLOGY USER CLASSIFICATIONS

From initial face-to-face interviews with various multimedia users within the MPS it was evident that numerous forms of technology user classifications exist. Furthermore, through additional research of the cognitive sciences it was realised that no single cognitive technique was applicable (without compromising results)

for all user situations. Therefore, it was discovered that depending on the technology user classification examined the cognitive analysis technique employed varies.

Two generic multimedia user classifications are identifiable. These two user classifications can be described as follows:

1. Multimedia technologies that have several user or user groups, each with various primary objectives (or goals) for its operation (for example, video conferencing technology users).
2. Multimedia technologies that are utilised by users or user groups who have an identical but specific primary objective for its use (for example, media and audio forensic laboratory technology users).

5.4 COGNITIVE TECHNIQUES

Having conducted research of cognitive mapping techniques within an organisational environment and as a problem solving approach, in addition to initial interviews, two cognitive mapping techniques are recommended. These techniques have been acknowledged due to the strong possibility of application to at least one of the fore mentioned user classifications. These techniques can be identified using the following terminology:

1. Causal Maps.
2. Multivariate Space Maps (or Repertory Grids).

Each cognitive mapping technique mentioned above will now be briefly discussed making reference to its application, to each multimedia user classification, which it has been judged suitable. However, before discussing each of the two cognitive mapping techniques an overview of Personal Construct Theory is beneficial, as both techniques have been derived from this theory.

5.4.1 Personal Construct Theory

Kelly's (1955) constructive alternativism provides the foundations for personal construct theory. The theory suggests that an individual processes information through a system of constructs, which allows for an understanding of the world (Jenkins and Johnson, 1992). Making *"sense of the world enables individuals to predict how, all things being equal, the world will be in the future, and to decide how we might act or intervene in order to achieve what we prefer within that world – a predict and control view or problem solving"* (Eden, 1990).

A construct is a dichotomy or continuum comprising of two poles, along which stimuli is positioned allowing each individual to cognitively evaluate stimuli, that is, make sense. Eden & Jones (see Jenkins and Johnson, 1992) elaborate further: *"the dichotomy corollary reflects the constraint / similarity assertion that constructs have two poles: an emergent pole such as 'descriptive' and a opposite pole, such as 'normative'."* In more simplistic terms constructs are personal rules by which individuals attempt to organise their thoughts.

5.4.2 Causal Map Technique

Causal maps (Eden, 1992) are often referred to as cognitive maps. Both of which are founded on George Kelly's theory of personal constructs. There is however differences, all be it small from a visual perspective, but conceptually rather large, between a true causal and cognitive map. Both mapping techniques are concerned with cognition and reflecting idiographic data elicited from research subjects. Causal maps are however a refined version of cognitive maps found particular in Eden's action research reports and takes on the additional form of influence indicators (i.e. negative and positive signs) positioned against core conceptual hubs (nodes). Figure 5.1 demonstrates the graphical nature of causal maps:

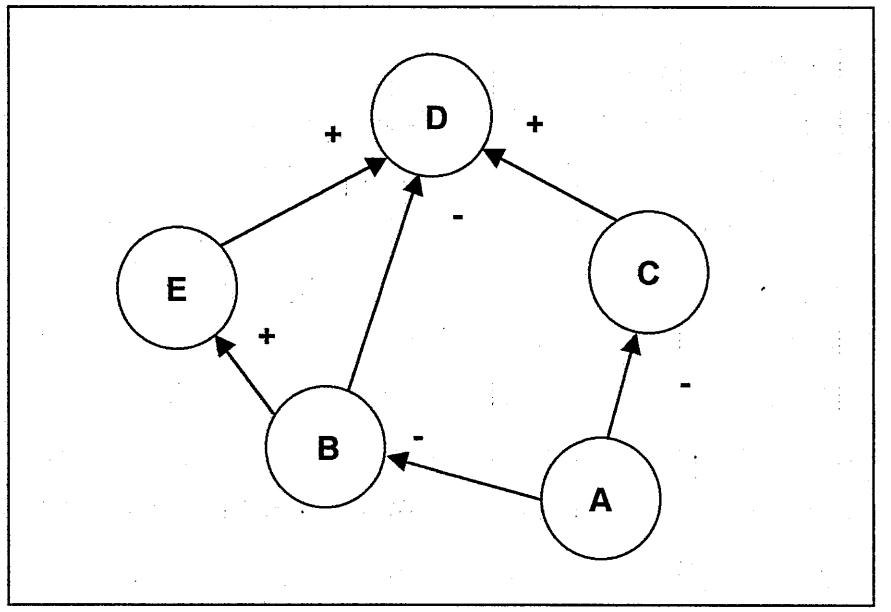


Figure 5.1: Cognitive Causal Map

Causal maps are proposed for use in determining perceived value in the following user situation:

1. Multimedia technologies which have several user groups, each with various primary objectives for its operation.

During the elicitation of idiographic data full recognition is given to the idiosyncratic ways in which each respondent views their multimedia experience. Having elicited respondents perceptions of the multimedia technology using a standardised interview format (see section 5.6 Causal Map Application), individual causal maps are developed and analysed. Comparisons of idiographic data is undertaken, without resorting to assumptions about the similarity of individual elements within the data or to the constraints present in collected data. Based upon Eden's aggregated causal map approach to developing an understanding of organisational cognition, emerging issues and meaning, not semantics may be addressed. Indications of emerging user issues and shared meaning may be recognised by less change / more similarity appearing in the aggregated causal map (Eden *et al*, 1993).

5.4.3 Repertory Grid Technique

The repertory grid, which falls into the category of multivariate space maps, is considered a flexible technique for eliciting a person's mental model for a given domain. As with causal maps, repertory grids have foundations in Kelly's construct theory (Kelly, 1995). Repertory grids have found favour with many researchers including Dutton *et al* (1989) for assessing how managers sort information related to strategic considerations; Ginsberg (1989) to assess how managers view diversification; Eden & Jones have utilised repertory grids in exploring operational research problems from a managerial cognition perspective (Eden & Jones, 1980; 1984).

In practice repertory grid technique can be combined with statistical considerations providing a means to conduct principle component analysis. This further analysis provides the means for developing a principle component picture of where different elicited concepts lie in relation to one another, given two dimensions of thought.

Repertory grids were utilised within the proposed framework for use in determining perceived value in the following user situation:

1. Multimedia technologies which are utilised by users who have an identical but specific primary objective for its use.

The first stage of the repertory grid technique involved eliciting elements by asking the respondent to name those influencing factors which are known and relevant (i.e. various multimedia technologies). The next stage involved eliciting the constructs. Constructs are the qualities that are used by people to think about elements, they are descriptors of the elements (i.e. aspect of multimedia technology such as functionality). Following the process of elicitation triading is used to identify two elements most similar, and then state how these are different from a third element. At this stage of the repertory grid technique it is possible to

arrange idiographic data into a grid, positioning elements and constructs relative to each other. Subjecting the grid to principle component analysis allows for the development of a map for each respondent's cognition. This map shows the underlying dimensions that differentiate between elements.

5.5 WHY COGNITIVE TECHNIQUES?

As with all well exercised cognitive techniques, their importance over preconstituted survey questioning is that concepts are not imposed 'on' the subject, they are obtained 'from' the respondent in a phenomenological interview. This results in the gathering of idiographic data, that represents native responses, as opposed to responses contaminated by a researcher's preconceptions (Despres, 1998).

Having gained these native responses and subjected them to the relevant mapping technique, respondents' subjective perceptions can be concluded upon and made available for objective transformation through the remaining stages of the proposed framework (see chapter 4).

5.6 CAUSAL MAP APPLICATION

Bearing in mind the fore mentioned considerations that have been detailed above, the following interview question were used for interviews aimed at allowing the developing of casual maps relevant for the objective evaluation framework.

General Question (Background)

- What is most important to you (interviewee) about the use of this technology to allow you to perform your role within this organisation (MPS)?

Specific Questions (Goals)

- Could you inform me of the various situations you use this technology for within this organisation (MPS)?

- Would you describe to me procedures and experiences you encounter during the use of this technology?
- For each of these technology usage situations previously identified and discussed, could you identify any technological characteristics you deem important for successful operation?
- How do you view the adequacy of this technology during each of the fore mentioned usage situations compared to other equivalent technologies you may be familiar with?

Other Questions (Reflection)

Throughout the interview it was often necessary that the researcher (interviewer) had to encourage the elicitation of opposite constructs as and when constructs were identified. The process of eliciting opposite constructs involved the interviewer asking the interviewee such questions as 'rather that?', 'as opposed to?', etc. This action aimed solely at clarifying the meaning of concepts not to influence or alter.

5.7 REPERTORY GRID APPLICATION

There are many variations on the form of interview that could be used to elicit idiographic data as part of the overall repertory grid technique. Smith (1979) identified six main stages, including a post-interview data analysis stage. Based on Smith's variation, excluding post-interview data analysis, the following five stages of the interview were utilised:

1. Explanation of the test to the subject.
2. Elicitation of the subject's elements and then written down on a separate card
3. Presentation of the triads to the subject. For each triad, one or more constructs are elicited.
4. Rating of elements after each construct is elicited.
5. On completion of data elicitation and rating related to the last construct, background data of the role of the individual is collected.

CHAPTER 6: MULTIMEDIA COMPREHENSION

6.1 INTRODUCTION

Before approaching users of multimedia technology it is absolutely necessary to have a good understanding of multimedia technologies and how the enlarged user population perceives these technologies. To achieve this understanding fundamental issues regarding multimedia must be presented. Thus, this chapter sets out to detail a thorough understanding of multimedia from the point of view of typical users and to relate this comprehension with implication that affect research results. Also provided in appendix C is another document titled 'Multimedia Comprehension'. This document examines further multimedia systems, technology and standardisation.

6.2 PERCEIVED MULTIMEDIA

The issue of defining multimedia presents particular problems. Part of the problem arises from the fact that the term multimedia represents many different concepts. Furthermore, a concept of multimedia that meets with ones own perception tends to find unchallenged acceptance, while the other possibilities are not considered, or worse, considered irrelevant. This pre-conceived view of multimedia could therefore greatly effect the acceptance of a definition of multimedia.

For example, from an application perspective, that is, a human being that is concerned with modern technological issues the following considerations may be of greatest interest:

- Signal processing
- Display technology
- World Wide Web technologies (Internet, Intranet and Extranet)
- Database technology, etc.

In this situation, a definition of multimedia based on these technological issues would tend to find acceptance before such considerations or concepts based on the human senses.

The fact that signal processing technology is at the very core of modern multimedia applications, which leverage numerous disciplines, may provide considerable justification for this technology perspective. However, to limit a definition, or ones understanding, of multimedia to pure technological issues would only serve to provide the following restrictions:

- Imply multimedia is a result of the convergence of modern technologies, and
- Place minimal importance or awareness of the human experience.

6.2.1 Multimedia Continuum

Multimedia may be considered a composition of basic elementary components, such as different audio types. These basic components originate from many diverse sources: individuals and synthesis. Moreover, multimedia may also be considered an extended visual experience, which incorporates representations of the real world and synthetic representations modelled based upon this world (Tescher, 1999).

Thus, in defining multimedia the view can be taken that a continuum for multimedia exists. At one extreme, multimedia is considered a label for the various components composed in a meaningful manner for representation purposes. While, to its opposite extreme, multimedia is a form of human experience. This human experience differs from those experiences typically encountered during day-to-day events. *"It includes not just accurate representations of the real world, but a world that does not exist if it were not for the multimedia experience"* (Tescher, 1999).

Leonard Chiariglione provides a definition of multimedia based upon the human experience. Chiariglone argues that the basic concept to consider when defining

multimedia is the human experience of the real world through the senses. The projection of the human experience through time and space lead to Chiariglone's concept of the 'virtual world'. Based on this observation, a definition of multimedia encompasses a combination of processes involved in a meaningful interaction of human beings with a virtual world. The basic elementary components of this type of interaction are creation, delivery, consumption and access.

During research of Chiariglone's definition of multimedia Andrew G. Tescher identified that the virtual world based definition highlights a long multimedia history. Tescher emphasised the fact that the term multimedia as a 'label' was recent however, historical applications of this multimedia concept were prevalent.

Forming a strong connection between comprehensive entertainment 'package' and Chiariglone's virtual-world based multimedia definition, Tescher provided the following historical examples:

- Theatrical presentation of a classical tragedy in ancient Greece
- Silent movie with an accompanying pianist in the early part of this century.

Further discussion of these two examples lead to the explanation that many of the elements modern observers of multimedia associate with multimedia applications can be found in historical entertainment packages. That is, these forms of entertainment provided the excellent sound, interactivity, and displayed a good synchronised environment.

This concept of a comprehensive entertainment package or virtual-world based multimedia also fits particular well with today's multimedia forms. Take for example modern blockbuster movies such as "The Mummy" (Universal Studios, 1999). This entertainment package demonstrates how real the virtual world experience can be received. Utilising several new technologies associated with modern multimedia, traditional real person involvement and realistic models in its production, this movie format recreates a "virtual world". Therefore, employing

both realistic representations and synthetics to generate realism can provide a virtual world that is perceived by the 'consumer' as a realistic experience.

6.3 MULTIMEDIA DEFINED

On reflection of both Chiariglone and Tescher views of multimedia it would be extremely difficult to ignore concepts based upon human experience or the historical technological considerations. Consequently, multimedia can be considered in terms of a 'world' perceived by the observer, utilising visual impulses, sound, tactile processes and fragrance (senses). Therefore, Tescher's definition of multimedia provides a particularly interesting definition: *"multimedia is the process of perception (real or virtual) as a result of the delivery of components affecting the human sensory process".*

6.3.1 Modern Multimedia

Multimedia as experienced by the human sensory system in today's environment is extremely similar to those experiences perceived by humans during the fore mentioned historical examples. Modern multimedia therefore follows closely the definition of the concept of an audio-visual system. With limitations resulting from the inability of most technologies to represent the other human senses of smell and, to a limited extent, touch (for an exception to this rule visit Disney World).

Referring back to the blockbuster movie example (see section 6.2.1: Multimedia Continuum) it is possible to elaborate on perception, from a general perspective, as experienced by a human prior to the delivery of components affecting the human sensory system. In the movie example, a form of entertainment that exhibits modern multimedia applications / technologies, it can be said that humans subconsciously prepare themselves for a virtual world experience. That is, the consumer of this experience positions him/her self for an audio-visual experience which cannot be obtained within his/her daily routines. When entering the movie house (or cinema) the consumer senses an atmosphere congruous to entering a virtual world. In this situation one could argue that this type of mental

preparation enforces the probability of maximising the experience in comparison to preparation of multimedia experienced in a working environment.

6.4 IMPLICATIONS FOR MULTIMEDIA USERS

Having reached the decision that multimedia is not a singular concept based solely on technological issues, but a process of perception resulting from experiences affecting the human senses, implications for users must now be considered.

Generally, multimedia needs to be continually developed and configured to advance the human sensory system. This process of development or evolution would aim to provide a virtual world experience that meets and even enhances the users' perceptions of the to-be multimedia experience. However, given technological constraints and the individuality of humans, such romantic ideals would prove extremely difficult if not impossible to achieve in today's pragmatic real world.

It is also worth noting that along side the fore mentioned multimedia continuum, conceptually, there may exist a human perception continuum. This conceptual notion would aim to demonstrate that the degree of human experience expected or perceived before encountering the virtual world varies in accordance to the relative position along the multimedia continuum. For example, when entering a room to conduct a video conferencing meeting one would probably expect a virtual world experience with limited use of the human sensory system compared to Universal Studio's 'Back To The Future' virtual world experience. Furthermore, real world conditions and experiences may also shape human perception of a 'to be' virtual world experience. Such considerations may include:

- Environment in which the virtual world experience will take place
- Frequency by which virtual world experiences are encountered
- Degree of virtual world expectation
- Degree of willingness to accept the virtual world experience

- Degree by which the human is prepared to 'let-go' of real world constructs, etc.

It is safe to assume that the above list is far from exhaustive. However, it serves its purpose of highlighting the extent of influence of individual perception in determining the level of multimedia experience. Technology, over time may reduce the gap between what is provided and that what is accepted (or expected) by the human sensory system. It could be stated, based on the concept of multimedia and human perception continuums co-existing, that if the multimedia medium is not configured to meet with human perceptions, the level of virtual world experience accepted would be greatly reduced. To use a quality term, 'deviation' between perceived and received experiences needs to be minimised.

6.4.1 MPS / DoT Multimedia Considerations

Multimedia is a process of perception as a result of the delivery of components affecting the human sensory process. It has also been suggested that these perceptions are extremely individualistic, and that the degree of perceptions associated with the multimedia experiences may be effected by such considerations as environment factors, expectations, frequency, etc. (i.e. context based). Thus, to contemplate development and / or configuration of a multimedia technology for the purpose of better addressing user perceptions of multimedia, an understanding of users' perceptions must be made determined.

6.4.2 User Perceptions: Practicalities

A larger number of individual multimedia technology users typically imply a larger number of diverse perceptions. To address all perceptions would prove to be extremely difficult given the real world constraints of time and money. However, identifying behaviourally homogeneous multimedia users with similar wants, needs and expectations would provide a more realistic solution. Having identified these behaviourally homogeneous groups, generalised perceptions may be

accessible through the use of cognitive mapping techniques. Generalised perceptions would then allow for the feasible development and / or configuration of multimedia technologies.

CHAPTER 7: IDENTIFYING USER VALUE

7.1 INTRODUCTION

Users (and customers) perception of value needs to be examined. Developing an understanding of this crucial point will allow for an approach to eliciting and organising user requirements in a manageable form. This section of the thesis concentrates on identifying perceived value.

7.2 PERCEIVED VALUE

There continues to exist a growing acknowledgement that how products and services perform, relative to customers' ideals and expectations, is the primary determinant of customer satisfaction. Drucker (1999) in his most recent publication: 'Management Challenges for the 21st Century', continues to emphasise the importance of understanding customers' perceptions of value if customer satisfaction is to be achieved and a business to succeed. Drucker states:

"The starting point has to be what 'customers consider value'. The starting point has to be the assumption – an assumption amply proven by all our experiences – that the customer never buys what the supplier sells. What is value to the customer is always something quite different from what is value or quality to the supplier. This applies as much to a business as to a university or to a hospital."

Drucker's statement may on occasion emphasise this deduced fact regarding supplier and customer perception of value rather extravagantly (i.e. never buys). However, such a polemic is not meant as a mere affable message, it is a powerful aphorism that has been proven to various degrees throughout time.

Drucker's view highlights the importance of what the customer of a product or service (whether internal or external) perceives as value or of a quality that meets with their ideals and expectations, in achieving customer satisfaction. To

achieve customer satisfaction, which is primarily associated with customer service, customer needs and what the customer defines as valuable must be determined. Having determined customer values it is these values that must define the product or service offered to the consumer or user.

7.3 CUSTOMER VALUE: CREATED ILLUSION

When dealing with what customers value or that what customers perceive as of a quality which encourages a purchase or service usage desire, caution must be exercised. Caution is necessary, as customers' values tend to be extremely diverse even within a behaviourally homogenous market.

Take for example, the situation where a manufacturer of a tangible product decides to better reflect customer needs through the objective of improved product functionality. In this situation improved functionality is known to be the number one desire of consumers within this product market place.

The first stage in the process of addressing customer needs tends to be the identification of what customers need (customer requirements). Members of a product development team interview users of the product asking them what is most important, to them, in terms of functionality, about the product they use (i.e. the products considered may not be from the same manufacturer). Each product user or consumer identifies those product attributes or functions that they consider important and can articulate upon. The collected product data are then aggregated and weighted relative to frequency of response, producing a prioritised list of what the customer requires.

This approach to identifying customer requirements is assumed to typify the voice of the customer. Its primary or underlying assumption is that there is one best answer for everyone. *"It functions as through there is one dominant attitude towards any given subject and regards differences as deviations from that normal attitude"* (Havener, 1993). However, what has actually been determined from

such an approach to better understanding customer values are requirements of an illusionary set of customers. This process of eliciting customer / user needs to determine perceived value is therefore based on unsound foundations. Aggregated data management has been allowed to dictate proceedings, compromising potential solutions.

As much as data management is important to organising and understanding customer requirements it should not play dominance to the process of determining perceived value. Further, it should not be assumed that an aggregated approach to data management aids achievement of requirements capture objectives. A recognition of diverse behaviourally inclined product / service users can lead to the realisation that disaggregated data management actually offers improved requirements capture possibilities.

7.4 BEHAVIOURALLY DEFINED CUSTOMERS

The skills required to accurately identify what the customer (or user) wants are based on the knowledges of psychology and sociology (Havener, 1993). It is with this recognition of humans and an understanding of their perceptions that can lead to the determination of customer value.

Consider the disaggregated data management approach to requirements capture. As an extreme definition, disaggregate as opposed to aggregate, recognises that each customer has a different set of perceived needs, ideals and expectations. However, for practical purposes, disaggregated means that within any behaviourally homogeneous market there exists groups of customers / users with significantly different set of wants. These groups of individuals represent attitudinally different segments within a common behaviourally defined market. What actually pleases one group may not necessarily please another.

Given this understanding it can therefore be stated that behaviourally homogeneous markets exist because products and / or services are created to

satisfy some human need. These needs may be perceived or perceived and expressed. Thus, products and / or services tend to be categorised into markets fundamentally based upon customer values. Furthermore, within each behaviourally defined market their tends to exist attitudinally different segments. These segments represent variations from the standard attitude that gains most recognition, and hence dominate the markets' characteristics.

7.5 ATTITUDINALLY DIVERSE SEGMENTS

Recognition of attitudinally diverse segments allows for the preparation to benefit from such phenomena. Assuming that customers or users are equal in terms of wants, needs and expectations only serves to increase the probability of reduced satisfaction.

By segmenting a behaviourally defined market into its attitudinally based groups either a focused approach can be adopted to address very specific needs, or an approach aimed at identifying common / shared needs can be utilised. Each approach however, requires the need to recognise variations in attitude and pro-actively take appropriate action to address the very different opportunities.

7.5.1 Advantages From Diverse Segments

Advantages of recognising attitudinally diverse segments as a opposed to attempting to improve customer / user satisfaction through typical collection of data on all possible candidates (i.e. aggregated data management) include:

- Possibility to address a larger audience or focus on specific segment needs
- Reduction in effort associated with data collection through pre-planning and well structured elicitation approach
- Recognition of attitudinal variations in values allows for improved satisfaction through well positioned product or service (leads to the position of being able to add to customer / user value)

- Seeks an understanding of customer / user perceptions as a posed to assuming historical assumptions about customers / users whom have dynamic needs.

7.6 NEEDS MATRIX

Shown in figure 7.1 is the basic structure of a Needs Matrix. This matrix allows for customer / user needs identified during researching each attitudinally diverse segment to be acknowledged in a manner that facilities decision making.

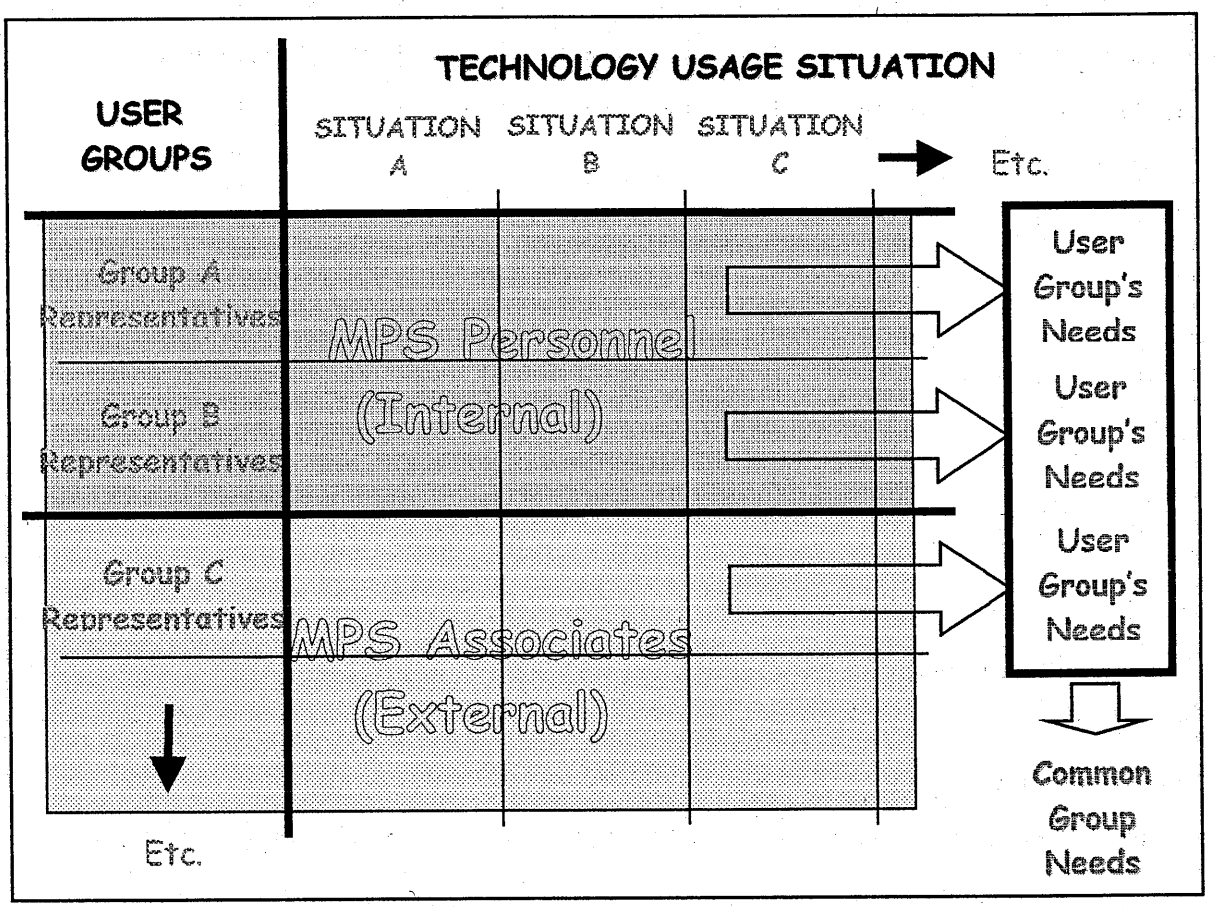


Figure 7.1: Basic Structure of a Needs Matrix.

Decisions associated with the Needs Matrix includes:

- Which user groups should be further analysed?
- From what technology usage situation should user group needs be analysed?

- Should common group needs be analysed further instead of specific user group needs or technology usage situations?
- Do the needs of each user group provide insights into immediate improvements possible for multimedia technologies?

CHAPTER 8: OBJECTIVE EVALUATION FRAMEWORK CASE STUDIES

8.1 INTRODUCTION TO CASE STUDIES

This section describes the results from two case studies conducted within the MPS, specifically working with users of multimedia technology. Each case study utilised an objective evaluation framework that recognises subjective requirements of users. The framework followed made use of either causal mapping or repertory grid technique to ascertain users' perceptions regarding the operation of technology. Once users' perceptions were obtained, an understanding of their technological needs were documented and employed as user requirements (or 'WANTs') within the quality function deployment (QFD) methodology. The QFD process facilitated an objective evaluation of subjective issues enabling the identification of technical specifications (or HOWs) that help satisfy users' perceptions of multimedia technology.

The first case study examines the use of causal mapping in conjunction with QFD to elicit and analyse users' perceptions regarding video conferencing technologies. The causal mapping technique was chosen as the primary phase of the framework, as it was believed this technique allowed behaviourally homogenous groups of users to be examined. These user groups effectively had varying video conferencing needs however, utilised similar technology. Thus, after examining users' perceptions regarding video conferencing technology, objective evaluation of those needs could be undertaken within a QFD model and conclusions drawn.

The second case study employed repertory grid technique to elicit a user's perceptions of ideal technology factors within phase one of the overall framework. Following phase one, again similar to the first case study, QFD can be employed to model subjective WANTs against technical HOWs and provide objectivity. This stage has however not be undertaken to the same extent as case study one, as QFD has been full explored. Repertory grid technique was

selected as the primary phase because this particular cognitive mapping technique was theoretically better suited for eliciting users' perceptions of numerous technology types. Conclusions are reported from actual case study experiences.

8.2 CASE STUDY RATIONALE

The use of MPS based case studies allowed for the validation of the objective evaluation framework with subjective impact. Furthermore, these case studies provided an excellent opportunity to demonstrate the framework as a business process applicable for use within the MPS.

The first case study, video conferencing example, details the operation of the complete framework while focusing on causal maps as the chosen phase one tool. Thus, having presented in detail the overall framework the second case study undertaken provides an opportunity to present repertory grids as a first phase tool.

8.3 VIDEO CONFERENCING CASE STUDY AIMS

The aim of the case study was to test the ability of the overall framework. This requirement would be satisfied if the framework could demonstrate the ability to examine both subjective and objective issues associated with the selection and use of multimedia technologies. Therefore, the results focused on both an understanding of subjective issues and an objective evaluation of technical specification to address users' quality requirements.

Another important aim of this particular case study included the suitability of causal mapping as an initial technique to elicit users' perceptions. The use of causal mapping required an interview to be conducted with representatives from different video conferencing user groups. However, it was not known at this early stage if the various individuals would respond in a manner that facilitated the effective production of causal maps. It was thus realised that an

interview would be deemed unsuccessful if understanding of users' technological needs were not obtained.

8.4 RESULTS FROM VIDEO CONFERENCING CASE STUDY

Interviews with six users of video conferencing technology were conducted over a four-week period. From these six interviews three were deemed suitable for further analysis using the objective evaluation framework with subjective impact. The interviews allowed for the identification of subjective issues. These subjective issues were considered personal to the three individual interviewees (or respondents). It was determined that subjective issues identified from this representative sample of multimedia users were acceptable for explanatory purposes. There was also recognition that each sample interviewee represented the subjective needs of a particular video conferencing user group with its own identifiably behavioural characteristics. Thus, for the video conferencing user groups shown in figure 8.1, an understanding of their specific user requirements (or subjective issues) arising from representative user experiences could be made explicit and addressed.

Analysis of the qualitative data collected from each respondent (see appendix D) enabled common constructs to be identified for each user group[1]. These constructs are provided in appendix D. Associated ratings were also determined given an informed understanding of each user groups' behavioural characteristics (see appendix D). Additionally, equipment specifications for each video conferencing system are documented in appendix D. Results from a system evaluation questionnaire completed by MPS / DoT representatives are also provided. MPS / DoT representatives produced these results independent of the objective evaluation framework for the purposes of analysing video conferencing system functionality and value for money.

[1] Only internal MPS video conferencing user groups provided sufficient data suitable for analysis and validation of the objective evaluation framework with subjective impact.

Results from the completed video conferencing case study include the following points listed below.

1. Common video conferencing requirements among police and civil representative of the MPS include:
   - Needs for available support from video conferencing suppliers
   - Initial training for all users of video conferencing technology
   - Familiar operating procedures, minimising re-configuration through default settings
   - Video and audio quality comparable with standard television equipment.

Addressing these common requirements is desirable if both police and civil video conferencing issues are to be improved simultaneously.

2. If either police or civil video conferencing issues are to be addressed separately, the relevant requirements can be taken from relevant 'user groups' categories and subjected to phase two of the objective evaluation framework. Segmented 'user groups' provide the necessary focus to ensure subjective impact is experienced when assessing technological possibilities.

3. It is also possible to address specific situational based user needs. For example, from figure 8.1 both police and civil representatives' 'Additional' situational needs could be analysed in more depth using the latter stage of the proposed framework.

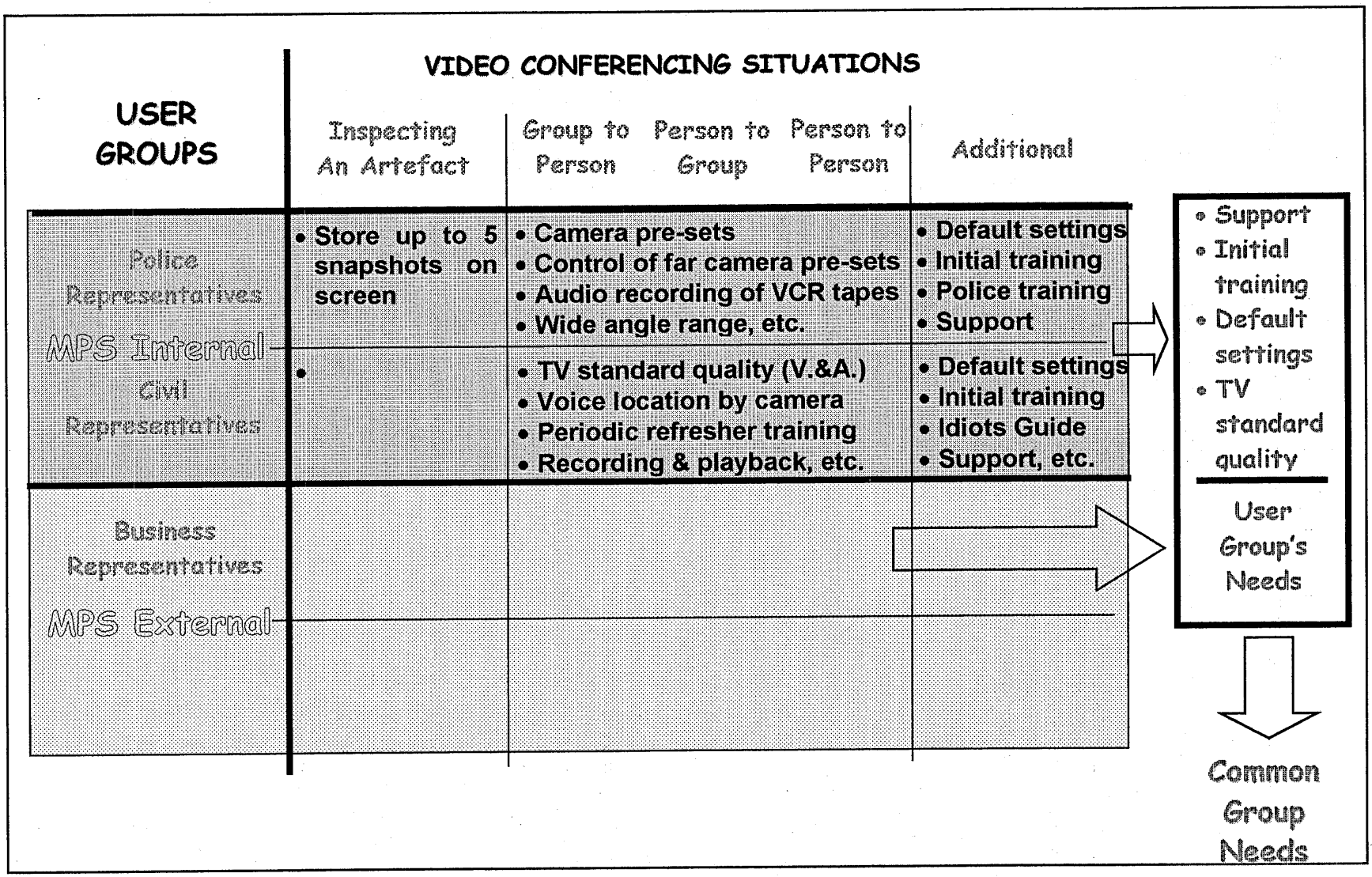


Figure 8.1: Video Conferencing User Group Segmentation Matrix (Needs Matrix)

8.4.1 Video Conferencing User Example

Respondent 'A' was a contract manager within the MPS transport division, consisting of a team of all civilian employees. This department had responsibility for the purchase, query and sale of a diverse range of police vehicles. All work entailed managerial and administrative tasks associated with ensuring police vehicles meet defined specifications stipulated by health and safety standards, policing regulations and the requirements of users. Any technical modifications that required physical work such as fitting bullet proof glass, up-grading engine parts, etc. was carried out by a recognised contractor.

Through a common need for frequent administrative and contractor communication, video conferencing facilities were made available. These facilities were however, at the time of the case study, considered temporary. As a result of this temporary arrangement certain unnecessary features visible within the video conferencing room were tolerated, and thus omitted from the study's results.

8.4.1a Constructs

Qualitative data was elicited during a 1 to 1.5-hour interview. This interview was planned based on information obtain from literature about the Theory of Personal Constructs (see Kelly, 1955), and a cognitive interview demonstration provided by several police artists. These police artists were trained in cognitive interviewing techniques and often utilised their skills when constructing facial depictions (electronic images) from data provided by witnesses of a crime.

Several questions were also developed before the interview took place. These questions were necessary to ensure that the respondent would focus their attention on providing data that reflected personal views and experience. Thus, these questions attempted to help the respondent remember or visualise the various situations they encountered when using video conferencing equipment.

Provided within appendix D are completed data collection packs used during each interview. The respondents' names have been omitted. However, all other data is presented. The main constructs identified for respondent 'A' are shown below in table 8.1.

	PERSONAL CONSTRUCTS
1	Familiar Operating Procedures
2	Minimum Set-up Effort
3	Video Quality
4	Audio Quality
5	Voice Location of Person Speaking (camera options)
6	Fixed Camera Position of V.C. Connected Participates
7	Recording and Playback of V.C. Meetings
8	Idiots' Guide (bullet point information)
9	Periodic Refesher Training
10	Support Availability

Table 8.1: Elicited Personal Constructs from Causal Maps for Respondent 'A'

8.4.1b Behavioural Profile

A behavioural profile as inferred from the causal maps was also documented and is presented below. This text based description aims to help gain an additional understanding of the behavioural characteristics for the user group. Having gained this understanding informed discussions could take place that reflects users' needs and expectations. Thus, the process of developing causal maps and a behavioural profile acts as a decision support tool resulting in greater understanding of users' perceptions regarding a particular multimedia technology.

Inferred Behavioural Profile:

For this user video conferencing technology is seen as providing increased flexibility. This flexibility is considered personal, as there is a choice associated with the use of video conferencing. That is, this particular person now has the option, given due consideration, whether to travel to their major contractor or conduct a meeting via video conferencing. Due consideration includes concerns regarding unproductive travel time, deteriorated personal appearance after travelling for several hours, extent of preparation and carrying restrictions. The effects of time spent travelling to the exclusion of office based work for that particular day is a major concern. Video conferencing is also considered another form of personal communication ("fact-to-face") complimenting the current options that exist.

While other video conferencing users may be interested in alternative set-up configurations, this user feels most comfortable with re-occurring experiences, which over time become familiar operations. When preparing for a video conferencing meeting there is an expectation that the equipment is in the same condition as previously experienced. Even though the user has some degree of understanding regarding video conferencing set-up options (i.e. re-configure camera angle, etc.) the expectation that the system offers 'no surprises' provides a 'certain degree of control'. The facility to conduct business meetings in a familiar environment with very little technical re-configuration needed (i.e. adjusting the equipment) is a major part of this users perception of a good video conferencing experience.

Considering the personal constructs documented in table 8.1 and the behavioural profile, each construct can be rated from the respondent's perspective. A scale of 1 to 10 was used, were 1 represents the less important issues and 10 the more important issues. This procedure of rating constructs will guide decision making by prioritising desired video conferencing attributes. The scale and rated constructs are presented below in figure 8.2.

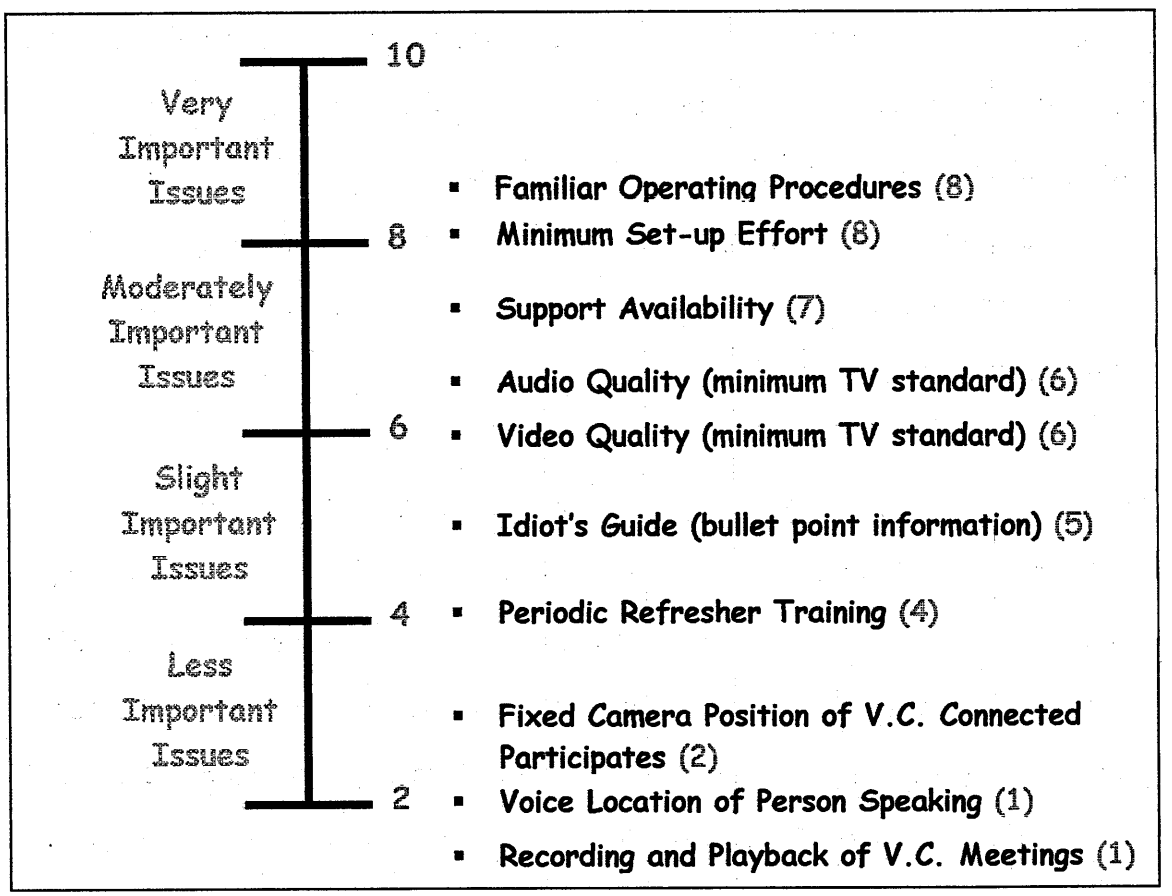


Figure 8.2: Desired Video Conferencing Attributes with Associated Ratings

8.4.1c QFD Analysis

Findings from the completed quality function deployment model for respondent 'A' can be found in appendix D. These findings are graphically depicted and provide an excellent method of reference to aid final decision-making. It is also beneficial to produce text-based results with sections taken from the graphical

QFD findings to better disseminate important aspects of this analysis. For example, further text-based information elaborating on the graphical findings for technical considerations is necessary. It should also be noted, that the QFD model shown in appendix D has been developed to address specific user needs. Technical features that are considered prerequisite video conferencing requirements are not included in this analysis. These prerequisite requirements are not necessarily major findings or results. Thus, presenting results without prerequisite video conferencing features aim to improve clarity and help emphasise priority considerations.

From reference to the initial QFD model completed for respondent 'A' several prerequisite video conferencing features are identifiable and can be eliminated from explanatory text-based result. These prerequisite features are presented in table 8.2.

Concentrating on the non-prerequisite user requirements that were identified by respondent 'A' and commenting upon the results of these priority considerations, several remarks can be made. These remarks will be presented in four stages before an overall concluding remark. Examining results in this manner is believed to aid understanding the meaning of each remark and sequential development of QFD findings.

The results from each QFD analysis stage are as follows:

1. Relationship Matrix

   The relationship matrix shows that all of the user's requirements (or WANTs) can potentially be addressed by some combination of technical specifications. Furthermore, all technical specifications affect several user requirements to varying degrees and therefore, should be considered in relation to the rated importance of each WANT. A specific example is discussed next.

PRODUCT SPECIFICATIONS	
1	Default Settings:
	Automatic Noise Suppression (audio)
	Automatic Gain Control (audio)
	Automatic Voice Optimised Speakers
	Automatic Near-End Mute Facility
	Automaticsensing of Power Supply
2	Video Attributes / Features:
	Picture-In-Picture Windowing Option
	Standrad VCR Recording & Playback Capability
3	Audio Attributes / Features:
	Full-Duplex Automatic Echo Cancellation
4	Camera Attributes / Features:
	Auto Focus (distance, field of view, pan & tilt)
	Zoom Range (distance from V.C. unit)
	Automatic Voice Located Camera
	Automatic Camera Exposure
	Camera Presets (near-end, far-end, etc.)
5	Document Camera Attributes / Features:
	Image Capture & Display (min. 310 x 230)
	Automatic / Manual Zoom & Display Facility
	Automatic / Manual Focusing & Display Facility

Table 8.2: Prerequisite Video Conferencing Requirements

If a video conferencing system is certified with the H.320 Video/Audio ISDN Standard and configured to FCIF (high-resolution) capacity, the user's requirement for 'image quality' would be satisfied. This understanding is graphically depicted in figure 8.3 below, by the black solid circles and their position within the matrix.

This initial stage of QFD model is extremely useful in ensuring that subjective user requirements are present and considered within the objective evaluation matrix.

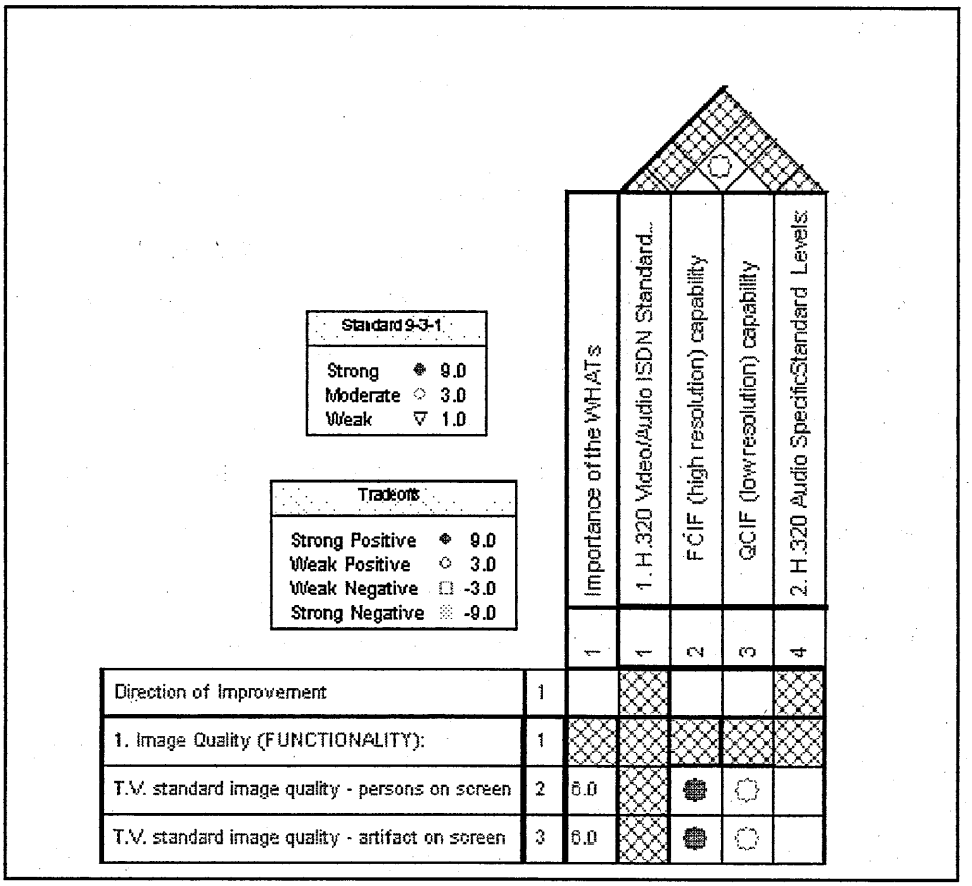


Figure 8.3: Relationship Matrix Analysis of Image Quality (insert)

2. Correlation Matrix

The correlation matrix shows that strong (or positive) interrelationships exist between the majority of technical specifications for Standard Compliance / Capability, Network Capability and Product Specifications (HOWs 1 to 31, see QFD model). Additionally, several negative interrelationships are apparent. An awareness of these negative interrelationships is important for trade-off decisions between technical specifications. There also exists a degree of interrelationships within Support Services' technical specifications

(HOWs 32 to 40). However, there are no interrelationships between these two enlarged groupings of technical descriptors (HOWS 1 to 40).

This trade-off matrix helps develop a thorough understanding of the technical feasibility of product configurations given the diverse specifications available within video conferencing systems.

3. Competitive Assessments and Prioritised User Requirements
   From conducting a competitive assessment of the currently utilised video conferencing system and alternative systems, an understanding of how each users requirement is being addressed is achieved. Figure 8.4 presents a graphical representation of the user's perception and how satisfactory each WANT is being addressed by the current video conferencing systems and two competing systems. As can be seen from the QFD line diagram, the PictureTel Swiftsite system would better satisfy the overall perceptions of respondent 'A'. Referring to the numerical parts of this figure, it can also be concluded that none of the video conferencing systems examined achieve the target attribute values for all user WANTs. For example, improvement is possible for the user requirement of 'idiot's guide to operation provided in bullet form'. The competitive assessment also provides identification of those user requirements that are satisfied beyond the necessary levels to meet with the user's perceptions. Recognising this information, technical specification trade-offs can be undertaken with greater confidence.

Direction of Improvement		Competitive Analysis	Current Product: Sony 5100	Competitor 1: Sony 3000	Competitor 2: PictureTel Swiftsite	Target Product Attribute Values	Scale-Up Factor	Max = 5.0 ○ Current Product: Sony 5100 ▒ Competitor 1: Sony 3000 ● Competitor 2: PictureTel Swiftsite Min = 0.0	Absolute Weight for V.C. User	
		1	2	3	4	5	6		8	
1. Image Quality (FUNCTIONALITY):	1									1
T.V. standard image quality - persons on screen	2		3.0	3.0	4.0	4.0	1.3		8.0	2
T.V. standard image quality - artifact on screen	3		3.0	3.0	4.0	4.0	1.3		8.0	3
2. Audio Quality (FUNCTIONALITY):	4									4
T.V. standard sound quality (minimum ref. level)	5		4.0	3.0	4.0	4.0	1.0		6.0	5
Minimised background sound across V.C. link	6		4.0	3.0	4.0	4.0	1.0		6.0	6
3. Camera Options (FUNCTIONALITY):	7									7
Automatic voice location of person/s speaking	8		5.0	5.0	5.0	5.0	1.0		1.0	8
4. Recording & Playback Quality (FUNCTIONALITY):	9									9
T.V. standard image quality from recordings	10		3.0	3.0	3.0	4.0	1.3		1.3	10
T.V. standard sound quality from recordings	11		4.0	3.0	4.0	4.0	1.0		1.0	11
1. Support Availability (USER SUPPORT):	12									12
Idiots guide to operation provided in bullet form	13		0.0	0.0	0.0	4.0	4.0		20.0	13
Access to external video conferencing support	14		3.0	3.0	4.0	4.0	1.3		9.3	14
2 Training Availability (USER SUPPORT):	15									15
Initial video conferencing usage training	16		4.0	4.0	4.0	4.0	1.0		4.0	16
Access to perodic 'refresher training'	17		0.0	0.0	0.0	3.0	3.0		12.0	17

Figure 8.4: Competitive Assessment & Priority User Requirements (Insert)

Overall, the competitive assessment and prioritised user requirements stage provides both graphical and numerical data to aid decision-making. This data also focuses on user requirements and provides objectivity.

4. Technical Competitive Assessment and Prioritised Specifications

   Technical assessment and prioritised specifications allow for the identification of technical specifications that are most needed to fulfil the user's requirements or need improvement. As a result of this stage specific objectives are determined from the numerical measurements, which are then used to guide the production of a specification list.

   For the purposes of addressing respondents' requirements and implementing video conferencing re-configurations this stage of the QFD model can be undertaken. However, as the purpose of this particular case study is explanatory, while providing demonstration of the framework, this QFD stage has been only partially completed.

8.4.1d Video Conferencing User Example Overall Concluding Remarks

From completing the overall framework (i.e. both phase one and phase two plus interim stages) of the video conferencing case study for respondent 'A', several concluding remarks can be stated. These remarks focus on technological and support issues realised from the objective analysis of subjective user requirements. Each remark is categorised below and is presented in order of importance.

1. Support Service

   According to the user's importance of WANTs 'access to external video conferencing support' can be addressed by utilising a video conferencing system that offers the following associated services:

   - 90 days free telephone based support
   - Maintenance and short term support (minimum 1 year)
   - Online manual / support / help facility
   - Paper based / quick reference guide.

Currently, the PictureTel Swiftsite offers the most compatible service to meet the user's perception of access to external video conferencing support. However, considering the other Support Service requirements large improvement could be achieved, especially in terms of providing an idiot's guide and access to periodic refresher training.

2. Image and Sound Quality

If respondent's 'A' perception of image and sound quality is to be satisfied a combination of Standards Compliance / Capability and Network Capability must include such technical specifications as:

- H.320 Video/Audio ISDN Standard
  - FCIF (high resolution) capability
- H. 320 Audio Specific Standard Levels
  - G.728 compatible
- Good Video/Audio Synchronisation (lip synch)
- Bandwidth Availability (fps):
  - ISBN based range 15 to 30 fps
- Transmission Speeds (Kbps):
  - 128Kbps to 384Kbps.

The above list of Standard Compliance and Network Capability specifications was also a high priority consideration during QFD evaluation. This priority association is derived from the user's importance of WANTs (i.e. second highest priority rating within the QFD model). From investigating standards compliance the overarching video/audio ISDN standard, H.320 was identified as having several levels. These levels, shown in table 8.3, offer alternative configuration possibilities for video conferencing manufacturers, providing trade-offs between quality and cost. Therefore, to satisfy respondent's 'A' perception of quality the QFD model recognises that a video conferencing system, which supports the highest H.320 standard

compliance (i.e. FCIF and G.728), is best suited to address stated user needs.

Audio Format	Transmission Bandwidth (Kbps)	Dynamic Bandwidth (Hz)
G.711	64	300 - 3,400
G.722	56	50 - 7,000
G.728	16	300 - 3,400
Video Format	Luminance (Pixels, Horizontal & Vertical	
QCIF	176H x 144V	
FCIF	352H x 288V	

Table 8.3: Video Conferencing H.320 Video/Audio ISDN Standard

3. Recording & Playback Quality

   Several technical specifications have been identified as being strongly related to achieving improved recording and playback quality for respondent's 'A' needs. However, by referring to the QFD model it is possible to notice that these technical specifications are very similar to those highlighted for image and audio quality. Thus, addressing image and audio quality technical specification would also lead to improve satisfaction levels associated with recording and playback quality. Again, the PictureTel Swiftsite video conferencing system currently offers the better technical configurations to meet these user needs.

8.5 VIDEO AND AUDIO LABORATORY CASE STUDY AIMS

The aim of these case studies was to test repertory grids as a phase tool within the overall framework. Similar to the video conferencing case study, the aim of

these case studies would be satisfied if the framework examined subjective user issues and provided an opportunity to objectively analyse these quality requirements.

Having, presented the results obtainable from QFD analysis (or phase two) specific benefits are presented for repertory grids as an opposed to the overall framework.

8.6 RESULTS FROM VIDEO & AUDIO LABORATOY CASE STUDY

Interviews were conducted with one representative from both video and audio forensic laboratory facilities. These interviews required two meetings with both representatives. The first set of meetings allowed for an understanding of the sequential operations undertaken during forensic examination of video and audio formats. A documented understanding of the audio forensic operations is provided in appendices E. The second set of meetings entailed structured interviews to elicit user perceptions regarding the operation of multimedia technology, relevant to their role with the MPS.

During both video and audio case study interviews an emphasis was placed upon the fact that repertory grid technique was being examined as a phase one tool. Therefore, explanatory case studies were necessary. These case studies were however limited by time and security restrictions. Thus, reductions in terms of content covered during elicitation of user requirements were enforced. Reductions can be summarised as follows:

1. Access to only one representative from both video and audio forensic operations.
2. A 5 x 5 repertory grid for structuring elicited user perceived needs was utilised.

Results from this examination of repertory grid within the overall objective evaluation framework are provided below in point form:

1. Five user defined audio recording device characteristics were elicited. These characteristics represented both technical and non-technical specifications, which if included in a new audio recording device would enhance the recording of undercover police operations.

2. Audio quality requirements identified as important include dynamics and frequency response. Thus, using quality function deployment to analysis the feasibility of achieving defined quality needs, dynamic and frequency response values of 80dB; 20Hz – 20KHz are advocated as ideal.

3. Recording length findings showed that a NAGRA SNST recorder offered the best option with a recording time of 2.5 hours. However, discussions about the Sony Scootman, which was rated with a value of 2, presented some additional interesting findings. For example, using digital technology and cassette storage media, the Sony Scootman employs a small buffer memory facility when automatically reversing the cassette to record on the opposite side. This design feature allows for a seamless turnover, and enables 2 hours of non-stop recordings.

4. Costs of audio recording devices vary drastically. Conventional micro cassette devices range from £50 to £100 plus, while the Sony Scootman costs around £800 and NAGRA equipment cost above £3,000. By including this cost information within phase two of the framework, it becomes possible to analysis cost differentials between technical specifications. For example, analysis of the micro cassette cost against user defined technical characterises quantifies exactly 'what you get for what you pay for'.

5. Ease of loading requirement identified Minidisk and conventional micro cassette audio recorders as having preferred loading mechanisms, given the choice from three other options. These two recording devices can be analysed in more depth using QFD to determine specific requirements that related to the loading facility.

8.6.1 Audio Laboratory User Example

Respondent 'E' was head of the audio forensic laboratory responsible for a small team of audio examination experts. Audio based information submitted by an officer of the law is examined by the forensic laboratory team for the purpose of determining if one of three possible post-processing services can be realised. These three post-processing services are as follows:

- Written transcriptions
- Witness statements and expert evidence in court
- Court playback.

A fundamental requirement to successfully producing audio based information suitable for one of the three post-processing services, is that the audio recording device captures suitable data. Examining one of today's commercially available digital recording devices developed for audio purposes can highlight an example of this fundamental requirement.

Minidisc players and Minidisc recording medium offer new possibilities for recording audible data. Utilising digital recording technology based on the MPEG-4 standard, Minidisc devices provide superb recording quality of perceptually noticeable sound. However, for perceptually inaudible data that can be enhanced by audio forensic techniques enabling the human ear to detect such signals, Minidisc devices do not record this data.

Minidisc devices developed based on the MPEG-4 digital audio standard embrace Auditory Making coding technology. A frequency domain phenomenon

where a low-level signal (maskee) can be made inaudible (masked) by a simultaneously occurring stronger signal (masker) is called 'Simultaneous Masking', and this occurs on all Minidisc devices. Figure 8.5 below briefly illustrates the principle of masking.

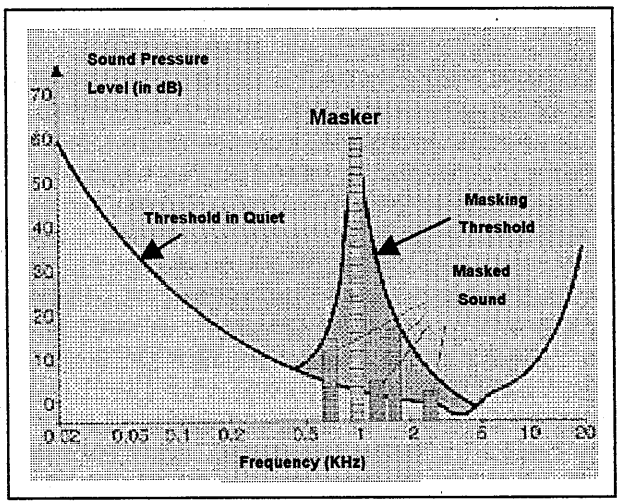


Figure 8.5: Sounds masked by Masking Threshold (Noll, 1997)

During recording of possible evidence on an undercover operation, if a stronger less important signal is simultaneously identified along with a weaker group of important audible signals, the Minidisc device will only record the stronger sound. Using terminology often disclosed within the audio laboratory, Minidisc recorders have 'limited intelligence'. That is, no enhancement of background sounds or perceptually inaudible (to the human ear) signals is possible, as these signals are not recorded on Minidisc devices. Thus, audio laboratory post-processing services cannot be performed. For undercover operations Minidisc devices offer limited capabilities.

The above Minidisc example demonstrates that audio forensic experts know of technical characteristics that have a direct impact upon the successful collection of audio data. This awareness is obtained from years of experience working with such technologies.

It is well known within the MPS / DoT that such expertise can contribute to the selection and development of technical specifications (solutions) to facilitate the objectives of functional operational areas. Thus, subjective issues associated with the users of operational technologies cannot be ignored, as their contribution will help obtain the fundamental technical requirements to ensure operational success.

8.6.1a Constructs

A limited quantity of qualitative data was elicited during a one-hour interview. The interview was based on a marketing approach to repertory grid technique. Primarily, repertory grids allowed for the elicitation of technology equipment used for recording audible signals during a surveillance police operation. Five recording devices (or pieces of equipment) were elicited and documented as 'elements' within the 5 x 5 repertory grid.

Random combinations of three elements and a pre-determined question enabled the identification of five desirable technological characteristics that audio recording devices, used in undercover operations, should include. These five technical characteristics represented respondent's 'E' personal constructs.

Provided in appendix E are completed data collection packs used during repertory grid interviews. For security reasons respondents' names have been omitted. However, all other data is presented. Five constructs identified by respondent 'E' are noted below in table 8.4.

	PERSONAL CONSTRUCTS
1	Dynamics
2	Frequency Response
3	Recording Length
4	Recording Device and Media Cost
5	Ease of Loading Media

Table 8.4: Elicited Constructs using Repertory Grids for Respondent 'E'

8.6.1b Repertory Grid Data Analysis

Using the element ratings provided by respondent 'E' for each construct, it is possible to identify combinations of user defined technical characteristics / specifications. These audio recording device characteristics are not currently available within one technology. One possible characteristic list taken from the Repertory grid data is shown in table 8.5 below.

User Identified Requirement	Technical / Non Technical Characteristics
Dynamics	80dB
Frequency Response	20 to 20,000Hz +/- 1dB
Recording Length	2.5 Hrs
Device & Media Cost	£50 - £100
Ease of Loading	N/A

Table 8.5: User Identified Requirements and Characteristics

With these user-defined details it becomes possible to test the feasibility of achieving such characteristics within one audio recording device. QFD provides the necessary structure to check the feasibility of certain combinations (interrelationships) of specifications within the correlation matrix. However, before considering QFD these user-defined specifications are reviewed to determine if QFD analysis is necessary and possible. Table 8.6 examines the specifications identified in table 8.5, providing information regarding suitability for QFD analysis.

User Identified Requirement	Highest Rated Element	Selected Element	Technical Specification	Suitable For QFD Analysis
Dynamics	No.2 & No.5	JBR	80dB	Yes
Frequency Response	No.2 & No.4	Mini Disk	20 to 20,000Hz +/- 1dB	Yes
Recording Length	No.1	SNST	2.5 Hrs	Yes
Device & Media Cost	No.3	Micro Cass.	£50 - £100	Yes
Ease of Loading	No.3 & No.4	Mini Disk	(Rated by user)	Yes

Table 8.6: Pre-QFD Analysis Check of User Requirements and Specification

8.6.1c QFD Analysis

Further analysis of the technical specifications identified by respondent 'E' can be undertaken within phase two of the objective evaluation framework with subjective impact. However, as a very limited amount of data was collected the completion of the QFD model would not provide much additional benefit. Before, further analysis is undertaken it would be preferred if other constructs were elicited and related to specifications. Additional specifications would provide a more complete understanding of technology characteristics and allow for improved QFD analysis.

8.7 SUMMARY

This chapter has presented results from two of the three case studies carried out within MPS. Results from these case studies have demonstrated that subjective user requirements can be recognised and further analysed within an objective evaluation framework. Altogether, the results from the case studies covered the testing of the complete framework, that is, phase one and two while giving consideration to those intermediate stages. The final chapter, chapter nine, will present specific conclusions and discussions regarding the development of the objective evaluation framework with subjective impact.

CHAPTER 9: DISCUSSIONS AND CONCLUSIONS

9.1 INTRODUCTION

This chapter presents discussions and conclusions for the complete research. The Research Findings section focuses on the objective evaluation framework with subjective impact and business process considerations. However, before this a Lessons Learnt section presents important learning experiences. Limitation and Issues of Concern are discussed. Implications are examined. Conclusions regarding the development of an objective evaluation framework with subjective impact are also documented.

9.2 LESSIONS LEARNT

Many lessons have been learnt during the undertaking of this research project. The skills necessary to complete a thesis have been practised and experience gained from their use noted for further exploitation. Extensive industrial and commercial contact was experienced during the lifetime of this research work. Such interaction provided an environment that allows a post-graduate researcher to absorb those pragmatic issues external of most academic institutions.

Development of an objective evaluation framework that recognises subjective requirements of multimedia technology users was particularly challenging. This challenge was extremely educational. The importance of knowing user (or customer) requirements was realised. Recognition of users' desire to help define technology specifications was also beneficial to witness. Practitioners' knowledge and willingness to explain their field of expertise can only be described as fascinating. Such practitioners provide a great source of information presented, most often, in an interesting and informative manner.

Objective analysis of requirements may, on first occasion, seem a long arduous process for determining and gaining a better understanding of user needs.

However, this process once started takes on a momentum that facilitates its completion. During this time great satisfaction is generated as ones knowledge of opportunities to achieve users requirements is realised. Two outcomes from this process are; objective findings, and personal satisfaction associated with knowing hard work pays dividends.

9.3 RESEARCH FINDINGS

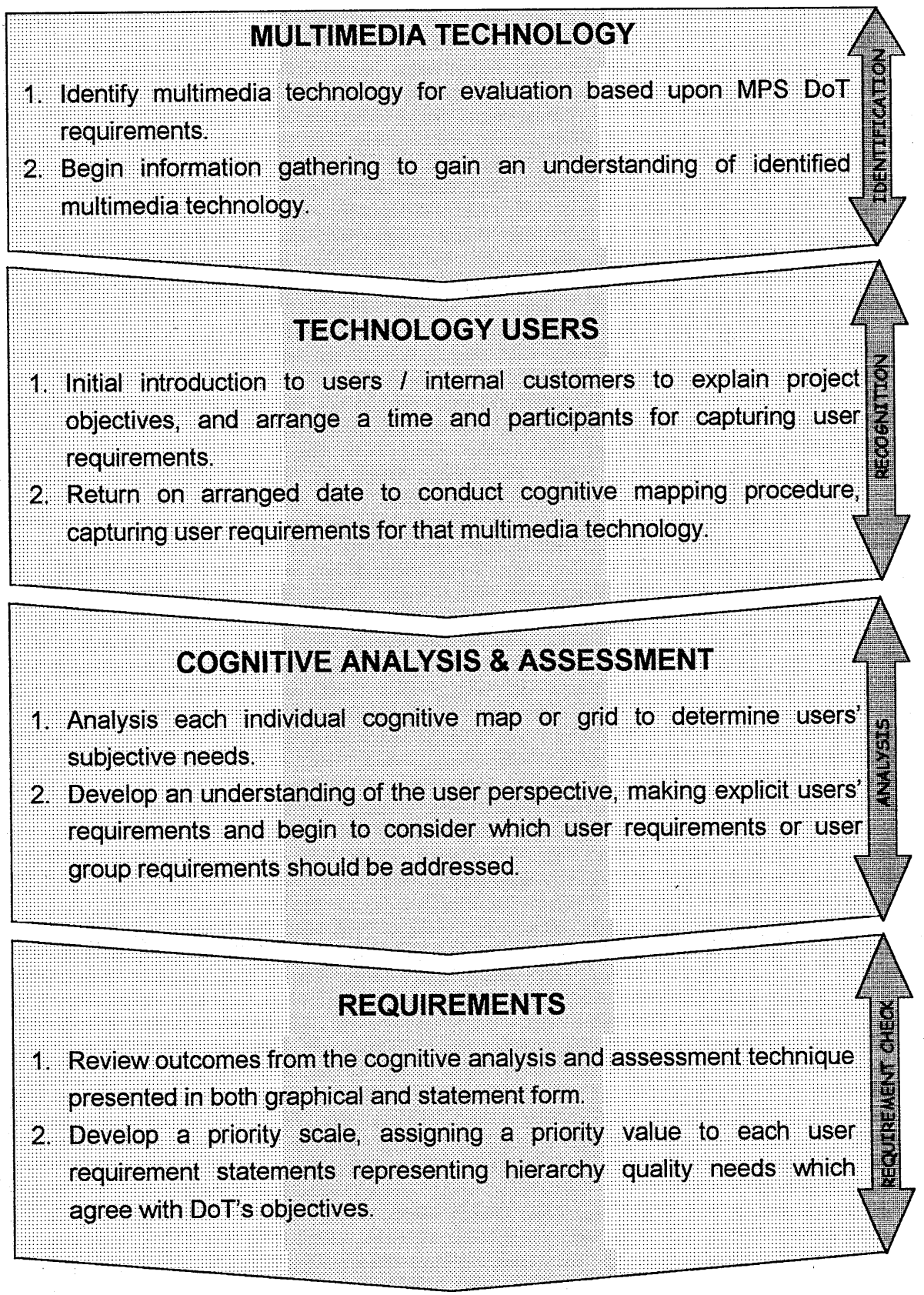
The aim of the research was to develop an objective evaluation framework with subjective impact. Additionally, three objectives required from the project were:

- Provide a business process for evaluating multimedia technologies in a way that is repeatable and unbiased
- Provide a sound foundation that accounts for the typical user of multimedia technologies
- Aid towards increased user satisfaction and confidence.

Achievement of the research aim was successful. This success was realised through generation, validation and documentation of an evaluation framework for multimedia technology that recognises objective and subjective requirements.

9.3.1 Results

The objective evaluation framework with subjective impact is provided over leaf. Within this framework a business process structure is identified (see text placed in each arrows at different stages of the framework).


MULTIMEDIA TECHNOLOGY
1. Identify multimedia technology for evaluation based upon MPS DoT requirements.
2. Begin information gathering to gain an understanding of identified multimedia technology.
IDENTIFICATION
TECHNOLOGY USERS
1. Initial introduction to users / internal customers to explain project objectives, and arrange a time and participants for capturing user requirements.
2. Return on arranged date to conduct cognitive mapping procedure, capturing user requirements for that multimedia technology.
RECOGNITION
COGNITIVE ANALYSIS & ASSESSMENT
1. Analysis each individual cognitive map or grid to determine users' subjective needs.
2. Develop an understanding of the user perspective, making explicit users' requirements and begin to consider which user requirements or user group requirements should be addressed.
ANALYSIS
REQUIREMENTS
1. Review outcomes from the cognitive analysis and assessment technique presented in both graphical and statement form.
2. Develop a priority scale, assigning a priority value to each user requirement statements representing hierarchy quality needs which agree with DoT's objectives.
REQUIREMENT CHECK

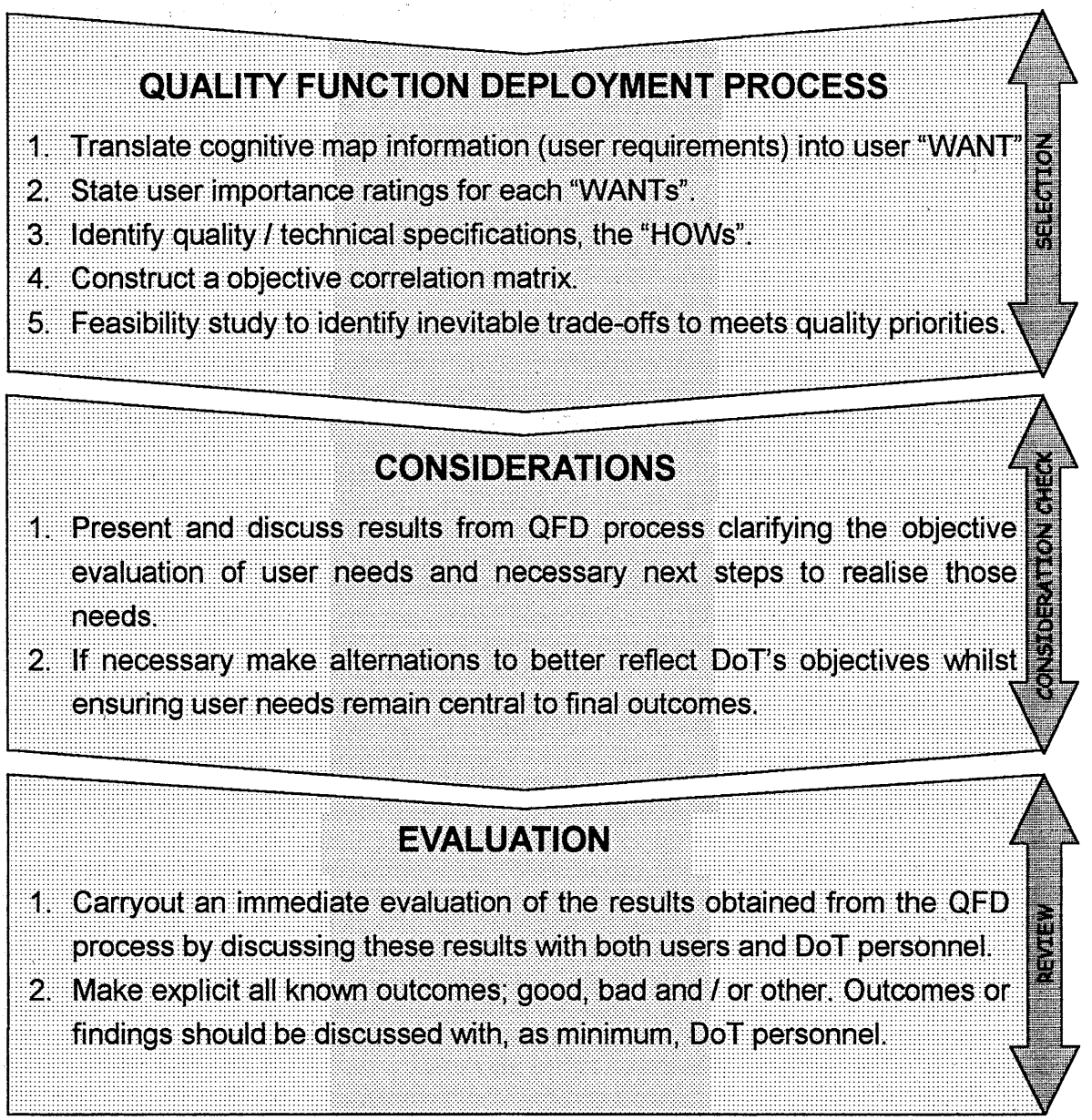


Figure 9.1: Objective Evaluation Framework with Subjective Impact: Business Process

This framework allows for the objective analysis of any multimedia technology currently used within the Metropolitan Police Service. Two generic classifications of multimedia technologies were identified during the research project. These are:

1. Multimedia technologies that have several user or user groups, each with various primary objectives (or goals) for its operation (for example, video conferencing technology users).
2. Multimedia technologies that are utilised by users or user groups who have an identical but specific primary objective for its use (for example, video and audio forensic laboratory technology users).

Whether using the framework to evaluate either multimedia classification (as noted above) subjective user requirements are given full consideration using cognitive mapping techniques during the business process stage: Analysis. These subjective issues are then objectively analysed from the users' perspective during the business process stage: Selection. Thus, ensuring user defined quality issues are addressed facilitates user satisfaction and confidence.

9.4 DISCUSSION: BUSINESS PROCESS CONSIDERATIONS

The development of an objective evaluation framework with subjective impact required that certain techniques and tools were selected and employed to facilitate the purpose of the framework. For example, quality function deployment was selected as a technique to quantify subjective user requirements and provide objectivity in their analysis. Thus, the framework has been developed, validated and documented based on certain techniques and tools that facilitate a business requirement applicable within the MPS.

Examining the framework's business process stages it is possible to demonstrate, logically, those techniques and tools utilised within it. Table 9.1 outlines techniques and tools employed within the framework and their relevance to business process stages. It should however, be noted that there is no distinctions being made between methodologies and techniques. This results from the desire to maintain a simple discussion.

Business Process Stages	Techniques (Methodologies)	Tools
Identification	Questioning	
Recognition	Explanation & Cognitive Mapping	Causal Maps or Repertory Grids
Analysis (subjective)	Disaggregated Data, Cognitive Mapping	Needs Matrix - Causal Maps or Repertory Grids
Requirements Check	Discussion	
Selection (objective)	Quality Function Deployment	
Consideration Check	Explanation & Discussion	
Review	Discussion	

Table 9.1: Framework Techniques and Tools Currently Utilised

Alternatively, several techniques and tools may be utilised for carrying out each business process stage. These alternatives would however require validation. The opportunity to alter these currently utilised techniques and tools increase the possibility of potential users accepting the framework as a business process.

9.5 ISSUES OF CONCERN

The main issue of concern with this research involves the initial decision to approach the development of an evaluation framework from an organisational perspective. This approach is certainly not wrong. However, others, especially those with strong scientific backgrounds, may have preferred an experimental approach. An organisational approach focuses more on organisational phenomena within its natural environment. An experimental approach utilises

laboratory based examinations of organisational situations within an artificial setting.

The decision to follow an organisational focus was derived from the Department of Technology's objective to provide fully recognition to subjective user issues. Additionally, as users of multimedia technology are very diverse, an experimental approach would have required very centralised analyses. Such analyses may have included image quality of moving or still video footage, aesthetics influence upon the examination of images viewed using multimedia applications, etc. This type of centralised research would have accumulated in a framework applicable within a very limited subset of multimedia technologies.

9.5.1 Limitation Of The Research

A limitation of the research conducted, results from the amount of direct effort exerted on examining the distinction between subjective quality and aesthetic values.

During the development of the multimedia technology evaluation framework a visit to Ravensbourne College of Art and Design was undertaken. This visit was organised to ascertain expert views on distinguishing between subjective and aesthetic values. Unfortunately, no positive possibilities were realised. An alternative approach was necessary.

Thus, an assumption was made regarding subjective quality and aesthetic values. This assumption was that recognition of users to identify subjective issues, which they deem of inferior quality, included the implicit acknowledgement of their aesthetic values. This assumption seamed reasonable when only considering the use of multimedia technologies to facilitate work that is not dependent on determining or interpreting accurate information. However, upon reflection of the needs of multimedia users in

surveillance and reconnaissance work, aesthetic qualities have important implication on the distortion of information.

9.6 IMPLICATIONS

The objective evaluation framework with subjective impact has been developed, validated and documented. It now remains necessary for the potential users of this business process to test its suitability against their current evaluation procedures. To do this, a pilot study may be ideal. A small number of individuals (i.e. technologies) from the Department of Technology could test the framework and give feedback to other colleagues. This pilot study would also allow for feedback regarding the modification of any techniques or tools currently advocated within the various business-process stages. For example, within the Analysis stage cognitive mapping techniques are currently suggested. There may be other applicable techniques, which have not yet been examined, but would prove more favourable with technologist.

9.7 CONCLUSIONS

The development of an objective evaluation framework with subjective impact was successfully achieved. Furthermore, the business process that this framework was founded upon has been demonstrated to be:

- Repeatable and unbiased
- Accounts for the typical user of multimedia technologies
- Aid towards increased user satisfaction and encourage user confidence.

Fundamental characteristics of the framework were demonstrated and validated from MPS based case studies. Three case studies were conducted. These included:

- Video conferencing case study,
- Video and audio laboratory case studies.

Results from each case study included an elicitation and examination of subjective user requirements, quantifying user requirements through an objective analysis phase and identification of overall framework outcomes.

Additionally, undertaking case studies allowed experience from the framework's testing to highlight pragmatic issues. Highlighted issues are detailed below.

Causal maps:
Causal map technique requires strong skills in cognitive interviewing. If these skills are not harnessed and displayed to respondents during elicitation of users' subjective issues, this technique may be deemed subjective.

Repertory Grid:
Repertory grid technique was found to be a favourable method, by respondents, for eliciting users defined requirements. This technique was also excellent at obtaining those technical characteristics known by experts to be beneficial, and which are available in current multimedia technologies.

Quality function deployment:
QFD was found to quantify subjective user requirements. QFD also provides the necessary focus on subjective issues to satisfy research objectives outlined by the MPS.

Overall framework:
It can be stated with a strong degree of confidence that the objective evaluation framework with subjective impact proposed within this research thesis was shown to achieve the initial aim and objectives.

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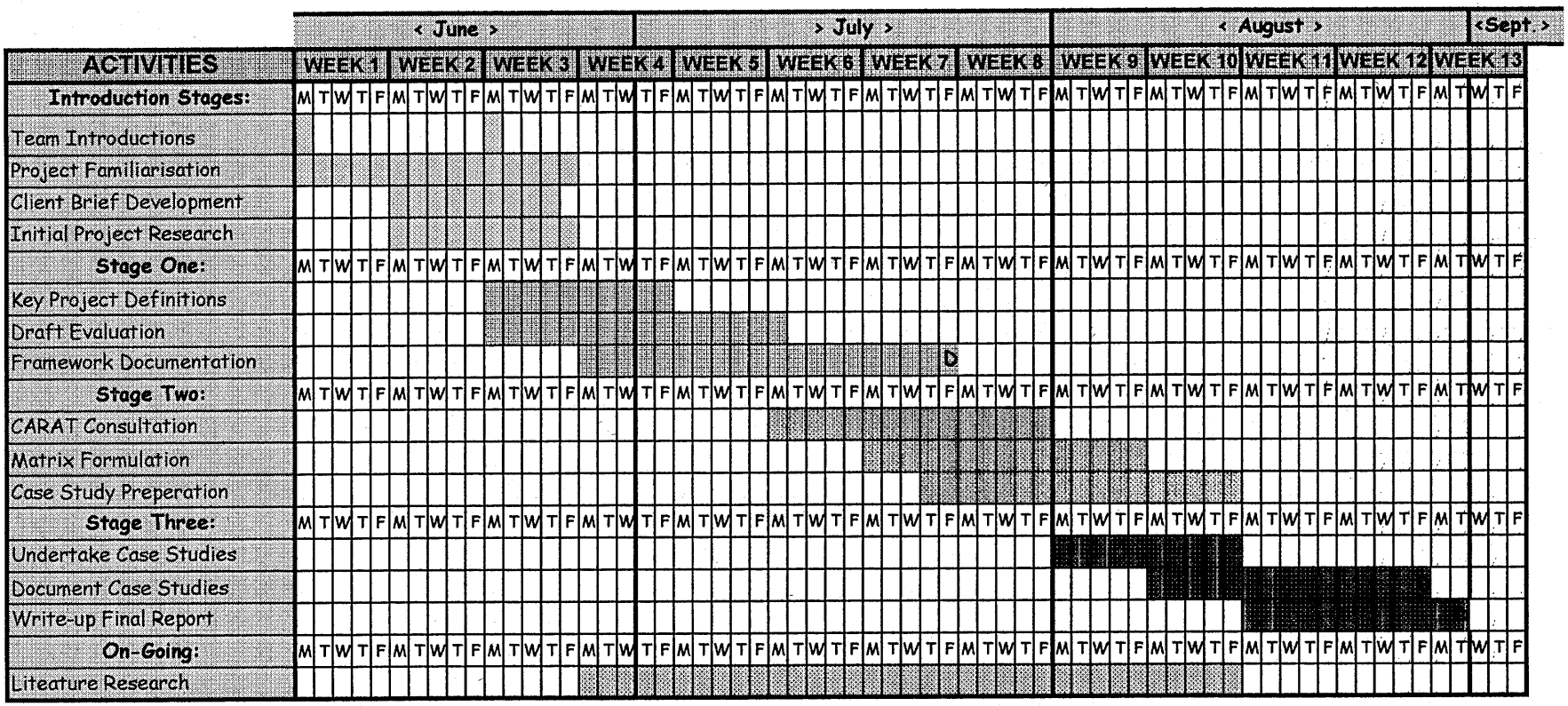
APPENDIX A: PROJECT PLAN

Objective Evaluation Framework
with Subjective Impact
Project Plan



Key: D = Deliverable

APPENDIX B: QFD OPERATIONAL STAGES

QUALITY FUNCTION DEPLOYMENT (QFD)

OPERATIONAL STAGES

Many proponents of QFD (Akao, 1990; Guinta ans Praizler, 1993) agree that QFD is a methodology that enables a team to make decisions. The House of Quality is the primary matrix within the complete QFD process. This matrix is especially powerful because of the amount on information that can be documented and analysed.

QFD methodology requires that a team ask questions about customer (or user) needs, competitors, and how their organisation will meet the challenges of providing products that delight the customer. Guinta and Praizler (1993) identified that the House of Quality matrix consists of the following operational stages:

COMPONENT	DESCRIPTION
Objective Statement	Description of goal, problem or objective of the team
WANTs	Product characteristics as defined by the customer
Importance / Weighted Values	Assigned to the WANTs indicating importance
HOWs	Ways of achieving WANTs
Traget Goels	Indicators to see if the team wants to increase or decrease a HOW or set a value for it
Relationship Matrix	Systematic means for identifying the level of relationship between WANTs and HOWs
Customer Competitive Assessment	Review of competitive product/service compared to teams product/service

How Mush	Specifications for each HOW and competitors' technical specifications
Probability Factors	Values indicating the ease with which the company can achieve each HOW
Absolute Score	Sum of the calculated values for each HOW column in the Relation Matrix
Relative Score	A sequential numbering of each HOW according to its Absolute Score

Table B.1: QFD Operational Stages

These components (operational stages) can be inserted into the House of Quality, which is illustrated below:

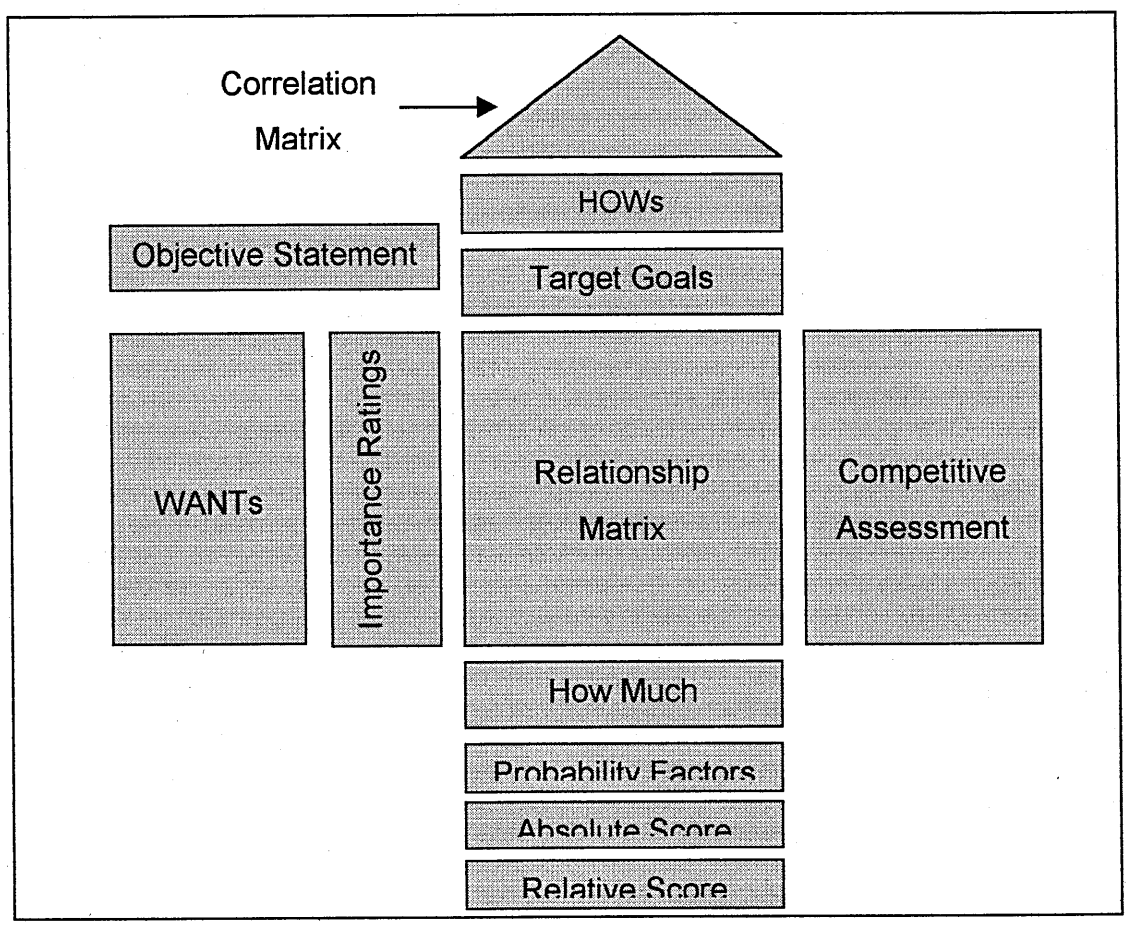


Figure B.1: House of Quality (Guinta and Praizer, 1993)

APPENDIX C: MULTIMEDIA COMPREHENSION

MULTIMEDIA COMPREHENSION

C.1 INTRODUCTION

This appendix section examines multimedia from a technology perspective. Before, undertaking MPS based case studies it was absolutely necessary to gain an appreciation of these technological issues. The understanding gained from reviewing this information makes the case study results much more meaningful. This information provides further background knowledge of multimedia.

C.2 MULTIMEDIA ISSUES

The term multimedia represents many different concepts. As a result of various concepts impinging on an appropriate definition, a tendency apparent within multimedia literature is side-tracking from this fundamental issue (Chen, 1997).

Taking the perspective that multimedia can vary conceptually, depending upon its position along a continuum, a wider understanding may be considered. For example, it could be asserted that multimedia is based on extended human vision or conversely, simply a label associated with the leverage of numerous disciplines. It is however, beneficial to identify that multimedia is composed of various basic elementary components. These components may originate from sources as diverse as individuals and synthesis, depending on disciplines leverage (Tescher, 1999).

C.2.1 Multimedia System Considerations

Modern applications of multimedia presentations are observed in assembled form. The generation of such presentations is fundamentally different depending on elementary component configurations, that is, visual or audio application combinations. During the assembly and development of the aggregated multimedia package certain system issues need to be addressed. These system issues are as follows (Tescher. 1999):

Relationship of elementary components and scene composition. The maintenance of the proper synchronisation as well as proper intercommunication among the individual elements is a basic role the underlying multimedia system process performs.

Delivery mechanism. Modern multimedia composition can provide transmission to customers at a remote location. The actual delivery process covers numerous categories: real- and non-real-time delivery, and communication channels of a variety of types (i.e. quality, bandwidth, and single and composite channels).

Human interaction and feedback. Although not a strict requirement it is assumed that modern multimedia applications are probably going to include active participation of the end user. The additional dynamic process that allows feedback, remaining consistent with the composition and the delivery mechanism, generates a highly demanding scenario.

In addition to the above system considerations, several technology issues are apparent and discussed by Tescher (1999). These considerations are presented in the following section.

C.2.2 Multimedia Technology Considerations

Modern aspects of multimedia are inherently digital. The maturity, restrictions and expected developments of digital technology have a profound impact on multimedia evolution. Key considerations resulting from digital technology developments include the following (Tescher, 1999):

Recording technology. Digital processing of visual data requires stable and high-speed electronic processing. The principle component is the 8-to-12-bit dynamic range of the required A/D converter for typical visual applications.

Representation of high-quality colour introduces additional demands on the digital recording process. Due to data compression requirements necessary during digital recordings, compression has become a necessary evil if modern multimedia technology is to become practical.

Delivery technology. Fundamental concepts include transmitting data via communication channels, utilising storage mediums and maintaining a continuously high degree of synchronisation with or without observer interaction. From a communication perspective, the key is cost-effective availability of reliable high bandwidth. Implementation of effective networks over the available physical channels is another critical component of the overall implementation scenario.

Final multimedia presentation. Actual multimedia presentation is typically accomplished through a physical display/audio system, which may contain additional processing functions. Similar to other elements of the delivery chain, the visual element is a critical component. Visual display devices include critical parameters such as both temporal and spatial resolution, colour representation, size, etc.

To facilitate the development of multimedia, standardisations have become a vital guide. Before discussing a particular multimedia standard a brief overview of standardisation is provided.

C.2.3 Standardisation

Standardisation commonly refers to the formal process, through various bodies, of developing a degree of conformance to a defined standard. De facto standards are also relevant to this explanation as some proprietary systems have such dominant influence that they achieve comparable levels of conformance.

Standardisation represents one of several technology resources that can have a considerable impact on the maturity of multimedia. Other maturity considerations include:

- Transition from analogy to digital
- Bandwidth limitations
- Available and affordable processing power
- Robust infrastructure (networks)
- Internet / World Wide Web
- Display Technology
- Specialised Components

C.3 MULTIMEDIA TECHNOLOGIES

Multimedia systems (which include numerous technologies) encompass a variety of information sources (or elementary components), such as voice, audio, graphics, animation, images and full-motion video. Various configurations of these information sources are presented in a growing range of applications. The current development within multimedia technologies has resulted from the merging of three industries: computing, communication and broadcasting (Furht, 1994).

Multimedia technologies can be categorised into two broad groups based on computing classifications. One group centres its efforts on the stand-alone multimedia workstation and associated applications. An example would include the use of a personal computer for interactive video usage. Limited potential is associated with this developing technological option. The other classification combines multimedia computing with distributed systems, which offer enormous potential. New applications based on distributed multimedia technology include multimedia information systems, on-demand multimedia services, and distance learning. Distributed multimedia technologies, however, require continuous data transfer over relatively long periods of time. Media synchronisation, very large storage, and special indexing and retrieval techniques suitable for multimedia

application represents additional major requirements. Together these growing requirements necessitate the continuous development of technical solutions / specifications of facilitate successful multimedia evolution (both from technical and commercial perspectives).

Currently, multimedia technology can store audio and video data, and then utilise this data at a later time in an application. Alternatively, transmission of the audio and video data in real time can be carried out. Live audio and video can be interactive, such as multimedia conferencing or non-interactive, as in TV broadcasting. Stored images (stills) can also be used in an interactive mode (browsing, etc.) or in a non-interactive mode (slide show, etc.). Thus, the complexity of multimedia technology and associated applications becomes apparent from the diverse range of functionality available.

The processing power required to enable the appropriate functionality from various application programs, such as software codecs (encode / decode), is considerably large. System architecture needs to provide high bus bandwidth and efficient input – output capacity. Storage and memory requirements continue to demand higher capacity, fast access times and improved transfer rates. While new networks and network protocols are necessary to allow higher bandwidth, low latency and low jitter is required for modern multimedia presentations. Researchers in the multimedia field continue to work on these issues both attempting to transform existing technology and develop new technologies. This research includes faster processors, high-speed networks, larger-capacity storage devices, new algorithms and data structures, video and audio compression algorithms, human-computer interfaces, real-time operating systems, object-oriented programming, information storage and retrieval, hypertext and hypermedia, languages for scripting, parallel processing methods and complex architectures for distribution systems (Furht, 1994).

C.4 MULTIMEDIA STANDARDS: MPEG

The Moving Pictures Expert Group (MPEG) within the International Organisation of Standards (ISO) has developed a series of audio / visual standards known as MPEG-1, MPEG-2 and MPEG-4. MPEG-1 and MPEG-2 were the first international standards in the audio / video-coding field of high-quality digital audio / video compression. While the recently completed MPEG-4 standard addresses standardisation of audio-visual coding for applications range from mobile-access, low-complexity multimedia terminals to high-quality multi-channel sound systems (Sikora, 1997). These standards have been reported as allowing interactivity and universal accessibility, while providing a high degree of flexibility (ISO/MPEG, 1994).

MPEG has started research on a new standard called 'Multimedia content description interface' (MPEG-7). This up and coming audio-visual standard does not cover coding rather its goal is to specify a standardised description of various types of multimedia information. MPEG-7 will for example extend common processing technology to visual databases. A typical application will be the search for video, graphics, or audio material in the sense of today's text-based search engines available through the World Wide Wed.

C.4.1 MPEG AUDIO FUNDAMENTIALS AND APPLICATIONS

The MPEG audio compression algorithm is the first international standard for digital compression of high-fidelity audio. Other audio compression algorithms addressed speech-only applications or provided medium-fidelity only performance (Pan, 1993). MPEG audio compression is also one part of a three-part compression standard that includes video and system considerations. The MPEG standard addresses compression of synchronised video and audio at a bit rate of about 1.5 megabits per second (Mbps). Reflecting rigid necessities to ensure interoperability the MPEG standard mandates the syntax of the coded bitstream, defines decoding, and provides compliance test for assessing decoder accuracy. This provides the guarantee that, regardless of origin, any

fully compliant MPEG audio decoder will decode an MPEG audio bitstream with a predefined result (Pan, 1995).

Generic MPEG audio coders exploit perceptual limitations of the average human auditory system. Much of the compression results from the removal of perceptually irrelevant audio signals. Thus, removal of such inaudible parts, referred to as distortions, enables MPEG audio compression of only signals heard by the human ear. In comparison with vocal-tract-model coders tuned for speech signals, MPEG audio coders are suggested to achieve compression without the need to make assumptions about the nature of an audio source. In keeping with MPEG's generic nature a diverse collection of compression modes can be offered. These are summarised below (Pan, 1995):

Sampling Rate. Audio sampling rates can be 32, 44.1 or 48 KHz.

Audio Channel Support. The compression bitstream can support one or two channels in one of four possible modes:

1. Monophonic mode for a single audio channel
2. Dual-monophonic mode for two independent audio channels (similar to stereo mode)
3. Stereo mode for stereo channels that share bits but do not use joint-stereo coding
4. Joint-stereo mode that takes advantage of either correlation between each stereo channels and irrelevancy of the phase difference between channels, or both.

Predefined Bit Rates. Compression bit rates can have one of several predefined fixed bit rates ranging from 32 to 244Kbps) per channel. Depending on sample rates, this translates into compression factors ranging from 2.7 to 24.

Compression Layers. Three independent layers of compression exist for MPEG audio, providing a wide range of trade-offs between codec complexity and compression audio quality. These layers are:

Layer I, the simplest, best suited for bit rates above 128Kbps per channel. For example Digital Compact Cassettes used Layer 1 compression at 192 Kbps per channel.

Layer II, has an intermediate complexity and bit rates around 128Kbps per channel. Applications include coding for digital audio broadcasting (DAB), storage of synchronised video-audio sequences on CD-ROM and full-motion on interactive Video CD.

Layer III, is more complex but offers better audio quality, particularly for bit rates around 64Kbps per channel. This layer suits audio transmission over ISDN lines.

Error Detection. The coded bitstream supports a optional cyclic redundancy check (CRC) error-detection code.

Ancillary Data. MPEG-audio provides a means of incorporating ancillary data within the bitstream.

C.4.2 MPEG VIDEO Fundmentials and Applications

New audio-visual applications in the fields of communication, multimedia and broadcasting became possible with the advent of digital video-coding technology. Opening the possibilities for more applications to a larger number of users therefore gave necessity for video-coding standards (Sikora, 1997). To meet this need, the MPEG group was formed to develop relevant coding standards.

Commercially, international standards for video communication systems and protocols aim to satisfy two important purposes: interoperability and economy of scale. Enabling manufacturers to vary their designs within the bounds of the MPEG standards provided an opportunity for interoperability. While economy of scale was achieved as data exchange via numerous storage mediums or via compatible communication networks was wide available within the marketplace.

Generally, video sequences contain significant amounts of statistical and subjective redundancy within and between frames. The ultimate goal of video source coding is the bit-rate reduction for storage and transmission by exploring both statistical and subjective redundancies and to encode a minimum set of information using entropy coding techniques (Sikora, 1997). This results in a compression of the coded video data. The performance of video-compression techniques depends on the amount of redundancy contained in the image data as well as on the actual compression techniques used for coding. A trade-off situation is typically encountered were coding performance and implementation complexity is considered (i.e. high compression with sufficient quality). Depending on an applications requirements lossless or lossy may be experienced when coded video data is decoded and displayed to the user.

To address statistical and subjective issues associated with compression techniques several modes of consideration are identifiable within the MPEG standards. These are summarised below:

Video-Coder Source Model. Video sequences usually contain statistical redundancies in both temporal and spatial directions. The basic statistical property upon which MPEG compression techniques rely is interpel correlation, including the assumption of correlated translator motion between consecutive frames. The MPEG compression algorithms employed can include:

1. Discrete Cosine Transform (DCT) coding techniques on images blocks of 8 x 8 pels to efficiently explore spatial correlation between nearby pels within the same image
2. Differential Pulse Code Modulation (DPCM) coding that employs temporal prediction (i.e. motion-compression prediction between frames), and
3. Hybrid DPCM/DCT coding.

Subsampling and Interpolation. The basic concept of subsampling is to reduce the dimensions of the input video and thus the number of pels to be coded prior to the encoding process. At the receiver decoded images are interpolated for display. Making use of specific physiological characteristics of the human eye, interpolation removes subjective redundancy contained in video data. Therefore, MPEG coding schemes divides the image into a Y:U:V ratio for particular applications to make use of known subjective redundancy.

APPENDIX D: VIDEO CONFERENCING CASE STUDY DATA

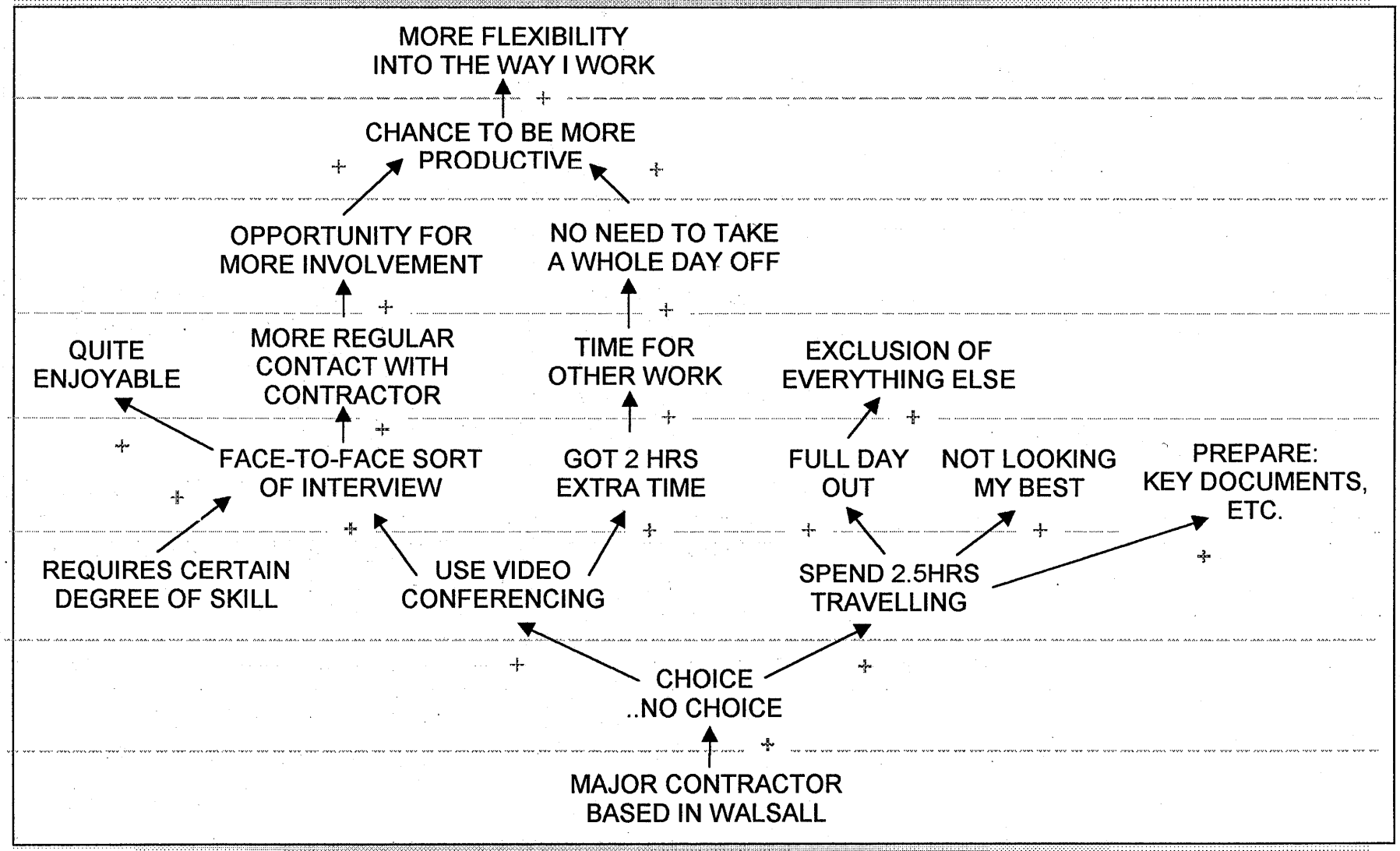
MPS: User Cognition Assessment

User Value:	Civil Representative (MPS Internal)	**User Ref.**	Respondent A
User's Name:	OMITTED	**Telephone:**	0171 230 8630
Position:	Contracts Manager	**Mobile Tel.:**	
Organisation:	Metropolitan Police Service	**Email:**	
Contact:	Transport Client Unit Cobalt Square Vauxhall		
City:	London	**Data Entry:**	Mr. J.P. Taylor
Country:	U.K. **Postcode:**	**Date:**	28th July 1999
MPS Relationship:	Civil employee within the Transport Client Unit department of the Metropolitan Police Service.		
Involvement:	Use video conferencing equipment to manage contract issues with contractor based at Walsall, England.		
Other:			

Adapted from: A Generic Guide to Requirements Capture (Woolton *et al*, 1998)

Background Question:

What is most important to you (interviewee) about the use of this technology, to allow you to perform your role within this organisation (MPS)?

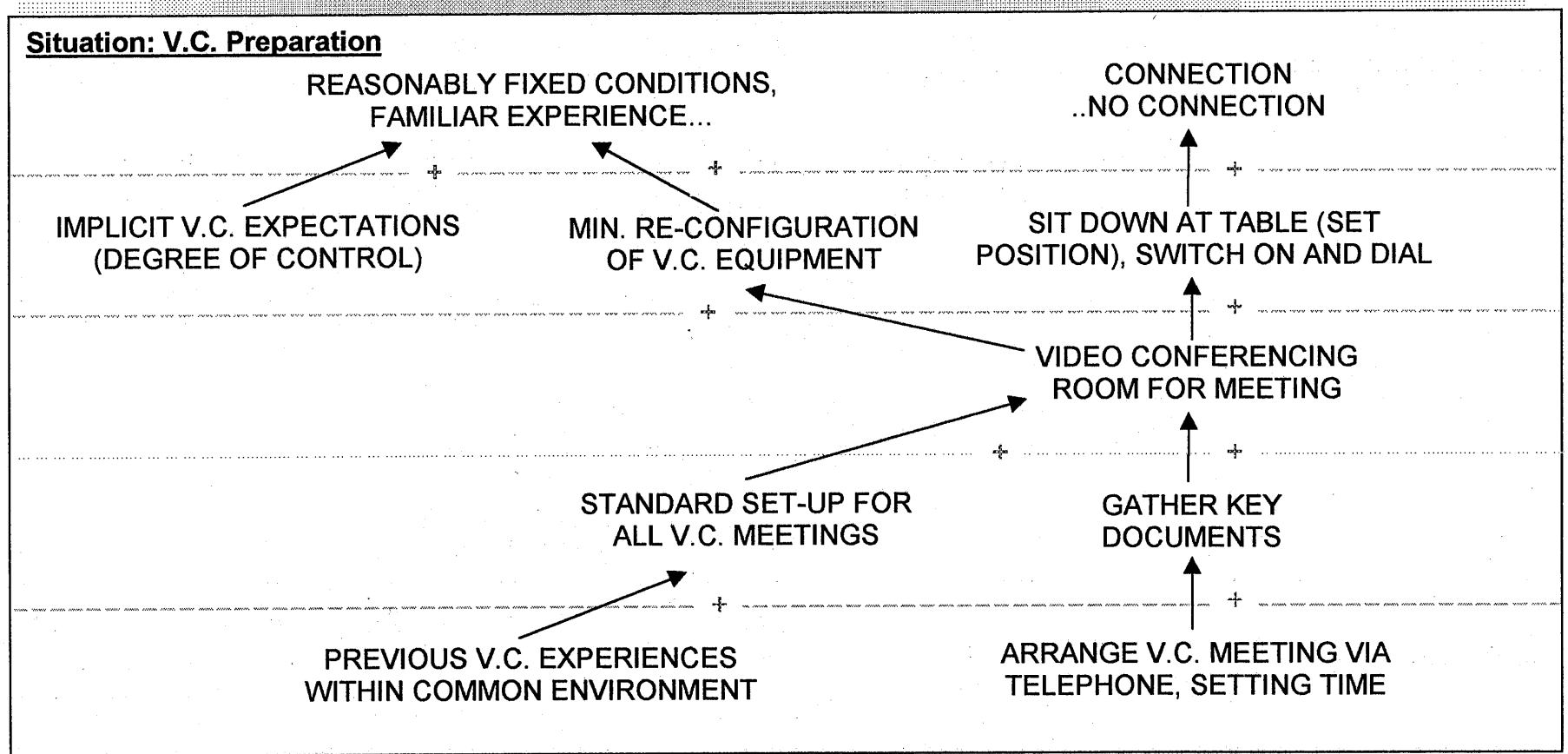


Specific Questions:

1. **Could you inform me of the various situations you use this technology for, within this organisation (MPS or associated business)?**

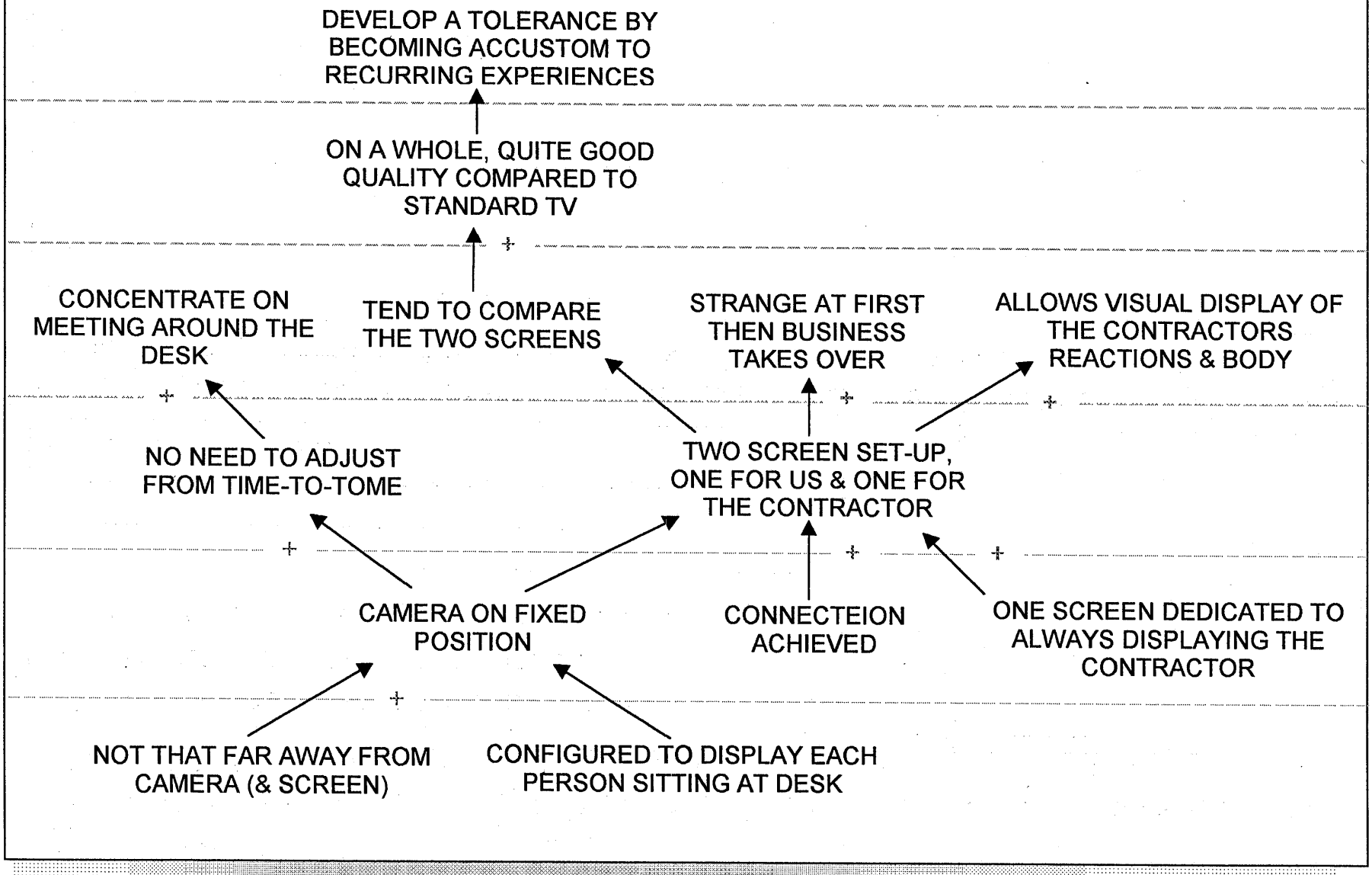
A. Preparation (generic) B. Person to person C. Person to group D. Group to person

2. **Would you describe to me procedures and experiences you encounter during the use of this technology for each situation previously identified?**



2. Continued

Situation: Person to person, Person to group & Group to person.



Specific Questions:

3. For each of the technology usage situations previously discussed, could you identify any technological characteristics you deem important for successful operation?

A. TV image and sound quality as minimum standard

B. Automatic location of person/s speaking by camera

C. Optional Maintenance Warranty

D. _____

E. _____

F. _____

G. _____

4. How do you view the adequacy of this technology during each of the fore mentioned usage situations compared to other equivalent technologies you may be familiar with?

Not familiar with other video conferencing systems.

Reflection & Additional Notes:

The process of eliciting opposite constructs will involve the interviewer asking the interviewee such questions as 'rather that?', 'as opposed too?', etc. The sole aim of this action is to clarify meaning of concepts not influence or alter. Notes pertaining to such actions can be documented below:

This space below is provided to document any additional notes.

Supplier: Sony 5100 video conferencing system, supplied by:

Gearhouse Ltd.,

69 Dartmouth Middleway,

Birmingham B7 4UA

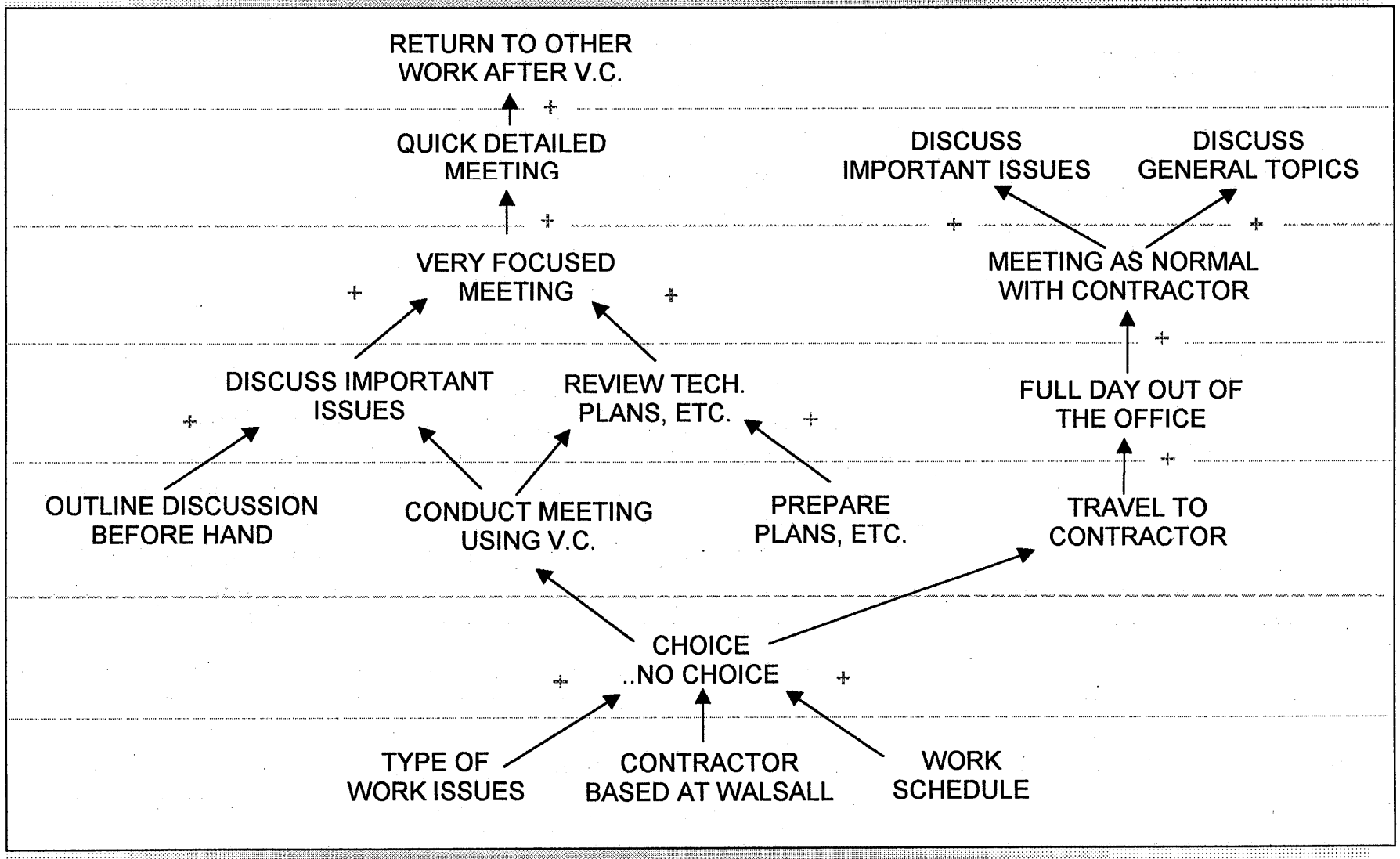
Tel.: 0121 380 2515

MPS: User Cognition Assessment

User Value:	Civil Representative (MPS Internal)	**User Ref.**	Respondent B & C
User's Name:	OMITTED	**Telephone:**	0171 230 8630
Position:	Vehicle Engineering	**Mobile Tel.:**	
Organisation:	Metropolitan Police Service	**Email:**	
Contact:	Transport Client Unit Cobalt Square Vauxhall		
City:	London	**Data Entry:**	Mr. J.P. Taylor
Country:	U.K. **Postcode:**	**Date:**	
MPS Relationship:	Civil employee within the Transport Client Unit department of the Metropolitan Police Service.		
Involvement:	Use video conferencing equipment to discuss contract issues with contractor based at Walsall, England.		
Other:			

Background Question:

What is most important to you (interviewee) about the use of this technology, to allow you to perform your role within this organisation (MPS)?



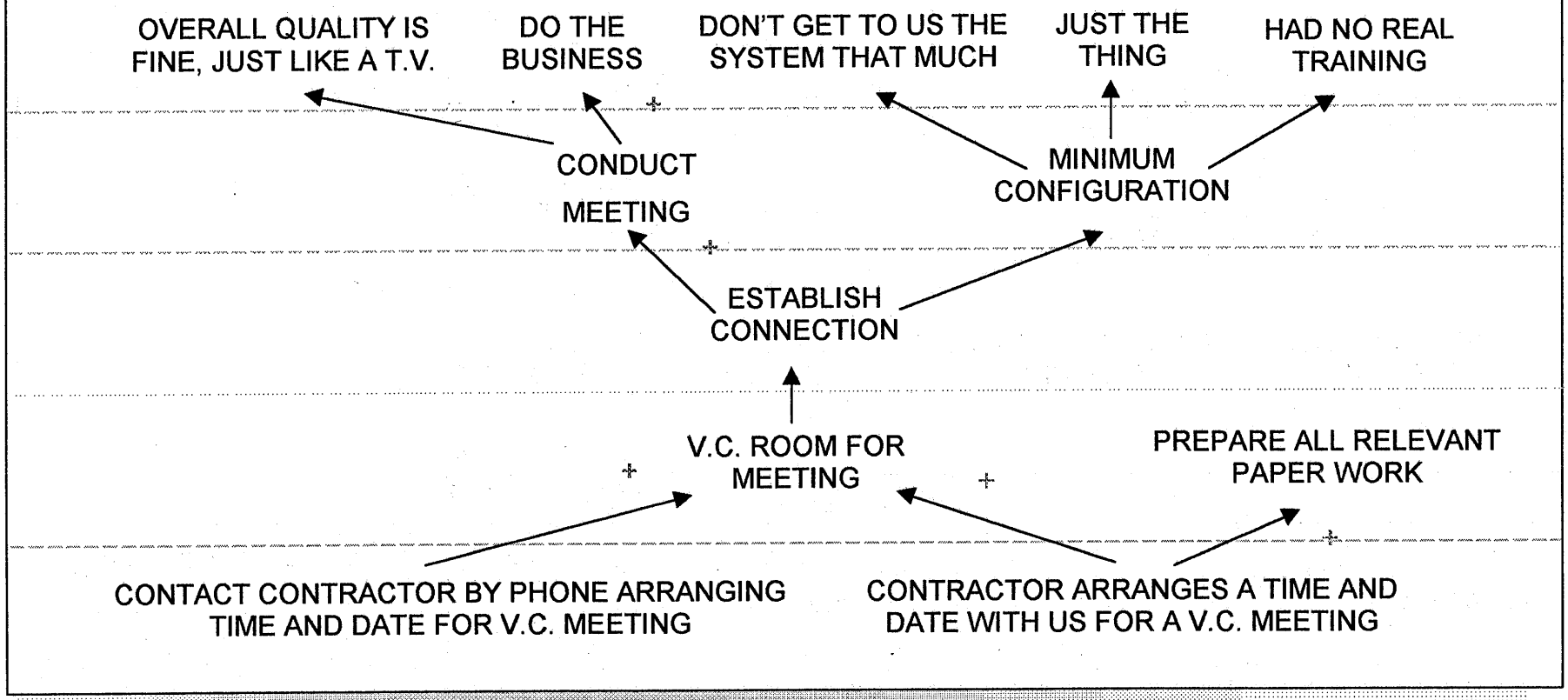
Specific Questions:

1. **Could you inform me of the various situations you use this technology for, within this organisation (MPS or associated business)?**

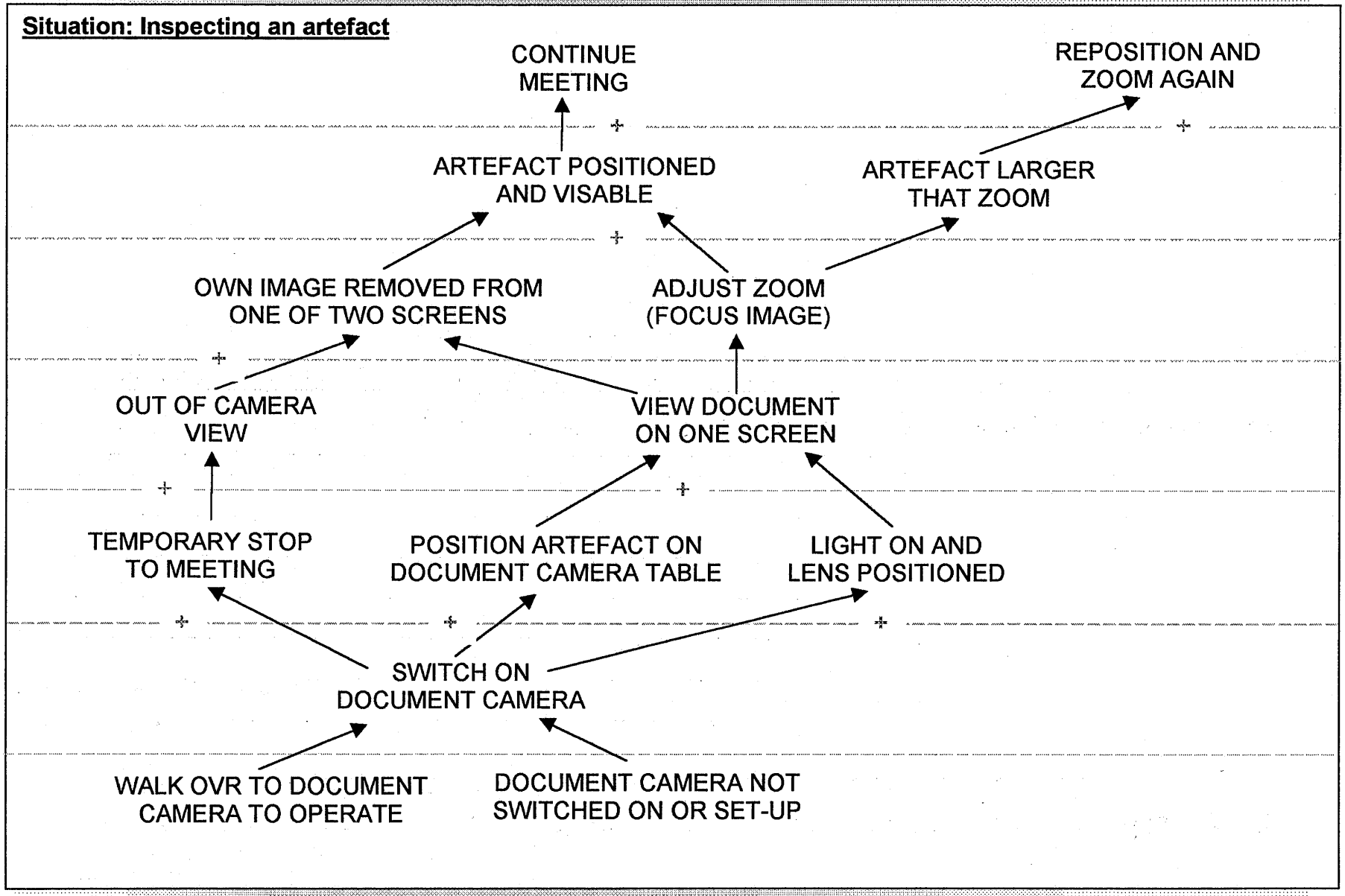
A. Person to group B. Group to group C. Inspecting an artefact

2. **Would you describe to me procedures and experiences you encounter during the use of this technology for each situation previously identified?**

Situation: Person to group, & Group to group



2. Continued


Situation: Inspecting an artefact
CONTINUE MEETING
REPOSITION AND ZOOM AGAIN
ARTEFACT POSITIONED AND VISABLE
ARTEFACT LARGER THAT ZOOM
OWN IMAGE REMOVED FROM ONE OF TWO SCREENS
ADJUST ZOOM (FOCUS IMAGE)
OUT OF CAMERA VIEW
VIEW DOCUMENT ON ONE SCREEN
TEMPORARY STOP TO MEETING
POSITION ARTEFACT ON DOCUMENT CAMERA TABLE
LIGHT ON AND LENS POSITIONED
SWITCH ON DOCUMENT CAMERA
WALK OVR TO DOCUMENT CAMERA TO OPERATE
DOCUMENT CAMERA NOT SWITCHED ON OR SET-UP

Specific Questions:

3. For each of the technology usage situations previously discussed, could you identify any technological characteristics you deem important for successful operation?

A. Training
B. Simple users' manual
C.
D.
E.
F.
G.

4. How do you view the adequacy of this technology during each of the fore mentioned usage situations compared to other equivalent technologies you may be familiar with?

Don't use this system that much never mind any others.

Reflection & Additional Notes:

The process of eliciting opposite constructs will involve the interviewer asking the interviewee such questions as 'rather that?', 'as opposed too?', etc. The sole aim of this action is to clarify meaning of concepts not influence or alter. Notes pertaining to such actions can be documented below:

This space below is provided to document any additional notes.

Supplier: Sony 5100 video conferencing system, supplied by:

Gearhouse Ltd.,

69 Dartmouth Middleway,

Birmingham B7 4UA

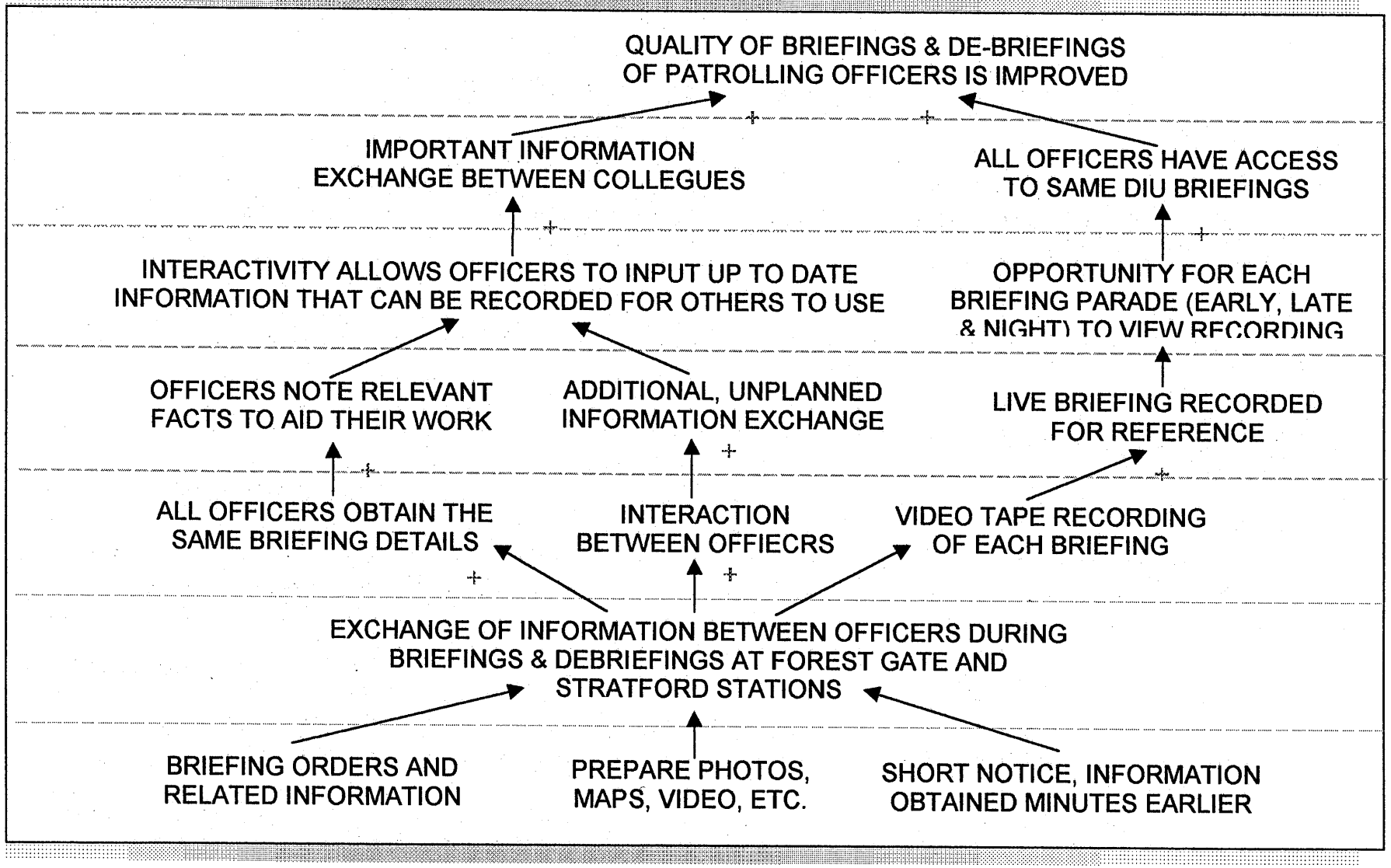
Tel.: 0121 380 2515

MPS: User Cognition Assessment

User Value:	Police Representative (MPS Internal)	**User Ref.**	Respondent D
User's Name:	OMITTED	**Telephone:**	0181 217 5260
Position:	Briefing Officer	**Mobile Tel.:**	
Organisation:	Metropolitan Police Service	**Email:**	
Contact:	Forest Gate Police Station Upton Park		
City:	London	**Data Entry:**	Mr. J.P. Taylor
Country:	U.K. **Postcode:**	**Date:**	27th July 1999
MPS Relationship:	Briefing police officer based at Forest Gate Police station.		
Involvement:	Involved in the briefing of police officers based in Forest Gate and Stratford using video conferencing facilities.		
Other:			

Background Question:

What is most important to you (interviewee) about the use of this technology, to allow you to perform your role within this organisation (MPS)?



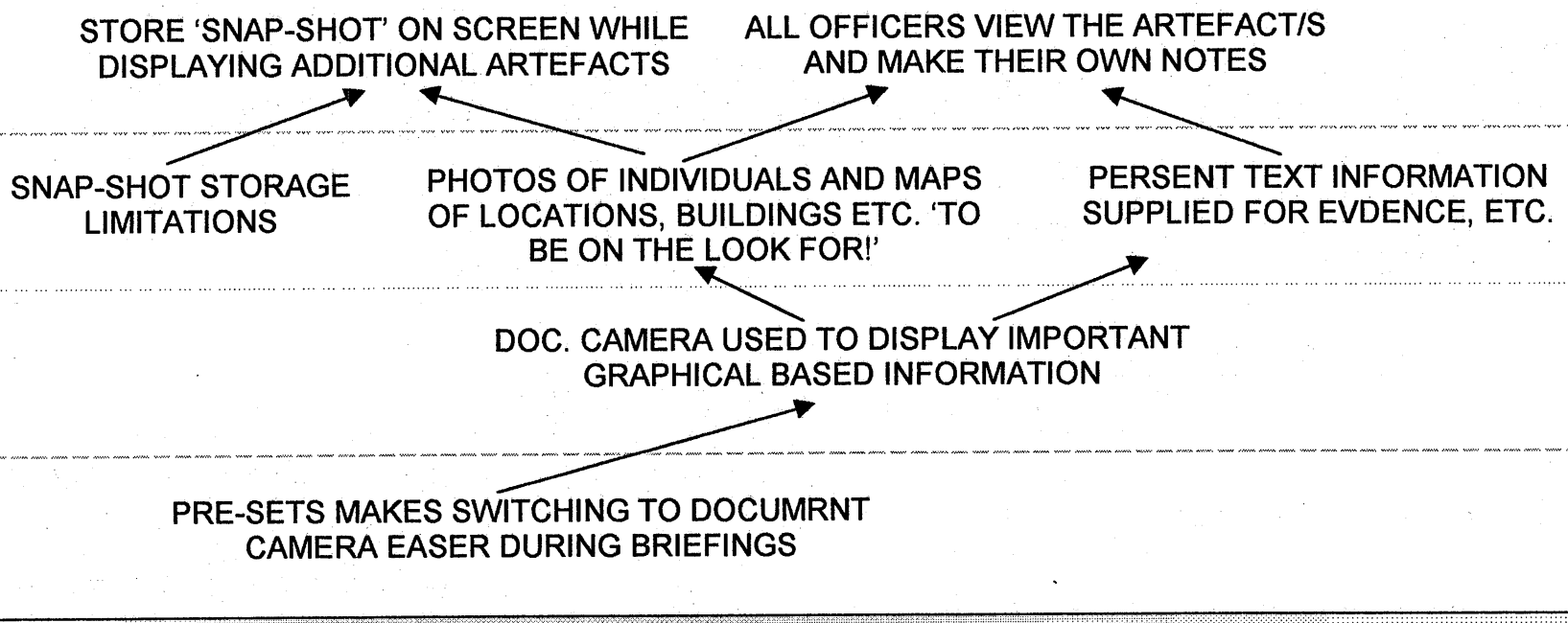
Specific Questions:

1. **Could you inform me of the various situations you use this technology for, within this organisation (MPS or associated business)?**

A. Inspecting an artefact B. Group to group

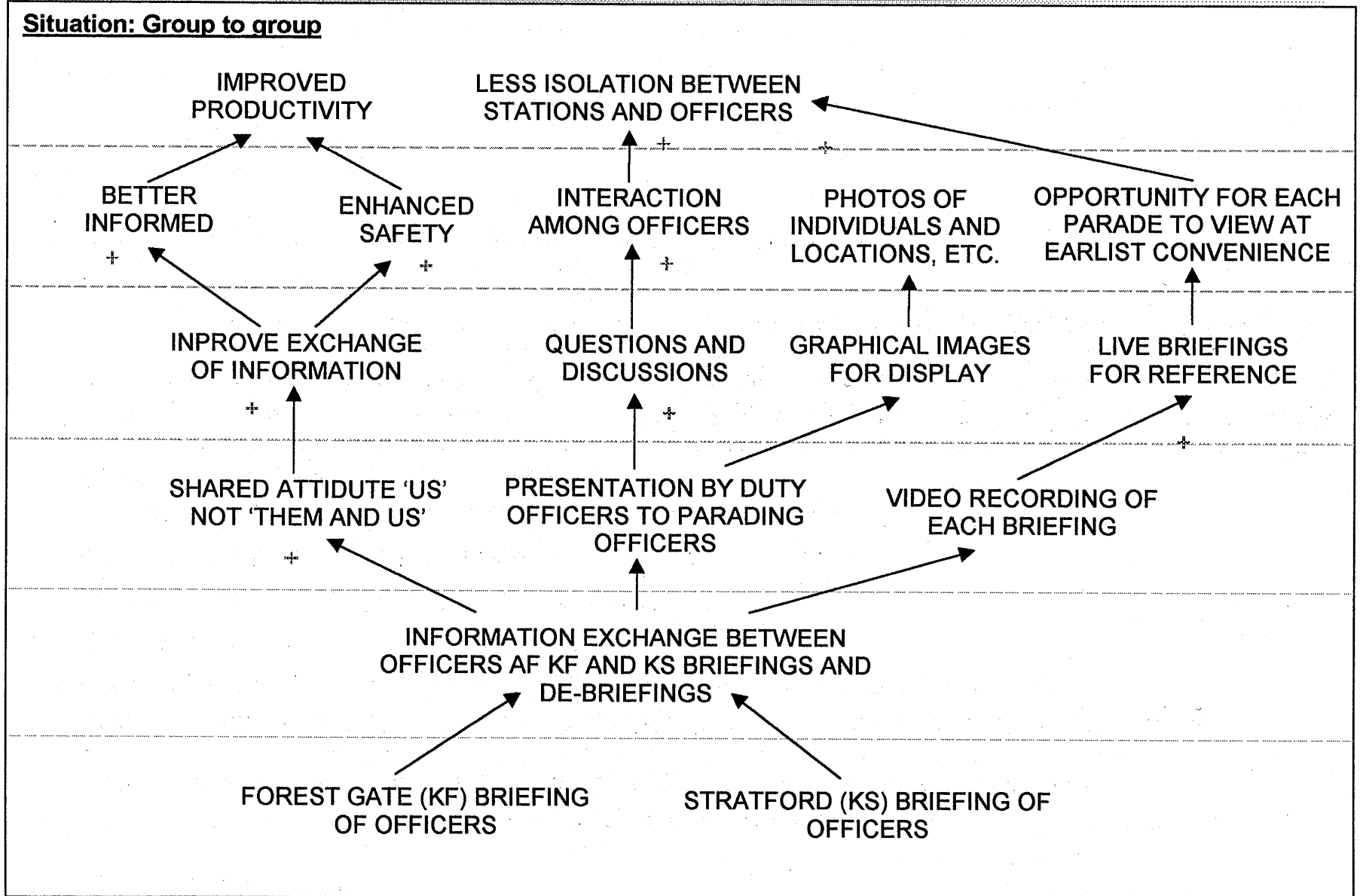
2. **Would you describe to me procedures and experiences you encounter during the use of this technology for each situation previously identified?**

Situation: Inspecting an artefact



2. Continued

Situation: Group to group



Specific Questions:

3. For each of the technology usage situations previously discussed, could you identify any technological characteristics you deem important for successful operation?

A. Camera pre-sets to allow for quick and accurate display of several common positions within the briefing room

B. Default settings to over-ride the effects of inexperience or tampering by untrained individuals

C. Improved angle range for sensing keypad signals

D. More than one snapshot storage facility (ideal number = 5)

E. Facility to control far-end camera pre-sets

F. Optional maintenance warranty

G. Police specific training.

4. How do you view the adequacy of this technology during each of the fore mentioned usage situations compared to other equivalent technologies you may be familiar with?

A. It is not possible to record the audio signal on the 'record VCR' from a video tape being played on the 'play VCR' during a live briefing.

B. Storage of one snapshot view is not adequate, this is a real limitation with the current system.

Reflection & Additional Notes:

The process of eliciting opposite constructs will involve the interviewer asking the interviewee such questions as 'rather that?', 'as opposed too?', etc. The sole aim of this action is to clarify meaning of concepts not influence or alter. Notes pertaining to such actions can be documented below:

This space below is provided to document any additional notes.

Supplier: Multisense Communications Ltd
2/3 High Street
High Wycombe
Buckinghamshire
HP11 2AZ
Tel.: 01494 461949

COMMON USER GROUP CONSTRUCTS

CIVIL REPRESENTATIVES[i]:

	CONSTRUCTS
1	Familiar Operating Procedures
2	Minimum Set-up Effort (minimum configuration)
3	T.V. standard quality (video and audio)
4	Video conferencing training (initial)
5	Voice Location of Person Speacking (camera options)
6	Fixed Camera Position of V.C. Connected Participates
7	Recording and Playback of V.C. Meetings
8	Idiots' Guide (bullet point information)
9	Periodic Refesher Training
10	Support Availability

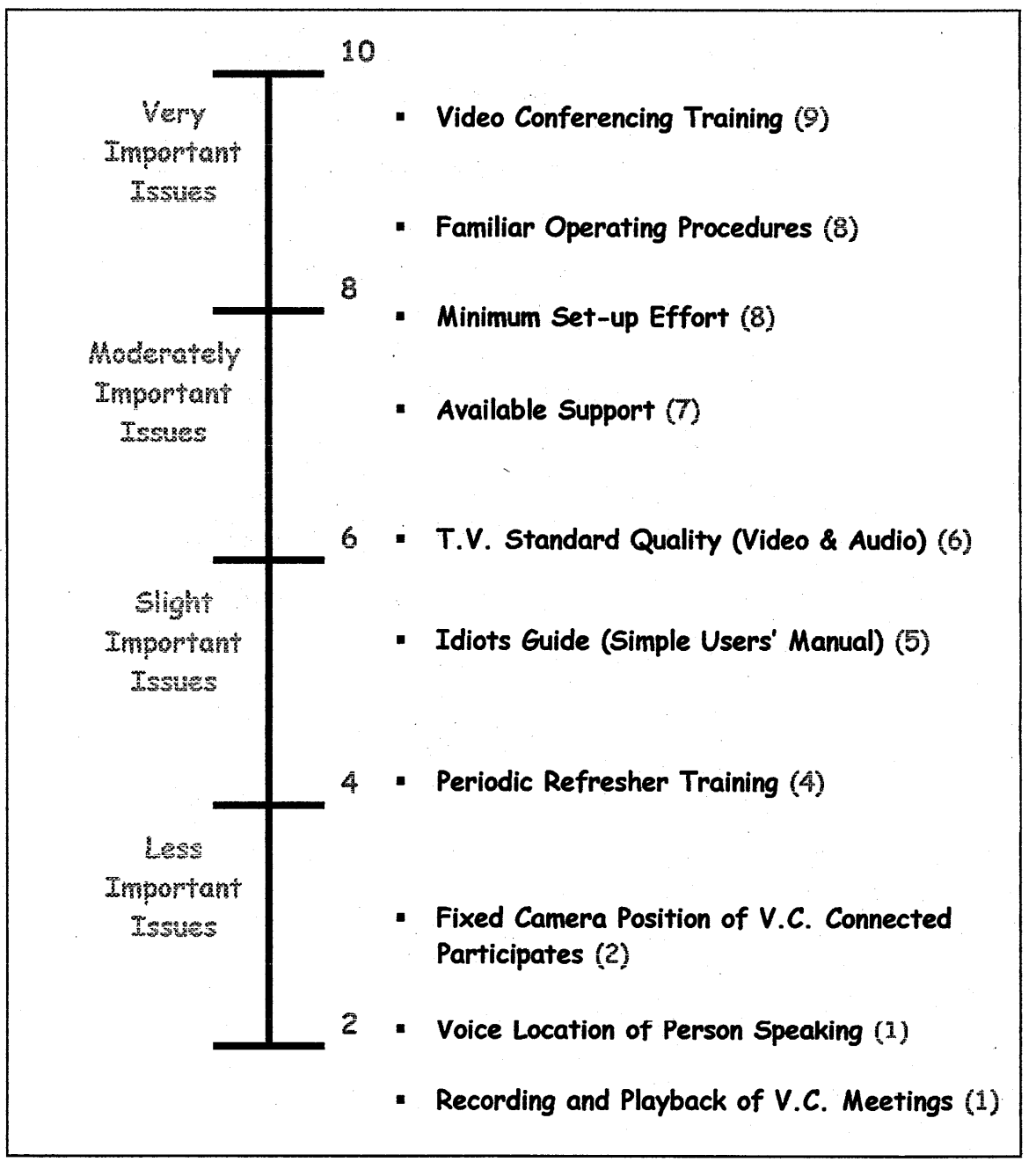
POLICE REPRESENTATIVES:

	CONSTRUCTS
1	Store up to five snapshot views on screen
2	Camera pre-sets (near-end, far-end, etc.)
3	Default settings
4	Wide angle range
5	Facility to control far-end camera pre-sets
6	Optional maintenance warranty support
7	Police specific training of video conferencing
8	Audio recording in addition to video (image) recording during playback on VCR tapes.

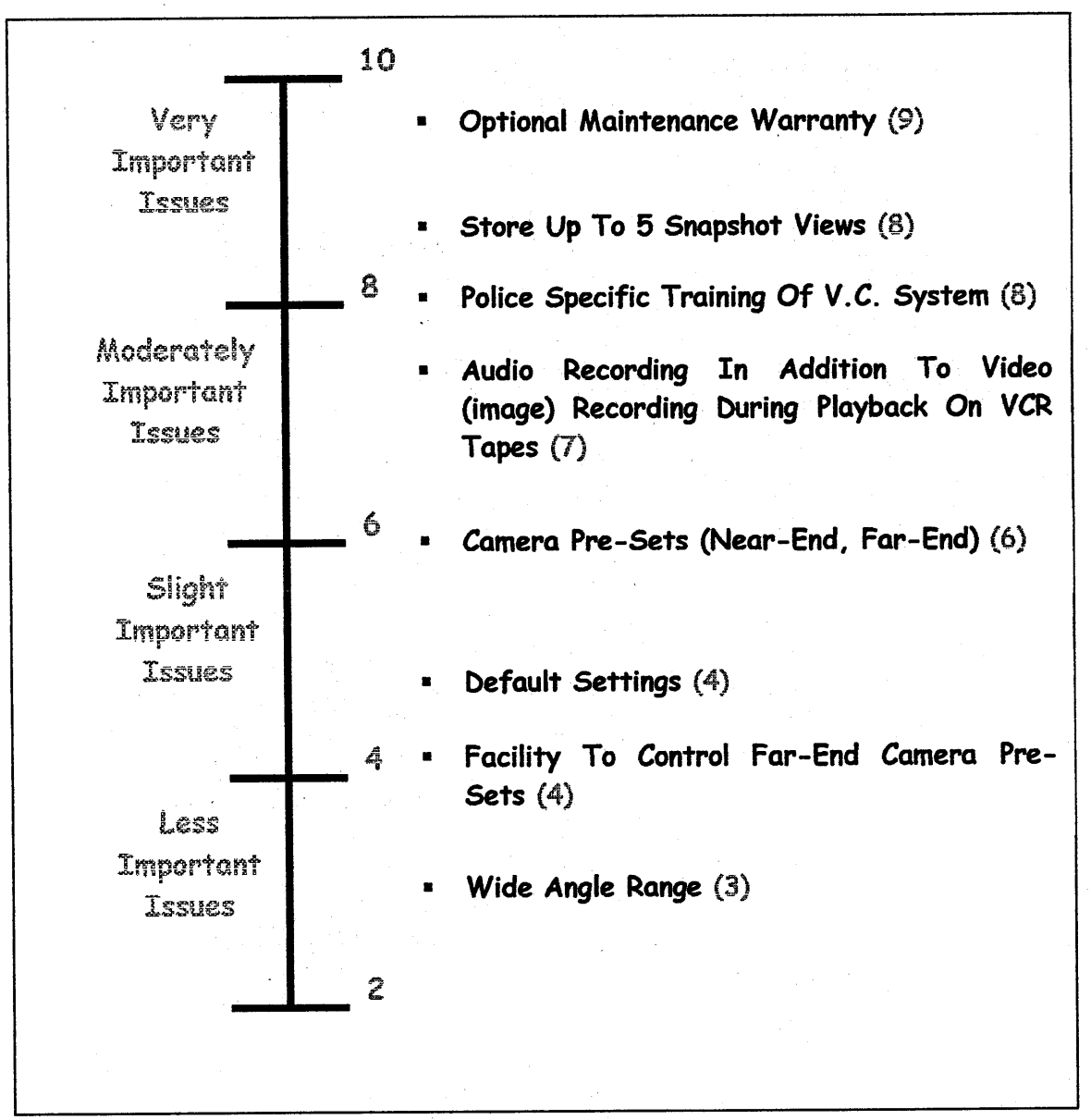
[i] Not including prerequisite video conferencing features.

ASSOCIATED CONSTRUCT RATINGS

CIVIL REPRESENTATIVES:



Police Representatives:



VIDEO CONFERENCING SYSTEM SPECIFICATIONS

CIVIL REPRESENTATIVES' SYSTEM:

Supplier:	Gearhouse Ltd.
Manufacturer:	Sony 5100 (Twin V.C. System)
System:	PCS3000P Codec
	Cabinet
	Graphics Table (T 500 GFX)
	2 x 29" Monitor (Dual Monitor Card)
	VHS VCR
	VID Control Cable
Est. Cost:	£14,500

POLICE REPRESENTATIVES' SYSTEM:

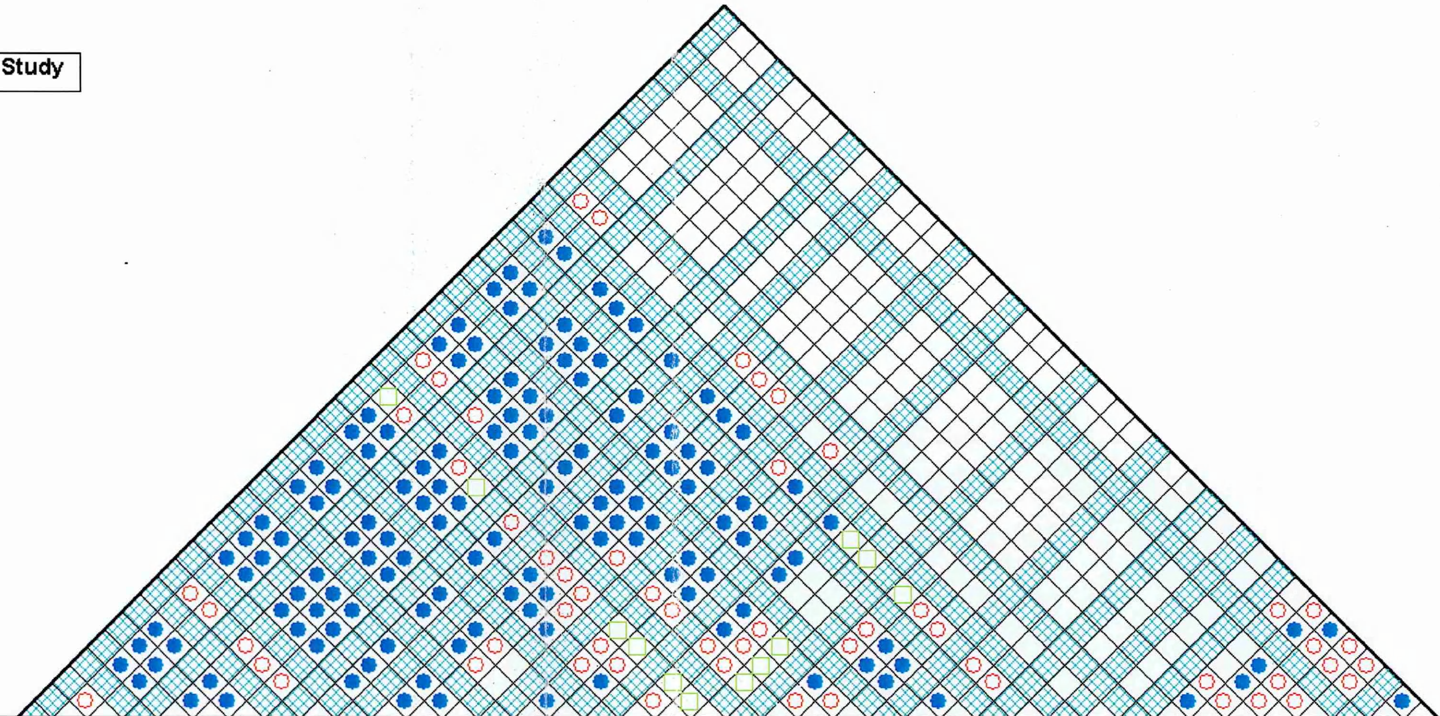
Supplier:	Multisense Ltd.
Manufacturer:	PictureTel / Swiftsite
System:	Sony T.V. Montior
	Cabinet
	Document Camera
	Additional Mini Monitor
	2 x Sony VHS VCRs
	Look At Me Button
Est. Cost:	£9,800

MPS SYSTEM EVALUATION QUESTIONNAIRE RESULTS

	Sony 3000	BT VS2	Thorn Swiftsite	Pic. - Tel Swiftsite	Sony 5100
Video	5	7	7	7	6
Audio	5	7	7	7	8
Lip Sync	5	7	7	7	4
Interface	5	7	7	7	5
Ease of Use	5	7	7	8	6
Pic. Quality	5	7	7	7	6
Front End	5	7	7	7	5

	Sony 3000	BT VS2	Thorn Swiftsite	Pic. - Tel Swiftsite	Sony 5100
VCR Playback	7	5: ISDN2 9: ISDN4	6: ISDN2	6: ISDN2	
Print Out	5		5		
Equipment Robustness	Good	Good	Good	Very Good	Good
Standards	H320	H320	H320	H320 PT720	H320 PT720
Bandwidth	Potentiall 256kbps	ISDN6	128kbps	128kbps	up to 384kbps
Software	Via PC	Yes	Yes	Yes	Yes
Multipoint	Built in 4 Sites	No: Via MCU	No: Via MCU	No: Via MCU	Built in 4 Sites
T120 Compatiable	Yes	Yes	Yes	Yes	Yes

Title: Video Conferencing User Case Study



Tradeoffs

Strong Positive	◆	9.0
Weak Positive	◇	3.0
Weak Negative	□	-3.0
Strong Negative	■	-9.0

Direction of Improvement

Maximize	↑	1.0
Target	●	0.0
Minimize	↓	-1.0

Standard 9-3-1

Strong	●	9.0
Moderate	○	3.0
Weak	▽	1.0

Columns 1–13: (1) Importance of the WHATs [less important (1) - very important (10)]; 1. 1. H.320 Video/Audio ISDN Standard:; 2. FCIF (high resolution) capability; 3. QCIF (low resolution) capability; 4. 2. H.320 Audio SpecificStandard Levels:; 5. G.711 compatible; 6. G.722 compatible; 7. G.728 compatible; 8. 3. H.323 Video/Audio LAN Standad:; 9. Selectable bandwidth; 10. 4. T.120 Data-Staring Standard:; 11. File Transfer; 12. Whileboarding; 13. Application sharing

	#	Imp. (1)	1	2	3	4	5	6	7	8	9	10	11	12	13
Direction of Improvement	1														
1. Image Quality (FUNCTIONALITY):	1														
T.V. standard image quality - persons on screen	2	6.0		●	○		▽	▽	▽		●		▽	▽	▽
T.V. standard image quality - artifact on screen	3	6.0		●	○		▽	▽	▽		●		▽	▽	▽
2. Audio Quaity (FUNCTIONALITY):	4														
T.V. standard sound quality (minimum ref. level)	5	6.0		▽	▽		○	○	●		●				
Minimised background sound across V.C. link	6	6.0		▽	▽		○	●	●		●				
3. Camera Options (FUNCTIONALITY):	7														
Automatic vioce location of person/s speaking	8	1.0													
4. Recording & Playback Quality (FUNCTIONALITY):	9														
T.V. standard image quality from recordings	10	1.0		○	○		▽	▽	▽		○				
T.V. standard sound quality from recordings	11	1.0		▽	▽		○	○	○		○				
1. Support Availability (USER SUPPORT):	12														
Idiots guide to operation provided in bullet form	13	5.0													
Access to external video conferencing support	14	7.0													
2 Training Availability (USER SUPPORT):	15														
Initial video conferencing usage training	16	4.0													
Access to perodic 'refresher training'	17	4.0													
Sum of Correlation values	1			24.0	12.0		12.0	18.0	24.0		42.0		2.0	2.0	2.0
Competitive Benchmarking Results	2														
Current Product: Sony 5100	3			1.0	5.0		5.0	5.0	4.0		2.0		5.0	5.0	5.0
Competitor 1: Sony 3000	4			1.0	5.0		5.0	5.0	5.0		2.0		5.0	5.0	5.0
Competitor 2: PictureTel Swiftsite	5			5.0	5.0		5.0	5.0	5.0		4.0		5.0	5.0	5.0
Degree of Technical Difficulty [not difficult (1) - difficult (10)]	6														
Target Technical Values [worst (1) - best (5)]	7			5.0	5.0		3.0	4.0	5.0		4.0		5.0	5.0	5.0
Absolute Technical Weights	8														
Relative Technical Weights	9														

Columns 14–27: 14. 5. Proprietary Versions:; 15. Data-sharing; 16. Video/Adio synchronisation (lip synch); 17. 1. Bandwdth Availability (fps):; 18. ISDN based range - 15 to 30fps; 19. LAN based range - 10 to 25fps; 20. POTS based range - 5 to 10 fps; 21. 2. Transmission Speeds (Kbps):; 22. Up to 128Kbps; 23. 128Kbps to 384Kbps; 24. 384Kbps to 500Kbps; 25. 3. Network Protocols:; 26. Euro ISDN protocols fully supported; 27. USA ISDN protocols fully supported

	#	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Direction of Improvement	1														
1. Image Quality (FUNCTIONALITY):	1														
T.V. standard image quality - persons on screen	2		○	●		●	○	▽		○	●	●		●	●
T.V. standard image quality - artifact on screen	3		○	●		●	○	▽		○	●	●		●	●
2. Audio Quaity (FUNCTIONALITY):	4														
T.V. standard sound quality (minimum ref. level)	5			▽		○	▽	▽		○	●	●		●	●
Minimised background sound across V.C. link	6			▽											
3. Camera Options (FUNCTIONALITY):	7														
Automatic vioce location of person/s speaking	8														
4. Recording & Playback Quality (FUNCTIONALITY):	9														
T.V. standard image quality from recordings	10		○	●		●	○	▽		○	●	●		●	●
T.V. standard sound quality from recordings	11		○	●		●	○	▽		○	●	●		●	●
1. Support Availability (USER SUPPORT):	12														
Idiots guide to operation provided in bullet form	13														
Access to external video conferencing support	14														
2 Training Availability (USER SUPPORT):	15														
Initial video conferencing usage training	16														
Access to perodic 'refresher training'	17														
Sum of Correlation values	1		12.0	38.0		39.0	13.0	5.0		15.0	45.0	45.0		45.0	45.0
Competitive Benchmarking Results	2														
Current Product: Sony 5100	3		3.0	2.0		5.0	0.0	0.0		5.0	5.0	0.0		5.0	5.0
Competitor 1: Sony 3000	4		3.0	3.0		3.0	0.0	0.0		5.0	1.0	0.0		5.0	5.0
Competitor 2: PictureTel Swiftsite	5		5.0	4.0		3.0	0.0	0.0		5.0	2.0	0.0		5.0	5.0
Degree of Technical Difficulty [not difficult (1) - difficult (10)]	6														
Target Technical Values [worst (1) - best (5)]	7		4.0	4.0		5.0	0.0	0.0		5.0	4.0	0.0		5.0	5.0
Absolute Technical Weights	8														
Relative Technical Weights	9														

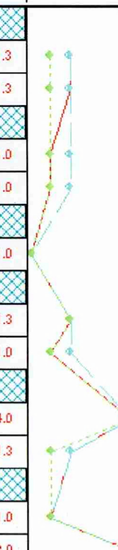
Columns 28–40: 28. 1. Video Attributes / Features:; 29. High-quality video frame rate 25 - 30fps; 30. 2. Audio Attributes / Features:; 31. High quality microphone; 32. 1. Technical Support:; 33. 90 days free telephone based support; 34. Maintenance and short term support (min. 1 year); 35. Optional extended support plans; 36. Online manual / support / help facility; 37. Paper based / quick reference guide; 38. 2. Training Support:; 39. Initial video conferencing training service; 40. Periodic training service available

	#	28	29	30	31	32	33	34	35	36	37	38	39	40
Direction of Improvement	1													
1. Image Quality (FUNCTIONALITY):	1													
T.V. standard image quality - persons on screen	2		●		▽									
T.V. standard image quality - artifact on screen	3		●											
2. Audio Quaity (FUNCTIONALITY):	4													
T.V. standard sound quality (minimum ref. level)	5		▽		○									
Minimised background sound across V.C. link	6				○									
3. Camera Options (FUNCTIONALITY):	7													
Automatic vioce location of person/s speaking	8				▽									
4. Recording & Playback Quality (FUNCTIONALITY):	9													
T.V. standard image quality from recordings	10		●		○									
T.V. standard sound quality from recordings	11		●		●									
1. Support Availability (USER SUPPORT):	12													
Idiots guide to operation provided in bullet form	13						▽	▽	▽	○	●		▽	▽
Access to external video conferencing support	14						●	●	○	●	●		▽	▽
2 Training Availability (USER SUPPORT):	15													
Initial video conferencing usage training	16									▽	▽		●	○
Access to perodic 'refresher training'	17									▽	▽		○	●
Sum of Correlation values	1		37.0		20.0		10.0	10.0	4.0	14.0	20.0		14.0	14.0
Competitive Benchmarking Results	2													
Current Product: Sony 5100	3		5.0		3.0		5.0	5.0	2.0	4.0	0.0		5.0	2.0
Competitor 1: Sony 3000	4		2.0		2.0		5.0	5.0	2.0	4.0	0.0		5.0	2.0
Competitor 2: PictureTel Swiftsite	5		4.0		3.0		5.0	5.0	2.0	4.0	0.0		5.0	2.0
Degree of Technical Difficulty [not difficult (1) - difficult (10)]	6													
Target Technical Values [worst (1) - best (5)]	7		5.0		4.0		5.0	5.0	3.0	4.0	4.0		4.0	4.0
Absolute Technical Weights	8													
Relative Technical Weights	9													

Competitive Analysis: 1. Competitive Analysis; 2. Current Product: Sony 5100; 3. Competitor 1: Sony 3000; 4. Competitor 2: PictureTel Swiftsite; 5. Target Product Attribure Values [worst (1) - best (5)]; 6. Scale-Up Factor; 8. Absolute Weight for V.C. User

#	1	2	3	4	5	6	8
1							
2		3.0	3.0	4.0	4.0	1.3	8.0
3		3.0	3.0	4.0	4.0	1.3	8.0
4							
5		4.0	3.0	4.0	4.0	1.0	6.0
6		4.0	3.0	4.0	4.0	1.0	6.0
7							
8		5.0	5.0	5.0	5.0	1.0	1.0
9							
10		3.0	3.0	3.0	4.0	1.3	1.3
11		4.0	3.0	4.0	4.0	1.0	1.0
12							
13		0.0	0.0	0.0	4.0	4.0	20.0
14		3.0	3.0	4.0	4.0	1.3	9.3
15							
16		4.0	4.0	4.0	4.0	1.0	4.0
17		0.0	0.0	0.0	3.0	3.0	12.0

Max = 5.0
○ Current Product: Sony 5100
Competitor 1: Sony 3000
● Competitor 2: PictureTel Swiftsite
Min = 0.0



APPENDIX E: VIDEO & AUDIO CASE STUDY DATA

AUDIO FORENSIC LABORATORY OPERATIONAL STAGES

BOOKING IN

The exhibited audio data storage media (i.e. cassette) is submitted with a Lab Form 1 and the submitting office's details are logged. A receipt for the storage media is issued.

The storage media is then placed into a locked store and the file placed in a queuing system waiting processing.

INITIAL EXAMINATION

In turn the tape is unsealed and examined usually for any defects, marks, etc. The audiocassette is then listened to and its content evaluated for possible enhancement techniques.

Detailed notes are kept of each examination.

AUDIO ENHANCEMENT

The off-tape signal is passed through whatever electronic filtering, noise reduction and gain control techniques the engineer feels necessary in order to optimise the 'intelligability' and 'clarity' of the recording. This can mean anything from a simple filter to a very complex chain of processes. Again, everything is logged in detail.

EVIDENTIAL COPIES

The enhanced version audio signal is then copied to three high quality compact cassette, one of which is sealed for court use. The chrome tape and Dolby reduction system used corresponds to playback equipment.

PACKAGING AND BOOKING OUT

The original cassette recording is resealed and returned to a secure store along with the copies produced. When collected by the Officer who originally submitted the cassette, a signature is obtained to ensure full evidential continuity.

POST-PROCESSING SERCOVES

The audio laboratory provides many services after relevant audio storage media is submitted for analysis. Three post-processing services are:

1. Written Transcriptions
2. Witness Statements and Expert Evidence In Court
3. Court Playback Preparation.

REPERTORY GRID INFORMATION

EXPLANATION OF PROCEDURES

To facilitate successful interaction between interview subjects (i.e. interviewees) and the person conducting the Repertory Grid interview, the following information exchange should take place:

INTERVIEWER. I am a postgraduate student from Cranfield University working with the CARAT Project Group within the Metropolitan Police Service (MPS). I am undertaking a three-month project that aims to develop an objective evaluation framework for technology (multimedia). The finalised framework must give consideration to the needs of users. That is, reflect subjective impact. Currently, we are determining user requirements through cognitive techniques. These techniques involve processes for eliciting and understanding idiographic data. As part of this, I am interviewing a number of multimedia users to develop an understanding of their opinions on various technology issues.

The interview will last approximately one hour and if you do not object, I would like to record this interview. The recording will reduce the needs for extensive note taking, and allow transcripts of the interview to be produced. Do you mind if the interview is recorded?

INTERVIEWEE. Answers

INTERVIEWER. This interview is standardised to allow for the comparison of results with other related interviews. It involves discussing different equipment (technology) that is used in this place of work. There are two stages to this interview these are now described:

1. The interviewee is asked to name 5 pieces of equipment that they use in their place of work and have formed opinions regarding their usefulness.

The name of each piece of equipment will then be documented on separate cards for later visual reference. Each card will have a designated number derived from a random numbering process. Three cards (called a 'triad') are then selected according to the order generated from the random numbering process. The first triad cards are shown and the following question is then asked by the interviewer:

"Please think about these three pieces of equipment and how two of them are similar, from the point of view of allowing you to undertake your role in this organisation, and different from the third?"

The process of splitting the three cards into two similar and one different is then conducted accompanied by verbal explanations.

2. Two of the three pieces of equipment noted in the triad were found to be similar from a certain point of view (i.e. functionality available to assess video footage, etc.) and different from the third in that ELICITED CONSTRUCT (i.e. contrast range, etc.). For the second stage these three pieces of equipment are rated on an appropriate scale (I.e. 1-5 scale). This requires firstly asking the interviewee to rate the current triad. After rating the triad shown, the remaining pieces of equipment (cards) are also rated using the same scale. Thus, a process of comparison in undertaken.

This two-stage procedure is continued with another set of triads. Reiterating the question " how are two similar, from the point of view of allowing you to successfully undertake your job, and yet different from the third?" Remembering that several important points (constructs) have already been identified.

REPERTORY GRID DATA COLLECTION (AUDIO)

INTERVIEWEE'S DETAILS

Name:	OMITTED (Respondent 'E')
Position:	Head of Audio Forensic Laboratory
Organisation:	Metropolitan Police Service
Contact Address:	Audio Laboratory
	113 Grove Park, Denmark Hill
City:	London
Country:	U.K.
Postcode:	SE5 8LE
Tel. (External):	0171 230 0244
Tel. (Internal):	60244
Tel. Mobile:	
MPS Relationship	Forensic engineer
Technology Involvement:	Audio analysis technologies
Other Information	
Data Entered By:	Mr. J.P. Taylor
Date of Entry:	5th August 1999

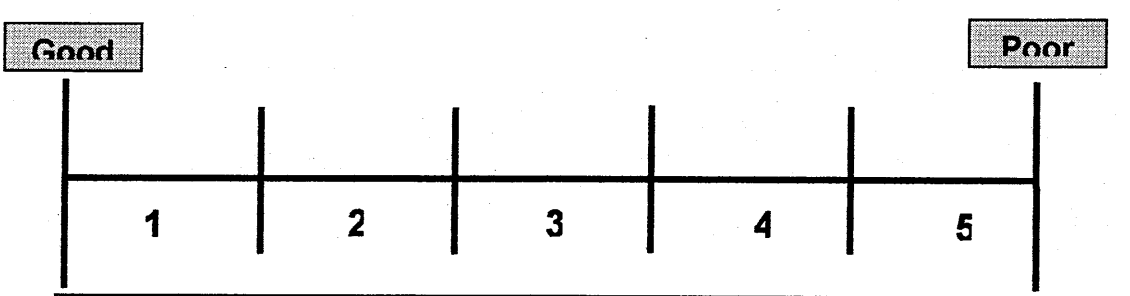
REPERTORY GRID TRIAD SELECTION

5 X 5 GRID

ORDER OF ELEMENTS	1	2	3	4	5					
ELEMENT (CARD) NUMBER	5	1	4	3	2					

	ELICITED EQUIPMENT (ELEMENTS) BY CARD NUMBER									
CONSTRUCT	No.1	No.2	No.3	No.4	No.5					
1st	X	X	X							
2nd	X			X	X					
3rd		X	X		X					
4th	X		X	X						
5th	X		X		X					

1 –5 REPERTORY GRID SCALE



Please rate each of the three pieces of equipment on a scale one (good) to five (poor).
Then, please rate the remaining pieces of equipment using the same scale.

REPERTORY GRID DATA

ELEMENTS

ELEMENTS	ELEMENT DESCRIPTIONS
No.1	NAGRA SNST (Sterophonic Professional Tape-recorded)
No.2	Sony Scootman
No.3	Conventional Micro Cassette
No.4	Mini Disk (Sony MZ-1)
No.5	NAGRA JBR (Subminiature Recorder)

CONSTRUCTS

CONSTRUCT	CONSTRUCT DESCRIPTIONS
1st	Dynamics
2nd	Frequency Response
3rd	Recording Length
4th	Recording Device and Media Cost
5th	Ease of Loading Media

REPERTORY GRID DATA

RATINGS

	1 - 5 SCALE RATING per CONSTRUCT				
ELEMENTS	1st	2nd	3rd	4th	5th
No.1	2	2	1	5	5
No.2	1	1	2	3	3
No.3	4	5	4	1	2
No.4	2	1	4	2	2
No.5	1	2	3	5	5

ADDITIONAL NOTES

INTERVIEW NOTES
Answers for each question were provided from the point of view of police
users of audio equipment for undercover operations.

REPERTORY GRID DATA COLLECTION (VIDEO)

INTERVIEWEE'S DETAILS

Name:	OMITTED (Respondent 'F')
Position:	Video Forensic Laboratory Engineer
Organisation:	Metropolitan Police Service
Contact Address:	Video Laboratory
	113 Grove Park, Denmark Hill
City:	London
Country:	U.K.
Postcode:	SE5 8LE
Tel. (External):	0171 230 0244
Tel. (Internal):	60244
Tel. Mobile:	
MPS Relationship	Forensic engineer
Technology Involvement:	Video analysis technologies
Other Information	
Data Entered By:	Mr. J.P. Taylor
Date of Entry:	5th August 1999

REPERTORY GRID DATA

ELEMENTS

ELEMENTS	ELEMENT DESCRIPTIONS
No.1	World Master CEL P256 (Television Standards Converter)
No.2	DPS-375 Time Base Corrector
No.3	ForA FA-4040
No.4	IVC GML-8000
No.5	JVC BR-S525E (Internal based timebase)

CONSTRUCTS

CONSTRUCT	CONSTRUCT DESCRIPTIONS
1st	Bandwidth Capability
2nd	Timing (ability to correct poor timeing in video)
3rd	Useability
4th	Connectivity
5th	Added functionality

REPERTORY GRID DATA

RATINGS

	1 - 5 SCALE RATING per CONSTRUCT				
ELEMENTS	1st	2nd	3rd	4th	5th
No.1	3	4	2	2	1
No.2	4	5	3	2	5
No.3	1	4	4	2	5
No.4	5	1	2	5	4
No.5	2	3	2	3	5

ADDITIONAL NOTES

INTERVIEW NOTES

USER IDENTIFIED REQUIREMENTS AND PRE-QFD CHECK

User Identified Requirement	Highest Rated Element	Selected Element	Technical Specification	Suitable For QFD Analysis
Bandwidth Cap.	No.3	FA-4040	5.5Mhz-3dB (Mono)..	Yes
Timing	No.4	GML-8000	Chrom. 4ns, Lum. 40ns..	Yes
Useability	No.s 1, 4 & 5	CEL P256	See Product Spec.	Yes
Connectivity	No.s 1, 2 & 3	DPS-375	See Product Spec.	Yes
Added Function.	No. 1	CEL P256	See Product Spec.	Yes

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