

THE ARTICULATION OF SHARED MEANING IN INFORMATION SYSTEMS DEVELOPMENT [CASE STUDY]

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ABSTRACT

This paper presents a case study showing how Repertory Grid Analysis (RGA) can be used to construct shared meaning during information systems development, implementation and use. RGA was used as one of the evidence gathering techniques during a multi-site interpretive study of the development and implementation of the National Automated Fingerprint Identification System (NAFIS) in England and Wales. The case study demonstrates the capacity of such constructions to identify problems arising during and after implementation as information systems are assimilated into their organisational setting. Using participants' constructions of issues, concerns and values, the research demonstrates how the tendency for the information systems development process to be abstracted from the social setting of the system can be reduced. The case study presents an innovative model of co-operation between information systems developers, users and researchers.

1. INTRODUCTION

The research presented represents one part of an intensive [Markus, 1999] or interpretive [Walsham, 1993] case study of the impacts of a large-scale information system, the National Automated Fingerprint Identification System (NAFIS) on the process and organisation of fingerprint work in England and Wales. The specialism and complexity of the fingerprint community was explored using Repertory Grid Analysis (RGA). In this research, RGA is used to provide a content-free medium for data gathering and analysis. This capacity suited the investigation of the specialised and complex fingerprint and automated fingerprint recognition (AFR) development community. Although the findings of the case are clearly specific to this specialised community, the implications are significant to developers, users and managers in other contexts.

The study illustrates how abstraction of the design process from the work setting arises through the use of formal development and project management methods, and how this can give rise to goal divergence between the developers and the workers carrying out the process being subjected to automation. Barley (1990) highlights the lack of research into this phenomenon and the need to make work processes the focal level of analysis. He comments that "amid the dust of the rush to downsize, re-engineer, compete, compute, empower and predict, work has almost disappeared from sight. There is more than a little irony here" (Barley, 1996).

The case investigates the nature, extent and implications of this goal divergence using Repertory Grid Analysis (RGA) to articulate issues and concerns by exploring fingerprint work. The longitudinal structure of the case spans the late phases of development, implementation and use of NAFIS, enabling changing work practices to be explored and explained as they occurred.

The research approach, findings and implications are discussed in detail after the following sections, which describe the context of the study and the information systems concerned.

2. THE PROCESS AND ORGANISATION OF FINGERPRINT WORK

Fingerprint work has evolved over the last 100 years in the UK. Despite recent advances in DNA profiling and other forensic techniques, it remains the principal means of identifying offenders responsible for crime and confirming the identity of individuals charged with a criminal offence. Despite their common dependence on the fingerprint image as the information medium, these two work processes have historically been differentiated in terms of their geographic organization and management responsibility.

Both processes depend upon a central database of fingerprints taken from offenders when they are arrested, known in the UK as 'ten prints'. The ten prints taken from offenders following charge are compared with the national collection, and the relevant criminal record updated or created as appropriate. Since the integrity of the data comprising the national criminal names database, held on the Police National Computer (PNC), depends on confirmation of offenders' identity, this process of ten-print verification has historically been the responsibility of the National Identification Service (NIS) in London.

Latent fingerprints or 'marks' recovered from a crime scene are compared with the database in an effort to discover the identity of the offender. Since crime detection is the responsibility of the local chief police officer, the scenes of crime identification process has historically been carried out locally. To support the autonomy of this local process, each of the 43 police forces in England and Wales has developed its own database of ten prints taken from offenders arrested in the force area. The national fingerprint collection in London currently comprises some 5 million criminal records, each with one or more sets of ten prints associated with them. Local fingerprint collections vary in size according to the geographic size and distribution of population and crime within each force area.

Both ten print verification and crime scene identification involve comparison of the detailed characteristics (or minutiae) within the fingerprint image. This work is both painstaking and time consuming, more so in the case of scenes of crime identification due to the poor quality of the source data (the mark) and the frequent absence of any information about the offender. Ten print verification differs in that, usually, ten print forms submitted for verification include a name and other details about the individual. Work processes have evolved that aim to minimize the amount of detailed comparison required. These include elimination of marks with insufficient characteristic detail for comparison, elimination of fingerprints with patterns dissimilar to the mark, classification of fingerprints according to pattern and characteristic incidence and the development of automated fingerprint recognition (AFR) systems to retrieve fingerprint images from the database for comparison.

AFR systems contribute to both ten print verification and scenes of crime mark identification processes by using an algorithm to rank the sets of ten prints they retrieve for comparison. The ranking represents the degree of similarity of the retrieved images to the enquiry image input. AFR systems have been used to support the ten print verification process in England and Wales for several years. They have also been used to support the scenes of crime identification process in a large number of forces. Such systems have included single force systems and collaborative systems supporting the majority of forces, but to date none has had an interface with the national database of criminal records held on PNC.

3. NAFIS

When fully deployed in 2001, NAFIS will consist of a central system; fingerprint bureau front-end-support systems to support the 43 police forces in England and Wales; an integrated communications system connecting the central system to the bureaux systems; two training systems; and a test and development system. NAFIS will utilise the Police National Network (PNN), to carry data between the central site and the police forces. The NAFIS Central Site is co-located with the Police National Computer. NAFIS will be one of the biggest image storage systems in Europe and will hold up to 90 million images and 3 million scenes of crime marks. Its search speed is one million fingerprint comparisons per second. The NAFIS architecture is designed to provide a foundation for future growth and technology insertion. State of the art AFR technology, improved work flow capabilities and access to an electronic office environment greatly increases the time that a fingerprint officer has to view and verify identifications. Modular and scaleable central and bureau system designs meet increased workload demand and increases in database sizes (for further details, see www.pito.org.uk/nafis).

NAFIS will provide access to the national fingerprint collection to all 43 forces in England and Wales. The interface to PNC supports verification of the criminal record by fingerprint staff as they compare fingerprints supplied following arrest and charge with those held in the national collection. There is universal agreement that the design phases of NAFIS were a great success due to the high level of involvement of fingerprint practitioners. As a result, NAFIS has an impressive technical design. The human-computer interface is particularly popular. The success of the design phase enabled NAFIS to be developed as a self-contained, ready to run AFR system. The description of NAFIS as 'just a fingerprint tool' became a touchstone used by fingerprint workers to show that they were comfortable with the system and did not feel threatened by it.

This claim highlighted the functional specialization in police work and limited exploration of NAFIS to the fingerprint community. Exploration was further limited by the dominance of scenes of crime mark processing in the work of fingerprint staff outside NIS. The success of the design and pilot phases of NAFIS and the sense of ownership felt by the fingerprint community led to rapid acceptance and exploitation of NAFIS within fingerprint bureaux. The availability of NAFIS scenes of crime functions preceded ten print verification in many bureaux. Since scenes of crime mark processing had historically been the primary function of the bureaux, the functions offered by NAFIS were quickly and readily assimilated into working practice. Although the implications of NAFIS for the ten print process were equally well documented as those affecting the scenes of crime process, their significance was not as widely understood during the development and pilot phases. The first phase of this research showed that in reality, NAFIS substantially affects both the scenes of crime identification and ten print verification work processes.

The work of fingerprint experts in identifying offenders from the marks left at local scenes of crime is changed by NAFIS due to the local availability of a fully searchable database of ten prints. Although theoretically searchable, the time and effort involved in manually classifying, retrieving and comparing ten print forms from the national collection has to date prevented such searches in all but the most serious cases. This was the most immediate and obvious benefit of NAFIS to fingerprint staff, particularly those in forces with little or no AFR experience. The scenes of crime process has been affected primarily by the capability to launch an increased number of speculative searches using NAFIS. The need for eliminations and other pre-search tasks reduces as the capacity and performance of the system improves.

The ten print process has been also affected by the performance of the system. The earlier centralized system involved sending paper ten print forms to London for verification. Time to complete the process was measured in weeks. NAFIS offered dramatic reductions in time. Combined with digital finger print image capture technology, verification of an offender's identity within one minute became possible. NAFIS provides the potential to change the sequence of events following arrest so as to exploit the improved process speed. Such a change would enable the police to identify people giving false details reducing difficulties in later stages of the judicial process and the incidence of aliases in the criminal record database. Significantly, NAFIS has devolved responsibility for ten print verification from NIS to the 43 local forces. Following charge, ten print forms are locally scanned and used to update the national fingerprint record from local NAFIS terminals. This has a number of advantages, including more timely input, local storage of ten print

forms and the removal of the need for two sets of ten prints. Most importantly, the devolved ten print process supported by NAFIS reduced the response time for verification from weeks to under a minute in many cases. This change had implications for elements of the verification process carried out by workers outside the fingerprint bureau.

The success of the development phase of NAFIS is demonstrated both by the robustness of the system itself and by the performance improvements described. NAFIS offers further opportunities to improve both scenes of crime mark processing and ten print verification processing. Despite the success of the development phase, a number of issues were highlighted during this research.

4. RESEARCH APPROACH AND PROCESS

This research addressed concerns among the practitioner community that neither the nature or extent of changes to fingerprint work brought about by NAFIS were widely understood or appreciated. The research therefore aimed to articulate the issues and concerns felt by fingerprint workers and others as NAFIS moved through the development phase, pilot operations and implementation into use as an operational system. There were concerns that despite substantial involvement of fingerprint experts in the development process, development activity had largely been abstracted from the organisational context of fingerprint work to developers in the USA. The organisational complexity of the police service in England and Wales, driven by a high degree of functional specialism, and the conflation of two distinct work processes into one new information system added to these concerns. The research focused on changes in working practices and perceptions during the latter stages of development and early stages of operational use of NAFIS. The use of RGA to explore participants experience of the changes enables the operational reality of work to be compared with the NAFIS design.

The fieldwork for the longitudinal study of the impacts of NAFIS was undertaken in two phases. The first phase lasted three months and involved two researchers spending periods of up to a week observing and interviewing the people involved in ten print verification and scenes of crime identification in one police force. As well as the fingerprint bureau, this involved work with crime scene examiners, detectives, criminal records administrators, laboratory and photographic technicians and managers at a number of levels. The aims of this initial phase were to immerse the researchers in the organizational context of fingerprint work and to articulate the issues and concerns emerging during NAFIS pilot operations to as many people as possible involved in the scenes of crime and ten print verification processes. The first phase of the research raised issues, concerns and questions that had significant implications for fingerprint processes nationally. These are set out in Beeson and Davis [1998] and included shifts in skill mix; changes to the physical working environment; the provision of out-of-hours cover by fingerprint staff; storage and organisation of local paper fingerprint collections; education and training issues and staff relocation, all of which had financial implications. The study was extended to include eight forces in order that these issues and their implications could be explored more fully.

The second phase of the research lasted 22 months, during which time each of the eight forces were visited 3 times, each time for a number of days, by the researchers. In addition to observation and interview, Repertory Grid Analysis (RGA) was introduced as a data gathering technique to support the interpretive approach to the study of IS described by Walsham [1993, 1999]. The initial fieldwork had highlighted the complexity of fingerprint work, and the dependence of people outside the fingerprint bureaux on the work carried out there: these people included crime scene examiners, forensic scientists, detectives and senior investigators. Given this complexity, it was important to maintain objectivity and avoid preconception about either fingerprint work or NAFIS. RGA was well suited to this task, providing a content-free method for gathering data (see Section 5 below). The use of RGA enabled the research to explore the complex setting and processes of fingerprint work in detail by developing and sustaining a dialogue with fingerprint workers. The advantage of this approach was that the agenda for discussion was not formulated in advance by reliance on procedural guides or other materials. Unlike questionnaires or interview schedules, the content of RGA is constructed by the participant. The data gathered using RGA complemented those gathered through observation and interview in the wider study of NAFIS, enabling a rich dialogue to be maintained through a

process of reporting and feedback. The oral dialogue that took place during the site visits continued by telephone, fax and e-mail. The dialogue was supported through the exchange of written summaries of the fieldnotes and responses to them by the participants. These written materials formed the basis of summary reports to the sponsoring body and the research participants [Beeson and Davis, 1999a, 1999b].

The research dialogue supported a “community of discourse” [Orr, 1996, p 82] that included fingerprint practitioners, the researchers and others involved in the fingerprint processes. Focusing the research at this community/process level provided the opportunity to gain rich insights into fingerprint work and the impacts of NAFIS on it. The following section explains how Repertory Grid Analysis (RGA) was used to articulate and interpret issues, concerns and values as they were constructed within this community.

5. REPERTORY GRID ANALYSIS OF FINGERPRINT WORK

Kelly [1955a, 1955b] developed Repertory Grid Analysis (RGA) as an investigative technique. RGA has been applied in a number of settings by Stewart and Stewart [1981], Thomas and Harri-Augstein [1985] and Stewart [1997]. 24 participants took part in the RGA over a period of 20 months.

The protocols developed by Thomas and Harri-Augstein [1985] were used in this research to gather and interpret qualitative data from participants who were directly involved with NAFIS. This use of RGA places less reliance on statistical analysis of the data and differs from the work of Hunter [1997] and others. The protocols enable RGA to be used as a “conversational technology” [Thomas and Harri-Augstein, 1985, p 38] to support the construction, exchange and negotiation of shared meaning.

The RGA interviews were bounded by a “universe of discourse” [Thomas and Harri-Augstein, 1985, p 43] that maintains a sense of purpose and direction to the conversation without imposing the constraints of an interview schedule or questionnaire. During the initial phase of RGA, participants identified a number of tasks in their experience of fingerprint work. The words used to describe the tasks were noted and each was transcribed onto a small card. When the participant and the researcher were satisfied that a complete list of tasks had been elicited, the cards with the task descriptions were presented to the participant in randomized groups of three. At this stage, the participant was asked to say which of the three tasks was the odd one out. Having made a selection, the participant was asked to explain how the task selected differed from the remaining pair, and what made the pair similar. The participant’s responses were recorded. This process, known as triadic elicitation, continued until repetition occurred. The task descriptions and the verbal constructs used to differentiate them were used to label the rows and columns, respectively, of a two dimensional grid. Each row was labeled at one end with the construct used to identify the odd task, and at the other with the construct used to identify the similarity of the remaining pair. In this way, each row represented what Kelly [1955] calls a bi-polar construct. Participants then completed the grid by considering each bi-polar construct in turn: a Likert scale was used to rate each of the task descriptions according to the bi-polar construct.

Two-dimensional cluster analysis was used to restructure the ‘raw’ grid. The rows (task elements) and columns (constructs) were re-ordered according to the degree of similarity in the ratings assigned to them by the participant. The algorithm used in this restructuring produces what Thomas and Harri-Augstein [1985] call a spaced-focused grid. At this stage the data analysis diverges from the more orthodox approach of Hunter [1997] and others. Rather than engage in further statistical analysis of the numeric data, the spaced focused grid is presented to the participant concerned. In addition to being re-ordered, the degree of similarity in the rankings assigned to the rows and columns is presented graphically using a percentage scale (see Figure 1). The technique is explained more fully in Davis [2001]. The graphical presentation highlights clusters of both task elements and constructs. During the final stage of the RGA interview participants explain the meaning and significance of the clusters in a process called talkback by Thomas and Harri-Augstein [1985, p 77]. The participant’s comments are recorded by annotating the grid.

During the second and third visits to each force the RGA process was repeated using the same universe of discourse. On completion, each participant was asked to compare the most recent annotated talkback grid with those completed during previous visits. This extension to the talkback protocol adheres to the principles

of personal construct psychology underpinning Kelly's work and enabled the participants to reflect on their own experience of changes to their work and the constructions used to describe them.

5.1. Commentary

Repertory Grid Analysis (RGA) enabled participants in the research to articulate their experience of fingerprint work. The elements and constructs that emerged from this work identified a number of issues and concerns that had not previously been recognised. Their significance to the NAFIS project is discussed below. The data gathered using RGA complemented those gathered through observation and interview, substantially increasing the intensity of the process of interpretation in the wider study of NAFIS. Section 7 discusses the implications of this experience for information systems development more generally.

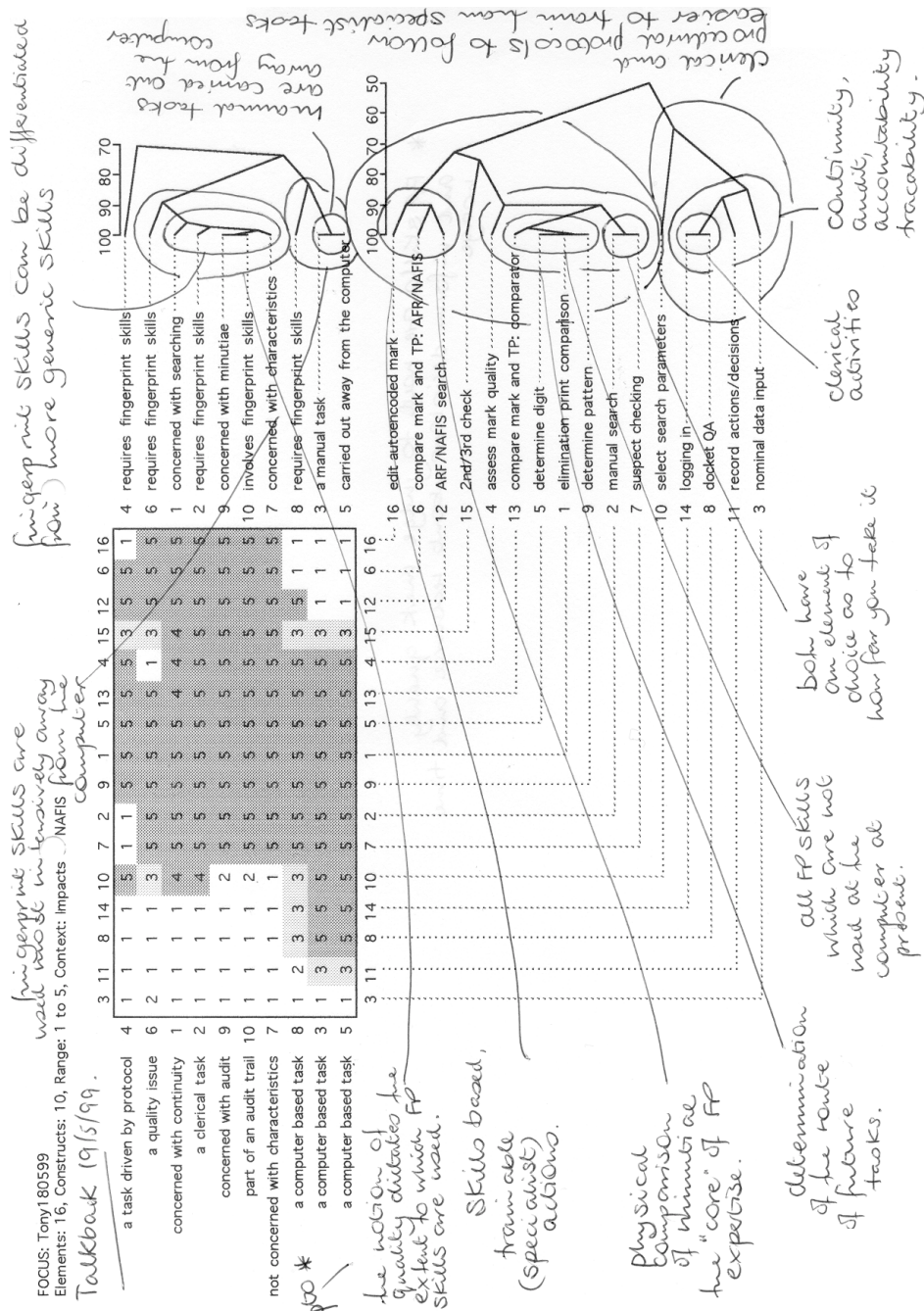


Figure 1: A Spaced-Focused Repertory Grid

6. RESEARCH FINDINGS

The talkback phase provided particularly rich insight into fingerprint work. Participants repeatedly found that the RGA process enabled them to articulate ideas and concepts that they had not realized, or not realized the significance of, or that they had previously been unable to describe verbally. These insights were used to extend their investigation beyond the fingerprint community. They were:

- Macroscopic versus microscopic analysis of fingerprint images
- Process continuity: inclusion and exclusion
- The interdependence of fingerprint work and administrative work
- Process automation, autonomy and control
- Performance, training and trainability
- Competence, status and responsibility
- Exploration, discovery and confirmation
- Process awareness and integration
- Nature of process outputs

The significance of these issues varied, as did the range of people affected by them. Some were specific to fingerprint work itself and so were only of concern to the people employed in the bureaux. Others concerned aspects of the fingerprint processes responsibility for which rested outside the fingerprint bureaux. The significance and utility of these findings can be illustrated by exploring one in more detail: the differentiation of microscopic and macroscopic examination of fingerprint images. Although this distinction was both intuitive and clear to fingerprint workers, it had not previously been expressed in this way. More significantly, task differentiation using this bi-polar construct enabled the significance of changes to fingerprint work processes brought about by NAFIS to be discussed in the context of current working practice. Working practices have evolved that minimize the time consuming and detailed work involved in comparing fingerprint images. Tasks performed early in both the scenes of crime identification and ten print verification process aim to minimize the amount of comparison work required. Many of the ten prints of people suspected of a particular crime are not subjected to detailed comparison with the mark found at a crime scene. If, for instance, the mark has a loop pattern, ten prints with whorl or arch patterns could be quickly excluded (eliminated) from further processing, saving time and AFR resources. Such elimination depends only on a macroscopic examination of the whole fingerprint image: there is no need for detailed examination or comparison of the minute detail of either fingerprint image. Similarly, if a set of ten prints provided by the crime victim or another person with legitimate access to the crime scene (an elimination set) is found to be identical with the mark under investigation, the mark is eliminated from any further comparison. Elimination represents a decision by the fingerprint expert to discontinue the comparison process. Anecdotal evidence from a number of fingerprint staff suggested that 40% of all submissions were eliminated in this way.

NAFIS workflow anticipated the system's use for all fingerprint processes, including eliminations, in order to fulfil a design goal of maintaining a comprehensive audit trail documenting the continuity of fingerprint evidence and the integrity of the process. This goal conflicted with the process optimization central to the existing working practice. Since NAFIS hardware and software automatically captured fingerprint images in sufficient detail to allow examination and comparison of the characteristic detail, a considerable amount of time would be needed. Fingerprint people felt they did not need the sophistication of NAFIS to eliminate fingerprints from further comparison. Articulation of the microscopic-macroscopic construct enabled this goal conflict to be discussed by developers, commissioners and users of the system. The workflow was amended to support continuation of the manual elimination of fingerprints from the comparison process.

This issue is one of several articulated through the RGA process that were fed back to the participants and discussed in the research reports [Beeson and Davis, 1999a, 1999b]. The research contributed substantially to the implementation process, supporting the community of discourse through the identification and resolution of issues and concerns.

6.1. Commentary

This example shows how, despite the acknowledged success of the design and development phases of NAFIS and the technical excellence of the system in use, perceptions of the changes to work processes brought about by the implementation of NAFIS varied widely. On reflection, it seems that despite the substantial number of fingerprint experts involved in the design and development phases; 'eliminations' had become commodified as an entity within the system design rather than one of the processes that comprise fingerprint work. The commonality of fingerprint images to all NAFIS processes may have contributed to this commodification.

Issues of similar significance were identified during discussion of the other eight concerns articulated during the RGA process. The focus on fingerprint work sustained by the RGA process supported a dialogue in the wider study of NAFIS in which the language was common to most if not all of the parties concerned. The maintenance of the dialogue over the years spanning pilot operations, implementation and use had a number of advantages. Firstly, the construction of shared meaning through the use of RGA cumulatively increased the familiarity of the researchers with fingerprint work. This learning experience was reciprocated among the participants in the research who became increasingly familiar with the research process and methods used. Secondly, increased understanding of the research process led to an increasing degree of trust between the researchers and participants. Thirdly, the increased awareness of issues and concerns articulated using RGA enabled the research dialogue to be widened to include interviews with people with the capability or responsibility to address them. This aspect of the research was particularly productive.

Although the illustration in Section 6 above is clearly specific to the specialist fingerprint community, it demonstrates the capacity of RGA to provide a medium for discussion of issues and concerns that accommodates unanticipated or unrealised phenomena. In this case, it enabled diverging views and expectations of NAFIS workflow to be reconciled, contributing directly to the implementation by improving understanding and use of the system. Eason (1988) and Scarbrough and Corbett (1992) suggest that the impacts of information system can never be fully predicted in advance. This theoretic position suggests that the technique has potential for application in other organisational settings.

7. IMPLICATIONS

In addition to providing the insights and enabling the reconciliation of diverging expectations described above, the innovative model of co-operation supported by the use of RGA generated data that complemented the measures used to assess NAFIS by the software developers and the system commissioners: their prime concern was with technical performance and contractual obligations. The capacity of RGA to articulate issues and concerns arising during and after development that might otherwise have remained undiscussed was particularly complementary to these primarily numeric indicators. The shared meanings constructed through the use of RGA increased the researchers' understanding of fingerprint work and the issues and concerns felt by the fingerprint community. This had a number of implications.

Firstly, there was a strong sense of ownership and control of the research process by the participants themselves. This gave rise to the increasing trust between the researchers and the participants and the expanding dialogue central to the research process. It also revealed some of the tensions inherent in the complexity of organisational politics in the police service. Walsham [1999, p378] notes that interpretive study of information systems inevitably meshes with organisational politics and that the outcome is not necessarily negative. On balance, this research confirms that view. Secondly, the increased understanding of fingerprint work acquired by the researchers increased the authority of the dialogue with participants, during

the RGA work and during interviews with other participants in the wider police community. This was important, not least since the participants numbered over three hundred and spanned the whole range of ranks in the police service up to and including Chief Constable. The shared understanding of NAFIS developed through RGA with the fingerprint community enabled the researchers to interact with the NAFIS developers, TRW SOI Inc., and the wider information systems development community. A significant outcome of the RGA was to shift the perception of the researchers within both the fingerprint and development communities from external consultants to facilitators of an internal dialogue.

Thirdly, the RGA and other work have given rise to significant synthesis of research and teaching. Clearly, the issues and concerns facing the police service as NAFIS is brought into operational use are typical of those facing any large, complex organisation involved in the processes of implementation and change. The study of NAFIS has provided the researchers with insights and examples that can readily be used to illustrate the nature and significance of the concepts in management information systems syllabi and textbooks, particularly at postgraduate level. In addition to this support of teaching by research, the research itself has benefitted from the teaching skills of the researchers. Many of the issues and concerns articulated during the RGA interviews prompted requests from senior managers for presentations and discussions. Presentation of the research findings to a group of senior managers in one force enable prompt and effective resolution of an operational problem that has arisen as a result of inappropriate distribution of responsibilities among staff following the introduction of NAFIS. The participants quickly assimilated the materials presented, an indication that the shared meanings acquired during the research had validity and meaning outside the immediate domain of fingerprint work.

8. LESSONS LEARNED

The case study has demonstrated the capacity of RGA to explore the work context of information systems development, implementation and use within an interpretive research framework. Much of the richness of the research findings and the implications of the case arise from the use of Thomas and Harri-Augstein's [1985] protocols supporting the use of RGA as a content-free data gathering technique, enabling the case study to move away from pre-ordinate approaches to the study of information systems development and use that tend to rely on technical and economic criteria.

The dialogue supported by the use of RGA facilitated the process of enquiry and debate among a wide range of participants in the NAFIS project. The research presents a new model of co-operation for information systems development capable of reducing the abstraction or decontextualisation that dependence on formal systems development methods can give rise to. Additionally, the emphasis of dialogue in the research process increased both the utilisation and utility of the research data by embedding them in the social milieu of information systems development, implementation and use.

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