

SmartFiles – ICT Innovation in Complex Criminal Investigations

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Abstract— The compilation of complex criminal investigation files presents a significant challenge to police investigators in distilling large quantities of investigative material into a meaningful blueprint to facilitate prosecutorial decision making. This paper highlights the potential value in using information and communications technology (ICT) to bundle together the raw materials of an investigation file including words, pictures and other media to present evidence to the first time user via multiple sensory modalities in a random access manner. In the research project underpinning this paper an extensive literature review was conducted along with qualitative interviews with experienced practitioners in the field. Proposals for innovation in complex criminal investigation files were developed and implemented using Action Research resulting in a *SmartFile* product characterised by dynamic interactive and navigational functionalities within a hypermedia environment. The innovative *SmartFile* was professionally reviewed and evaluated. Evaluations indicate considerable support for ICT led innovation of complex criminal investigation files. Such a step will improve the communication of evidential findings from complex criminal investigations to decision making authorities. This paper highlights the potential that exists to radically redesign, innovate and dramatically improve the complex investigation file product by implementing changes in work strategies and process design using ICT as a central lever. This will lead to process and operating efficiencies in the file compilation process and follow on efficiencies in the time required for prosecutorial decision making. The present study clearly identifies the value which the use of hypertext navigational linking adds to an executive summary of a complex criminal investigation file and how ICT

led re-engineering of complex investigation files will facilitate in a value adding way the communications objective of the product.

Keywords — information and communications technology, smartfiles, criminal investigation, product innovation, interactive navigation, hypermedia.

I. INTRODUCTION

“People generally remember 10% of what they read, 20% of what they hear, 30% of what they see, and 50% of what they hear and see.”

Treichler [1] p.15

The responsibility for the maintenance of law, order and for the investigation of crime in most countries lies with the national police force, in Ireland this is An Garda Síochána (Guardians of the Peace). Investigations into serious crimes such as murder, complex fraud and organised crime typically carry with them a heavy collateral load of documentary and other materials including statements of evidence from witnesses, recordings of interviews with suspects, documentary evidence and CCTV footage. A key field of operational activity in the criminal investigation process is the manufacture of the end product – ‘The Investigation File’ which has a target audience of law officers charged with prosecutorial decision making.

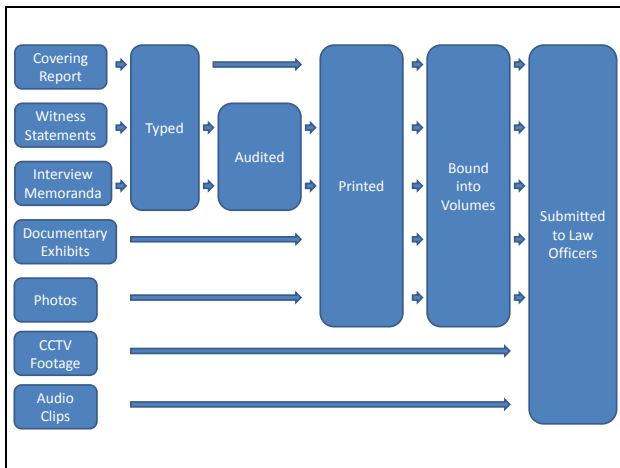
Some of the areas of activity in investigation file compilation include drafting the covering report, auditing

statements of evidence, printing documentary materials (statements, reports, crime scene photos) and binding the materials into paper volumes.

These activities are represented in the operations processing graphic for investigation file compilation included at Figure 1 below.

Figure 1 – Operations Processing Graphic – File Compilation (Current)

(Timeframe in Complex Cases 4 – 24 months)



The principal goal of the investigation file is to communicate the evidential findings of the investigation firstly to senior management in the police force and thereafter to professional law officers who determine whether criminal charges are warranted and what those charges will be. The key issue therefore is communication.

In recent times rapid ICT advancement has increased the complexity of the nature and type(s) of evidence which form the basis of criminal investigation files. What is now apparent is the requirement for the criminal investigation process to keep pace with developments in ICT and a key part of this is the emergent demand for a redesign of the way in which investigation files are constructed.

This paper seeks to address that requirement, setting in context the investigation file compilation process, examining the drivers for change, implementing innovative change in a live criminal investigation using action research methodology and evaluating the outcomes.

As larger more complex investigations become more commonplace a demand is apparent for innovation of the existing investigation file product and / or the development of new and innovative facilitating products and services to add value to the investigation file. The aim of the undertaking is to develop a product that will communicate effectively the findings of a complex criminal investigation in a clear, meaningful and succinct way.

II. SETTING THE CONTEXT

In consideration of the academic context of a research study seeking to improve the manner in which complex criminal investigation files are compiled, a number of areas of theoretical focus are relevant.

The activity of investigation file compilation is part of the criminal investigation process and criminal investigations are core organisational activities for police services. Any proposed improvement to this process therefore falls within the domain of Operations Management and the sub-domain of Product Innovation.

The purpose of the investigation file is to communicate evidential findings and the raw materials underpinning the file comprise different forms of media (e.g. Closed Circuit Television (CCTV) footage, audio recordings, crime scene photographs). It is therefore appropriate to review the literature on Multimedia Communication towards the aim of improving the communication capacity of complex investigation files.

The communication goal of the complex criminal investigation file also necessitates a review of the literature on the transfer of knowledge or information – also known as learning. Specifically, Interactive and Navigational Learning in light of the types of raw materials available and the large volumes typically contained in a complex criminal investigation file.

Operations Management and Product Innovation

Slack, Chambers and Johnston [2] describe the primary goal of an organisation’s operations as the transformation process which combines the input materials and information with transforming resources and through this output products and services result. Facilitating products and services may be produced during an operation to support the core product and service offerings of the business. In this analysis the authors describe typical police operations processes as follows –

Table 1 – Police Operations Processes (adapted from Slack et al [2] p.13)

Operation	Inputs	Processes	Outputs
Police	<ul style="list-style-type: none"> Police Officers Computer Systems Information Systems Public (citizens and criminals) 	<ul style="list-style-type: none"> Crime Prevention Crime Detection Information Gathering Detaining Suspects 	<ul style="list-style-type: none"> Lawful Society Public with a Feeling of Security

The current study focuses specifically on an area of activity not explicitly listed but coming under the encompassing process of ‘Crime Detection’.

A review of past research in this domain finds academic focus on areas as diverse as the use of technology and statistical analysis to assist operational police planning [3] [4], the utility of decision support systems for crime detection [5], factors influencing repeat victimization [6], and new strategies for investigation and detection [7].

Key concepts in the field of improving operations management are process redesign, process innovation, process improvement and / or process transformation. In the field of crime detection past research on reengineering of practices has been limited to areas in the forensic sciences such as fingerprinting [8] and DNA profiling [9].

Hammer and Champy [10] defined such improvement as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical contemporary measures of performance determined by the business type.

Multimedia Communication

In the 21st century the environment of communications has undergone rapid and profound development and change due in the main to the revolution in information and communications technology. As stated by Peterson and Levene [11] “the relation between the individual and the universe of information has changed for good, as it also did with the invention of printing, and we need to leverage these conditions so as to accentuate the positive and turn them to the good” (p.2).

Multimedia is defined as the use of text, graphics, animation, pictures, video and sound to present information [12].

Multimedia communication refers to “the combination of multiple technical resources for the purpose of presenting information represented in multiple formats via multiple sensory modalities” [13] p.117. Multimedia environments are characterized by the ability to present information in a non linear or random access manner [14].

Mayer [15] highlighted the usefulness of multimedia communication where written words combined with illustrations or animations used dual channel communication to affect meaningful learning in an audience through active cognitive processing. The author described a number of effects of relevance to the current study. The ‘multiple representation principle’ stated that it was better to present an explanation in words and pictures than solely in words [16]. The term ‘multimedia effect’ was used to describe the process whereby readers absorb information more deeply from exposure to words and pictures than to words alone [17] [18] [15]. The term ‘spatial contiguity effect’ was used to describe the finding that deeper learning takes place when printed words are placed near rather than far away from corresponding pictures [17] [19]. The term ‘coherence effect’ was used to describe the finding that learners absorb information more deeply when extraneous material is excluded rather than included [15] [18].

Mitchell [20] examined the potential benefits of multimedia on learning and found that multimedia based products resulted in an increased level of engagement when compared with written papers or text. Within the area of police operations the benefits of multimedia communication have previously been employed in campaigns to increase road safety awareness and reduce traffic fatalities [21] in addition to appeals for information using social media platforms [22].

It is therefore apparent that the focus of the current study – to innovate complex criminal investigation files may have much to gain from the documented beneficial effects of multimedia communication. The raw materials available in a

complex criminal investigation may be bundled together using pictures, words and other media in close spatial proximity to present the evidence to the first time user via multiple sensory modalities in a random access manner excluding extraneous information for optimal information transfer.

Interactive and Navigational Learning

Pea and Gomez [23] drew attention to the increasing use of interactive multimedia technologies in the education sector and the potential of innovative technological solutions to enhance learning. The authors also referred to the advent of “dynamic documents incorporating live animation, video clips and sound annotations” (p.74). Lawless and Brown [14] highlight the importance of learner control for effective learning in multimedia environments arguing that where a learner has the opportunity to select information meaningful to them and to determine how to sequence exposure to that information, more effective knowledge acquisition occurs.

Guimaraes, Chambel and Bidarra [24] examined the creation of rich learning environments through the use of video information together with the exploration of non-linear access and navigation and found that users of products appreciated the freedom to access and integrate different resources. This resulted in users constructing their own knowledge maps. The ability to integrate video in hyper documents promoted deeper understanding due to the contextualised explanations and illustrations enabled by the integration of text and video. Gall and Hannafin [25] in a framework study of the benefits of hypertext¹ highlight that the use of navigation enabling technology offers users opportunities for choice and increases willingness to interact with a product. Jensen, von Voigt, Nejdil and Olbrick [26] examined the use of interactive 3D visualisation learning in science students and found that interaction can improve learning outcomes. Philpot and Hall [27] examined the use of interactive software with engineering students and reported positive effects when compared with non interactive groups. The author used the term ‘edutainment’ to describe this process as had earlier researchers [12]. Mayer and Chandler [28] conducted experiments into user interaction and its effect on levels of understanding of multimedia communications and found that where learners were enabled to exercise control over the pace of a presentation they performed better on transfer of information tests.

Buchanan and Owen [29] highlight the benefits of ‘within document navigation’ which permits different forms of engagement by the reader – initial quick reading, deep analysis of a document and detail checking. The authors describe three principal forms of navigation interaction in digital documents –

- 1) ‘Click Through Navigation’ which provides a snap shot of the destination information,

¹ Hypertext is text which allows a reader to click on a word in one document and immediately access information from another document, or from another place in the same document. Hypertext is an easy-to-use and flexible format to share information and is the underlying concept defining the structure of the World Wide Web. A Hyperlink is a term used to describe a reference point in hypertext that links to other text, tables, images or other media. Hypermedia is a logical extension of the term hypertext and describes a scenario where graphics, audio, video, plain text and hyperlinks intertwine to create a generally non-linear medium of information.

- 2) 'Hyperlink Navigation' which places the destination information in its entirety in front of the reader and
- 3) 'Thumbnail Navigation' which presents a reduced view of the target information to the reader.

Su and Klein [30] describe a hypermedia system as an environment where information is presented in a non linear way by interconnecting knowledge nodes into a network through the use of hypertext. The benefits of hypertext are that it offers a reader more control over their experience allowing them to make choices about how to proceed through a text. Readers can make choices based on their prior knowledge and experience. The authors highlight a number of difficulties which the use of hypertext creates including an increase in cognitive demand which can be counter acted through the provision of indexes and content lists and also maps presented to the reader providing an overview of the structure. The authors suggest that future research should investigate the usability of navigation tools in practical settings.

Shapiro and Niederhauser [31] examined hypertext, navigation tools and learning and argued that "reader's past experience and prior knowledge led them to make choices about the sequence for reading information in the hypertext in ways that are not possible when reading printed text" (p.607). This presents the potentially beneficial scenario where experts in a particular field are not forced to read material which is already in their knowledge but can navigate to material which is required reading from which they will gain new information and understanding.

Dee-Lucas and Larkin [32] examined the effectiveness of providing hypertext readers with a content map and found that such an aid improved both navigation and memory for topics contained in the text. Similar effects have been recorded in other research [33].

It is clear from a review of the existing literature on interactive and navigational learning that this discipline has much to offer the present study. Integration of dynamic interactive and navigational functionalities within a hypermedia investigation file environment in the presence of a content map is likely to enhance user control and willingness to interact. These measures will ultimately improve information transfer assisting in the communications objective of the investigation file product.

It is clear that fundamental theoretical tenets of operations management, product innovation, multimedia communication, and interactive and navigational learning as explicated above set the theoretical framework for the current study.

III. METHODOLOGY

Insider Action Research

Action research may be described as a disciplined process of inquiry undertaken to assist improvement and/or solve a problem at hand.

Insider action research is described by Coughlan and Shani [34] as a way in which an organisation can develop new

capabilities which will enable the organisation to achieve its outcomes in better, more efficient ways. Insiders are full members of the organisation who have a unique perspective on systems and processes unseen by outside researchers – "deep level insight" (p.644). This perspective enables truthful evaluation and assessment of research interventions dispensing with processes of researcher or executive filtering which can take place with alternate approaches to research.

Action research is characterised by opportunistic planned interventions in real time situations and a study of those interventions as they occur. The strength of the approach lies in the fact that it provides direct access to the area of investigation [35] making it an ideal methodology for the current study.

Coughlan and Coughlan [36] outline six principal activities in the action research process –

1. Data Gathering – hard (statistics, financials) or soft (interviews, observations)
2. Data Feedback – rendering data for analysis
3. Data Analysis – links need to purpose, must be collaborative, i.e. include members of client system
4. Action Planning – what needs to change, in what parts of the organisation.
5. Implementation – making the desired changes
6. Evaluation – reflecting on outcomes, reviewing process to enable planning of next cycle of action.

During the course of the action research process Coughlan and Coughlan [36] also recommend the establishment of an Action Research Steering Group comprising researchers and members of the client system (organisation, customers). The role of this group is to guide data analysis and action planning before ultimately evaluating objectively the results of the research process.

The Current Study

Having established the research rationale and the necessity and desirability of the proposed project (pre-step) the next steps in the action research process are data gathering, data feedback, data analysis, action planning, implementation and evaluation [36].

In advance of commencing the research project proper an Action Research Steering Group was established in light of Coughlan and Coughlan's [36] recommendation. The group comprised the following members –

1. **The Researcher** (Author) – an experienced criminal investigator and an organisational mentor and knowledge expert in incident room co-ordination and investigation file compilation.
2. **The Senior Investigating Officer** – an experienced Senior Investigating Officer and former head of the *Organised Crime Unit* in An Garda Síochána.
3. **The Multimedia Analyst** – a member of the *Garda Síochána Analysis Service* with skills in multimedia presentation and extensive experience in crime analysis and report writing.
4. **The Information Technology Expert** – a newly appointed Incident Room Co-ordinator with an academic background in information technology and an expert level of computer literacy.

5. **The Report Writer** – a detective officer with twenty five years experience investigating crime and compiling investigation files and a recognised expert at report writing.
6. **The CCTV Analyst** – a staff member qualified in the processing of complex CCTV footage and a qualified user of the Kinesense© 1.6 LE software system designed for searching and retrieving footage from third party analogue or digital CCTV systems and for analysing video evidence.

Data Gathering

The methodological approach to data gathering adopted was soft or qualitative in orientation. Questionnaires were completed by five key co-ordination and management stakeholders in the field of complex criminal investigation towards the aim of gathering qualified observations about the shortcomings or potential areas for improvement in the compilation of complex investigation files. Questions focused on the length of time taken to complete a complex investigation file, the human resources involved in the process, the most time consuming phases and the most difficult or challenging aspects of the process. The rationale for determining the questions posed was that limited information was required corresponding to the finite areas of activity that constitute investigation file compilation. The principal aim of the data gathering phase was to establish areas for improvement in the investigation file compilation process.

The data gathering respondents comprised qualified and experienced Incident Room Co-ordinators (IRC's) with familiarity in the compilation of complex criminal investigation files and a Senior Investigating Officer (SIO) with experience in managing organised crime operations and investigations and in reading and reviewing complex criminal investigation files. Early questions sought to establish the respondents' levels of experience. All had more than five years in their field with a number having over fifteen years experience.

An online survey tool² was employed for ease of use and to overcome geographical difficulties. This measure overcame any possibility of researcher bias which can occur during face to face questionnaire sessions.

Following initial background questions to gauge level of experience and computer literacy, participants were asked questions to determine the typical length of time taken firstly to compile a complex crime investigation file and secondly to review the file, and also the personnel resources usually required. Further questions then sought to identify the most time consuming and the most difficult or challenging activities normally experienced in file compilation and those that required improvement. In these questions respondents were locked into a set of alternatives in their responses reflecting actual areas of activity in investigation file compilation such as auditing statements of evidence, summarising testimony, writing the covering report and printing and binding the finished

product. This measure was designed to gather observations about areas that could be changed and avoid respondents drifting in their responses into wider areas of investigation co-ordination. Each question had a free text 'Other' answer option in an attempt to safeguard against an area of activity being overlooked by the researcher.

Data Feedback

Examination of the responses from participants indicated that all respondents were extensively experienced (>5 years) in the compilation of complex criminal investigation files and possessed either competent (spreadsheet/database generation) or excellent (hyperlinking, publishing) information technology skills. With regard to the length of time taken to complete a complex criminal investigation file responses varied from four months to twenty-four months. Personnel requirements were typically two incident room staff on a full time basis with increased numbers during busy periods. The most time consuming and difficult activities for respondents all related to the composition of the covering report. With regard to aspects of complex criminal investigation files which require improvement, the SIO respondent suggested the following –

- 1) The covering report was typically too long and too detailed
- 2) The file format was cumbersome (paper volumes, discs of CCTV) as CCTV could often not be viewed due to variations in recording formats; the format did not facilitate the reader obtaining a strategic overview of the evidence in a case.
- 3) Evidence was difficult to unearth due to superfluous information contained in the investigation file.
- 4) Files were too large in paper format – in one case example 30 volumes.

Data Analysis

The findings from the questionnaires conducted with key stakeholders identified a number of areas of activity and characteristics of complex criminal investigation files which constituted a roadmap of opportunities for product innovation in this area.

The Action Research Steering Group set about discussing possible process and product improvements to complex criminal investigation file compilation and identified a number of areas highlighted in the theoretical framework with potential. The group posited that an electronic approach to file compilation was possible taking advantage of the potential benefits of interaction and navigational linking to leverage the virtues of multimedia learning as highlighted in the review of literature in this area. The group also suggested that the conventional lengthy covering report was not fit for purpose and should be replaced by an executive summary which would frame succinctly the key findings of the investigation.

Before engaging in action research Coughlan and Coughlan [36] state that what is needed is a real issue of both research and managerial significance. On the basis

² SurveyMonkey. Available at <https://www.surveymonkey.com/>

of their analysis of the data gathered the following research proposition was put forward by the Steering Group to frame the key issue in the current study;

A multimedia interactive investigation file – ‘*SmartFile*’ with navigational linking via an executive summary is effective in communicating the findings of a complex criminal investigation

Action Planning

Armed with a research proposition to examine the Action Research Steering Group set about planning the innovation of the investigation file product in a live complex investigation into the activities of an organised criminal gang engaged in the commission of serious crimes.

The task of the Action Research Steering Group was to determine a means by which the investigation file could be redesigned in an innovative way to combine all of the relevant evidential material obtained and generated during the course of the investigation guided by the research proposition of the current study. This evidential material included statements of evidence of witnesses and others persons, typed memoranda of interviews with detained persons, search warrants, CCTV footage, audio clips, custody documentation, forensic authorisations and relevant legislation.

At the outset the Steering Group examined the areas of activity that constitute investigation file compilation and assessed if any could be improved upon in light of the recommendations of questionnaire respondents and the findings of the literature review.

The Steering Group recommended the reengineering of the conventional covering report as an executive summary much reduced in size and containing only the material relevant to prosecutorial decision making. This move would take account of the ‘coherence effect’ described by Mayer [15] whereby learners learned more deeply when extraneous material was excluded rather than included.

It was contended that the executive summary should be written in a newspaper style format combining text with adjacent relevant pictures taking account of the ‘multimedia effect’ where readers learned more from exposure to words and pictures than to pictures alone and of the ‘spatial contiguity effect’ whereby deeper learning took place when pictures were placed near rather than far away from corresponding pictures [15]. It was also recommended by the Steering Group that significant or important text extracts describing key findings of the investigation should be placed in stand-out highlighted bold print to draw the reader’s attention.

The Steering Group considered it essential that all forms of multimedia evidence were rendered into a format universally playable on any computer with basic factory installed software programmes.

The Steering Group recommended the use of ‘hyperlink navigation’ as distinct from ‘click through’ and ‘thumbnail’ navigation [29] as a means of enabling readers of the executive summary to access the statements of

evidence of all witnesses and other persons and the memoranda of interview with suspects. This option was chosen as it was felt that snap shots or reduced views of the target documents were of little use to a reader who wished to conduct deep analysis or detail checking. The Steering Group also identified greater potential value in linking to a specific passage of text rather than expecting the reader to sift through a lengthy statement or memorandum seeking the information required.

The Steering Group determined that the most effective way to integrate the relevant multimedia forms of evidence (CCTV footage, audio clips) into the investigation file was to employ embedded hypertext links within the executive summary to enable one click access of the pertinent material by the reader.

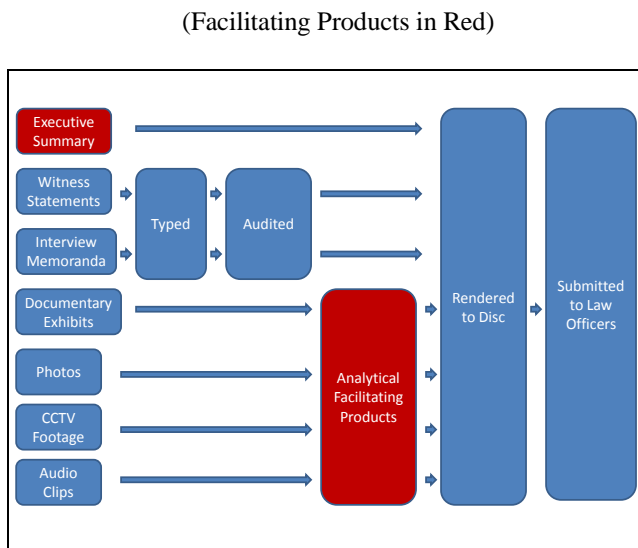
The Steering Group also decided that a content map should be included within the executive summary to provide an overview of the contents and structure of the electronic investigation file and to act as a navigational tool. The content map would outline the non linear interconnecting information nodes in the network allowing the reader to make informed choices about how to proceed through the text and media material.

The Steering Group also recommended that significant streams of complementary documentary and multimedia evidence gathered during the investigation be integrated into subject specific media productions featuring the items of evidence sequenced in chronological order in a multimedia format to assist comprehension in the viewer. This proposed measure leveraged the positive benefits highlighted by Najjar [12] of showing closely related and supporting information together. Such productions were termed ‘Sequence of Events’ features and constituted effective facilitating products to the core operational activity of communicating the findings of the complex criminal investigation file.

The Steering Group recommended the development of an additional facilitating product in the form of a succinct Powerpoint© Presentation bundling together technologies of image capture, voice recording and high resolution graphics. This presentation would act as a front end to the investigation file designed to engage the reader from first contact. This presentation would be designed to distill the complexity of the investigation to a series of key findings and recommendations and would incorporate the ‘Sequence of Event’ productions referred to above to provide the reader / viewer with a complete overview of the investigation without extraneous information. The presentation in essence would leverage the benefits of the ‘multimedia effect’ as described by Mayer [15].

In light of these recommendations a revised graphic combining the old and the new areas of activity in criminal investigation file compilation was designed as depicted in Figure 2.

Figure 2 – Operations Processing Graphic – File Compilation (Proposed)



Implementation

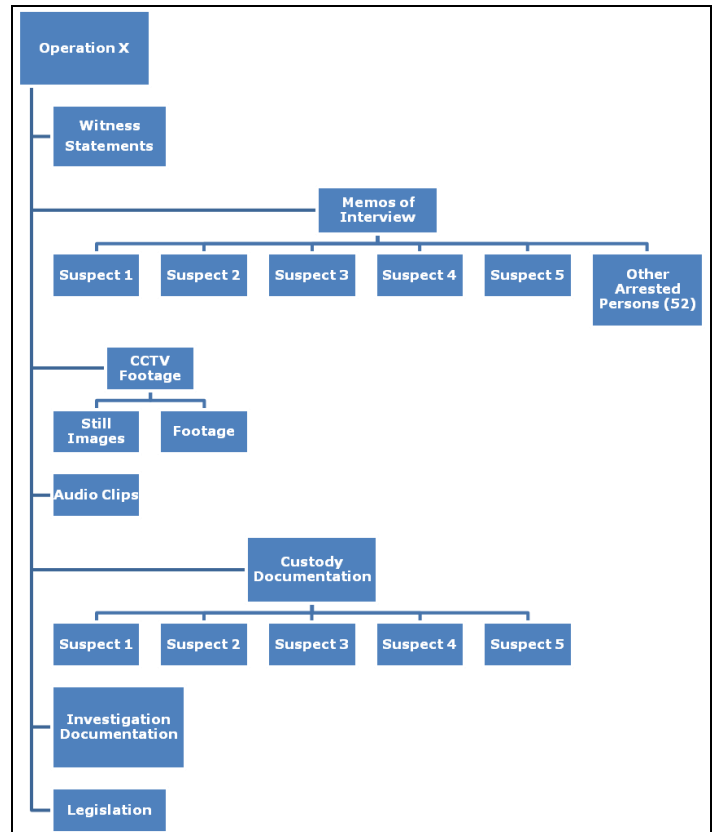
The raw materials or input materials available in this research study with which to implement the changes to the operations process of investigation file compilation were as follows – typed statements of evidence, typed memoranda of interview, crime scene photographs, discs containing CCTV footage, discs containing audio recordings of phone calls to the emergency services and financial documentation detailing assets held by suspects.

The transforming resources available comprised both physical and human. Physical resources included a fully equipped incident room, computers and software (MS Word®, MS Powerpoint®, Kinesense LE 1.6®, Adobe Acrobat®). The human resources available for design and implementation of the changes were the following staff members who were members of the Steering Group – the Researcher, the Multimedia Analyst, the CCTV Analyst, the Report Writer and the Information Technology Expert.

In terms of the implementation of the action research program to redesign the complex criminal investigation file in the current study the recommendations of the Steering Group were each allocated to process owners. Governance and supervision responsibilities were assigned to the Senior Investigating Officer and the Researcher respectively.

The Researcher and Senior Investigating Officer assumed responsibility for designing the content map for inclusion in the re-engineered investigation file and were best placed to do so having an overall view of the nature and types of evidence contained within the investigation. The content map was simple in nature and indicated the file structure within the reengineered investigation file. An anonymous version of the content map is included at Figure 3 for reference.

Figure 3 – Content Map (Anonymous)



A folder structure corresponding to the content map was created for use in classifying the raw materials underpinning the investigation file.

Responsibility for rendering the various elements of CCTV evidence into a common format universally playable on any computer with basic software was given to the CCTV Analyst who used specialist software (Kinesense LE 1.6) and equipment to extract the relevant clips of footage before rendering the clips into Windows Media Video (wmv) files which could be played on any computer with the free software player – Windows Media Player which is pre-installed on any computer using the Windows® Operating System. The task of rendering the clips of CCTV evidence was accomplished in three days.

The responsibility for reconstituting the covering report as an executive summary was assigned to the Report Writer. The task of reducing the conceptual size of the report and including only material relevant to prosecutorial decision making presented initial difficulties for the Report Writer who did not feel qualified to determine what constituted relevant and what was extraneous information. A small number of consultations with the Researcher and the Senior Investigating Officer overcame this difficulty however and the report was written in a period of seven days with edits completed. The executive summary was composed using Microsoft Word®.

The executive summary document was then passed to the Information Technology Expert who formatted the text

and layout into a newspaper style and inserted selected relevant images (e.g. crime scene photographs). Highlighted enlarged text outtakes were generated by the Researcher to draw attention to and accentuate salient pieces of evidence in the report. This process took two days.

The Information Technology Expert then proceeded to place embedded text hyperlinks in the report to link items of interest to the target information. Witnesses' names were hyperlinked to their statements of evidence, references to available CCTV footage were hyperlinked to the rendered CCTV clips, references to audio recordings of telephone communications between persons of interest were linked to the audio files, and references to financial documentation were hyperlinked to the actual bank records. The linking process was accomplished using Adobe Acrobat© and took just one day to complete.

Once complete the executive summary document complete with hypertext links was converted from a Microsoft Word© document into Adobe Acrobat© Portable Format Document (PDF) which publishes the document contents and permits single click access and the installation of security settings.

Responsibility for the development of the 'Sequence of Event' productions was given to the Multimedia Analyst who pieced together salient streams of evidence in a variety of formats into a meaningful narrative for specific relevant events. 'Sequence of Events' productions were developed for the periods during which serious crimes were committed and also for financial transaction evidence uncovered against the suspects. These documentary type productions combined CCTV footage of the commission of the crimes, audio recordings of witnesses contacting the emergency services, photographs of the crime scenes, maps of the locations of relevance, and additional information placed on title slides or placeholders as required. Items were placed in chronological order to add narrative effect aiding comprehension in the viewer. The end result of the development of these facilitating products was the production of a set of coherent easily digestible narratives of significant aspects of the evidence uncovered by the investigation which constituted 'must sees' by those charged with prosecutorial decision making. This was the most time consuming part of the innovation process and took eleven days in total.

Responsibility for the development of the Powerpoint© Presentation was given to the Researcher who combined the key findings from the executive summary with the 'Sequence of Events' clips to generate a succinct presentation which refined the material generated and produced by the investigation to a series of key findings and recommendations the context and basis for which could be easily understood by the reader / viewer. The file when complete was saved as a Powerpoint© Show (PPS) which would play automatically once selected and occupy in full the screen of the viewer eliminating any potential distractions. The Powerpoint© Presentation took two days to create.

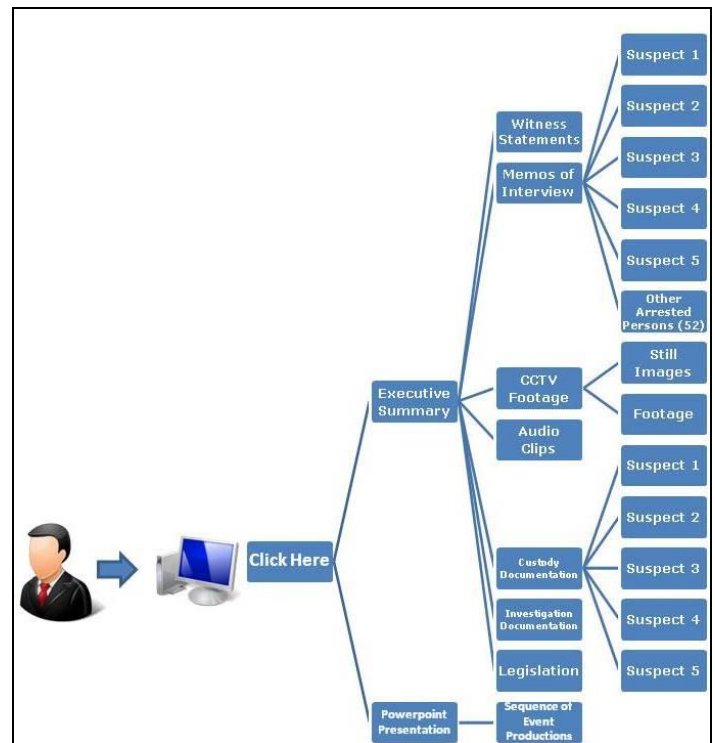
Following the development of the executive summary, Sequence of Events productions and the Powerpoint© presentation the materials comprising the investigation file were transferred to a disc in accordance with the file structure as set out in the content map.

To address security concerns both the executive summary and the Powerpoint© presentation were password protected and locked for editing to mitigate against unauthorised access to the files and unapproved copying and editing of the executive summary. Printing of the document was permitted in light of the likelihood that some users would prefer reading on paper as distinct from a screen and also enabling note making. These security settings were implemented using Adobe Acrobat©.

For ease of initial navigation a 'readme' type of file entitled 'Click Here' was placed in the root menu of the folder system and first time users were guided from this file to either the executive summary or Powerpoint© presentation depending on their viewing preference.

The intended manner in which the reader would interface with the product is depicted in Figure 4.

Figure 4 – User Interface with *SmartFile*



The redesigned investigation file complete with facilitating products was for the purpose of the present study given the name – 'SmartFile'. From the commencement of the implementation process to the finalisation of the end product twenty two days had elapsed. This is in stark contrast to the timeframe set out by respondents for complex investigations as conventionally between four and twenty four months.

IV. RESULTS AND EVALUATION

A qualitative methodological approach was taken to the evaluation of the *SmartFile* developed during the action research study. Questionnaires were completed by key stakeholders in the review of complex criminal investigation files who were firstly afforded an opportunity to examine and interact with the *SmartFile* as a first time user. These evaluations were conducted towards the aim of gathering qualified observations about the virtues or shortcomings of the *SmartFile* and suggestions around areas for improvement for future cycles of research.

The respondents comprised an expert Incident Room Co-ordinator, experienced Senior Investigating Officers (SIOs) and a Senior Professional Officer from the office of the Director of Public Prosecutions with extensive experience in reviewing complex criminal investigation files.

As in the data gathering stage of this cycle of the research study an online survey tool was employed to collect evaluations for ease of use. Overall eight professionals evaluated the *Smartfile* – a mentor IRC, six SIOs, and a professional legal officer from the office of the Director of Public Prosecutions in Ireland.

Responses from evaluators included the following comments and descriptive terms - “impressed, the future”, “documentaries in presentation provided excellent overview. Allowed easy grasp of case”, “visually striking, user friendly, impressive and professional”, “superb, innovative, efficient, excellently put together, very professional, the way complex files should be done in the future”, “unbelievably useful and simple to click a person’s name and get their testimony in context”, “the index to the folder structure layed out the contents well allowing an overview of the disc”.

The following evaluation comments were made by the directing law officer at the office of the Director of Public Prosecutions –

“Having used this SmartFile for the first time I am in no doubt but that this is the way forward, particularly in regard to complex and lengthy files. I found it to be very efficient and resulted in a significant reduction of the time that I would have otherwise used had the file been in the traditional paper format... In my years in this Office I have often had to tackle some very large files consisting of numerous volumes. I was very impressed with the SmartFile as referred to. At the outset I did not get that 'swamped' feeling that one often gets with a new large file. The layout of the executive summary was excellent, thereby enabling me to get an overall grasp of the case very quickly. Of particular significance is that I was able to access the relevant statements etc. with greater efficiency and speed than I would with a full paper file. In essence I was able to decide on the appropriate prosecutorial directions in a much more efficient manner.”

Although not part of the evaluation process the barrister charged with prosecuting the offences arising from the

investigation made the following comments within the advice on criminal proofs –

“You might pass on my compliments to the authors of the Book of Evidence in this case. I am still coming to grips with the technicalities but can see it is the way forward in these matters.”

The theoretical and practical implications of the evaluations of the *SmartFile* are discussed hereunder.

V. DISCUSSION

In this section the results will be discussed in detail and their theoretical and practical implications will be examined.

Research Proposition

The action research study set out to examine the following research proposition –

A multimedia interactive investigation file – *SmartFile* with target specific navigational linking via an executive summary is effective in communicating the findings of a complex criminal investigation.

The results indicate considerable support for the value of multimedia investigation files with navigational linking via an executive summary as effective in communicating the findings of a complex criminal investigation. The time required to review the *SmartFile* by the professional officer from the office of the Director of Public Prosecutions was reduced when compared with the time taken to review a similar paper based file suggesting efficiencies in the information transfer or communications process.

Taken together these results validate the rationale for the research project undertaken. The project sought at the outset to radically redesign, innovate and dramatically improve the complex criminal investigation file product by implementing changes in work strategies and process design using information technology. This process resulted in a redesigned operations processing workflow. The end result –an enhanced electronic investigation file or *SmartFile* bundled together the raw materials generated by the investigations in a way that leveraged the benefits of multimedia communication to engage the user via multiple sensory modalities while excluding extraneous information. The redesigned product was characterised by dynamic interactive and navigational functionality within a hypermedia environment which increased engagement with the product and resulted in more efficient information transfer to the user.

Research Implications

The findings of the current study carry a number of important theoretical and practical implications.

Theoretical Implications

The evaluation results in the current analysis succeed in relating in a value adding way the theoretical framework to the redesigned investigation file or *SmartFile*. In doing so, the results carry some important implications for existing theoretical perspectives on a number of issues.

The present study derives from principles not driven alone by technology but rather from knowledge of the functioning of the human mind and perceptual system. The development of an executive summary to replace the conventional covering report incorporating the presentation of text and accompanying images to the reader leveraged the benefits of the ‘coherence effect’ and the ‘spatial contiguity effect’ [15]. The Powerpoint© presentation also leveraged the positive benefits of words and pictures over words alone described by Mayer [15] as the ‘multimedia effect’. The hyperlinked navigational nature of the executive summary enabled all three forms of analysis - initial quick reading, deep analysis and detail checking [29] in a single product offering. The action research findings in the current study therefore succeed in reinforcing existing theoretical standpoints while contributing to the body of knowledge and research in a number of areas of communication and learning.

Embedded hypertext links from the executive summary offered users opportunities for choice and also enabled immediate access of extraneous material towards the aim of increasing the willingness to interact with the products developed [25]. The reported experiences of those who engaged with the *SmartFile* reinforced the theoretical utility of the content map and hypertext linking as aids to navigation and learning.

The current study provides an excellent example of ‘Building’ in the ‘Buy versus Build’ theoretical debate in information and communications technology. This project used widely available, low cost software and non expert change agents to revolutionise an area of operational activity and product design. In effect this research project is an example of how new capabilities can be developed in an organisation by bundling together existing competencies and skills with new technologies to enable exceptional performance [37].

Practical Implications

An essential feature of productive science is the establishment of a direct link between research and action. The results of successful research must therefore prove of benefit in the environment under examination. The findings in the present study carry a number of important implications for the compilation of complex investigation files.

The present study clearly identifies the value which the use of hypertext navigational linking adds to an executive summary of a complex criminal investigation. A potential challenge however to the use of hypertext in the presentation and communication of criminal investigation files to audiences is the issue of computer literacy. Past research has found that computer literate readers with high levels of computer literacy and hypertext experience are better able to use the non linear structure of a hypertext network than readers with low computer experience resulting in differences in reading ability

[38] [30]. Conklin [39] drew attention to a drawback to the use of hypermedia which can result in a reader becoming disoriented or getting lost in a network. Hypertext use has also been found to result in an increase in cognitive demand. This finding is less relevant however in the current times as we live in an information economy [40] and the majority of professionals are familiar with electronic mail and internet browsing both of which commonly feature hypertext networks and links. Should this difficulty prove manifest a short program of computer literacy training should overcome the challenge.

Francik, Rudman, Cooper and Levine [41] highlight the difficulties which arise within an organisation when new innovative technologies create work pattern changes. As a consequence the new technologies are often resisted by the organisation resulting in a requirement for system planners to work through the resistance. In a similar vein Coghlan and Casey [35] refer to the character of action research as subversive in the sense that it threatens existing organisational norms. This is an issue worthy of consideration in the implementation of any programme of change predicated on the findings of the current study.

Corrigan and Joyce [42] highlight the reality in public service organisations that a variety of stakeholders, changing missions and transient policy makers mean that achieving enduring operational efficiencies is extremely difficult. A valuable implication for practice of the findings in the current study is that the enhanced use of information technology in the compilation of complex criminal investigation files will lead to process and operating efficiencies as the production of volumes of paper materials will be all but eliminated. Follow on efficiencies in the time required for prosecutorial decision making at the professional prosecutors’ office will also follow.

Overall, the results of the present study have a multitude of implications for the compilation of complex criminal investigation files in police forces. Thinking differently is what product innovation is all about. Grover and Malhotra [43] described the critical success factors as active executive support, getting buy-in from major interest groups, consideration of technical and social changes together and effective project and change management. The present study succeeded in attracting executive support from the highest level in the organisation – the Commissioner, and secured important buy-in from the greatest stakeholder in the investigation file business – the office of the Director of Public Prosecutions. These positive steps should next be combined with a program of change management whereby training and competency building in the new processes in investigation file compilation take place while remaining at all times cognisant of the social and cultural realities within the organisation.

VI. CONCLUSIONS

The compilation of complex investigation files detailing serious and organised criminal activity presents a significant challenge in distilling large quantities of investigative material into a meaningful blueprint to facilitate prosecutorial decision making.

This research study focused on operations management aspects of complex criminal investigation in particular the specific area of product innovation in investigation file compilation. The project constituted an exploratory insider action research study into the potential for redesigning complex criminal investigation files using principles of information and communications technology and the psychology of multimedia communication and interactive learning.

The literature on operations management, multimedia communication, interactive media and navigational learning was reviewed. Qualitative interviews were conducted with experienced practitioners and stakeholders in the area of complex criminal investigation.

The purpose of the project was to radically redesign, innovate and dramatically improve the investigation file product by implementing changes in work strategies and process design using information technology as a central lever. The project set about bundling together the raw materials of pictures, words and other media in close spatial proximity to present the evidence contained in an investigation file to the first time user via multiple sensory modalities in a random access manner excluding extraneous information. Proposals for product innovation were developed and implemented in an action research study under the governance of a Steering Group. The newly developed product featured dynamic interactive and navigational functionalities within a hypermedia environment to enhance user control and willingness to interact. A content map was incorporated to augment this process.

The objective of the developed product was to improve information transfer in a first time investigation file user and thus to facilitate in a value adding way the communications objective of the product.

The enhanced investigation file – *SmartFile* was professionally reviewed and evaluated. The evaluations indicate considerable support for an organisation wide information and communications technology led redesign of complex criminal investigation files incorporating target specific navigational linking via an executive summary and the use of facilitating products. Such a progressive step will improve the communication of evidential findings from complex criminal investigations.

The theoretical and investigative implications of these findings were discussed.

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