INSTRUMENTS OF POWER

Developing and Applying Diplomatic Analysis to Enhance Archival Interpretation and Research Uses of Technical Drawings

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ABSTRACT

This study presents a solution to the difficulties of making historical technical drawings available for research. In archives services, such hard-copy drawings are frequently found to be much less manageable than other forms of archival record. Technical drawings can be very complicated intellectually, while also being large and awkward to handle. Archival effort might thus be directed towards making less difficult forms of record available for research. These problems, which impede access to research resources, have not been attended to in the literature.

A new way of understanding technical drawings has been created through an innovative development of diplomatic analysis. Traditionally used for historical text analysis, diplomatic has not been applied previously to graphical records such as technical drawings. With this theoretical lens, and statistical techniques, the research design followed the principles of mixed methods methodology.

The core of the study comprised a detailed quantitative survey and analysis of a statistical sample of C20th technical drawings. Language was found to be the key to their better understanding. A model was developed to translate the language of technical drawing concepts and characteristics into archival terms. The survey's statistically robust and replicable results identified concepts and characteristics that were generic, or nearly so. When interpreted and described, those ubiquitous elements will provide a means to enhance understanding of technical drawings held as archives. The research results therefore provide a sound basis for drafting practical guidance for interpreting and processing such technical drawings. That guidance will help to make technical drawings more accessible to researchers.

Diplomatic theory has been extended by this research. The utility of diplomatic's application to graphical records has been demonstrated. So, too, has diplomatic's extension to records capable of being reprographically reproduced. Unexpectedly, questions have arisen for technical drawings' certification and authorisation in their original contexts of use. The robust research design and methodology that has been developed is capable of generalisation in future research.

KEYWORDS: Diplomatic analysis, technical drawings, engineering drawings, mixed methods, quantitative survey, sampling

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Chapter 1: Introduction

Despite entreaties that diplomatic should be an essential tool in every archivist's armoury, [1] that textual analysis method is probably not one routinely employed by many archivists at the turn of the twenty-first century. Certainly, diplomatic theory for traditional textual records has not been a well-examined topic in the archival literature of that period.

In marked contrast is the explosion of literature for diplomatic's application to recordkeeping in electronic environments. [2] That development of diplomatic from its traditional use with medieval texts was truly innovative. The research reported in this thesis further extends the scope of diplomatic theory and practice. This thesis describes and discusses how diplomatic principles were applied to graphical records, as exemplified by technical drawings.

This exploratory and descriptive research investigated ways in which technical drawings could be made more comprehensible to archivists. These custodians of historical technical drawings would then be better enabled to make the drawings more accessible to researchers.

Guided by the research's stated aims and desired outcomes, this thesis reports on all important areas of success and failure, and identifies those areas requiring further research. The experiences gained within this research are therefore available to be applied productively to future research.

1. Introduction to Chapter One

This introductory chapter sets the scene for the description of the research that has been carried out. The chapter provides information that contextualises the research. Information is given that is essential to understanding the concepts and definitions that are used within the thesis.

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1 T. Eastwood, 'Foreword', in *Diplomatics: New Uses for an Old Science*, L. Duranti (Lanham, MD, 1998), vii-viii; M. Moss, 'The Scent of the Slow Hound and the Snap of the Bull-Dog: The Place of Research in the Archival Profession', in *New Directions in Archival Research*, M. Procter and C. P. Lewis, eds., (Liverpool, 2000), 8-9, 13-15; L. Duranti, *Diplomatics: New Uses for an Old Science* (Lanham, MD, 1998), 57 and n.46.

2 Exemplified by that for the UBC and InterPARES Projects. See Literature Review: 2.4 InterPARES – Theoretical frameworks and methodologies, *46*.

The chapter contains seven substantive principal sections:

- Background to the Research
- Purpose of the Research
- Research Question, Aims, and Objectives
- Introduction to the Research Design and Methodology
- Outline of the Thesis
- Key Definitions Used in the Thesis
- Research Scope and Limitations

2. Background to the Research

This section starts with a brief summary of the development of technical drawing in Britain, to provide historical context to the research. The values that inhabit technical drawings as 'Instruments of Power' are then explained, followed by a description of new values that technical drawings can attain as archives. The problems associated with realising archival research values are then described. This background section concludes by introducing diplomatic analysis – the lens through which those problems were investigated in this research.

2.1 The historical context of technical drawing

This research, and therefore this contextual summary history, focuses on technical drawing in Britain. [3] Technical drawing in continental Europe was founded on a more theoretical basis than in Britain. The way in which technical drawings were executed was very different in Britain and the USA. [4]

Two forms of architecture provide early evidence for technical drawing in Britain. Within naval architecture, ship plans survive from the late sixteenth century. [5] On land, there were some limited moves towards standardisation of drawing conventions from the seventeenth century. Architectural drawings developed rapidly in the seventeenth and eighteenth centuries, by which time technical drawing was architecture's normal design medium.

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3 This section generally draws upon: P. J. Booker, *A History of Engineering Drawing* (London, 1979), and K. Baynes and F. Pugh, *The Art of the Engineer* (Guildford, 1981).

4 See Literature Review: 4.1.1 Engineering drawing – theory, practices, and processes, *64*.

5 Baynes and Pugh, *The Art of the Engineer*, 70-7.

Architectural drawing conventions were also used in emerging engineering disciplines – in drawings of steam engine houses, for example. The conventions of plan, elevation, and section were used in design and production control. Separately, improvements to drafting techniques were stimulated by military requirements for map making and ship design. [6]

The increasing number and range of industrial manufacturing enterprises in Britain from the mid-to-late eighteenth century gave rise to growing numbers and types of technical drawings. [7] Scaled, detailed, machinery drawings began to appear, with those of Boulton and Watt ostensibly in the vanguard of sophistication. [8]

Scaled drawings were increasingly produced from the 1830s in the new locomotive building industry [9] – regarded as a foundation of modern technical drawing. The Drawing Office became a key feature of industrial manufacturing enterprises during the nineteenth century, generating numerous drawings and associated records. By the mid-nineteenth century, technical drawing in Britain had attained superb standards of detail and artistry. Full-colour iconic images of steam ships and locomotives, for example, celebrated technological triumph.[10]

From the 1870s, the introduction of new reproduction processes for technical drawings gave added impetus to their escalating level of creation. [11] The processes by which drawings were created, and the industries that they represented, continued to expand apace in the twentieth century. So, too, did the variety of drawing types, notwithstanding increasing standardisation of their graphical conventions.

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6 Ibid., 31-2, 34, 52-4.

7 K. Baynes and F. Pugh, *The Art of the Engineer: Two Hundred Years in the Development of Drawings for the Design of Transport on Land, Sea and Air* [Exhibition Catalogue] (1978), 5-6; Booker, *A History of Engineering Drawing*, 128.

8 Baynes and Pugh, *The Art of the Engineer*, 35-7, 62-9. See also: J. B. Richardson, 'The Contribution of the Firm of Boulton & Watt to Engineering Drawing'. PhD Thesis. (University of Reading, 1989).

9 C. J. Heap, 'Engineering Drawings - their Selection, Storage and Use', *Business Archives: Principles and Practice*, 63 (1992), 39-40.

10 Baynes and Pugh, *The Art of the Engineer*, 129. Such iconic images are exemplified at 145, 148, 152-3, 160, 165, and 167-71.

11 J. H. Andrew, 'The Copying of Engineering Drawings and Documents', *Transactions of the Newcomen Society*, 53 (1981-2), 7; L. O. Price, *Line, Shade and Shadow: The Fabrication and Preservation of Architectural Drawings* (New Castle, DE, 2010), 145-6.

The range of technical drawings' subjects, form, media, and means of production within the twentieth century is impossibly large to summarise. Notably, though, the first two decades saw a significant decline in the use of colour. More drawings were required for each product that was designed, leaving less time for artistic embellishment. Increased commercial awareness, the complexities of colour-coding, and war-time pressures also played their parts. [12] Drawing reproduction processes, meanwhile, produced largely monochrome derivative drawings.

By the end of the twentieth century, computer-based processes had largely overtaken manual means of technical drawing origination. Hard-copy drawings, though, were still used in large numbers for many post-origination purposes.

2.2 Instruments of Power

Historically – as in the twenty-first century – technical drawings were often powerful expressions of new and innovative thought. As such, they might truly, as well as figuratively, be regarded as:

> value-laden instruments of power. They emerge from organizational cultures and personal psychologies of great complexity, multiple relationships, and many identities. [13]

Those multiple values imbued a technical drawing with power in different ways. At the start of a project, a drawing's first purpose might have been as an iconic image to influence a reluctant client. Beyond that, though, its evident purpose was not to exist just as an illustration. [14] A technical drawing's core value was as an information artefact that acted as an authentic and reliable surrogate for a physical artefact. Specifically, a technical drawing's purpose was to communicate, to known standards, the information that was required to produce, operate, maintain, or record such physical artefacts. Technical drawings graphically

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[12] Baynes and Pugh, *The Art of the Engineer*, 175-8.

[13] T. Cook and J. M. Schwartz, 'Archives, Records, and Power: From (Postmodern) Theory to (Archival) Performance', *Archival Science*, 2, 3-4 (Sep, 2002), 178. I unashamedly acknowledge my use of this quotation in a context quite different from that employed by the original authors; it is though perfectly apposite to the present case.

[14] Although on completion of a project, drawings were also sometimes presented or copied for more important customers. Some of the finest drawings were also exhibited as works of art. Baynes and Pugh, *The Art of the Engineer*, 164-6, 171.

represented such information more concisely and coherently than was possible through a textual description [15] – literally, 'a picture tells a thousand words'.

Given such power, technical drawings were necessarily drafted to act as clear and unambiguous documents. Often, those instruments were to be acted upon in circumstances remote from their time and place of creation. They were created from the same premise as medieval charters – that 'truth was too important to leave to chance'. [16] Technical drawings could be reasonably considered, therefore, to have value as reliable records – accurate representations of the facts to which they attested. [17]

Such powerful instruments required close and careful control. Many individual technical drawings formed complicated aggregations of interrelated records, in multiple versions. The consequences of acting upon an incorrect rendering of a drawing – an unrevised version or out-of-date copy – could be catastrophic. Technical drawings therefore required stricter management control than many other forms of record. Such control was often exercised both within the drawings themselves,[18] and in systems external to them.[19]

The value of technical drawings as iconic images has been noted. They had a power to persuade and enlighten where words might not. Equally, though, the complexity of technical drawing images can hinder understanding of them. Power

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15 J. Sime, 'Technical Records: The User and His Needs', *Proceedings of the Annual Conference, 1983*, 64-80 (Business Archives Council, 1983).

16 M. Clanchy, *From Memory to Written Record: England, 1066 – 1307*, 2nd ed. (Oxford, 1993), 149, cited by C. Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', *Journal of the Society of Archivists*, 26, 1 (Apr, 2005), 12.

17 Following: The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 3: What is a Reliable Record in the Traditional Environment?' (InterPARES Project, nd) [Online] http://www.interpares.org/UBCProject/tem3.htm (accessed 03 Sep, 2007); InterPARES 2 Project and others, 'InterPARES 2 Project: A Framework of Principles for the Development of Policies, Strategies and Standards for the Long-Term Preservation of Digital Records' (InterPARES 2 Project, 2008) [Online] http://www.interpares.org/ip2/display_file.cfm?doc=ip2(pub)policy_framework_document.pdf (accessed 25 Jun, 2011).

18 See, for example: Discussion: 4.4.2 Record of Changes, *202*; 5.3.1 Primary Production Certification, *232*. That such internal control was not always present, though, is considered in: Discussion: 4.4.3 Analysis of the Record of Changes, *203*; 5.3.4 Combined Certification Concepts, *248*.

19 See Discussion: 4.5 Archival Bond, *208*.

is then retained by the image creators, rather than being transferred to others who need to know a technical drawing's meanings. [20]

Manifestations of other values can be clearly seen in many technical drawings, although their true meanings might not be fully appreciated at first sight. The values of a technical drawing's corporate creator can be indicated by the ways in which a drawing is presented. For example, corporate power was not always expressed solely though the overt application of corporate names, logos, and trade marks. [21] As technical drawings became more sophisticated within engineering enterprises, so too did the means of their control. Individual creativity in drawing layout and presentation became supplanted by corporate drawing design rules. In some cases, such control even became an end in itself. [22]

Elements of individual power did undoubtedly reside within the hierarchies of engineering design and drawing offices. Yet the power of those individuals – designers, drafters, checkers, and approvers – came to be overtly indicated on technical drawings only as sets of initials in check boxes. [23] The rights in the designs and drawings that they created, by contrast, were explicitly claimed on the drawings as corporate intellectual property. [24]

Nonetheless, whether power was more or less demonstrated in these instruments, the intent was the same. It was to create a culture where technical drawings were to be regarded as authoritative records that were to be obeyed in every detail. That technical drawings sometimes failed to display even the residual power of their individual creators, yet were still sufficiently powerful to be obeyed, was a particularly unexpected finding of this research. [25]

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20 See Introduction: 2.4 Problems with technical drawings, *8*;

21 See Discussion: 4.3 Special Signs – Enterprise Logos and Trade Marks, *199*.

22 J. K. Brown, 'When Machines Became Gray and Drawings Black and White: William Sellers and the Rationalization of Mechanical Engineering', *Journal of the Society for Industrial Archeology*, 25, 2 (1999), 40, 42; J. K. Brown, 'Design Plans, Working Drawings, National Styles: Engineering Practice in Great Britain and the United States, 1775-1945', *Technology and Culture*, 41, 2 (2000), 232-3.

23 See Discussion: Clause of Corroboration – Signature-Date Block, *233*.

24 See Discussion: 5.1.3 Rights Owner – Name and location, *220*.

25 See Discussion: Implications of the authorisation findings, *253*.

2.3 Archival research values of technical drawings

Their original uses at an end, technical drawings might attain new values in archives settings. Some of those values fit with Schellenberg's long-standing conceptualisation of records' values, [26] while others do not.

Firstly, archival technical drawings facilitate the historical research of products and processes, by encapsulating information in ways in which texts alone cannot. Such research employs what has been conceptualised as a record's informational value. It is a measure of how useful a record's content is to research once its primary use has ended. [27]

In the context of appraisal decisions, one criterion for determining such informational value is the form of the record – whether or not it can be easily understood by others. This issue is fundamental to the research uses of technical drawings; the principal aim of this investigation is to resolve it.

Secondly, evidential value has been conceptualised as that which bears on the organisational and cultural contexts of records' creation and use. In technical drawings, such value is most clearly associated with issues of corporate power and control. Using evidential value to research those topics might enable technical drawing – and drawings – to be more firmly situated within histories of industry and enterprise.

Such informational and evidential values were conceptualised as unintended by-products that emerged once a record became inactive. Both value concepts have therefore been conceived as being secondary to the primary value of a record. Primary value is that which a record has for its creator – for administrative, financial, or legal uses, for example. Normally, records containing primary value would necessarily be retained by their original creators or successors. [28]

However, despite having continuing primary value, some technical drawings have been removed from their original contexts, to be managed as archives. Some such drawings record historically engineered infrastructure, products, and processes

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[26] T. R. Schellenberg, *Modern Archives: Principles and techniques* (Chicago, 1956), 16, 28-32, 133-160.

[27] Schellenberg, *Modern Archives*, 148.

[28] Schellenberg, *Modern Archives*, 28-9.

that still require care and management.[29] Other archival technical drawings represent historic buildings, vehicles, and machinery that have long gone out of use, but have become foci for industrial archaeology, heritage conservation, or enthusiast restoration.[30]

In the latter cases especially, the value sought in the content of archival technical drawings is closest to that which was required by the drawings' original creators. In Schellenberg's value scheme, that would be primary value. Yet that scheme would view the same content, when used in an archival research context, as being of secondary informational value. Schellenberg's value scheme is therefore unable to accommodate such cases. All those cases, though, clearly seek the core value originally intended to be imbued in a technical drawing – that of an artefactual surrogate, reliable across the passage of time.

2.4 Problems with technical drawings

What, then, are the problems with technical drawings in archive settings? Even when they are acquired, why might such value-laden records remain unavailable for research?

Two central factors conspire against them:

1. The structural complexity of technical drawings necessarily increased over time, to reflect the products that they depicted. To the untrained eye, that complexity has tended to mask the content and contextual information that the drawings contain.
2. The sheer scale and diversity of technical drawings' production and reproduction has sometimes left archivists facing them in overwhelming numbers.

2.4.1 Problems for archivists

When first appraising technical drawings, archivists must – as with all records – determine what the drawings represent, in all their facets of content and

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29 For example, the historical infrastructure of the canals network, much of which is still in use more than two centuries after its construction.

30 See, for example: Heap, 'Engineering Drawings - their Selection, Storage and Use', 41-2, 47; Sime, 'Technical Records: The User and His Needs', 64-80. The British Steel Archive Project planned to use its 'plans' of 'iconic and recognisable structures' to promote a newly catalogued archive: J. K. F. Heggie, 'The British Steel Archive Project: Forging New Kinds of Partnerships to Preserve Significant Business Archives', *Business Archives: Principles and Practice* 98 (May, 2009).

structure, and in all their contexts, individually and in aggregation. Only then can intellectually based archival processing decisions be taken. [31] However, technical drawings pose four particular problems for many archivists. That is especially the case for the many archivists in general practice in local record offices, who might have little engineering or science background knowledge. [32]

Firstly, the graphical conventions of technical drawing are a special language with different dialects and many accents. [33] If archivists do not understand the language, they cannot start to understand properly what the data in a drawing represent. [34] Nor, despite the 'air of great authority and definitive completeness' that a technical drawing might exude, [35] can archivists determine how reliable and authentic the record is.

Secondly, technical drawings often illustrate objects or processes within subject areas that are unfamiliar to many archivists. Specialist knowledge can be sought, but those who are most familiar with technical drawings selected for archival preservation will not survive for as long as the drawings themselves. More generally, drawing office personnel who are familiar with manual origination processes for technical drawings are also a fast-diminishing and finite population.

Thirdly, many technical drawings contain some form of data that indicates their contexts of creation and use. In aggregations, such data can provide evidence of records' whole-part relationships, and of record-keeping systems. Technical drawings can thus be more appropriately selected, arranged, and described for research. The data might also inform wider understandings of the drawings' organisational and cultural contexts. Yet such data might not be obvious to archivists who are unfamiliar with the data structures of technical drawings.

Finally, many copies or multiple copies of technical drawings exist. They may have been used or re-used in similar or different contexts, and be found in

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31 Heap, 'Engineering Drawings - their Selection, Storage and Use', 40-1.

32 G. E. Gorman and P. Clayton, *Qualitative Research for the Information Professional: A Practical Handbook*, 2nd ed. (London, 2005), 15.

33 Baynes and Pugh, *The Art of the Engineer*, 15; H. Belofsky, 'Engineering Drawing: A Universal Language in Two Dialects', *Technology and Culture*, 32, 1 (1991), 23-46; Brown, 'Design Plans, Working Drawings, National Styles', 195-6, 235-7.

34 E. S. Ferguson, *Engineering and the Mind's Eye* (Cambridge, MA, 1992), 87-8.

35 Ibid., 3.

aggregation, or individually divorced from any apparent context.[36] Their status as reliable records might be difficult to assess. Where intellectual data are deficient, the physical characteristics of a technical drawing can help with its interpretation. The medium of a drawing's support, and its means of production or reproduction, for example, can point towards a drawing's status as an original or copy, its intended use, and its potential reliability. All these points are developed later.[37]

2.4.2 Consequences of the problems for archivists

These four problems illustrate the difficulties that archivists can face when trying to interpret technical drawings. More practical issues of physical size, bulk, and original storage conditions[38] might become more likely to govern the initial acquisition of technical drawings.

Even if acquired, technical drawings worthy of archival preservation might then be discarded for want of sufficient interpretative knowledge, or be imperfectly appraised. Better-understood related textual records, containing comparable archival research values, might be retained without their graphical counterparts. Yet the one record genre often forms an essential complement to the other. Only a balanced selection of records enables a full and proper understanding of the topics that they represent.

Technical drawings that are selected as archives might still remain inaccessible to researchers. There are easier types of record to describe and make available. Businesses might therefore be disproportionately represented by textual records such as minute books and accounts, than by graphical records such as technical drawings. Those technical drawings that are catalogued might be imperfectly described, though lack of knowledge. That lack of expertise can exist not only for the special subjects that technical drawings often depict. The information form itself often provides the first barrier to archival understanding.

The way in which technical drawings encapsulate information clearly provides opportunities for efficient and effective research. Yet technical drawings can still

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36 Heap, 'Engineering Drawings - their Selection, Storage and Use', 47.

37 See: Chapter 5:Discussion, *149*.

38 Ibid., 39-42; S. Hughes, 'The City Engineer's Plans Project', *Archives and Manuscripts*, 20, 2 (Nov, 1992), 237-8; M. Moss, 'Death on the Clyde', *Dunaskin News* (Glasgow, 2002) [Online] http://www.gla.ac.uk/services/archives/news/dunaskinnews200207/deathontheclyde/ (accessed 17 Sep, 2010).

remain inaccessible to those researchers who lack the skills to interpret and use them.[39] Different archives services might therefore require different approaches to interpreting and describing technical drawings, based upon knowledge of the needs of the typical researcher at their particular service.[40]

All these problems combine to produce a situation where the archival resources for researching the histories of enterprise and business, and especially of industrial engineering and manufacture, for Britain's period of industrialisation, are unbalanced.

2.5 A potential solution through diplomatic analysis

Archival scholarship has not addressed these problems for technical drawings, but they seem eminently suited to diplomatic analysis. Diplomatic's granular approach to documentary analysis was developed and traditionally applied to texts. Would it be possible to adapt diplomatic to the analysis of graphical records? If feasible, such analysis would enable the complexity of technical drawings to be intellectually disentangled. A practical means of interpreting technical drawings could then be developed for archivists and researchers.

Diplomatic's origins and subsequent development have been well described[41] – although there is less agreement about the adoption of the term itself.[42] In 1681, Mabillon's[43] *De Re Diplomatica*[44] laid down a new methodology for critical textual analysis. His purpose was to create rules and terms to help ascertain the truthfulness or falsity of documents that were of fundamental importance to his religious order. Mabillon's new rules were based on 'comprehensive, systematic, theoretical analysis'.[45] The 'rigour, transparency, and methodological precision'

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39 Brown, 'When Machines Became Gray and Drawings Black and White', 29.

40 Heap, 'Engineering Drawings - their Selection, Storage and Use', 41-2.

41 See, for example: L. E. Boyle, 'Diplomatics', in *Medieval Studies: An Introduction*, ed. J. M. Powell (Syracuse, NY, 1976), 69-101; Duranti, *Diplomatics: New Uses for an Old Science*, 36-40; Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 1-24.

42 In the UK, and hence in this thesis, the term used is 'diplomatic'; in other Anglophone countries it is 'diplomatics'.

43 Dom Jean Mabillon (1632-1707) Benedictine of the Congregation of Saint Maur, writing while at the Abbey of Saint Germain-des-Près, Paris: Boyle, 'Diplomatics', 69-70; Duranti, *Diplomatics: New Uses for an Old Science*, 37.

44 J. Mabillon, *De Re Diplomatica* [Concerning the Matter of Diplomatic] (Paris, 1681).

45 Marc-Robin Wendt, 'Digitalisierungsprojekt: Jean Mabillon - De Re Diplomatica Libri VI ' (Introduction) (Berlin State Library: Prussian Cultural Heritage Foundation, nd) [Online] http://141.20.85.26/mabillon/index.html (accessed 19 Aug, 2010).

of Mabillon's methods have been equated with those of his better-known scientific contemporaries.[46] Mabillon's methods were applied and developed during the subsequent three hundred years, but only to textual records.

Then, in the late twentieth century, traditional diplomatic theory was innovatively developed by Duranti, for use with records created in electronic environments.[47] The ensuing international projects were testament to renewed interest in diplomatic theory and practice.[48]

Following Duranti, some rather more tentative applications of diplomatic to other forms of non-textual records have been reported.[49] None, however, have described attempts to develop diplomatic principles for graphical records generally, or for technical drawings specifically. Nonetheless, Williams' 2005 analysis of diplomatic concluded that:

> It is clear...that the principles of diplomatic might quite legitimately be applied to all administrative records in any environment.[50]

It is diplomatic's structured, granular, and comprehensive approach to document analysis that makes the approach an appropriate lens through which to view technical drawings. An extension of this very old science would not only fill a gap in archival knowledge and practice, but would also contribute to an international landscape of developments in diplomatic.

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[46] S. Ross, 'Digital Preservation, Archival Science and Methodological Foundations for Digital Libraries: Keynote Address at the 11th European Conference on Digital Libraries'. Budapest, 17 Sep, 2007. [Online] http://www.ecdl2007.org/Keynote_ECDL2007_SROSS.pdf (accessed 20 Aug, 2010). See also: Boyle, 'Diplomatics', 71.

[47] Duranti, *Diplomatics: New Uses for an Old Science*. The main body of this text was originally published as six journal articles, between 1989 and 1992. The six articles were republished in book form, with a new Introduction, in 1998. Unless the context requires, all references in this thesis are to this later edition.

[48] The UBC and the InterPARES Projects: The UBC Project was reported at: L. Duranti, T. Eastwood, and H. MacNeil, *Preservation of the Integrity of Electronic Records* (Dordrecht, 2002). The InterPARES Projects' website is at http://www.interpares.org/ (accessed 07 Jun, 2011).

[49] J. M. Schwartz, '"We Make Our Tools and Our Tools Make Us": Lessons from Photographs for the Practice, Politics, and Poetics of Diplomatics', *Archivaria*, 40 (Fall, 1995), 40-74; N. Bartlett, 'Diplomatics for Photographic Images: Academic Exoticism?', *American Archivist*, 59, 4 (Fall, 1996), 486-94; E. Parinet, 'Diplomatics and Institutional Photos', *American Archivist*, 59, 4 (Fall, 1996), 480-5; A. G. Miller, 'Exhibiting Integrity: Archival Diplomatics to Study Moving Images' (Abstract), *Archivaria*, 55 (Spring, 2003), 100; J. L. Simpson, 'Broadcast Archives: A Diplomatic Examination' (Abstract), *Archivaria*, 55 (Spring, 2003), 71-2.

[50] Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 8.

3. Purpose of the Research

The intent of this research was to develop means by which technical drawings could be more comprehensible to archivists. These problematic but value-laden records could then be made more accessible for research use.

The investigation focused on manually originated technical drawings, in Britain, between the 1920s and the 1980s. That period led to the wide-scale replacement of hard-copy drawings by outputs from computer aided design (CAD) systems.

Every technical drawing typically possesses an abundant range of physical and intellectual data elements. Physical elements include, for example, a drawing's size, the material of its support medium, and the process by which the drawing was created. Data for some such physical elements might not be tangibly apparent, necessitating data extraction by inference rather than by direct observation.

Intellectual elements include the languages used, the presence of amendments and annotations, and the use of certification signatures and dates. Many such data elements might be recorded using special conventions that are quite different from those used in other types of record. Data might again be hidden, but this time intellectually, rather than physically.

Nonetheless, the key information that archivists need of technical drawings is the same as that required for any more conventional type of record – name of creator, date of creation, and scope and content, for example. Within diverse technical drawings, data for some of this information will always be available. Many more data elements, though, are only present in less than 100% of drawings.

This exploratory and descriptive research [51] therefore studied a statistical sample of technical drawings in detail, using the lens of diplomatic theory. The aim was to identify data elements that were always, or very often, found in the sampled technical drawings.

Those near-generic data elements were then assessed to determine the extent to which they might make technical drawings more comprehensible to archivists.

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51 H. R. Bernard and G. W. Ryan, *Analysing Qualitative Data: Systematic Approaches* (Thousand Oaks, CA, 2010), 8-9.

The data elements had to be both inherently useful to understanding, and broadly unrelated to the content depicted by the drawing. Archivists would not then have to rely upon specialist subject knowledge when interpreting the data that those elements contained.

When appropriately interpreted, those generically useful data elements would provide a new intellectual foundation for understanding technical drawings. That foundation could be developed in future research, in consultation with archivists and researchers. Practical guidance for the interpretation of technical drawings could be written. Archivists would then have a tool with which they could more confidently make processing decisions about technical drawings. Researchers would benefit from the improved archival management of technical drawings that such increased confidence should bring about.

4. Research Question

The purpose of the research having been established, it can be encapsulated in a Research Question:

> **How might traditional textual diplomatic theory be developed and applied to the examination of technical drawings, as an exemplar of graphical records, to enable their more efficient and effective archival interpretation and processing, and hence improve their availability for research use?**

4.1 Research Aims and Objectives

The way in which this question was to be answered was formulated in a series of conceptual aims and operational objectives. Those aims and objectives were linked, respectively, to the research's intended outcomes and outputs. The degree to which those outcomes and outputs were delivered is assessed in the thesis conclusions,[52] as a measure of the success of the research.

The research aims and outcomes, and the objectives and outputs that are linked to them, are shown within Tables 1–4, following.

[52] See Conclusions: 2. Delivery of the Research Outcomes, *263*.

Aims	Intended Outcomes
1. Using the lens of diplomatic theory, develop means by which technical drawings can be made more comprehensible to archivists.	1. Developed a new research design and methodology, using diplomatic, archives, and records theory, to discover, quantify, and analyse the intellectual and physical concepts and characteristics of technical drawings.
2. Implement and evaluate such means using an exemplar statistical sample of technical drawings.	2. Statistically estimated, and described, concepts and characteristics that were effectively generic within the sampled technical drawings, and which had potential to enhance archivists' understanding.
3. Ensure that such means as are developed will enable: • replication of the results of this research. • comparable work to be undertaken on other exemplars of technical drawings, in future research. • indicative generalisation of results, with appropriate caution, to other technical drawings' populations.	3. Developed and sufficiently described a research design and methodology that was able to deliver statistically robust and replicable results, and be successfully applied to the analysis of other technical drawings.

Table 1: Research Aims and Intended Outcomes

Objectives	Intended Outputs
1.1 Develop means of understanding of technical drawings that: 1.1.1 Minimise the need for archivists to: • comprehend the special graphical conventions used • possess specialist knowledge of subject content 1.1.2 Especially enable archivists to interpret data that: • are not manifestly apparent within technical drawings • provide contextual information for technical drawings	A generic analysis methodology developed, based on concepts and characteristics derived from diplomatic, archives, and records theory, rather than from technical drawing practice or specialist subject areas.
1.2 Define concepts and characteristics, developed from diplomatic and complementary archives and records theory, which might occur within technical drawings.	Interim Data Definition Model developed for the concepts and characteristics that might be found in technical drawings, to provide initial variables for the technical drawings' data survey.
1.3 As well as intellectual concepts and characteristics, specifically consider what information might be derived from the physical concepts and characteristics associated with a technical drawing's medium of support, and processes of production and reproduction.	An assessment made of the extent to which data for physical concepts and characteristics could be derived from technical drawings by archivists using only their five physical senses. Such a sensory approach excluded specialist conservation science support.

Table 2: Research Objectives and Intended Outputs for Aim and Outcome One

Objectives	Intended Outputs
2.1 Draw a robust statistical sample of technical drawings from an exemplar population.	A 400-member stratified sample of technical drawings drawn from a defined population.
2.2 Survey the frequencies of occurrence of the defined intellectual and physical concepts and characteristics within the sample of technical drawings.	A survey of individual variables undertaken for each of the sample cases.
2.3 Statistically estimate the frequencies of occurrence of those concepts and characteristics in the exemplar parent population of technical drawings.	All frequencies of occurrence estimated at 95% Level of Confidence.
2.4 Identify those concepts and characteristics that were always, or very often, present within the technical drawings sample, and, by statistical inference, within the parent population.	Determined the concepts and characteristics that were present in > 90% of the sampled cases.
2.5 Qualitatively assess the extent to which those near-generic concepts and characteristics might help archivists more easily to understand technical drawings.	Near-generic concepts and characteristics of potential importance listed and described.

Table 3: Research Objectives and Intended Outputs for Aim and Outcome Two

Objectives	Intended Outputs
3.1 Develop a research design and methodology that is conceptually and statistically robust, practically amenable to implementation, and is replicable and scalable.	Developed and sufficiently described a research design and methodology that was able to deliver statistically robust and replicable results, and be successfully applied to the analysis of other technical drawings.
3.2 Consider the potential for this survey's results and findings to provide a foundation for future comparative research on other technical drawings of wider topical, temporal, or geographical scope, and at different levels of aggregation.	Delivery of this output is dependent on, and subsumed within, the delivery of the output above.
3.3 Consider the potential to generalise this research's newly developed research design and methodology to other cases of technical drawings, of diverse forms, and as a model means of analysis of graphical records more generally.	Delivery of this output is dependent on, and subsumed within, the delivery of the output above.
3.4 Consider the potential for this research's results to be indicatively generalised, with appropriate caution, to other technical drawings' populations.	Delivery of this output is dependent on, and subsumed within, the delivery of the output above.

Table 4: Research Objectives and Intended Outputs for Aim and Outcome Three

5. Introduction to the Research Design and Methodology

To meet the research aims and objectives, the research design and methodology had to be developed as a robust model. That model would fulfil the immediate needs of the research. It would also enable replication of results from the research sample, and be generalisable to other cases of technical drawings, of diverse forms. The research design and methodology might also serve as an exemplar means of analysing graphical records more generally.

The immediate purpose of the research design was to enable both exploratory and descriptive research.[53] The design was complex. Both quantitative and qualitative methodologies were used within a multi-phase mixed methods study.[54] By using a mixed methods design, putatively incommensurable philosophical positions could be respected. Such positions existed in both the methodologies and the disciplines that were unavoidably brought together. The research's overarching theoretical perspective was provided by diplomatic.

The research design encompassed three main sequential stages:

1. Theoretical definition of concepts and characteristics in technical drawings
2. Quantification of concepts and characteristics in a technical drawings sample
3. Analysis and selection of concepts and characteristics of potential importance to understanding technical drawings

Theoretical data for concepts and characteristics were first qualitatively collected from the literature, using a combination of grounded theory, and a modified form of content analysis. A Data Definition Model was developed. The data within this model were used to construct the instruments for the technical drawings survey.

A statistically robust stratified sample of technical drawings was drawn for survey. Survey data for concepts and characteristics were collected using classical content analysis.

The data were used in three ways. Firstly, they enabled continual qualitative refinements to be made to the Data Definition Model as the survey progressed.

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53 Ibid., 8-9.

54 See Research Design: 2. A 'Mixed Methods' Research Design, *71*.

That model was used, in turn, to refine the data collection instruments, iteratively.

Secondly, but more importantly, the survey data were also analysed as quantitative data. A statistical estimation was made of the frequency of occurrence of each individual concept and characteristic within the sample's parent population of technical drawings.

Finally, the data for the concepts and characteristics that occurred very frequently within the sampled technical drawings were qualitatively assessed. Concepts and characteristics that had potential to enhance archivists' understanding of technical drawings were identified. Those concepts and characteristics were described within this research, and form a basis for future consultation beyond this research.

6. Outline of the Thesis

The key topics within this thesis are now identified, chapter by chapter. Following this introductory chapter, Chapter 2 reviews selected literature appropriate to the research scope. The purpose of the literature review was threefold: to identify current knowledge, and gaps in knowledge, within the research scope; to underpin the development of the Data Definition Model; and to contribute data to that model.

Chapter 2 contains three principal sections, for diplomatic, archives and records, and technical drawings. The literature for diplomatic was most blessed with theory; that for archives, records, and technical drawings progressively less so. That situation reflected the practical nature of technical drawing in particular. The relevant archives and records literature was also largely concerned with applied theory and practice. That which was reviewed was both specific to archival technical drawings, and more general in nature.

Chapter 3 first situates and conceptualises the research design and methodology. The entire design is then summarily described. Next, three key design areas are considered in more detail: the Data Definition Model, representation of the research population through the technical drawings' sample, and the collection of technical drawings' survey data. These descriptions are in sufficient detail to enable replication of the research design and methodology in future research.

Measures taken to mitigate bias and other error risks are noted. So, too, are the statistical inference limitations inherent in the research design and methodology.

Chapter 4 presents the results and analysis of the technical drawings' data survey. The chapter is introduced by a brief description of how the raw survey data were converted into reliable research results, from which findings could be made. Seventy-four sets of results are reported. They form the basis for the discussion that then follows.

Chapter 5, the discussion, is the core of this thesis. The first purpose of that discussion is to show the extent to which the results answered the research question. In so doing, traditional diplomatic theory is considerably developed, on two levels. At the higher level, the developments are largely in response to the reprographic reproduction of records. Such new theory can, of course, be applied ubiquitously to any record capable of reprographic reproduction. Further developments, to meet the special needs of technical drawings, have generally been made in a more detailed way, at a lower level. Throughout the discussion, consideration is given to previous work reported in the literature.

Chapter 6 presents the conclusions that underline the whole thesis. Those conclusions are prefaced by a restatement of the state of knowledge before the research commenced. The contribution that the research has made towards answering the research question can then be better assessed. That assessment is made by considering the actual research outcomes against those that were noted as intended in Table 1, above. The extent to which the research was successful is thus clearly indicated. Areas where the research claims a contribution to knowledge are then indicated. So, too, are areas where this research's findings have identified a need for further research.

A set of four appendices provides the data that was collected during this research, and from which the thesis has been written. The large volume of data precludes its complete presentation in hard form. Several forms of data have therefore been provided, in complete and summary form.

7. Key Definitions Used in the Thesis

The ways in which similar concepts are defined and labelled differ across research. Wherever possible, authoritative definitions have been adopted in this study. Sometimes, though, existing concepts have had to be adapted, or new ones developed and defined. To aid further reading, this section presents some key definitions that have been developed or adopted within this investigation.

This research's fundamental unit of analysis was the individual technical drawing. Individual forms of component were also defined within a technical drawing, to facilitate more granular analysis. Definitions of those components are now presented, before proceeding to the definition of a technical drawing itself.

7.1 Definitions of a technical drawing's components

A technical drawing was conceptualised as comprising four types of component, each located at a progressively deeper level of analysis: [55]

• **Concepts**, which are made up of:
• **Characteristics**, which can embody:
• **Attributes**, which can embody:
• **Facets**, the lowest level of this conceptualisation.

Illustrating the use of this component model, the dimensions of a technical drawing's support were conceptualised thus:

• Support Medium: **Concept**
• Support Medium – Form: **Characteristic**
• Support Medium – Form – Dimensions: **Attribute**
• Support Medium – Form – Dimension – Long: **Facet**

55 For all these components, the research generally followed the definitions of usages given by: ISO / EIC, *ISO/IEC 11179-1:2004(E): Information Technology: Metadata Registries (MDR): Part 1: Framework*, 2nd ed. (Geneva, 2004); ISO, *ISO 5127:2001: Information and Documentation - Vocabulary* (Geneva, 2001).

Both the Data Definition Model and the final set of survey data shared these components as common 'building blocks' that represented technical drawings.[56]

The higher-level components – concepts and characteristics – were ubiquitous. Attributes and facets were sometimes present at lower levels. Every component possessed a value,[57] which was either visible – 'manifest', or hidden – 'latent'.

These technical drawing components are now described and defined.

7.1.1 Concepts

At the risk of introducing circularity, it is essential to conceptualise a concept. Concepts have been defined as 'mental constructs' or a 'units of knowledge'.[58] When linked by a system of logical statements or propositions that explain their relationships, they are the components of theory.[59]

In this research, following standard definitions, concepts were generally used at three levels:[60]

• **General Concepts**, which can contain:
• **Specific Concepts**, which can also contain:
• **Individual Concepts**, the lowest level of this conceptualisation.

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56 B. L. Berg, *Qualitative Research Methods for the Social Sciences*, 6th ed. (Boston, 2007), 19-20; J. H. Turner, ed., *Theory Building in Sociology: Assessing Theoretical Cumulation* (Newbury Park, CA, 1989), 5.

57 Either a Data Value or a Label Value. See Introduction: 7.1.3 Record Component Values, *26*. These value concepts are entirely separate from those previously described at: Introduction: 2.2 Instruments of Power, *4*, and 2.3 Archival research values of technical drawings, *7*.

58 ISO / EIC, *ISO/IEC 11179-1:2004(E): Information Technology: Metadata Registries (MDR): Part 1: Framework*, 9 cl. 5.

59 Berg, *Qualitative Research Methods for the Social Sciences*, 19-20; Turner, *Theory Building in Sociology: Assessing Theoretical Cumulation*, 5.

60 ISO / EIC, *ISO/IEC 11179-1:2004(E): Information Technology: Metadata Registries (MDR): Part 1: Framework*, cls.3.2.13, 3.2.14; ISO, *ISO 5127:2001: Information and Documentation - Vocabulary*, cl. 4.2.2.4.10.

Illustrating the use of this concept model, the hierarchy of concepts for the Process Medium of Manual Drafting was conceptualised thus:

• Process Medium: **General Concept**
• Primary Production Process: **Specific Concept**
• Manual Drafting: **Individual Concept**

Generically at any of these three levels, a concept comprises two distinct elements. A symbolic element – a word, symbol, or term – denotes the concept, while an associated element defines it. [61] In this research, a slightly modified form of that approach was used. Data Elements represented the higher-level components that the research defined as making up a technical drawing. Data for those components were initially drawn from theory in the Data Definition Phase, and later modified and supplemented during the survey. A Label Element provided the data for the symbolic element of each Data Element. These Label Element data were drawn from theory, derived from the survey, or supplied if neither source could provide them.

Concepts were constructed to represent both the physical and the intellectual elements of a technical drawing. For example, physical concepts included those for the process used to create a technical drawing, and for the material of a drawing's support. Intellectual concepts included those for a technical drawing's reference code, and for the ways in which technical drawings portrayed objects.

Figure 1, following, illustrates this research's conceptualisation of a concept.

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61 Berg, *Qualitative Research Methods for the Social Sciences*, 19-20.

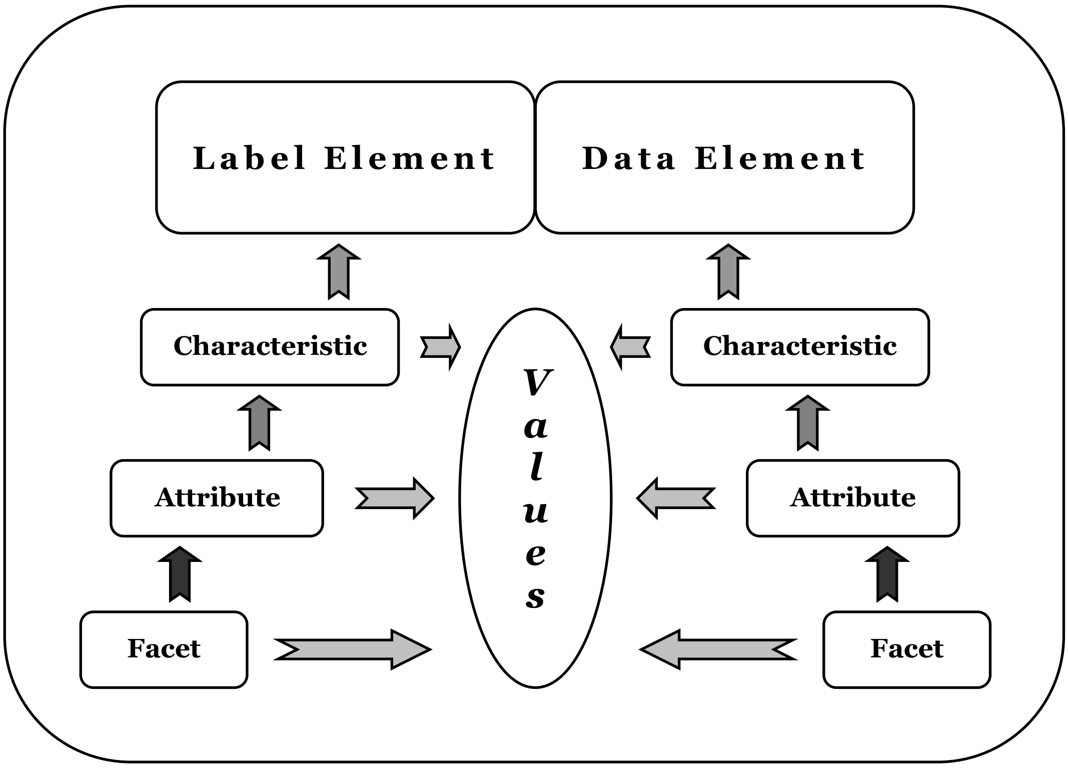

Figure 1: Conceptualisation of a concept

7.1.2 Characteristics

Even when considered individually, concepts were too large an intellectual unit to be fully understood in the level of detail necessary for this research. Each concept could be more easily understood through examination of the 'unique combination of characteristics' that combined to form it. [62] Lower-level characteristics were also more likely to be practically observable and quantifiable than less tangible concepts. Such practical considerations would be critical to the success of the technical drawings' data survey. They would also enable the survey results to be evaluated against existing bodies of knowledge. [63]

Characteristics of concepts were typically used to record the presence or absence of a concept within a technical drawing, the spatial and conceptual positions of a concept within a drawing, and the form of a concept. Attributes and facets of form – material colour, and regularity of support dimensions, for example – were also recorded where more granular detail was required.

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62 ISO / EIC, *ISO/IEC 11179-1:2004(E): Information Technology: Metadata Registries (MDR): Part 1: Framework*, 2 cl. 3.2.3.

63 Following Berg, *Qualitative Research Methods for the Social Sciences*, 36-7.

7.1.3 Record Component Values

Every record component within each concept was ascribed a value. That value was determined either by direct measurement of the component, by the transcription of its data content, or by the application of a controlled term to the component. Missing values were described in one of three ways – 'Not Present', 'No Data', or exceptionally, 'Not Known'. The aggregation of all component values within a single concept provided the value for that concept.

A single technical drawing was then represented by the aggregation of all the data for those record components and values that were discovered within the drawing. The combination of such data for all the surveyed technical drawings provided the research's total dataset, as illustrated in Figure 2, below.

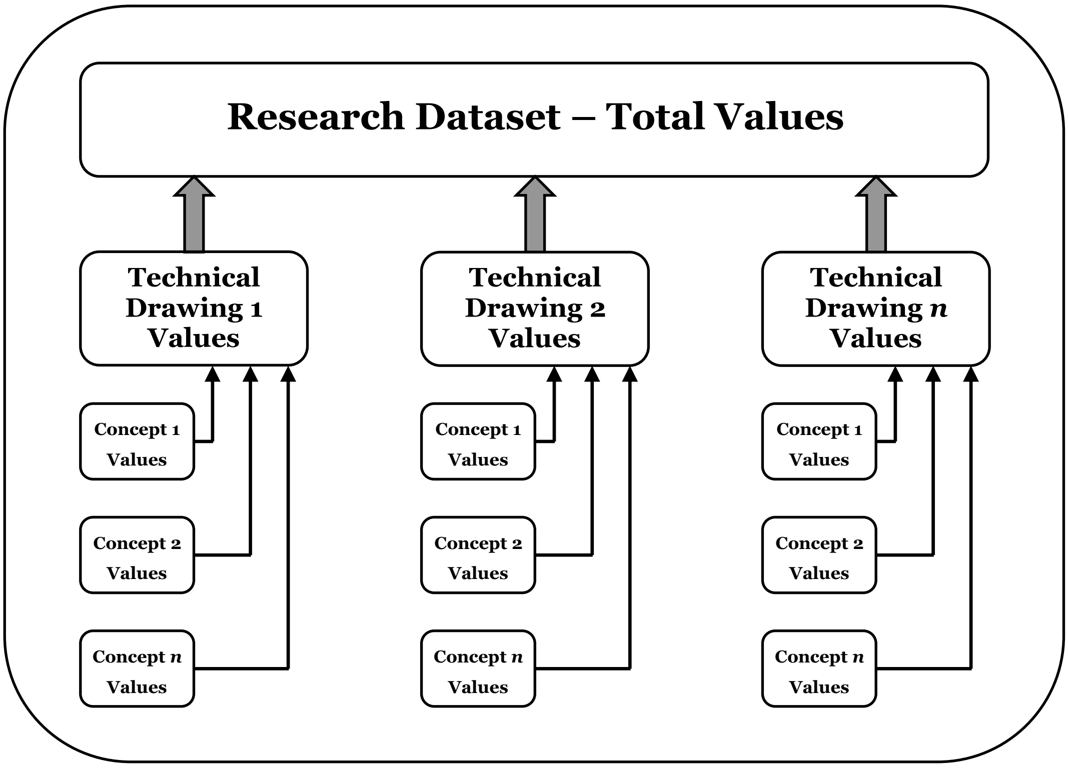

Figure 2: Aggregation of record component values

The component values were either manifestly evident as data within a surveyed technical drawing, or could be inferred from the drawing. Data Values and Label Values most often existed at the level of the characteristic.

For illustration, a Data Element conceptualised as 'Drawing Reference Number' might be indicated by a Label Element having a Label Value 'DRG. NUMBER'.

The Data Value of the Data Element itself would be the inscribed Drawing Reference Number.

This ideal case was by no means the norm. Across the diversity of technical drawings, different Label Values were sometimes used to denote essentially the same form of Data Element. For example, the Data Element conceptualised as ‘Intended Use’ [of the depicted object] was found with Label Values that included ‘First Used [On]’, ‘Originated For’, and ‘Remarks’. Data Elements and Data Values were also present without Label Elements.

7.1.4 Latent Data

Latent data coding requires text to be interpreted to identify concepts even if certain words are not present. [64] Latent data therefore had to be inferred from the technical drawing as a whole, or from components of it. That approach was avoided as much as possible, because the ultimate aim was to identify data that would be manifestly clear to archivists and researchers when they read a technical drawing. However, some data could only be inferred. They included, for example, those for a drawing’s support material, its process of production or reproduction, and for the drawing’s Stage of Realisation.

7.2 Definition of a technical drawing

Conceptualisations of a technical drawing’s components were necessarily built up from theory. The definition of a technical drawing itself could be more directly drawn from the literature. [65] I defined a technical drawing as a specific concept within a general concept of graphical material. [66] The specific concept of a technical drawing was then defined in this research as: [67]

> Technical information, given on an information carrier, graphically presented in accordance with agreed rules and usually to scale.

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64 Bernard and Ryan, *Analysing Qualitative Data: Systematic Approaches*, 292.

65 See Literature Review: 4.1.3 Definitions of a technical drawing and associated concepts, *68*.

66 Following Bureau of Canadian Archivists, 'Appendix D: Glossary' in *Rules for Archival Description*, 2008 revised ed. (Ottawa, 2008) [Online] http://www.cdncouncilarchives.ca/RAD/RAD_Glossary_July2008.pdf (accessed 20 Sep, 2010). The general concept of graphical material used here therefore equated to *RAD2008*’s ‘general material designation’ of ‘graphic material’.

67 British Standards Institution, *BS ISO 10209-1:1992: Technical Product Documentation - Vocabulary - Part 1: Terms Relating to Technical Drawings: General and Types of Drawings* (London, 1992), 2 cl. 2.11; British Standards Institution, *BS 6100–1:2004/BS ISO*

This definition encompassed the very wide range of topical, temporal, and geographical variations in the forms of technical drawings that exist globally.

7.2.1 Architectural, building, and construction (ABC) drawings

It could be argued that at least some architectural drawings were more akin to works of art. On that basis, so too might highly developed engineering drawings of the mid-nineteenth century. Furthermore, all those types of drawings graphically represented products and processes within technical environments. I therefore decided that within this research, all drawings of an architectural, building, construction, and engineering nature would be included within the defined specific concept of a 'technical drawing'.

Drawings associated with architecture, building, and construction do, though, form a natural cluster. That group might contain both artistic architectural representations and building and construction drawings of a more technical nature. The group is distinct from other representations of technical activities such as general engineering products and processes.

7.2.2 Definitions within technical drawings

Therefore, within the specific concept of a 'technical drawing', the research identified two individual concepts, whose scopes followed those defined by an existing archival description standard: [68]

- Architectural, building, and construction (ABC) drawings
- Engineering drawings

While the research's practical investigation was focused on engineering drawings, it was theoretically informed as much by the literature for ABC drawings as for engineering drawings. It was therefore appropriate to consider that the research was scoped for technical drawings as defined here.

6707–1:2004: Building and Civil Engineering - Vocabulary - Part 1: General Terms (London, 2004), 72 cl. 7.2.10.

68 Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings', in *Rules for Archival Description*, 2008 revised ed. (Ottawa, 2008), 6-4, [Online] http://www.cdncouncilarchives.ca/RAD/RAD_Chapter06_March%202008.pdf (accessed 14 Sep, 2010); Bureau of Canadian Archivists, *Appendix D: Glossary*, D-2, D-9.

8. Research Scope and Limitations

The study was necessarily bounded and logistically constrained by three theoretical and practical factors:

- The definition of technical drawings within this research
- Within that definition, the topical, temporal, and geographical scope of technical drawings selected for investigation
- Reactions to opportunities and threats during the course of the research

This section first describes and justifies the scope of the research, including two changes to topical scope that were made as the research progressed. Limitations that were caused by those changes are then discussed. Other limitations, which were associated with the chosen research design and methodology, are discussed in Chapter 3. [69]

8.1 Research Scope

Within the research's definition of a technical drawing, the topical, temporal, and geographical scopes of those to be studied were defined at an early stage. Those boundaries were not inflexible, though – it was thought likely that some adjustment would be needed as the research developed.

8.1.1 Topical scope

In the event, there were two noteworthy changes to the topical scope of the research. The first change occurred within the first months of the research. Although it narrowed both the topical and temporal scope of the research, that change had a beneficial effect overall. The second change to topical scope occurred midway through the research, and imposed limitations on the investigation. These changes to the topical scope are now discussed.

Initially planned topical scope

Pre-investigation scoping and planning had already identified sufficient technical drawings' populations that were accessible from my research base. [70] I therefore initially intended to research technical drawings that had been produced during a

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69 See Research Design and Methodology: 4. Research design and methodological limitations, *112*.

70 These populations included those made available by archives services under normal public access conditions; those held in archives' and museums' reserve stores, and exceptionally made available; and those still held by their creators, again exceptionally made available.

range of different activities. The findings from each particular case would then be compared and contrasted. The research scope could be adjusted by including more or fewer different activities, as time allowed.

Revised topical scope of technical drawings

At an early stage of the research, an unexpected opportunity arose to acquire a statistically valid sample of technical drawings from the commercial vehicle industry. It was clear that the research could benefit greatly from that opening. To have the subjects of the research immediately to hand would mean that I could work far more flexibly than would otherwise be possible. More detailed investigation could be carried out, with the easy ability to revisit specific technical drawings when questions arose. That straightforward access would better enable sound theory to be developed from practical investigations.

Immediate access to technical drawings would also enable a rigorous and repeatable research methodology to be more easily developed. Testing and refining that methodology in house would ease its application in future research of technical drawings, especially where they were not so readily accessible.

A concentration in depth on one population of technical drawings would narrow the topical scope of the research. However, although industry-specific, these drawings did encompass a broad scope of general engineering practice. Therefore, the topical scope would still be broad enough to enable some degree of generalisation of findings to similar engineering drawing populations.

I decided that immediate access to technical drawings, and the consequent effects, offered the greater potential for sound research. The research was modified accordingly. In the event, the commercial vehicle technical drawings provided more than ample scope for research in both breadth and depth.

Revised topical scope of concepts

Before the technical drawings could be surveyed, a theoretical model had to be constructed of the concepts that they were likely to contain.[71] The model would enable survey instruments to be constructed. That theoretical data definition

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[71] See Research Design and Methodology: 3.1 Data Definition, *78*.

work clearly identified more concepts than could be practically surveyed within the available time.

The problem was not one of too many concepts in themselves. To be satisfactorily understood, each concept needed to be characterised in several ways. The difficulty lay in the burgeoning volume of data that was required to facilitate that understanding for the many concepts that were identified.

Although problematic, it was helpful to know that this situation existed. It clearly highlighted that the broader approach that had been planned originally would have been ineffective. Only an in-depth survey of technical drawings would provide data of sufficient granularity for their individual concepts to be identified and characterised for analysis.

However, the necessary deeper investigation would only be possible by narrowing the overall breath of the technical drawings' concepts to be investigated. It was obvious that some further re-scoping was essential. That would impose some limitations upon the research, as discussed below. [72]

Specific exclusions to topical scope

The decision to concentrate on the commercial vehicle drawings necessarily required the exclusion of architectural drawings from the research. [73] Engineering drawing and architectural drawing standards and practices were so different within the twentieth century that both topics could not considered within the available research time. Other specialist topics, for which separate technical drawing standards were in place, were also excluded. [74]

Printed literature containing technical illustrations was also considered to be beyond the scope of the research. Parts catalogues, and vehicle maintenance and operating manuals, for example, contained forms of technical illustration such as exploded, cut-away, or X-ray views. Such drawing conventions were employed to ease understanding by less technically minded readers. They were not the

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72 See Introduction: 8.2 Research Limitations, *32*.

73 I had initially considered that they might provide a useful comparison to engineering drawings.

74 Including such diverse topics as technical glassware, optical elements and systems, and drawing practice for engineering diagrams and their symbols.

conventions normally used for the more complicated forms of technical drawing that this research was designed to investigate.

8.1.2 Temporal scope

The research was initially planned to focus on the period from the early nineteenth century to the late twentieth century. That was the era of hand-origination and mass reproduction of technical drawings, when they became so prolific as to now make their archival management most problematic.

The acquisition of the commercial vehicle drawings narrowed the temporal scope of the investigation. They covered the period from the late 1920s to the late 1980s. This narrowing was not entirely disadvantageous, again because of the exploratory nature of the research. I considered that by initially investigating twentieth-century technical drawings, the most complicated picture of concepts and characteristics would be found.

I also anticipated that, in general, such findings could be applied, in future research, to less well-developed drawings of earlier periods. That approach would be more productive than trying to generalise findings from nineteenth-century technical drawings to their more-developed twentieth-century counterparts.

8.1.3 Geographical scope

Britain, Europe, and the USA have all drafted technical drawings using different practices, standards, and projection methods. As was the case for architectural drawings, attempting to include such diversity within this initial study would not be practicable. Furthermore, the commercial vehicle drawings used in the research were of British origin. In the main, therefore, the research drew on British sources for technical drawings' theory and practice. References to theory and practice elsewhere are clearly noted at the appropriate points.

8.2 Research Limitations

Research limitations are defined as potential weaknesses of an investigation.[75] Their reporting is essential to enable informed assessments to be made of the quality of the research.

75 J. W. Creswell. *Research Design: Qualitative and Quantitative Approaches* (Thousand Oaks, CA, 1994), 110.

The limitations occasioned by the overabundance of concepts and characteristics are discussed here. They were the removal of consultation activities, and the consequential need to select concepts and characteristics for investigation without that external advice.

8.2.1 Consultation

I had planned to submit the data gathered, within the theoretical model of concepts and characteristics, for consultation with archivists and researchers. Their views would be taken as to which concepts and characteristics were potentially of importance to understanding technical drawings, and hence worthy of practical investigation.

However, the data to be consulted upon were far more extensive and complicated than had been foreseen. It was felt that too much time would be required to edit, interpret, and disseminate the data for consultation. Even if that work could have been done, substantial time was anticipated to be required in responding to consultation queries, and processing and analysing the responses. Further consultation was therefore cancelled, and the consultees advised accordingly. This was a very regrettable but necessary decision. Consultation would have been worthless if the research for which it was intended could not have been completed.

8.2.2 Selection of concepts and characteristics

It will be remembered that the research objectives included the identification of those concepts and characteristics that were generic, or nearly so, and which would be of potential importance to understanding technical drawings. It now fell to me alone to select the concepts and characteristics to be investigated. The potential for researcher bias was obvious, but selection was essential.

My selections were guided firstly by diplomatic, archives, and records' concepts and characteristics, rather than those derived from technical drawing. That placed the selection within the appropriate disciplinary area. I then considered which concepts might be of importance. Those such as drawings' reference code, signatures, and dates, for example, were clearly of potential interest. Indications of material surface texture, geometric tolerancing, and the graphical conventions for drawing lines, were not.

The problematic area lay between those two extremes, where the potential importance was unclear. It included intellectual concepts – drawing aspect and stage of realisation, for example – as well as those that were more tangible. I did not exclude, for any reason, any concept that I thought to have potential importance. In this respect, I erred very much on the side of caution, and included more concepts and characteristics than I would probably have done with the benefit of consultation. This important topic is discussed in more detail, later. [76]

[76] See Research Design and Methodology: 3.1.4 Purposive selection of concepts and characteristics for survey, *83*.

Chapter 2: Literature Review

1. Introduction

The literature review had three aims:

1. Identifying current knowledge, and gaps in knowledge, within the area of research interest – the diplomatic analysis of technical drawings.
2. Providing underpinning for the notions of three initial data definition models, for diplomatic analysis, archives and records, and technical drawing.
3. Contributing data for the concepts, characteristics, and terms (CCTs) that populated those models.

The chapter is divided into four principal sections. It comprises this Introduction, and three sections considering the literature for theory and practice in:

- Diplomatic
- Archives and Records
- Technical Drawings

These were diverse areas of literature, where no single search or critical appraisal strategy was appropriate to all. The first findings from the disciplinary literature searches bore heavily upon the search strategy itself, and on this review. Literature of direct relevance to the central research topic was found to be very limited. As will be seen in this chapter and elsewhere in the thesis, many questions and issues could therefore only be answered or considered through inference and analogy from wider literature sources. When seeking relevant and useful literature, it was sometimes difficult to keep those broader searches within reasonable contextual limits.

2. Diplomatic

The search for diplomatic literature was an iterative process. Its starting point was Duranti's *Diplomatics: New Uses for an Old Science*,[77] to gain a more complete initial understanding of her innovative theoretical developments. The focus then moved to sources that would contribute data for diplomatic concepts,

77 Duranti, *Diplomatics: New Uses for an Old Science*.

characteristics, and terms. The search concentrated on applications of diplomatic within the archival literature, rather than that for historical research. That gave a more direct focus on topics likely to be of relevance. [78]

During the course of this research, literature appeared periodically from the projects applying diplomatic principles to documents and records in electronic environments. Some project papers were in draft form, not reflecting finalised authoritative project outcomes. Instances of internal inconsistency were noted in some documents. More substantive journal literature was also produced. Again, though, some of that literature reflected views that were refined as the projects progressed. The projects' firm and final conclusions were therefore mostly not available in time to inform this research's development. Some did though prove useful for *post-hoc* comparison purposes. [79]

That situation also contributed to the iterative nature of this part of the literature search. That was not always beneficial. It was too easy to become caught up in discussions about emerging diplomatic concepts, for example, which were ultimately found to have little relevance to records in traditional environments. [80] That extensive literature is only discussed here if it had direct bearing upon this research. Unless specifically stated, this review therefore relates only to documents and records in traditional environments. There was though much literature for diplomatic applications to records in what were termed 'contemporary environments'. [81] It was not always clear whether those environments applied to records in traditional, electronic, or hybrid forms.

That area of literature dated predominantly from the late 1980s to the late 2000s. It reflected the upsurge in diplomatic's profile during that time. Some other literature was considered for the preceding part of the twentieth century. Even

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78 Ibid., 29.

79 In general, the literature for the InterPARES 1 Project was of most relevance. As the first part of what was, by 2010, a three-phase project, that literature was not specifically titled InterPARES 1. Much of this literature was dated significantly earlier than it was found to be available on line.

80 That is, 'hard-copy' information artefacts.

81 As illustrated by: InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES): From Traditional Diplomatics to Contemporary Archival Diplomatics' (InterPARES 1 Project, 2000) [Online] http://www.interpares.org/display_file.cfm?doc=ip1_lineage_of_elements.pdf (accessed 10 Oct, 2007); H. MacNeil, 'Contemporary Archival Diplomatics as a Method of Inquiry: Lessons Learned from Two Research Projects', *Archival Science*, 4, 3-4 (2004), 199-232.

earlier literature, which stretched back to the late seventeenth century, was substantially inaccessible directly, for language reasons. Some could though be partially accessed through secondary texts.

For those texts that I could directly access, the main factor of concern in critical analysis was relevancy. The lack of directly relevant literature meant that considerable care had to be taken when drawing inferences from what was available. For example, the photograph was the only form of visual or graphical record to which diplomatic principles had been applied in the literature. Yet the structure and visual content of a photograph is quite dissimilar to that of a technical drawing. [82]

The diplomatic literature of most relevance to this research was situated at the opposite ends of a three-hundred year time span. It is reviewed here thematically, and broadly chronologically, in the following five sections:

- Mabillon – *De Re Diplomatica* (1681)
- Post-Mabillon literature before Duranti
- Duranti – *Diplomatics: New Uses for an Old Science* (1989-92)
- InterPARES – Theoretical frameworks and methodologies
- Diplomatic for non-textual records in traditional environments

2.1 Mabillon – *De Re Diplomatica* (1681)

Diplomatic's origins and early development have been well described.[83] It is generally accepted that Mabillon's [84] *De Re Diplomatica* [85] established, in 1681, the method of critical textual analysis that became known as 'diplomatic'. [86]

Mabillon generalised his principles from an examination of some 200 documents of various types. He was conscious to select a variety of documents from the same

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82 I make here a conceptual distinction between visual records such as photographs, and graphical records such as technical drawings. The content of the former is normally an image composed of a blend of tones and / or colours. The content of the latter is normally one comprising lines, shapes, and symbols.

83 See, for example: Boyle, 'Diplomatics', 69-101; Duranti, *Diplomatics: New Uses for an Old Science*, 36-40; Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 1-24.

84 Dom Jean Mabillon (1632-1707) Benedictine of the Congregation of Saint Maur, writing while at the Abbey of Saint Germain-des-Près, Paris: Boyle, 'Diplomatics', 69-70; Duranti, *Diplomatics: New Uses for an Old Science*, 37.

85 Mabillon, *De Re Diplomatica*.

86 Boyle, 'Diplomatics', 70-1; Duranti, *Diplomatics: New Uses for an Old Science*, 37.

source, and which resulted from the same process or procedure. He was thus able to compare and contrast the documents' different characteristics of 'internal and external form, support, writing, language, and style'. Mabillon was then able to infer which characteristics might be expected to be found within documents of a particular type, created for a particular purpose, by a particular source. [87]

Furthermore, he was able to conceptualise the systems that contributed to document creation – the acts, persons, and procedures. That 'decontextualising and universalising' [88] of all the concepts and characteristics of document creation established an inductive methodology for diplomatic analysis that remained valid at the turn of the twenty-first century. [89]

Mabillon's scope was extensive. [90] He laid not only the foundations for diplomatic and palaeography, but also provided underpinning for sigillography and chronology. [91] The first two volumes of *De Re Diplomatica* detailed the principles of diplomatic criticism. Different types of documents were defined, and their media of production, languages, and scripts characterised. Mabillon described documentary structures, a document's status over time, the use of formulae and titles, the roles of chanceries and their clerks, the naming of witnesses, and the uses of seals and annotations. Six chapters were devoted to systems of chronology and the dating of documents. [92]

Volumes Three to Six contained arguments and illustrations supporting Mabillon's stated principles. They included a list of the general rules that should

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87 Ibid., 37-8, and F. Blouin and B. Delmas, 'Special Section on Diplomatics and Modern Records (Introduction)', *American Archivist*, 59, 4 (Fall, 1996), 412-3, cited by Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 13, 22 n.71.

88 H. MacNeil, *Trusting Records: Legal, Historical and Diplomatic Perspectives* (Dordrecht, 2000), 21.

89 MacNeil, 'Contemporary Archival Diplomatics as a Method of Inquiry', 225-6.

90 As evidenced by the subtitle alone: 'Six books in which is explained and illustrated whatever pertains to the antiquity, matter, handwriting, and style of old instruments; to seals, monograms, subscriptions, and dating; and to antiquarian, legal, and historical disciplines.' Translation following Boyle, 'Diplomatics', 73.

91 Duranti, *Diplomatics: New Uses for an Old Science*, 37-8; MacNeil, *Trusting Records: Legal, Historical and Diplomatic Perspectives*, 124 n.88; Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 5; C. Harrison, 'Thomas Madox and the Origins of English Diplomatic Scholarship', *Journal of the Society of Archivists*, 29, 2 (Oct, 2008), 154.

92 Duranti, *Diplomatics: New Uses for an Old Science*, 37-8; MacNeil, *Trusting Records: Legal, Historical and Diplomatic Perspectives*, 20; Wendt, 'Digitalisierungsprojekt: Jean Mabillon - De Re Diplomática Libri VI' (Introduction).

be considered when assessing documents.[93] Volume Five was essentially the first work on palaeography.[94] The final volume contained copies of the documents that Mabillon had examined while developing his thesis.[95]

In 1704, a *Supplementum*[96] gave Mabillon's replies to critics of *De Re Diplomatica*. After Mabillon's death in 1707, his assistant Ruinart[97] published a second edition,[98] in 1709. The contents of the *Supplementum* were incorporated where appropriate into Mabillon's original text. That edition therefore reflected Mabillon's most developed thoughts and responses to his critics.[99]

A third edition of *De Re Diplomatica*[100] was published in 1789, incorporating additional material gathered by the Italian philologist Adimari.[101] It took account of more recent developments in diplomatic. To its disadvantage, the respective contributions of Mabillon and Adimari were not differentiated within the significant additions and changes.[102]

Mabillon's rules provided not only a new method of textual criticism, but also one that was based on 'comprehensive, systematic, theoretical analysis'.[103] The 'rigour, transparency, and methodological precision' of Mabillon's methods have

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93 J. Mabillon, 'Liber Tertius, Caput VI', in *De Re Diplomatica*, 2nd ed. (Lutetiæ-Parisiorum, 1709), 241-2, [Online] http://141.20.85.26/mabillon/index.html (accessed 19 Aug, 2010). I am grateful to Dr Alfred Hiatt for his advice on this point.

94 Duranti, *Diplomatics: New Uses for an Old Science*, 38.

95 MacNeil, *Trusting Records: Legal, Historical and Diplomatic Perspectives*, 20-1; Wendt, 'Digitalisierungsprojekt: Jean Mabillon - De Re Diplomática Libri VI' (Introduction).

96 J. Mabillon, *Librorum De Re Diplomatica Supplementum. In Quo Archetypa in His Libris Pro Regulus Proposita, Ipsaeque Regulae Denuo Confirmantur, Novisque Speciminibus & Argumentis Afferentur & Illustrantur*. (Lutetiæ-Parisiorum, 1704) [Online] http://141.20.85.26/mabillon/index.html (accessed 17 May, 2011).

97 Dom Thierry Ruinart (1657-1709): J. P. Kirsch, 'Ruinart, Thierry' in *The Catholic Encyclopedia*, C. G. Herbermann and others, eds., (New York, 1913) Vol. XVIII, 223-223.

98 J. Mabillon, *De Re Diplomatica,* 2nd ed. (Lutetiæ-Parisiorum, 1709) [Online] http://141.20.85.26/mabillon/index.html (accessed 19 Aug, 2010).

99 Boyle, 'Diplomatics', 92; Wendt, 'Digitalisierungsprojekt: Jean Mabillon - De Re Diplomática Libri VI' (Introduction).

100 G. Adimari, ed., *De Re Diplomatica: Tertia Atque Nova Editio*, 3rd ed. (Neapoli, 1789).

101 Giovanni Adimari: Wendt, 'Digitalisierungsprojekt: Jean Mabillon - De Re Diplomática Libri VI' (Introduction).

102 Ibid.

103 Ibid.

been equated with those of his better-know scientific contemporaries.[104] Boyle felt that no other writer had or could be expected to match the scope of Mabillon's *res diplomatica*.[105] Mabillon's general principles for diplomatic endured for some three centuries before being significantly reinterpreted. As a product of its time, though, *De Re Diplomatica* reflected only a limited range of textual documents, and said nothing about non-textual documents.

2.2 Post-Mabillon literature before Duranti

2.2.1 The literature in Continental Europe

Over the next three centuries in Continental Europe, the diplomatic literature expanded in both volume and scope. Toustain and Tassin's widely compassed *Nouveau traité de diplomatique* (1750-1765),[106] for example, has been regarded as entering the field of applied diplomatic. Its immediate influence was evidenced by a contemporaneous translation into German,[107] and its durability by an abridged French version seven decades later.[108] Methodologically, the principles of Toustain and Tassin's text were considered still valid after 250 years.[109]

In the nineteenth century, diplomatic was increasingly applied to many historical studies of medieval documents. It came to be regarded as an auxiliary science of history. Even so, diplomatic retained legal usages, and also provided a foundation for archival science.[110]

By the end of the nineteenth century, new diplomatic handbooks in Continental Europe had largely displaced *De Re Diplomatica* as the text of first choice.[111] That scholarship continued well into the twentieth century. Some texts were more

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104 Ross, 'Digital Preservation, Archival Science and Methodological Foundations for Digital Libraries', 9. See also: Boyle, 'Diplomatics', 71.

105 Ibid., 71, 73, 79.

106 R. P. Tassin and C. Toustain, *Nouveau Traité De Diplomatique ... Par Deux Religieux Bénédictins De La Congrégation De Saint-Maur* (Paris, 1750-1765).

107 Published between 1759 and 1769: Boyle, 'Diplomatics', 71.

108 Published 1838: Ibid., 71.

109 Duranti, *Diplomatics: New Uses for an Old Science*, 39.

110 Ibid., 39-40 and n.16, 54-7; MacNeil, *Trusting Records: Legal, Historical and Diplomatic Perspectives*, xi, 86.

111 O. Guyotjeannin, 'The Expansion of Diplomatics as a Discipline', *American Archivist*, 59 (Fall, 1996), 416-7; MacNeil, 'Contemporary Archival Diplomatics as a Method of Inquiry', 202 n.11; Wendt, 'Digitalisierungsprojekt: Jean Mabillon - De Re Diplomática Libri VI' (Introduction).

wide ranging in their scope than others, [112] but none brought diplomatic appreciably closer to the analysis of graphical forms of documents.

2.2.2 Anglophone literature

In England, the literature was firmly inclined towards applied diplomatic. [113] Madox, [114] in 1702, came closest to providing an Anglophone text for diplomatic's general principles. However, his *Formulare Anglicanum* applied Mabillon's principles of diplomatic analysis. [115] Madox did not therefore provide this research with a different diplomatic perspective.

Almost three centuries later, Boyle's 'exemplary' [116] and 'elegant' [117] essay did propose a different way of implementing diplomatic analysis. Reacting to other scholars' conservative views regarding the scope of diplomatic, Boyle felt that Mabillon's 'openness' of the *quidquid* – 'whatever pertains' – should prevail. Diplomatic should be applied to all forms of documentary sources, whether or not they were juridical in nature. [118]

Boyle's analysis was though primarily based on the document as a narrative communication, rather than as a repository of forms and formulae. [119] He provided no systematic method for extracting the concepts, characteristics, and

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112 Boyle, 'Diplomatics', 73-75, 79; D. C. Skemer, 'Diplomatics and Archives', *American Archivist*, 52, 3 (Summer, 1989), 380-1; Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 6-7; Ross, 'Digital Preservation, Archival Science and Methodological Foundations for Digital Libraries', 9.

113 K. Major, 'The Teaching and Study of Diplomatic in England', *Archives*, 8, 39 (Apr, 1968), 115-17; C. N. L. Brooke, 'The Teaching and Study of Diplomatic in England (Contribution)', *Archives*, VIII, 39 (Apr, 1968), 133; Duranti, *Diplomatics: New Uses for an Old Science*, 40 n.17. See, for example: T. Madox, *Formulare Anglicanum*, (London, 1702); H. Hall, *Studies in English Official Historical Documents* (Cambridge, 1908); R. B. Pugh, *Calendar of the Antrobus Deeds before 1625* (Devizes, 1947), cited by Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 5.

114 Thomas Madox (1666-1727), the 'Historiographer Royal': Harrison, 'Thomas Madox and the Origins of English Diplomatic Scholarship', 152-4; D. R. Woolf, 'Madox, Thomas (1666–1727)', in *Oxford Dictionary of National Biography*, H. C. G. Matthew, B. Harrison and L. Goldman, eds., (Oxford, 2008) [Online] http://www.oxforddnb.com/view/article/17767 (accessed 17 May, 2011).

115 Harrison, 'Thomas Madox and the Origins of English Diplomatic Scholarship', 158.

116 Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 6.

117 Ross, 'Digital Preservation, Archival Science and Methodological Foundations for Digital Libraries', 9. Ross regarded Boyle's essay as the 'finest succinct discussion of diplomatics of which I am aware'.

118 Boyle, 'Diplomatics', 75.

119 Ibid., 77.

terms within a document, beyond the bounds of seven 'basic questions'.[120] For that reason, stimulating as his approach was, it was not considered a suitable method for the investigation of documents within this research.

2.3 Duranti – New Uses for an Old Science (1989-92)

2.3.1 Definitions and scope

The most significant contribution to the diplomatic literature since the seminal European texts was Duranti's *New Uses for an Old Science*.[121] While regarded as 'densely expressed', it has also been endorsed as 'essential reading'.[122] It was an important text for this research, and is therefore considered in some detail.

Duranti intended to provide an English-language text for general diplomatic principles.[123] It would respond to 'an immediate practical need' – for archives students, and to a 'perceived intellectual need' – to explain diplomatic to North American archivists.

She defined the 'science' of diplomatic as the 'body of diplomatic theory, methods, and practices'. The procedural rules of diplomatic analysis constituted the diplomatic 'discipline'.[124] General diplomatic applied to 'abstract and atypical general documentation'. Special diplomatic – here, 'applied' – was the application of general principles to the criticism of particular classes of records.[125] Here, this form of criticism is termed 'diplomatic analysis'.

The generally accepted distinction between diplomatic and 'archival science' – a nineteenth century 'outgrowth' of diplomatic – was recognised.[126] The single document was the concern of diplomatic, each document being 'linked by a unique bond to the activity ... producing it'. In archival science, documents held multilateral relationships in aggregations. Each document's unique bond remained, but it was probably not the only relationship that a document

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120 Ibid., 80-90.

121 Duranti, *Diplomatics: New Uses for an Old Science*.

122 Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 6.

123 Duranti, *Diplomatics: New Uses for an Old Science*, 1-3.

124 L. Duranti, 'The Reliability and Authenticity of Electronic Records', in Duranti, Eastwood, and MacNeil, *Preservation of the Integrity of Electronic Records*, 23, 63 n.2.

125 Duranti, *Diplomatics: New Uses for an Old Science*, 31 and n.6.

126 Ibid., 40 n.16.

possessed.[127] The correspondence between archival science and 'special' archival science was similar to that between diplomatic and special diplomatic. [128]

Traditionally, diplomatic had only been applied to documents containing juridically relevant facts. [129] Following from Carucci [130] and Tessier,[131] and adapting Cencetti,[132] Duranti removed that requirement for a juridical element. If documents were 'created according to a procedure, routine, or habit, and in the context of practical activity', [133] diplomatic might be defined as:

> the discipline which studies the genesis, forms, and transmission of archival documents, and their relationship with the facts represented in them and with their creator, in order to identify, evaluate, and communicate their true nature. [134]

2.3.2 Duranti's development of diplomatic theory

The original format of *New Uses* is important when considering its content. Duranti committed herself to six consecutive six-monthly journal articles. [135] Her initial intentions were not overtly to advocate diplomatic, to provide a personal interpretation of it, or to develop diplomatic ideas 'in new directions'. Duranti intended her approach to be 'fundamentally theoretical', although she would attempt to situate diplomatic within territory familiar to her audience. [136]

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127 Ibid., 79-80. The concept of the archival bond – 'vincolo archivistico' – was first described by G. Cencetti, 'Il Fondamento Teorico Della Dottrina Archivistica', *Archivi*, II, VI (1939), 39-40, although Jenkinson had also made a similar connection. See: L. Duranti, 'The Archival Bond', *Archives and Museum Informatics*, 11, 3-4 (Sep, 1997), 216, n.8.

128 Duranti, *Diplomatics: New Uses for an Old Science*, 32-3.

129 'Juridical' is a broader concept than 'legal', referring to 'the nature of abstract legal concepts': Ibid., 43-4 and n.22.

130 Ibid., 44 and n.26. Both Duranti and MacNeil credited Carucci for the 'first sustained effort' to adapt diplomatic analysis to contemporary records. As well as removing the need for a juridical element, Carucci also broadened diplomatic's scope by including documentary aggregations, and moved the focus of diplomatic analysis from documentary procedures to administrative procedures. Although situated within a specific context of Italian administration, Carucci's work initiated the merging of diplomatic and archival science concepts and principles: MacNeil, 'Contemporary Archival Diplomatics as a Method of Inquiry', 204 and nn.19, 21.

131 Duranti, *Diplomatics: New Uses for an Old Science*, 44 and n.27.

132 Ibid., 45 and n.28.

133 Ibid., 44.

134 Ibid., 45.

135 Ibid., 16 n.33.

136 Ibid., 5, 28.

Her first article attracted considerable interest and feedback. That 'sceptical enthusiasm' – as Duranti put it – prompted her to change the direction of the series.[137] Duranti's new aim was to produce a complex, rigorous, and decontextualised diplomatic standard that could encompass both 'traditional' as well as electronic records, and which would be 'acceptable to everyone'. She was starting to develop diplomatic theory. [138]

The publication schedule then became a 'major problem'. Duranti had not set out with a 'carefully planned outline' for her papers, and there was soon 'no time to do any substantive research'. She considered her fifth article – 'The Form of Documents and their Criticism' [139] – to be the most under-developed. Unfortunately, its subject was also the one of greatest interest to this research. [140]

Over time, Duranti has revised the elements and structure that she initially proposed for diplomatic criticism. [141] She has also retracted some concepts because they 'confused the readers'. Duranti used her sixth article – originally intended to be a conclusion – to rebut emerging criticism, to suggest possible uses for diplomatic 'in the modern records environment', and to 'exhort' colleagues to take up her 'quest'.[142]

Duranti professed 'surprise and dismay' that her first three articles had been regarded by European archivists as a 'major reinterpretation of traditional diplomatics'.[143] Her work stimulated considerable discussion. Much of the

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137 Ibid., 9-10. Duranti was also awarded the Association of Canadian Archivists' W. Kaye Lamb Prize for 1990, for that first article. Ibid., 13-14 and n.23.

138 Ibid., 10-12.

139 Ibid., 133-58.

140 Ibid., 4, 16-17 and n3.

141 The first such revisions are noted in Ibid., 17 n.33. The journal article reference cited by Duranti is somewhat conflated with a later book on the same subject: L. Duranti and H. MacNeil, 'The Protection of the Integrity of Electronic Records: An Overview of the UBC-MAS Research Project', *Archivaria*, 42 (Fall, 1996), 46-67; Duranti, Eastwood, and MacNeil, *Preservation of the Integrity of Electronic Records*. Further revisions have occurred as Duranti has applied her theories in practice. See, for example: Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 15-16, and L. Duranti, 'Concepts and Principles for the Management of Electronic Records, Or Records Management Theory is Archival Diplomatics', *Records Management Journal*, 9, 3 (Dec, 1999), 152.

142 Duranti, *Diplomatics: New Uses for an Old Science*, 3-4, 12-13, 17-18.

143 Ibid., 19-20.

ensuing literature was though of little relevance to this research. That which was of direct worth is discussed below.[144]

2.3.3 Relevance to this research

What was the importance of *New Uses* to this research? Care had to be taken to remember the work's 'protelyzing' purpose,[145] and its sometimes shaky foundations – both admitted by its author. It was also important not to overly rely upon it just because it was the only contemporary English-language text available for general diplomatic principles. Only those parts that were relevant, and perceived to be theoretically sound, would be of worth to the research.

By moving diplomatic into a late twentieth-century records environment, Duranti faced a fundamental issue. Diplomatic had traditionally been applied only to single documents – not to the twentieth-century commonplace of records in aggregations. The principles and methods of diplomatic would require adaption to meet that quite different records environment.[146] Duranti also hoped that others would attempt to apply diplomatic principles to 'special media archives' including 'visual documents'.[147]

In this research, general diplomatic principles *were* to be applied, in essence, to a single document – the technical drawing as an information artefact. Its form would also be a visual one. Although diplomatic analysis was to be used to investigate multiple cases of technical drawings, each would be viewed in isolation, as single documents. That is not to say that concepts and characteristics relating to their aggregation were to be ignored. They would be considered, but it was anticipated, only as a very small proportion of the overall analysis. Care therefore needed to be taken to consider Duranti's theories in their appropriate contexts.

One area where *New Uses* was useful was in its definitions of higher-level concepts, which helped situate lower-level concepts and characteristics. Duranti saw such a 'definitional component' as the 'first important contribution' that

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144 See Literature Review: 2.4 InterPARES – Theoretical frameworks and methodologies, *46*, 2.6 Diplomatic for non-textual records in traditional environments, *50*.

145 Ibid., 10, 12.

146 Ibid., 31.

147 Ibid., 98 n.15.

diplomatic made to archival work. It clearly identified and consistently named the meaning and role of a document's constituent parts. Archival description shared the need for such standardisation, and could benefit from diplomatic's terminological precision. It provided the foundations for all diplomatic theory and methodology. Diplomatic's approach, though, had to be applied against a background of archival science terminology that Duranti saw as 'very inconsistent' and lacking in clarity. [148]

The contributions of *New Uses* to this research were therefore its inclusive definition of diplomatic, conceptualisations of the pure and applied disciplines, and their relationships with archival science. All were described with a concern for precise terminology, which helped to populate the Diplomatic Data Definition Model (Diplomatic DDM) with lower-level concepts, characteristics, and terms, as is described later.[149]

2.4 InterPARES – Theoretical frameworks and methodologies

Literature for the InterPARES projects [150] was published throughout the course of this research. Although those projects were concerned with records in electronic environments, some of the literature surrounding two inter-related issues – theoretical frameworks and methodologies – was of particular relevance to this research.

2.4.1 Theoretical frameworks

Within the InterPARES 1 Project, contemporary archival diplomatic [151] principles were used, in a theoretical-deductive approach, to construct a diplomatic model

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148 Ibid., 11, 163, 181 and n.35.

149 See Research Design and Methodology: Diplomatic Data Definition Model, *79*.

150 'InterPARES Project: International Research on Permanent Authentic Records in Electronic Systems' (InterPARES Project) [Website] http://www.interpares.org/ (accessed 07 Jun, 2011). This section of the literature review also includes related literature published outside the formal scope of the InterPARES projects, but which comments upon them.

151 The term 'contemporary archival diplomatics' was coined by MacNeil, first in H. MacNeil, 'Trusting Records: The Evolution of Legal, Historical, and Diplomatic Methods for Assessing the Trustworthiness of Records, from Antiquity to the Digital Age'. PhD Thesis. (University of British Columbia, 1998) [Online] https://circle.ubc.ca/handle/2429/10157?show=full (accessed 12 Oct, 2010), and subsequently in MacNeil, *Trusting Records: Legal, Historical and Diplomatic Perspectives*, 89, to 'characterise the hybrid nature of the methodology': H. MacNeil, *Re: Contemporary Archival Diplomatic*s, (Pers Comm, 07 Oct, 2010). The genesis of contemporary archival diplomatics was accessibly summarised in MacNeil, 'Contemporary Archival Diplomatics as a Method of Inquiry', 204-6.

of an ideal electronic record. The model, embodied in a *Template for Analysis*,[152] provided the theoretical framework for research into records' authenticity.[153] It identified all possible concepts and characteristics that such an electronic record might contain, based on prior knowledge. The *Template* used concepts and characteristics identified by the UBC Project as its starting point. [154] Many traditional diplomatic concepts and characteristics – of particular relevance to this research – were traced back to their origins in the works of French, German, and Italian scholars.

The research underpinning the *Template for Analysis* was published in a comprehensive report [155] that became available at about the time that I was finalising this research's similarly scoped investigation. It therefore provided a useful check against my own work. [156]

2.4.2 Methodological issues

MacNeil [157] was critical of the ways in which diplomatic had been applied in both the UBC Project and InterPARES 1. Some of her conclusions were very relevant to this research.

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[152] InterPARES 1 Project: Authenticity Task Force, 'Template for Analysis' (InterPARES 1 Project, 2000) [Online] http://www.interpares.org/book/interpares_book_j_app01.pdf (accessed 08 Sep, 2007).

[153] H. MacNeil, 'Providing Grounds for Trust: Developing Conceptual Requirements for the Long-Term Preservation of Authentic Electronic Records', *Archivaria*, 50, 52 (Fall, 2000), 55-67; InterPARES 1 Project: Authenticity Task Force, 'Authenticity Task Force Report' (InterPARES 1 Project, nd) [Online] http://www.interpares.org/book/interpares_book_d_part1.pdf (accessed 08 Sep, 2007); MacNeil, 'Contemporary Archival Diplomatics as a Method of Inquiry', 215-7.

[154] Eight UBC Project Templates were developed, of which the first four, for records in traditional environments, were of most relevance to this research: The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 1: What is a Record in the Traditional Environment?' (InterPARES Project, nd) [Online] http://www.interpares.org/UBCProject/tem1.htm (accessed 03 Sep, 2007), 'Template 2: What is a Complete Record in the Traditional Environment?' (InterPARES Project, nd) [Online] http://www.interpares.org/UBCProject/tem2.htm (accessed 03 Sep, 2007), 'Template 3: What is a Reliable Record in the Traditional Environment?' (InterPARES Project, nd) [Online] http://www.interpares.org/UBCProject/tem3.htm (accessed 03 Sep, 2007), 'Template 4: What is an Authentic Record in the Traditional Environment?'(InterPARES Project, nd) [Online] http://www.interpares.org/UBCProject/tem4.htm (accessed 03 Sep, 2007).

[155] InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES): From Traditional Diplomatics to Contemporary Archival Diplomatics' (InterPARES 1 Project, 2000). Despite its date, I first accessed this report, online, on 10 Oct, 2007.

[156] Had I known of it earlier, I would probably have adopted it without having to undertake this very substantial phase of work independently.

[157] MacNeil, 'Contemporary Archival Diplomatics as a Method of Inquiry', 199-232.

Both projects adopted a postpositivist deductive approach to the records under analysis. Ideal diplomatic models were constructed of reliable and authentic records in traditional and electronic environments. However, the models were not empirically compared with the realities being investigated. [158] MacNeil argued that research using contemporary archival diplomatic should return to the inductive roots of traditional diplomatic, as exemplified by Mabillon. An empirical-inductive model should be developed from case-study data, and compared against the existing theoretical-deductive contemporary archival diplomatic model. More robust and representative ideal-type theoretical-deductive models could then be developed. [159]

MacNeil also speculated that interpretivism would offer a useful counterbalance to the then-current postpositivism of contemporary archival diplomatic, and enhance diplomatic's relevance as a method of enquiry. An interpretivist philosophy would encourage the view that contemporary archival diplomatic provided a particular view of reality, rather than exactly reflecting it. [160]

2.5 Diplomatic concepts of extrinsic and intrinsic elements

Traditionally, individual elements of diplomatic analysis have been located within two specific diplomatic concepts – extrinsic and intrinsic. Extrinsic elements have been defined as 'those which constitute the material make-up of a document and its external appearance'. They can be examined without reading a document. The essential characteristic of traditional extrinsic elements, though, is that they are only present in an 'original' document. [161]

Diplomatic's intrinsic elements, by contrast, have been defined as 'the integral components of [a document's] internal articulation'. Intrinsic elements provide the means by which a document's content is presented. [162] Traditionally, these elements have been formed into three groups – the protocol, the *corpus* or text, and the eschatocol. Different combinations of intrinsic elements within those

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[158] Ibid., 227.

[159] Ibid., 225-6.

[160] Ibid., 228-30.

[161] Duranti, *Diplomatics: New Uses for an Old Science*, 134 and n.5, citing A. Pratesi, *Elementi Di Diplomatica Generale* (Adriatica Editrice, nd [?1962]), 53.

[162] Ibid., 141.

groups signify different Information Forms of document.[163] Intrinsic elements would be present in both 'original' documents, and in manually drafted copies of them.[164]

This traditional conceptualisation of intrinsic and extrinsic concepts started to break down in late twentieth-century interpretations of diplomatic theory to records in electronic formats. The concept of Language, for example, traditionally an extrinsic element, was initially repositioned as an intrinsic element. Later, Language was reclassified as part of the Physical Form of records in electronic media.[165] The concepts of Annotations and Medium have also been repositioned as diplomatic theory has developed in the electronic records environment.[166]

The terms 'extrinsic' and 'intrinsic' have also been found used in a completely different context. Porter and Thornes used the concept of intrinsic and extrinsic attributes to characterise the 'categories' of information that they described for cataloguing architectural drawings.[167]

The intrinsic attributes were those that constituted the 'physical make-up' of the document. This meant not just its medium and form, but also its internal articulation. The extrinsic attributes referred to contextual characteristics outside the document – associated persons, places, objects, and subjects, for example. They provided access points to catalogue descriptions. These notions of intrinsic and extrinsic attributes were quite dissimilar to those understood in diplomatic, and Porter and Thornes did not refer to diplomatic theory.

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163 Following Boyle, 'Diplomatics', 84-5, and Duranti, *Diplomatics: New Uses for an Old Science*, 150.

164 Intrinsic elements would also be present in reprographic reproductions of records, as discussed later. See Discussion: 1.3.1 Extrinsic and intrinsic elements in reprographically reproduced records, *152*.

165 Duranti, *Diplomatics: New Uses for an Old Science*, 134, 136-8; InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES)', 7, 9, 47.

166 See, for example: Duranti, *Diplomatics: New Uses for an Old Science*, 16-17, 133-58; H. MacNeil, 'Conceptualizing an Authentic Electronic Record'. Society of American Archivists' Conference. Denver, CO, 31 Aug, 2000.; L. Duranti, 'The Concept of Electronic Record', in Duranti, Eastwood, and MacNeil, *Preservation of the Integrity of Electronic Records*, 12-20; L. Duranti and K. Thibodeau, 'The Concept of Record in Interactive, Experiential and Dynamic Environments: The View of InterPARES', *Archival Science*, 6, 1 (2006), 16-21 and *passim*.

167 V. Porter and R. Thornes, 'Building a Common Framework for Catalogue Entries', in *A Guide to the Description of Architectural Drawings* (New York, Los Angeles, [1994]) [Online] http://www.getty.edu/research/publications/electronic_publications/fda/building.html (accessed 05 Nov, 2011);

2.6 Diplomatic for non-textual records in traditional environments

Despite suggestions that diplomatic might be applied to non-textual records,[168] very few instances of its practical application have been reported. Two archives student dissertations have described successful applications of special diplomatic analysis to audio-visual archives.[169]

Closer to this research, the scant literature for diplomatic applications to visual records was dominated by Schwartz.[170] She examined the contribution that diplomatic might make to better understandings of photographs in archives. Bartlett[171] and Parinet[172] wrote on similar themes. Both Bartlett and Schwartz saw merit in diplomatic as a useful analytical approach to the interpretation of photographs in archives – Swartz with rather more caveats. Archivists should not unnecessarily limit themselves to any one conceptual framework. Diplomatic analysis alone could not provide all the answers.

Schwartz made a highly detailed and lengthy theoretical examination of diplomatic concepts 'in the context of photographic form and function'.[173] The visual quality of a photograph clearly presented those concepts differently from the graphical representation of a technical drawing. Nonetheless, some of Schwartz's arguments could be related from the one record form to the other.

3. Archives and records

This element of the literature review is something of an aggregation of narrowly focused areas within the literature for archives and records theory and practice. Its purpose is to contribute to the second and third objectives of the literature review – to provide underpinning theory for the Archives and Records Data

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168 For example: Quétin, noted by Parinet, 'Diplomatics and Institutional Photos', 482 and n.5, Nesmith, noted by Schwartz, "We Make Our Tools and Our Tools Make Us", 66 n.14; B. Delmas, 'Manifesto for a Contemporary Diplomatics: From Institutional Documents to Organic Information', *American Archivist*, 59, 4 (Fall, 1996), 439-40, 447; Williams, 'Diplomatic Attitudes: From Mabillon to Metadata', 20.

169 Miller, 'Exhibiting Integrity: Archival Diplomatics to Study Moving Images', 100; Simpson, 'Broadcast Archives: A Diplomatic Examination', 71-72. Only theses abstracts were accessible for these writers.

170 Schwartz, "We Make Our Tools and Our Tools Make Us", 40-74.

171 Bartlett, 'Diplomatics for Photographic Images: Academic Exoticism?', 486-494.

172 Parinet, 'Diplomatics and Institutional Photos', 480-485.

173 Schwartz, "We Make Our Tools and Our Tools Make Us", 40.

Definition Model (DDM), and to contribute data for the concepts, characteristics, and terms to populate it.

Differences between diplomatic and archival science were noted earlier. Diplomatic's development into contemporary archival diplomatic had attempted to recognise records' multi-lateral relationships, the concept of the archival bond, and the importance of contexts. It had not been entirely successful.

The purpose of this part of the literature search was therefore to help complement this research's Diplomatic DDM. I anticipated that two areas of archives and records literature might augment it:

1. Special theory and practice associated with technical drawings held by archives services, including concepts, characteristics, and terms for technical drawings as records, and their underpinning theory.
2. General theory and practice associated with generic concepts, characteristics, and terms for archives and records, and their underpinning theory.

As described later,[174] these concepts, characteristics, and terms from the archives and records domains were used to construct a Data Definition Model to complement that for diplomatic. Because diplomatic provided the primary perspective for the research, this Archives and Records DDM did not need to be as developed as that for diplomatic. Less archives and records literature therefore needed to be assessed and reviewed.

This review of the archives and records literature therefore continues with the following sections:

- Technical drawings as archives – theory and practice
- General records as archives – theory and practice

3.1 Technical drawings as archives – theory and practice

As defined in this research,[175] the term 'technical drawing' was intended to include, *inter alia*, drawings from the engineering, architectural, building, and construction fields. Given the sparse literature for all those forms of technical drawings held by archives services, it is convenient to consider it all together.

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174 See Research Design and Methodology: Archives and Records Data Definition Model, *79*.

175 See Introduction: 7.2 Definition of a technical drawing, *27*.

The literature reviewed here was drawn from the archival domain, not from those of architecture or engineering. It considered architectural and engineering drawings from an archival management perspective.[176] The literature was mainly focused on technical drawings from the mid nineteenth century to the late twentieth century. It had international and different national perspectives, which particularly enabled comparison of concepts, characteristics, and terminologies.

Given the thinness of the literature, it was tempting to rely on the predominant architectural drawings' literature [177] when investigating engineering drawings. The two record types shared many common physical characteristics. That enabled the conservation literature, particularly, to be ubiquitously applied.

Intellectually, the two types of drawings also shared some elements of description. The literature for arrangement and description was though almost all concerned with architectural drawings. That was problematic for consideration of engineering drawings, given that they came from a very different generic context of production and use. Furthermore, drawing practices differed internationally, even within the separate disciplines of architecture and engineering.

No clear general conclusion could therefore be reached about the appropriateness of applying the literature for architectural drawings to engineering drawings – or *vice versa* – in archives settings.

With those caveats, the literature for technical drawings held by archives services could be effectively reviewed through three themes:

- Guides to arrangement and description
- Underpinning theory, and professional practice
- Media of support, and processes of production and reproduction

3.1.1 Guides to arrangement and description

The cataloguing guidance for architectural drawings [178] provided rich sources of concepts, characteristics, and terms, as did their associated glossaries and

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[176] Literature drawn from technical drawings' original contexts of production and use is considered later. See Literature Review: 4. Technical Drawings – Theory and Practice, *61*.

[177] While these texts encompassed all forms of architectural records, I concentrate here only on those aspects relevant to architectural drawings.

[178] V. Porter and R. Thornes, *A Guide to the Description of Architectural Drawings* (New York, Los Angeles, [1994]) [Online]

thesauri.[179] Porter and Thornes' *Guide* represented international cooperation not just between custodians of architectural archives, but also with their users. Many common needs were identified. The resultant *Guide* was not regarded as a finished work. Rather, it was 'a basis for further progress' which addressed 'key conceptual issues', but from which several 'major questions' remained unanswered.[180] Those prefatory comments were unduly modest; the *Guide*'s range and depth of cataloguing concepts, characteristics, and terms was mined extensively for this research.

Porter and Thornes[181] referred to the Getty *Art & Architecture Thesaurus* (*AAT*)[182] as a suitable means of terminology control when using their *Guide*. The Getty *AAT* was extensively searched for concepts, characteristics, and terms relevant to this research. Although an exceptionally rich and well-founded source, the Getty *AAT* suffers from one serious disadvantage. Structurally, it is very complicated, which makes it very difficult to search or browse effectively.

Bingham,[183] in the Introduction to his own *Cataloguing Guide*, noted that Porter and Thornes had proved the difficulties involved in cataloguing architectural drawings.[184] His *Guide* reflected long experience by many practitioners cataloguing architectural records at both the Royal Institute of British Architects (RIBA) and the British Library. Although his *Guide* was a very summary internal

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http://www.getty.edu/research/publications/electronic_publications/fda/index.html (accessed 05 Nov, 2011); N. Bingham, *Cataloguing Guide* (London, 1998).

179 Getty Vocabulary Program, ed., *Art & Architecture Thesaurus (AAT)* (Los Angeles, 1983-) [Online] www.getty.edu/research/conducting_research/vocabularies/aat/ (accessed 26 Mar, 2010); British Architectural Library, *Architectural Keywords* (London, 1982).

180 H. A. Millon, 'Preface' in *A Guide to the Description of Architectural Drawings*, Porter and Thornes, [Online] http://www.getty.edu/research/publications/electronic_publications/fda/pref.html (accessed 06 Nov, 2011).

181 Porter and Thornes, 'Building a Common Framework for Catalogue Entries' in *A Guide to the Description of Architectural Drawings*, [Online] http://www.getty.edu/research/publications/electronic_publications/fda/building.html (accessed 06 Nov, 2011).

182 Getty Vocabulary Program, *Art & Architecture Thesaurus (AAT)*.

183 Bingham, *Cataloguing Guide*.

184 Ibid., 3.

document,[185] Gawne[186] provided a very useful complement to it in her description of its application to the practical cataloguing of architectural records.

Bingham's *Guide* was a fruitful source of concepts, characteristics, and terms. He also recommended[187] the use of subject terms from RIBA's *Architectural Keywords*.[188] Although the concepts, characteristics, and terms culled from that source were considerably more limited in scope than those from the *AAT*, they provided the best available source for British architectural records' description.

Only one text provides comparable guidance for the arrangement and description of engineering drawings. The Canadian *Rules for Archival Description* (*RAD2008*)[189] supplies standard sets of data elements appropriate to the description of general and specific archival materials, at multiple levels.[190] One such standard set is within the detailed rules for cataloguing architectural and technical drawings.[191] Although *RAD2008* conflates the two categories of drawings,[192] the granular structure of the standard meant that it was not problematic for this research. The range and depth of detail of described data elements is impressive. Those elements within *RAD2008* contributed by far the majority of concepts, characteristics, and terms used in the Archives and Records DDM.

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185 I gratefully acknowledge the supply of this internal document by the RIBA Library: Drawings and Archives Collections.

186 E. Gawne, 'Cataloguing Architectural Drawings', *Journal of the Society of Archivists*, 24, 2 (Oct, 2003), 175-87.

187 Bingham, *Cataloguing Guide*, 17.

188 British Architectural Library, *Architectural Keywords*. A later internal RIBA document noted that this source was 'very out-of-date': *Procedures Manual for the Special Collections*, (London, nd [?2005]). Nonetheless, in 2009 it was found still to be available for use at the RIBA Library –Drawings and Archives Collections, accompanied by a series of lists of new and amended keywords dated up to 2005.

189 Bureau of Canadian Archivists, ed., *Rules for Archival Descriptio*n, 2008 revised ed. (Ottawa, 2008) [Online] http://www.cdncouncilarchives.ca/archdesrules.html (accessed 14 Sep, 2010).

190 M. Procter and M. Cook, *Manual of Archival Description*, 3rd ed. (Aldershot, 2000), 49.

191 Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings'.

192 *RAD2008*'s definitions of architectural and technical drawings essentially encompassed what is defined in this research as architectural and engineering drawings: Ibid., 6-4.

3.1.2 Underpinning theory, and professional practice

Two broader treatments [193] placed architectural records within their contexts of production and use. Both were useful in that regard, but of the two, Lowell and Nelb [194] provided a much more presentable publication, highly illustrated, and well referenced. Its North American terminology helpfully complemented that of the European and British texts. Daniels and Peyceré [195] provided a useful Glossary as part of the ICA *Guide*. They recognised that terminology for architectural archives was often used 'imprecisely'. The Glossary therefore defined terms broadly, and gave alternatives.[196] That breadth was a strength for this research – it better enabled comparison with terms defined elsewhere.

Both Daniels and Peyceré, [197] and Lowell and Nelb, gave good accounts of the types of architectural drawings, the ways in which they represented their subjects, and the architectural process stages that instigated them. It was that latter aspect which held the key to understanding technical drawings generally. As O'Riordan said,[198] the 'natural rhythm' of the architectural process gave its records logic and structure, from first thoughts to final completion. Archivists who understood that process could more easily gain intellectual control over architectural records.[199]

Lowell [200] recommended rigorous appraisal of architectural drawings, given their special storage needs. At the item level, appraisal issues included what she termed the 'mystique of drawing'. [201] Archivists comfortable with appraising textual records might feel 'uncertainty and fear' when faced with drawings, linked

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193 M. Daniels and D. Peyceré, eds., *A Guide to the Archival Care of Architectural Records, 19th-20th Centuries*. (Paris: International Council on Archives: Section on Architectural Records, 2000) [Online] http://www.ica.org/sites/default/files/ArchitectureEN.pdf (accessed 25 Mar, 2010); W. Lowell and T. R. Nelb, *Architectural Records: Managing Design and Construction Records* (Chicago, 2006), 197.

194 Ibid.

195 M. Daniels and D. Peyceré, 'Glossary of Specialized Terms for Archives of Architecture' in *A Guide to the Archival Care of Architectural Records, 19th-20th Centuries*, 133-137, [Online] http://www.ica.org/sites/default/files/ArchitectureEN.pdf (accessed 25 Mar, 2010).

196 Daniels and Peyceré, eds., *A Guide to the Archival Care of Architectural Records, 19th-20th Centuries*, 11-12.

197 Ibid.

198 C. O'Riordan, 'Architectural Records: Managing Design and Construction Records' (Review), *Journal of the Society of Archivists*, 28, 1 (Apr, 2007), 109-11.

199 Ibid., 109.

200 W. Lowell, 'Appraisal', in *Architectural Records: Managing Design and Construction Records*, W. Lowell and T. R. Nelb, 69-87.

201 Ibid., 75, 77.

to the ‘mysteriously creative world of art’. They might not understand what the drawings meant, how they were intended to be used, or how they might be used – or not used – in the future. Nonetheless, the same professional responsibilities of appraisal should be applied as were used for textual records.

Despite her attention to item-level appraisal factors, elsewhere, Lowell [202] deprecated the individual description of architectural drawings. It might be appropriate for ‘unique single items’ such as individual works of art or maps, but constituted disproportionate effort for drawings within large design collections.[203] For Daniels, [204] though, their item-level cataloguing was ‘common’. Description might be brief, but could also be ‘extensive’ for ‘significant or heavily-used’ drawings.

Heap [205] cogently recognised the artificiality of distinguishing between engineering drawings and other formats of engineering records. It was ‘entirely false and a purely administrative device’. [206] While noting the need to provide researchers with an ‘accurate and balanced’ selection of records,[207] she also recognised the practical difficulties. It was not just a matter of judicious appraisal, but also of adequately resourcing the special needs of engineering drawings’ storage, conservation, cataloguing, and access. Heap described the use of bundle lists for engineering drawings as a way to reduce cataloguing time. They would though fail to answer ‘many’ readers’ enquiries.[208]

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[202] W. Lowell, 'Arrangement and Description', in *Architectural Records: Managing Design and Construction Records*, W. Lowell and T. R. Nelb, 89-105.

[203] Ibid., 100.

[204] M. Daniels, 'Description of Architectural Records' in *A Guide to the Archival Care of Architectural Records, 19th-20th Centuries*, M. Daniels and D. Peyceré, eds., 77-88, [Online] http://www.ica.org/sites/default/files/ArchitectureEN.pdf (accessed 25 Mar, 2010).

[205] Heap, ‘Engineering Drawings - their Selection, Storage and Use’, 39-48. See also: Sime, ‘Technical Records: The User and His Needs’, 65.

[206] Heap, ‘Engineering Drawings - their Selection, Storage and Use’, 48.

[207] Ibid., 40.

[208] Ibid., 47.

3.1.3 Media of support, and processes of (re)production

The research's investigations into media of support and processes of production and reproduction were not as successful as had been hoped.[209] Therefore, only the most significant of the substantial literature that was examined is reviewed.

For the fabrication, reproduction, and preservation of technical drawings, Price's *Line, Shade and Shadow* was outstanding.[210] That Price was writing in a North American context, about architectural drawings rather than those for engineering, was of little concern. The text's breadth and depth of scope was more than sufficient to be read across to engineering drawings. It was though unfortunate that such a work became available only towards the very end of this research. Its principal worth here, therefore, was to corroborate much that had already been less-easily won from other sources.

For document reproduction processes alone, two further texts were also excellent. Kissel and Vigneau concentrated on *Architectural Photoreproductions*.[211] Batterham took a wider brief,[212] but specifically excluded processes used only for architectural drawings reproduction.[213] The two works were therefore complementary.

Writing for the non-specialist keeper of architectural drawings, Kissel and Vigneau approached their task comprehensively. A technical glossary prefaced flowcharts to aid identification of reproduction processes. Each process was then described in detail, starting with the diagnostic features that would aid process identification. Equally usefully, the media of supports normally associated with each process were also noted.

Many colour illustrations were provided, some at high levels of enlargement to show particular diagnostic features. Despite their excellent reproduction, I still

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209 See Discussion: Problems of identification of support materials, *168*, Problems of identification of reprographic processes, *176*.

210 Price, *Line, Shade and Shadow: The Fabrication and Preservation of Architectural Drawings*.

211 E. Kissel and E. Vigneau, *Architectural Photoreproductions: A Manual for Identification and Care*, 2nd ed. (New Castle, DE and New York, 2009), 125.

212 I. Batterham, *The Office Copying Revolution: History, Identification and Preservation* (Canberra, 2008), 200.

213 The book did though include processes which were used for *both* document copying and architectural drawing copying: Ibid., 1.

found difficulty in matching those surrogate images to my original research examples. I felt that I would have been better able to use this text after practical training in the recognition of photoreproduction processes and their associated support media. *Architectural Photoreproductions* would then have made an excellent *aide-mémoire*, rather than having to act as my primary source of information.

Batterham took a process-by-process approach, grouping similar techniques together. His work was also highly illustrated, and, with more ground to cover, much larger. That ground included far more contextual information than provided by Kissel and Vigneau. Reproduction equipment, material, and processes were dealt with in detail, textually and graphically. Batterham's extensive glossary listed the processes he described, and their associated equipment manufacturers and materials suppliers.

Together, the three texts undoubtedly provided the best available sources for understanding architectural drawing reproduction processes and their associated media. It was most unfortunate that they were still insufficient to meet the practical needs of this research. However, as Tait and Sterlini [214] found, many surveyed 'collections managers' – as opposed to conservators – had difficulty in confidently identifying reproduction processes and support materials. [215]

3.2 General records as archives – theory and practice

Literature was required to provide data for generic archives and records concepts, characteristics, and terms in the Archives and Records DDM. The literature should also contribute to the model's underpinning theory. The model was to be compared with that for diplomatic. It should therefore give the most objective archives and records' perspective that was possible, reflecting the latest and widest consensus of thought for theory and practice in archival description.

Initially, the most promising source was a putative ICA *Glossary*, developed from an internationally wide range of terms and definitions. Reported in 2000, it was

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214 J. Tait and P. Sterlini, 'Care and Conservation of Architectural Plans: A Survey of Current Practice in the UK and Ireland', *Journal of the Society of Archivists*, 20, 2 (Oct, 1999), 149-59.

215 Ibid., 151-2, 157.

still not accessible in 2010. [216] I therefore decided that international archives and records standards would be the form of literature best able to meet the need. Of those considered, the most relevant standards [217] were BS ISO *15489-1:2001* [218] and *ISAD(G) 2nd Edition* (*ISAD(G)2*). [219] The former provided the required abstract conceptualisation of a record, from which an Archives and Records DDM could be developed. The latter gave a starting point for the population of the model with general archival concepts, characteristics, and terms.

3.2.1 Conceptualisation of a record

BS ISO *15489-1:2001* is the first, general, part of a two-part standard for records management. It was developed though an international desire to standardise records management best practice, building upon the Australian records management standard AS *4390*.[220]

As a records management standard, BS ISO *15489* does not include the management of archives. [221] That was not problematic in this context. What could be taken from this source was its high-level abstract conceptualisation of a record, provided by the essential components of metadata used to describe it – structure, context, and content. [222]

3.2.2 General archival concepts, characteristics, and terms

The only international standard providing general rules for archival description is *ISAD(G)2*. Its rules are stated to be applicable 'irrespective of the form or

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216 P. Carucci, 'Terminology and Current Records', (ICA, Committee on electronic and other current records) [Online] http://www.ica.org/sites/default/files/terminology_eng.html (accessed 05 Oct, 2010).

217 In this specific context, I consider together both formal international standards, such as those of ISO, with professional archival standards, such as those of ICA, while recognising that they are not equivalent in status as standards.

218 British Standards Institution, *BS ISO 15489-1:2001 - Information and Documentation - Records Management - Part 1: General* (London, 2001).

219 International Council on Archives, *ISAD(G): General International Standard Archival Description*, 2nd ed. (Ottawa, 2000).

220 Standards Australia, *AS 4390.1-1996: Records Management - General* (Sydney, 1996).

221 British Standards Institution, *BS ISO 15489-1:2001 - Information and Documentation - Records Management - Part 1: General*, 1, cl. 1 and n.1.

222 Ibid. For a more detailed view of metadata about records, see also: British Standards Institution, *BS 23081-1:2006: Information and Documentation. Records Management Processes. Metadata for Records. Principles*. (London, 2006), 12-14 cl. 9.2. For content, context, and structure as attributes of a record, see: E. Shepherd, 'Archival Science', in *Encyclopedia of Library and Information Sciences*, M. J. Bates, ed., 3rd ed., Vol. 1 (Boca Raton, FL, 2010), 180-1.

medium of the archival material'. However, they do not give guidance for 'special materials', for which 'manuals…already exist'.[223]

Although designed for multi-level description, *ISAD(G)2*'s twenty-six elements were insufficiently granular for the needs of this research. I therefore also draw from the more detailed general rules and guidance provided by *MAD3*[224] and *RAD2008*.[225] In synthesis, all three sources provided the necessary array of general archival concepts, characteristics, and terms to a sufficient depth of detail.

The UK's *MAD3* has adopted *ISAD(G)*'s original data structure,[226] but provides a greater level of detail within each data element. The content of each element is explained, and rules given for its use.[227] Concepts, characteristics, and terms of interest to this research were selected from the data elements within *MAD3*'s Archival Description Sector.[228]

While *RAD2008*'s overarching principles are 'grounded in fundamental archival theory',[229] its rules provide flexibility to accommodate a range of Canadian archival descriptive practices.[230] Nonetheless, they are highly structured, and aligned to library descriptive practice. Their structure follows the *General International Standard Bibliographic Description*[231] (*ISBD(G)*),[232] while their

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223 International Council on Archives, *ISAD(G): General International Standard Archival Description*, 7, para. 1.4.

224 Procter and Cook, *Manual of Archival Description*, 320.

225 Bureau of Canadian Archivists, *Rules for Archival Description*.

226 Procter and Cook, *Manual of Archival Description*, 44.

227 Ibid., 66.

228 Ibid., 66-90.

229 Bureau of Canadian Archivists, 'Statement of Principles', in *Rules for Archival Description*, 2008 revised ed., xxii, [Online] http://www.cdncouncilarchives.ca/RAD/RAD_Principles_July2008.pdf (accessed 06 Oct, 2010).

230 S. Watson, 'Preface to the 2008 Edition', in *Rules for Archival Description*, 2008 revised ed., xiv, [Online] http://www.cdncouncilarchives.ca/RAD/RAD_Frontmatter_July2008.pdf (accessed 06 Oct, 2010).

231 Bureau of Canadian Archivists, 'General Introduction', in *Rules for Archival Description*, 2008 revised ed., 0-6 and n.7, [Online] http://www.cdncouncilarchives.ca/RAD/RAD_GeneralIntro_July2008.pdf (accessed 06 Oct, 2010).

232 Working Group on the General International Standard Bibliographic Description, ed., *ISBD(G): General International Standard Bibliographic Description: Annotated Text* (London, 1977).

descriptive style is compatible with the *Anglo-American Cataloguing Rules*, *2nd Edition*,[233] (*AACR2*).[234]

RAD2008's rules aim to enable archival description at any level. Their integrated structure allows general rules to be supplemented by more specific rules for less common archival materials or forms.[235] The 'General Rules for Description'[236] were those from which concepts, characteristics, and terms were selected for inclusion in this research's Archives and Records DDM.

4. Technical Drawings – Theory and Practice

The literature reviewed here also relates to the first three objectives of the literature review. It is again something of an amalgam of topics. The preceding section considered technical drawings in archives settings. Here, the literature was drawn from the domains of engineering and architecture – technical drawings' original contexts of creation and use.

As was noted earlier, the activities that resulted in the creation of technical drawings were very widely scoped – impossibly wide for a comprehensive review of their literature to be attempted. The subject of the technical drawings available for this research could though be scoped mainly within general mechanical engineering. A similarly non-specialised view is therefore reflected in the engineering literature that informed the research. Despite the many technical differences between engineering and architecture, some architectural drawings literature also had importance for the research, and is therefore also reviewed.

Chronologically, the literature review covers the period from the late eighteenth century, when recognisable technical drawings began to appear. It ends in the late twentieth century, when manual origination began to give way to Computer Aided Design (CAD). The literature of most concern is for the six decades from the 1920s to the 1980s – the date range of the investigated technical drawings.

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233 Bureau of Canadian Archivists, 'General Introduction', 0-1.

234 M. Gorman and P. Winkler, eds., *Anglo-American Cataloguing Rules*, 2nd ed. (Ottawa: 1988).

235 Bureau of Canadian Archivists, 'General Introduction', 0-1.

236 Bureau of Canadian Archivists, 'Chapter 1: General Rules for Description' in *Rules for Archival Description*, 2008 revised ed., [Online] http://www.cdncouncilarchives.ca/RAD/RAD_Chapter01_July2008.pdf (accessed 06 Oct, 2010).

Even within those comparatively narrow boundaries, a wide range of topics was necessarily reviewed to inform this aspect of the research. This principal section therefore considers the literature for technical drawings in four sections:

- Conceptualisation of engineering drawing
- Engineering drawing – theory, practices, and processes
- Standards for technical drawing
- Definitions of a technical drawing and associated concepts

4.1 Conceptualisation of engineering drawing

This section essentially distinguishes between the activities of design and drawing within engineering. It thus enables engineering drawings of all forms to be clearly recognised as documents and records that are products of engineering design activities, and only then as products of engineering drawing activities.

Conceived as both science and art, [237] engineering design has also been regarded as the core activity of engineering. [238] Rather than being orderly, engineering design might be termed 'chaotic growth'. [239] The outcome was a series of designs expressed as engineering drawings, ranging from the initially general to the ultimately detailed and specific. [240]

This was the 'art of the engineer' [241] – the 'very essence of engineering'.[242] Engineering designers were able to communicate their intentions – however broad or narrow – through engineering drawing. This inherent part of the design activity involved building and testing ideas in miniature – modelling on the drawing board. This was not thinking as conceptualisation, but 'thinking as

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[237] E. T. J. Layton, 'American Ideologies of Science and Engineering', *Technology and Culture*, 17, 4 (Oct, 1976), 698; Ferguson, *Engineering and the Mind's Eye*, 23.

[238] Layton, 'American Ideologies of Science and Engineering', 696.

[239] Ferguson, *Engineering and the Mind's Eye*, 37.

[240] C. Mitcham, *Thinking through Technology: The Path between Engineering and Philosophy* (Chicago, 1994), 223.

[241] W. Grimson, 'AC 2007-1611: The Philosophical Nature of Engineering: A Characterisation of Engineering using the Language and Activities of Philosophy'. Honolulu, Hawaii, 24-27 Jun, 2007. (American Society for Engineering Education, 2007). [Online] http://www.icee.usm.edu/ICEE/conferences/asee2007/papers/1611_THE_PHILOSOPHICAL_NATURE_OF_ENGINEERING_.pdf (accessed 17 Mar, 2010).

[242] Layton, 'American Ideologies of Science and Engineering', 696. The 'ideology of design' and its position within engineering formed a large part of the subsequent discussion of his paper, 700-1. See also: W. G. Vincenti, *What Engineers Know and how they Know it: Analytical Studies from Aeronautical History* (Baltimore, 1990), 6, and Mitcham, *Thinking through Technology*, 220.

picturing or imagining' – as an artist does.[243] Especially aided by pictorial or symbolic languages,[244] it was a form self-communication – just as others might use words for thinking. It was also a valuable kind of external memory. Once this intimate conversation had ended, the design was conceptually complete.[245]

That did not necessarily mean that the design was sufficiently developed, or recorded, to be realised in production. It might still be a back-of-the-envelope conception. The designer-engineer might then employ the rigour of engineering drawing to define the solution closely.[246] That activity could be undertaken either directly by the designer-engineer, or indirectly by drafter-technicians.

A distinction has been cogently made between design and 'one of its languages, drawing'.[247] While design was a mental activity, engineering drawing was a 'recording process'. Undertaken by drafters rather than designers, it served to communicate finished designs to others. In that regard, designing and drafting were not inseparable.[248]

Once finalised in a definitive drawing, a design solution would require wider communication. Before the advent of chemical reproduction processes, engineering drawings were traced and copied by hand. That became an activity in its own right, producing 'many very finely finished drawings'.[249] That work has been popularly conceptualised as the 'art of the engineer'.[250] However good an artist, though, the copyist was clearly distinguished from the engineer-designer, and from the drafter.[251]

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[243] Ibid., 220-1, 224.

[244] Ibid., 221-2; E. S. Taylor and others, 'Report on Engineering Design', *Journal of Engineering Education*, 51, 8 (Apr, 1961), 648.

[245] Ibid., 647-8.

[246] D. McGee, 'From Craftsmanship to Draftsmanship: Naval Architecture and the Three Traditions of Early Modern Design', *Technology and Culture*, 40, 2 (1990), 216; Brown, 'When Machines Became Gray and Drawings Black and White', 33-4.

[247] Taylor and others, 'Report on Engineering Design', 647.

[248] Ibid., 647-8; Booker, *A History of Engineering Drawing*, xv.

[249] Ibid., 133.

[250] Baynes and Pugh, *The Art of the Engineer*.

[251] Booker, *A History of Engineering Drawing*, 134.

4.1.1 Engineering drawing – theory, practices, and processes

British theoretical perspectives

Booker [252] has furnished the only general work on the history and development of engineering drawing in Britain. He traced the development of engineering drawing from its earliest days, to a 1960s-1970s terminal date that usefully coincided with that adopted by this research.

He observed, though, that it was 'very much more difficult' to follow the development of engineering drawing theory and practice in Britain than on the Continent. [253] Nineteenth-century British writers took different stances about engineering drawings' underlying concepts and theory.[254] There seemed to have been some 'muddle' over what engineering drawing was perceived to be. [255] That was in stark contrast to Monge's [256] seminal work on descriptive geometry, [257] which became a 'key subject in French technical education'. [258]

Booker's concentration on the development of geometrical theory was rather outside the focus of this research. He did though give sufficient information to enable engineering drawing to be contextualised historically. I did not therefore seek out literature that was contemporary with the topic's historical development.

Baynes and Pugh's consideration of the more empirical origins of technical drawing was of greater relevance to this research. A book, [259] exhibition catalogue, [260] and resource materials [261] presented *The Art of the Engineer* from the late sixteenth to late twentieth centuries. The profuse illustrations and

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252 Ibid.

253 Ibid., 128.

254 For example, Farish was associated with the first descriptions of an isometric drawing system. For Bradley, orthographic projection was almost to be taken for granted. Heather republished what he considered to be the essentials of Monge's descriptive geometry. Cunningham also attempted to promote Monge's work to a British audience. While Binns wrote about orthographic projection from first principles for civil engineering students, Davidson's work assumed 'utter ignorance' on the part of his craft pupils: Ibid., 114-39.

255 Ibid., 142.

256 G. Monge, *Géométrie Descriptive* (Paris, 1795).

257 Booker, *A History of Engineering Drawing*, 86-113.

258 Ibid., 104.

259 Baynes and Pugh, *The Art of the Engineer*.

260 Baynes and Pugh, *The Art of the Engineer*, [Exhibition Catalogue], 1-28.

261 K. Baynes and F. Pugh, *The Art of the Engineer: Two Hundred Years in the Development of Drawings for the Design of Transport on Land, Sea and Air* [Catalogue Pack] (1978).

accompanying captions provided a wealth of information about different types of technical drawings.

American theoretical perspectives

Further afield, some American literature assisted with the analysis of the technical drawings under investigation. Brown, in two substantial papers,[262] discussed in detail the interpretation of mid-nineteenth century mechanical engineering drawings in America.

I had not initially sought literature that did not directly relate to British technical drawings. As Brown noted,[263] technical drawing practice had developed along 'unique national lines', each reflecting individual national environments. The literature for one national context might therefore not necessarily reflect that of another. However, Brown's detailed analyses included much that could be transferred to the study of the British technical drawings investigated here.

Other American writers also contributed useful knowledge. The languages of engineering drawing were debated by Belofsky,[264] and Mori,[265] while McGee[266] developed Jones's[267] framework of design traditions 'from craftsmanship to draftsmanship'.

Practices and processes

The development of technical drawing in Britain has been accompanied by an abundance of literature that varies in scope, depth, and substance. Although much of that literature comprised textbooks biased towards practical training, some also contained contextual information of worth to the research.[268] So, too,

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262 Brown, 'When Machines Became Gray and Drawings Black and White', 29-54; Brown, 'Design Plans, Working Drawings, National Styles', 195-238.

263 Ibid., 199.

264 Belofsky, 'Engineering Drawing: A Universal Language in Two Dialects', 23-46.

265 S. Mori and H. Belofsky, 'Engineering Drawing - a Universal Language in Two Dialects - Comment and Response', *Technology and Culture*, 33, 4 (Oct, 1992), 853-7.

266 McGee, 'From Craftsmanship to Draftsmanship', 209-236.

267 C. J. Jones, *Design Methods: Seeds of Human Futures* (London, 1970), 15-24.

268 Including, for example, technical drawing terminology and its variations, organisation of technical drawing offices and production processes, drawing media and materials. Two of the most useful texts were: J. D. Poole, *Engineering Drawing for Technician Engineers* (London, 1978), and C. H. Simmons and D. E. Maguire, *A Manual of Engineering Drawing Practice* (London, 1974), [Revised 1995, 2004, 2009].

did the short-lived mid-twentieth century journal of the Institution of Engineering Draftsmen and Designers. [269]

Useful literature for the business processes within which engineering drawings were created and used was much less in evidence – in contrast to the situation for architectural drawings. [270] That literature has enabled architectural records types to be more easily identified and contextualised, and their archival research values assessed. Comparable business processes within engineering design and drawing offices have yet to be analysed in the archival literature, although some historical accounts exist as a starting point. [271]

4.1.2 Standards for technical drawing

Within technical contexts of creation, technical drawing was a specialist activity that normally conformed to strict rules and conventions. The earliest date of the technical drawings studied in this research broadly coincided with the introduction of national engineering drawing standards. The full range of relevant standards – both current and withdrawn – was accessed, although no papers describing their development were known to be available. [272]

Two main series of British Standards provided the basis for technical drawing practice – BS 308 for engineering drawing, [273] and BS 1192 for architectural and building drawing. [274] They developed in parallel during the twentieth century.

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[269] Institution of Engineering Draughtsmen and Designers, *Engineering Drawing and Design*, Vol. 1.1 to 5.2 (London, 1947-51).

[270] See, for example: Daniels and Peyceré, eds., *A Guide to the Archival Care of Architectural Records, 19th-20th Centuries*, 143; Gawne, 'Cataloguing Architectural Drawings', 175-187; Lowell and Nelb, *Architectural Records: Managing Design and Construction Records*, 197.

[271] See, for example: W. S. Bott, 'Graduates' Association: Twelve Months' Revision of a Drawing Office', *Proceedings of the Institution of Mechanical Engineers*, 63, Parts 3-5 (1902), 1003-12; J. Clayton, 'Method and System in the Locomotive Drawing Office', *Journal of the Institution of Locomotive Engineers*, 7 (1917), 375-437; R. G. Wickham, 'Drawing Office Organisation', *Journal of the Institution of Locomotive Engineers*, 14 (1924), 241-59; C. E. Appleyard, 'Locomotive Drawing Office Practice', *Journal of the Institution of Locomotive Engineers*, 28 (1937), 313-56.

[272] McWilliam, in his examination of 'The Evolution of British Standards', noted the poor survival of the British Standards Institution's own records, literature, and even historical standards: R. C. McWilliam, 'The Evolution of British Standards'. PhD Thesis. (University of Reading, 2002). I gratefully acknowledge Dr McWilliam's kindness in making his thesis available to me.

[273] Originally conceived in 1927 as 'Engineering Drawing Office Practice', the standard's focus changed in 1953 to 'Engineering Drawing Practice'.

[274] The intent of this standard similarly changed over time. First published in 1944 as 'Architectural and Building Drawing Office Practice', by 1969 it was simply titled 'Building Drawing Practice'.

Both sets of standards were interlinked to others with more specific purposes – drawings' media,[275] and their reproduction processes,[276] for example.

The first British Standard for Engineering Drawing Office Practice was BS308:1927.[277] It appears to have been the first such national standard anywhere.[278] This first text was revised in 1943, and subsequently in every decade up to 1993. By then, the first edition of eleven pages had expanded into a three-part standard totalling some 210 pages. BS308 was 'highly regarded' – even the BSI itself felt able to note that the standard had enjoyed a 'certain reputation'.[279] The quest for international standardisation eventually led to its withdrawal and replacement by a much wider range of standards.[280]

The BS308 series was used in great detail, to provide data for concepts, characteristics, and terms to construct and populate the Technical Drawings Data Definition Model.[281]

The BS 1192 series, first published in 1944, was broadly comparable in its scope to the BS308 series. Its drafting conventions for architectural and building drawing were though quite dissimilar to those for engineering. They were not therefore

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275 British Standards Institution, *BS 1340-43:1946 Drawing Papers (Tracing, Detail and Cartridge)* (London, 1946); British Standards Institution, *BS 3429:1961: Specification for Sizes of Drawing Sheets* (London, 1961); British Standards Institution, *BS 1342:1962 Specification for Detail Drawing Paper*, 1st revised ed. (London, 1962).

276 British Standards Institution, *BS 4210:Part 1:1967 Specification for 35 mm Microcopying of Engineering Drawings and Associated Data: Part 1: Recommended Procedures* (London, 1967); British Standards Institution, *BS 4212:1967 Guide to the Selection of Processes for Reproducing Drawings* (London, 1967).

277 British Engineering Standards Association, *BS 308:1927 Engineering Drawing Office Practice* (London, 1927), 1-11. In 1931, the British Engineering Standards Association (BESA) was re-named the British Standards Institution (BSI): McWilliam, 'The Evolution of British Standards', 15.

278 British Standards Institution, *BS 308-1:1993: Engineering Drawing Practice. Recommendations for General Principles*, 7th Edition (London, 1993), 4; McWilliam, 'The Evolution of British Standards', 142-3. McWilliam also noted that BS308 was one of the best-selling standards.

279 C. H. Simmons, D. E. Maguire, and N. Phelps, *Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards*, 3rd ed. (Oxford, 2009), 5; British Standards Institution, *BS 308-1:1993: Engineering Drawing Practice. Recommendations for General Principles*, 4.

280 The changes to the standards' structure substantially outweighed those of their recommendations for drawing practices. There was considerable overlap of standards during the 1990s, the complexity of the situation resulting in the publication of overarching guidance in British Standards Institution, *BS 8888:2000: Technical Product Documentation (TPD). Specification for Defining, Specifying and Graphically Representing Products* (London, 2000): Simmons, Maguire and Phelps, *Manual of Engineering Drawing*, 5-6.

281 See Research Design and Methodology: Technical Drawings Data Definition Model, *80*.

used directly to populate the Technical Drawings DDM. The BS 1192 series did though inform the framework's construction in other ways, providing valuable information not found in BS 308. [282]

Many other British and International standards were also used to inform the research. Current standards were often used to inform theory, while earlier withdrawn standards were typically used to trace the development of particular aspects of technical drawing.

4.1.3 Definitions of a technical drawing and associated concepts

The term 'technical drawing' was found to be used inconsistently in the literature. In this research, only usages within engineering, architecture, building, and construction needed to be considered. A usable definition of the term was sought from two specific areas of the literature – British Standards for technical drawing, and archival standards for description.

The rules and conventions for 'engineering drawing' were clearly differentiated in British Standards from those for 'architectural and building drawing'.[283] There were no such rules for 'technical drawing' – the concept was to be found defined only in more general terms in British Standards. [284]

In 1996, it was noted that international standards used the term 'technical drawing' in a generic sense, to include 'all drawings of a technical nature'. [285] In the same context, the terms 'building drawings' and 'construction drawings' were also used, 'to identify drawings for those purposes'. However, no specific term

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[282] For example, a diagrammatic explanation of how to cut standard drawing sheet sizes from rolled media incidentally defined hitherto-unknown number codes for standard drawing sizes. Elsewhere, the dates of introduction of 'plastic' sheet materials as drawing support media could be traced, as could the progressive changes to recommended drawing reproduction processes.

[283] In the BS 308 series and the BS 1192 series. The changes in the titling and intent of those standards, as the series developed, are not relevant to this particular point.

[284] British Standards Institution, *BS ISO 10209-1:1992: Technical Product Documentation - Vocabulary - Part 1: Terms Relating to Technical Drawings: General and Types of Drawings*, 2 cl. 2.11; British Standards Institution, *BS 6100–1:2004/BS ISO 6707–1:2004: Building and Civil Engineering - Vocabulary - Part 1: General Terms*, 72 cl. 7.2.10.

[285] British Standards Institution, *PD 308:1996 Guide to the European Standards for Engineering Drawing in the BS EN Series*.

was used to identify 'drawings for industrial manufacture', which, 'in English-speaking countries', would be termed 'engineering drawings'.[286]

RAD2008, the only archival description standard to specify rules for architectural and technical drawings' description, clearly distinguishes between them. Put simply, architectural drawings are concerned with all aspects of architecturally designed buildings and other 'objects'. Technical drawings portray stationary structures other than buildings, and moveable objects.[287] The term 'engineering drawings' is not used in this standard; it is clearly subsumed within the term 'technical drawings'. Those conflicting standards-based definitions were successfully reconciled in this research, as reported in Chapter One.[288]

Both standards and the wider literature were then used extensively to help define lower-level concepts within technical drawings. They included, for example, concepts for information forms – plans, illustrations, diagrams, and sketches. The literature helped distinguish between different forms of orthographic and pictorial projection drawing. It also provided information for many other types of technical information forms, in both graphical and textual formats.[289]

However, it was found that the literature for different types of technical drawings sometimes described or defined similar concepts in different ways. Some terms were found to be specific to only one individual concept. At times, differences also reflected individual national practice. Care was therefore necessary when using the technical drawings' literature to develop and define concepts and terms appropriate to this research.

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286 Ibid., 1.

287 Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings', 6-4; Bureau of Canadian Archivists, 'Appendix D: Glossary', D-2, D-9.

288 See Introduction: 7.2 Definition of a technical drawing, *27*.

289 See Discussion: 4.7 Information Form, *211*.

Chapter 3: Research Design and Methodology

1. Introduction

Following this introductory section, the research design and methodology are presented in four principal sections:

- A 'Mixed Methods' Research Design
- Selected Design Details
- Research Design and Methodological Limitations
- Data Management

The research design and methodology were separate entities, albeit closely inter-linked. The design was the plan that enabled the research question to be answered. The methodology provided the theoretical perspective within which that design was situated. A mixed methods design was employed, which used diplomatic as its theoretical perspective.

The requirements of the research design were derived from the research question,[290] as developed by the research aims.[291] In essence, means had to be designed to enable technical drawings to become more comprehensible to archivists. The setting within which technical drawings were to be understood was not, of course, that of original-use engineering or architecture. Rather, it was a setting of archival understanding, where interdisciplinarity was inherent. Archival information models are almost always developed to explain information models originating from other disciplines. Consequently, while each of those other disciplines has an associated hermeneutic, archivists have to contend with a double hermeneutic.[292]

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[290] See Introduction: 4. Research Question, *14*.

[291] See Introduction: Table 1: Research Aims and Intended Outcomes, *15*.

[292] This issue of the double hermeneutic has been succinctly explained and referenced in A. Gilliland and S. McKemmish, 'Building an Infrastructure for Archival Research', *Archival Science*, 4, 3-4 (Sep, 2004), 170-1. For more detail, 'Some Background to Hermeneutics' prefaced a discussion which concluded with 'LIS and Hermeneutics' in J. M. Budd, *Knowledge and Knowing in Library and Information Science* (Lanham, MD, 2001), 270-87.

The research design perspective therefore had to be derived from that current-use discipline – the archival setting. However, just as technical drawings' terminology was largely foreign to archivists, the archival lexicon was not the language of technical drawings. Simply attempting to impose an archival perspective upon records of such a highly technical nature was likely to be problematic. A research design and methodology was required that accommodated the concepts, characteristics, and terminologies of both archives and technical drawings.

2. A 'Mixed Methods' Research Design

As illustrated by Figure 3, following, a research design was developed to undertake the research in six phases. Save for phases two and three, conducted in parallel, the phases were implemented broadly sequentially. There was also considerable iteration between phases three and four, as initial theoretical concepts were modified by survey data. [293]

The design used mixed approaches to the research at the levels of methodology, method, and technique. As such, the design followed the principles of the 'third methodological movement' – a methodology that is often termed 'mixed methods'. [294] I now briefly introduce that methodology, arguing that it was a valid approach for this research.

2.1 Situating the Research Design

The methodology of mixed methods is not novel. It is merely theoretically formalising what many researchers have already been doing in their 'traditional' approach to research design – using quantitative and qualitative research methods, techniques, and instruments as appropriate to their needs. [295]

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293 The 'inductive-deductive research cycle': C. Teddlie and A. Tashakkori, *Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences* (Thousand Oaks, CA, 2009), 26.

294 C. Teddlie and R. B. Johnson, 'Methodological Thought since the 20th Century', in *Foundations of Mixed Methods Research*, C. Teddlie and A. Tashakkori, 76; J. W. Creswell and V. L. Plano Clark, *Designing and Conducting Mixed Methods Research* (Thousand Oaks, CA, 2007), 5-6. The term 'mixed methods' should be regarded as more a flag of convenience than a definition.

295 Teddlie and Tashakkori, *Foundations of Mixed Methods Research*, 7; J. W. Creswell and A. Tashakkori, 'Editorial: Differing Perspectives on Mixed Methods Research', *Journal of Mixed Methods Research*, 1, 4 (2007), 306. 'This paradigm for building knowledge – the continual combination of inductive and deductive research – is used by scholars across the humanities and the sciences alike and has proved itself, over thousands of years.': Bernard and Ryan, *Analysing Qualitative Data: Systematic Approaches*, 266.

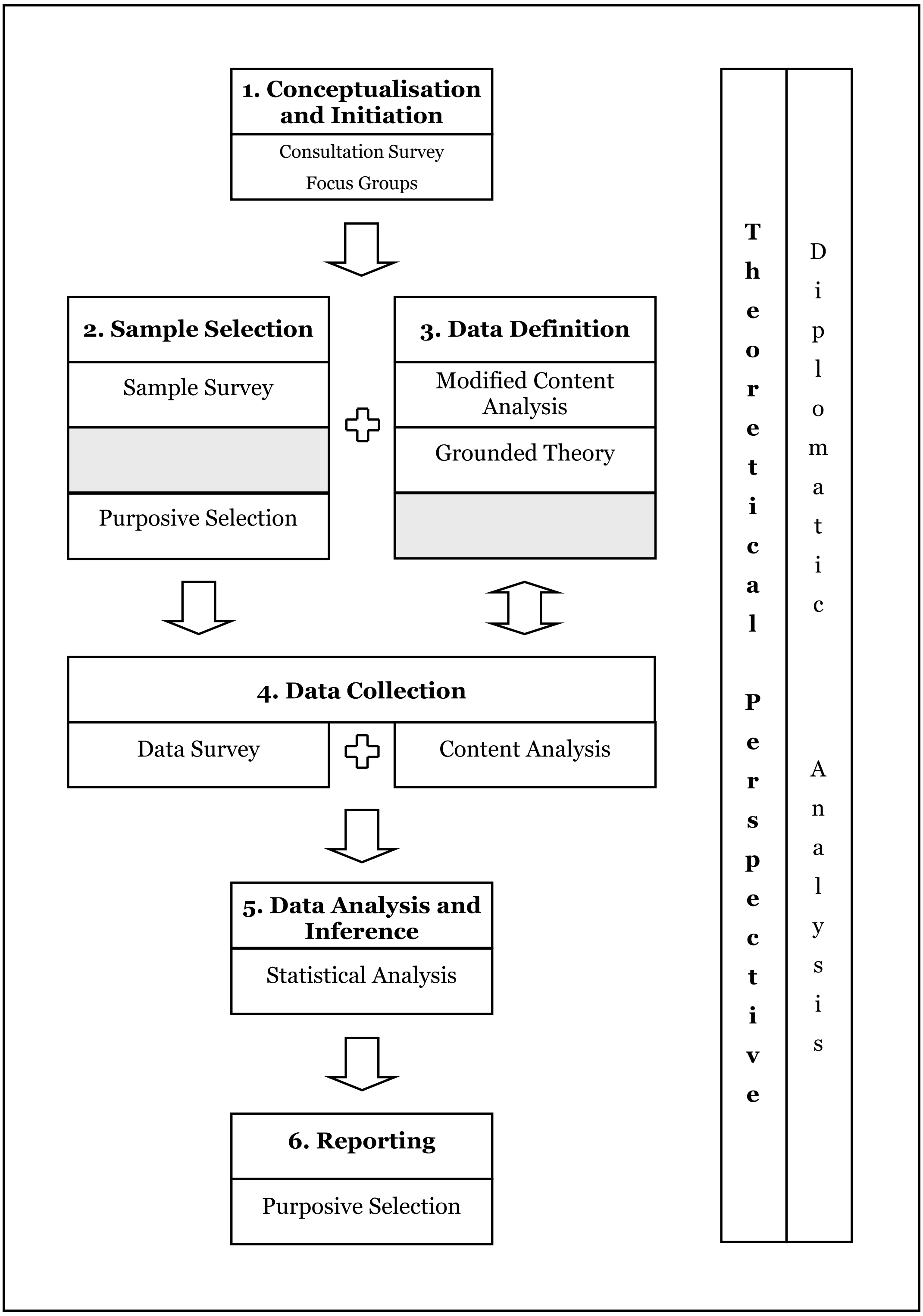

Figure 3: The Research Design: Methods Employed

It is also difficult to agree with the argument that the mixed methods approach is unsound because it brings philosophical incommensurability to research.[296] 'Real research is never purely inductive or purely deductive'.[297] In this research, a single philosophical position could not encompass all the principal research methods employed – diplomatic analysis, content analysis, grounded theory, and sampling and statistical analysis. Nor could a single position be identified for the disciplines involved – engineering, diplomatic, and archives and records management. Some framework was required, within which those putatively incommensurate positions could be brought together.

An effective resolution was found in the mixed methods' Complementary Strengths Thesis. It required that the qualitative and quantitative components of a study be kept separate. The complementary strengths of each component's paradigmatic position could then be realised.[298]

2.2 Conceptualising the Research Design

The research design was tested against a synthesis of seven design factors to assess the degree to which it matched accepted norms for a sound mixed methods design:[299]

1. Both quantitative and qualitative approaches were used, making this a mixed methods study.
2. This was a monostrand design, which contained six phases.[300]

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[296] See, for example: E. G. Guba and Y. S. Lincoln, 'Paradigmatic Controversies, Contradictions, and Emerging Influences', in *The Sage Handbook of Qualitative Research*, N. K. Denzin and Y. S. Lincoln, eds., 3rd ed. (Thousand Oaks, CA, 2005), 200-1; Teddlie and Tashakkori, *Foundations of Mixed Methods Research*, 15, 73; Creswell and Tashakkori, 'Editorial: Differing Perspectives on Mixed Methods Research', 305.

[297] Bernard and Ryan, *Analysing Qualitative Data: Systematic Approaches*, 265.

[298] Teddlie and Tashakkori, *Foundations of Mixed Methods Research*, 96, 98. See also: J. M. Morse, 'Principles of Mixed Methods and Multimethod Research Design', in *Handbook of Mixed Methods in Social & Behavioral Research*, A. Tashakkori and C. Teddlie, eds., (Thousand Oaks, CA., 2003), 191, cited by C. Teddlie and A. Tashakkori, 'Major Issues and Controversies in the use of Mixed Methods in the Social and Behavioral Sciences', in *Handbook of Mixed Methods in Social & Behavioral Research*, A. Tashakkori and C. Teddlie, eds., 17, 19. Sale and others importantly noted the need to explicitly label phenomena when working across paradigms: J. E. M. Sale, L. H. Lohfeld and K. Brazil, 'Revisiting the Quantitative-Qualitative Debate: Implications for Mixed Methods Research', in *The Mixed Methods Reader*, V. L. Plano Clark and J. W. Creswell, eds., (Thousand Oaks, CA, 2008), 369.

[299] Teddlie and Tashakkori, *Foundations of Mixed Methods Research*, 140-7. Teddlie and Tashakkori focussed on only the first four factors, considering the remaining three to be associated with 'methodological components' of research design. This research used all seven factors, with some mediation, finding them to be particularly powerful in helping to evaluate all the methodological issues involved.

3. Quantitative and qualitative approaches were mixed in 'combination'.[301]
4. Mixing of methods occurred across all six phases of the research, and within three of them.[302]
5. Both qualitative and quantitative approaches had equal priority within the design as a whole. With one exception,[303] they were also given equal priority within individual phases of the design.[304]
6. The role of this research design was to facilitate exploratory and descriptive research.[305] The research design itself was experimental and developmental.[306]
7. This research was conducted throughout from the perspective of diplomatic. Not only did it provide the context for the design, but its theoretical structure also legitimately influenced the way in which the research could be conducted.

Within the mixed methods literature, this research's design most closely matches Creswell's 'Sequential Exploratory Strategy'.[307] The purpose of that strategy is to use quantitative data and results to test elements of theory that emerge from a qualitative phase of enquiry.[308] The strategy's primary focus is to explore

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300 Teddlie and Tashakkori also used the term 'phase' to denote a strand. That term has been used in this research to denote an individual activity component of a strand, to differentiate that activity from the same authors' use of the term 'stage': Ibid., 144-6.

301 This factor takes a slightly broader view than that of Teddlie and Tashakkori, in considering all the design phases, rather than just those directly associated with data processing: Ibid., 141, 146.

302 Within Teddlie and Tashakkori's definitions, this lack of full integration within all phases would define this research design as only 'quasi-mixed'. The authors also inferred that multiple strands and inferences were essential components of a mixed methods design: Ibid., 142. However, because of the equal priorities given to the methodological approaches in the fifth design factor, this research design fully meets Creswell and Plano Clark's conditions for mixed methods: Creswell and Plano Clark, *Designing and Conducting Mixed Methods Research*, 79-84.

303 The Purposive Selection of examples of technical drawings, within the Sample Selection phase.

304 The weighting decision was driven by the research requirements, although I also believed in principle that both methodologies were of equal merit as research approaches, as discussed in, for example: B. Hall and K. Howard, 'A Synergistic Approach: Conducting Mixed Methods Research with Typological and Systemic Design Considerations', *Journal of Mixed Methods Research*, 2, 3 (Jul, 2008), 248-69.

305 Bernard and Ryan, *Analysing Qualitative Data: Systematic Approaches*, 8-9.

306 Teddlie and Tashakkori presented this factor as the 'Functions of the research study'. As before, they argued against its inclusion on the ground that the eventual study might differ from the initial design: Teddlie and Tashakkori, *Foundations of Mixed Methods Research*, 140. I agree, and have therefore amended this factor's intent to indicate the functions of the research *design*.

307 J. W. Creswell, *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, 3rd ed. (Thousand Oaks, California, 2009), 209 Fig. 10.2 (b), 211-2. An almost exact match to this design was found in a practical example, rather than in an ideal type: V. L. Plano Clark and J. W. Creswell, eds., *The Mixed Methods Reader*, 525-6.

308 Creswell, *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, 3rd ed., 211-2, citing J. M. Morse, 'Approaches to Qualitative-Quantitative Methodological

phenomena, and, in particular, to determine their distribution within a chosen population. It can also be used to generalise qualitative findings to different samples. This strategy is often the 'procedure of choice' when existing research instruments are inadequate or not available, and a new instrument needs to be developed. Finally, the Sequential Exploratory Strategy may be implemented within an explicit theoretical framework. [309] All those factors were present within this research.

2.3 The Research Design in Six Phases

The research was conducted in six phases. They are illustrated by Figure 3, above, and by a similar view, using mixed methods notation, in Figure 4, following.

The phases and their interrelationships are now briefly described. The general flow of activities is sequential from Phase One to Six. Phases Two and Three were conceptually conducted in parallel. The reiterative data flows between Phases Three and Four could not be adequately illustrated, and should therefore be noted in this description.

Phase One – Conceptualisation and Initiation – comprised research preparation and initial consultation activities. [310] In Phase Two, a statistically valid sample of technical drawings was drawn for use in Phase Four. Examples were also selected for qualitative analysis.

The Data Definition Phase – Phase Three – involved qualitative data collection and analysis. That activity produced the initial, theory-based Data Definition Models of concepts and characteristics. The model was then empirically built upon in Phase Four – Data Collection. [311]

Triangulation', *Nursing Research*, 40, 2 (Mar / Apr, 1991), 120-3; D. L. Morgan, 'Practical Strategies for Combining Qualitative and Quantitative Methods: Applications to Health Research', *Qualitative Health Research*, 8, 3 (May, 1998), 362-76; Creswell and Plano Clark, *Designing and Conducting Mixed Methods Research*, 275.

309 Creswell did not clearly differentiate between this option for his Sequential Exploratory Strategy, and the more explicit use of theoretical lenses within his Sequential Transformative Strategy. However, Mertens clearly showed that the transformative paradigm was associated with social action-type issues. It was thus not appropriate to this research: Creswell, *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*, 3rd ed., 211-3; D. M. Mertens, 'Transformative Paradigm: Mixed Methods and Social Justice', *Journal of Mixed Methods Research*, 1, 3 (Jul, 2007), 212-25.

310 See Introduction: 8.2.1 Consultation, *33*.

311 See Research Design and Methodology: 3.1 Data Definition, *78*.

Phase Four comprised two concurrent sub-phases.[312] Conceptually and practically, this was the most complicated component of the research design. The qualitative data from the Data Definition Phase were used to define the questions to be asked within new survey instruments, and to pre-code Data Values to ease data entry.

The previously drawn sample of technical drawings was then surveyed. The survey's purpose was to capture quantitative data – the frequencies of occurrence of individual concepts and characteristics in technical drawings. Yet the survey data were used qualitatively as well as quantitatively. As new concepts and characteristics emerged from the survey, those qualitative data were used to modify, reiteratively, the existing theoretical Data Definition Model. The continually revised model was then used to modify the survey instruments reiteratively. This practical mixing yet intellectual separation of quantitative and qualitative approaches within a single phase exemplified a sound use of mixed methods.

When quantitative data collection had been completed, the data were integrated with the final qualitative iteration of defined concepts and characteristics. What was now a new quantitative dataset was then analysed within Phase Five.[313] The data were described and inferences made.

In the final phase – Reporting – a qualitative selection was made of those concepts and characteristics that might be of most importance to archivists' and researchers' understandings of technical drawings. Those results are reported in Chapter 4, and discussed in Chapter 5. That selection also forms the basis for future consultation, beyond the scope of this research.

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312 See Research Design and Methodology: 3.3.1 Data Collection, *106*.

313 See Results: 4. Data Analysis, *119*.

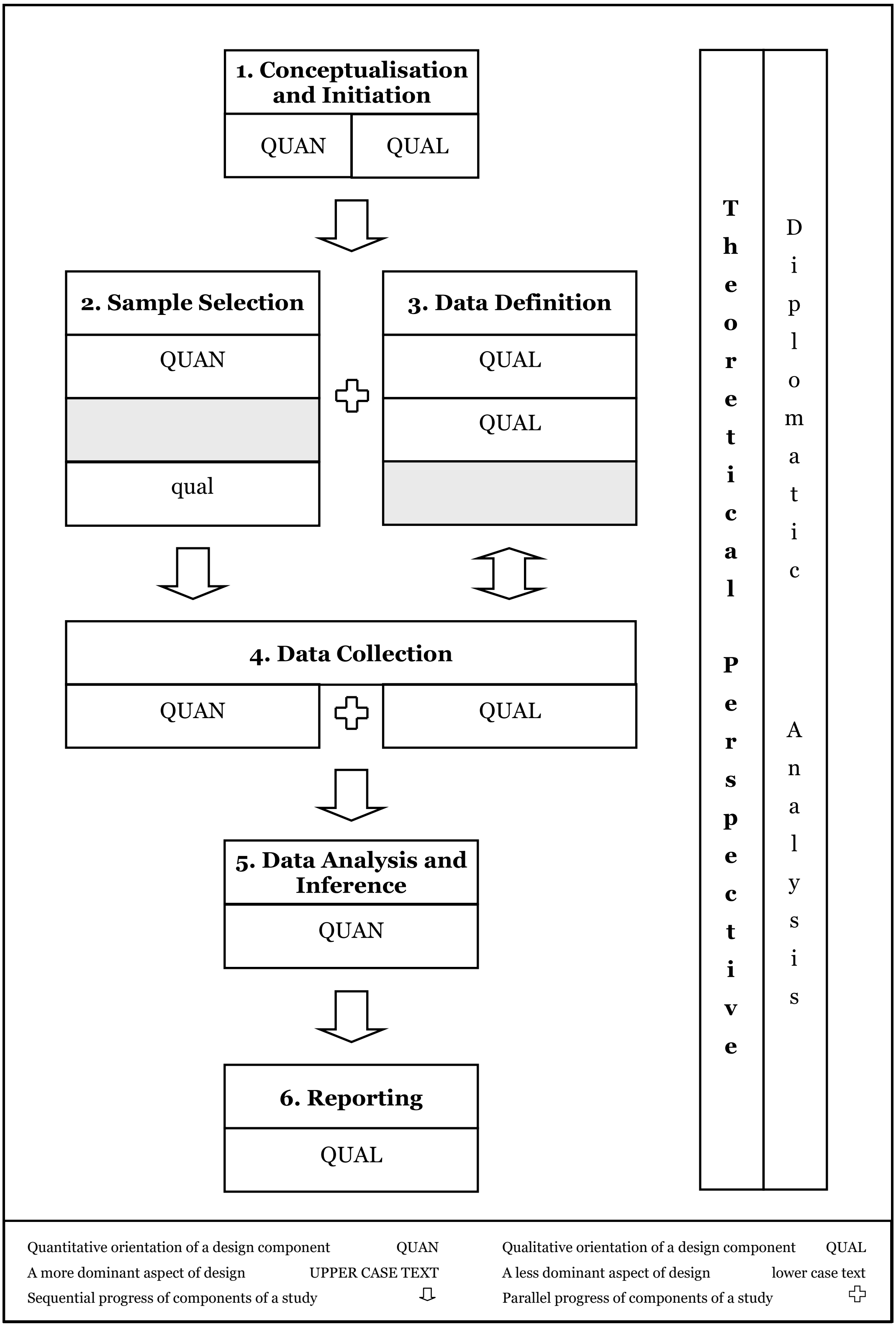

Figure 4: The Research Design: Mixed Methods Notation [314]

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314 Following Creswell and Plano Clark, *Designing and Conducting Mixed Methods Research*, 40-2.

3. Selected Design Details

Three areas of the research design and methodology are now described in more detail, sufficient to enable their replication in future research:

- Data Definition
- Representation of the Research Population
- Data Collection through Sample Survey

3.1 Data Definition

This section discusses an interdisciplinary model of concepts, characteristics, and lower-level components that might be found in a technical drawing. The initial construction of the model, through individual disciplinary models, is described. The mixed methods approach to producing those models is also set out. The successful development of the resultant Interdisciplinary Data Definition Model is seen to rest upon an issue of language.

The development of the Data Definition Model is described under the following headings:

- Purpose of data definition
- An interdisciplinary approach to data definition
- The Interdisciplinary Data Definition Model
- Purposive selection of concepts and characteristics for survey
- A methodological approach to data definition
- Pre-testing the concepts and characteristics
- An issue of language

3.1.1 Purpose of data definition

The purpose of the Data Definition Phase was to produce a model of the concepts and characteristics that might be found in technical drawings. Once sufficiently complete, the model was used to help create the data collection instruments for the technical drawings' survey. Pre-coding those instruments with terms and values for concepts, characteristics, and lower-level components would help to minimise time-consuming on the fly data entry during the survey. The model also provided a structure within which a disciplinary perspective could be realised as an outcome of the technical drawings' survey.

3.1.2 An interdisciplinary approach to data definition

It was clear that the terminology used within the model required careful consideration. Technical drawings would use technical expressions, rather than the languages of diplomatic analysis or archival science. That technical tongue therefore had to be mapped to one more understandable to archivists.

This language problem was overcome by mapping concepts and characteristics, from each discipline of interest, to create an Interdisciplinary Data Definition Model. Three discipline-specific conceptual frameworks were first constructed:

- Diplomatic Data Definition Model (Diplomatic DDM)
- Archives and Records Data Definition Model (Archives and Records DDM)
- Technical Drawings Data Definition Model (Technical Drawings DDM)

Each framework contained a relational set of concepts and characteristics derived from their respective literature, as now summarily described.[315]

Diplomatic Data Definition Model

The Diplomatic Analysis Framework was populated with the widest range of diplomatic concepts, characteristics, and terms that could be gleaned from the literature. They represented a diversity of views of diplomatic that ranged from its seventeenth-century foundations to late twentieth-century conceptualisations for records in electronic formats.

Archives and Records Data Definition Model

It was necessary to complement the Diplomatic Analysis Framework with some concepts and characteristics for archives and records. This Archives and Records Framework did not need to be as developed as that for diplomatic. It did though particularly need to consider concepts and characteristics for archives and records in aggregations.[316] Specialist concepts, characteristics, and terms for the archival description of technical and architectural drawings were also important.

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[315] These were descriptive data – nominal index codes, or tags, rather than ordinal value codes: Bernard and Ryan, *Analysing Qualitative Data: Systematic Approaches*, 87, 90.

[316] The need for such 'refinement[s] of the diplomatic approach' in records' analysis was highlighted in InterPARES 1 Project: Authenticity Task Force, 'Authenticity Task Force Report', 24-5.

Data for these concepts and characteristics were drawn from international and national standards and cataloguing guides for archives and records. Such sources represented the greatest degree of consensus that had been obtained for the relevant concepts, characteristics, and terms.

Technical Drawings Data Definition Model

Models for engineering and architectural drawing practice were progressively established during the twentieth century, through British and international standards. They developed into all-encompassing intellectual structures for the graphical expression of the products of those disciplines – technical drawings.

These well-developed standards were very well suited to the research needs. They existed for the entire period covered by the research's technical drawings sample – the 1920s to the 1980s. Some general level of concurrence was therefore thought likely between the standards and the conventions used for the sampled drawings. Even if such concurrence was not present, the later versions of the standards covered a very wide range of technical drawing concepts. They would therefore provide more than sufficient data for the Data Definition Model.

The Technical Drawings DDM was therefore almost exclusively developed from the BS 308 series.[317] Other British Standards were also used to furnish data for technical drawings' concepts and characteristics that were outwith the scope of BS 308.[318]

Diplomatic, Archives, and Records Data Definition Model

The Diplomatic DDM and the Archives and Records DDM were combined, to form a composite Diplomatic, Archives, and Records Data Definition Model. That model was conceptually at the same level as the Technical Drawings DDM.

3.1.3 The Interdisciplinary Data Definition Model

Finally, the new Diplomatic, Archives, and Records DDM and the Technical Drawings DDM were merged to form the Interdisciplinary Data Definition Model, as illustrated by Figure 5, following. The model and its siblings were constructed

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317 British Standards for engineering drawing [office] practice during the period 1927 to 1972.

318 They included, for example, standards for drawing sizes, drawings' media, and drawings' requirements for microform reproduction.

in the form of a matrix table model-type.[319] Data were held in both MS Word Tables and Excel spreadsheets to allow for flexibility of use.

Size of the Data Definition Model

It was then possible to start to quantify the concepts and characteristics that were present within the model. The number would be an estimate, because the model was still under development, and did not represent a final outcome. At that stage, the model's principal purpose was as a tool to help develop the survey instruments. I accepted that this theoretical starting point would be very unlikely to produce data for every concept and characteristic encountered during the technical drawings' survey.

The model was found to contain thirty-eight general concepts.[320] They ranged across all the topics represented by the initial disciplinary frameworks. From archival science, for example, were concepts of contexts and referencing; from diplomatic, concepts of subscription and dating; and from technical drawing, concepts of drawing size and graphical representation.

The true size of the model could, though, only be indicatively expressed in terms of the lower-level concepts and characteristics that it contained. While 716 such components could be identified, that was a misleading figure. The number of components within some general concepts would be determined by incalculable permutations of characteristics, attributes, and facets. What was certain, though, was that very substantially more components had been theoretically identified within a technical drawing than could be surveyed in the available research time.

The conundrum presented by this overabundance of potential survey components was unsurprising. While the size of the Data Definition Model was undoubtedly problematic, the size of that problem could not have been known until the model had been created. This was, of course, exploratory research. However, it had been necessary to define as complete a set of concepts and characteristics as possible. Without such a complete set, it would not have been possible to select a well-founded sub-set of concepts and characteristics for investigation by survey.

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319 Following Bernard and Ryan, *Analysing Qualitative Data: Systematic Approaches*, 128-9, especially Table 6.1., adapted from A. Strauss and J. Corbin, *Basics of Qualitative Research: Grounded Theory Procedures and Techniques* (Newbury Park, CA, 1990), 158-175.

320 See Appendix A.

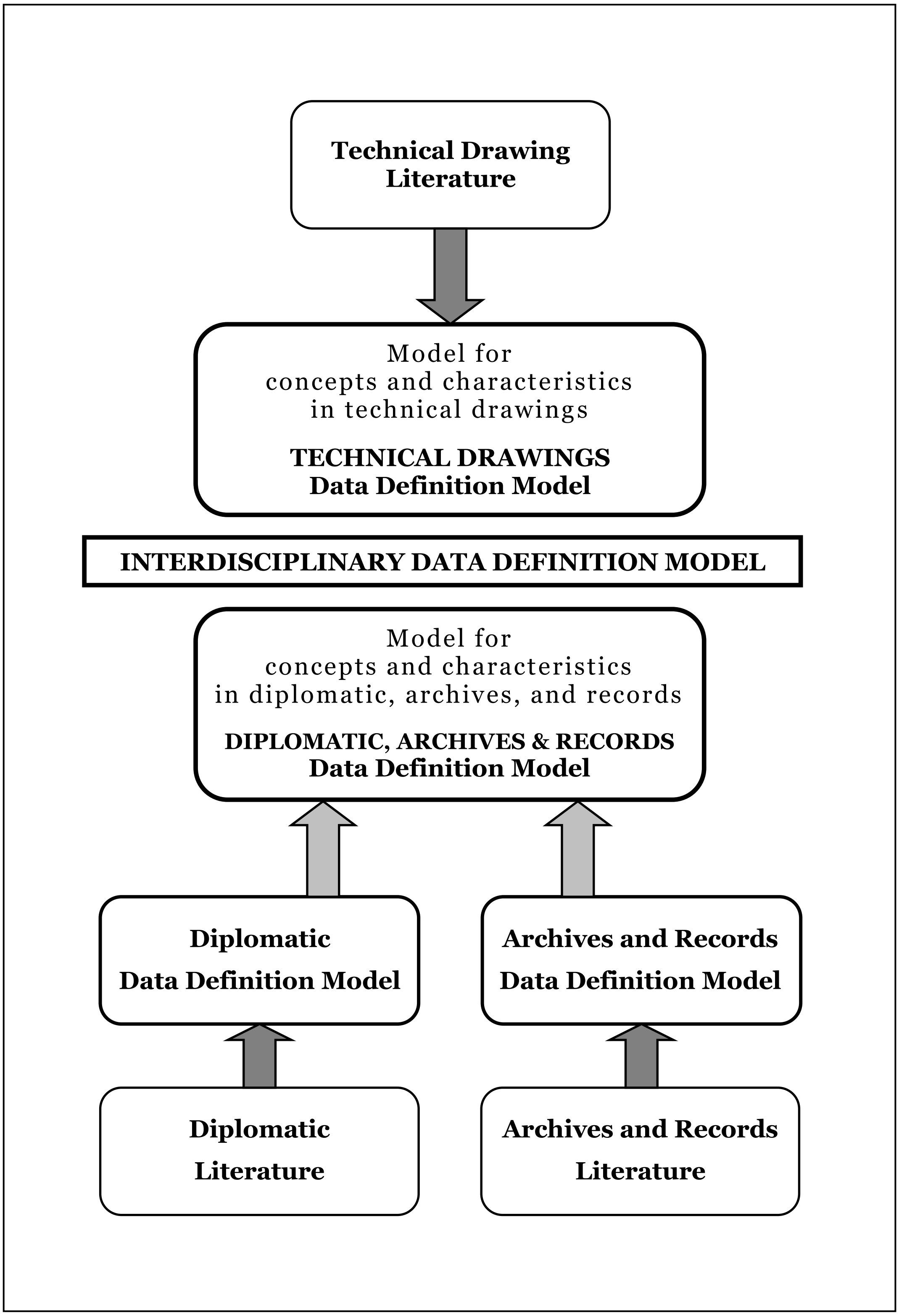

Figure 5: Development of the Interdisciplinary Data Definition Model

3.1.4 Purposive selection of concepts and characteristics for survey

Nonetheless, the indeterminately large quantity of components in the Data Definition Model was particularly problematic. As has been noted,[321] it was impossible to disseminate the findings for consultation. It was therefore necessary to purposively select components for survey without the benefit of external views.

The selection criteria were obviously critical to the success of the research. If a concept or characteristic was excluded at this stage, its potential for making a technical drawing more comprehensible obviously could not be assessed. On the other hand, the inclusion of concepts and characteristics whose potential to aid understanding was clearly negligible would simply increase the survey scope unnecessarily. The greatest problem lay in deciding where the line between inclusion and exclusion should be drawn. The subjectivity of the choices made was clearly recognised.

The decisions were therefore made on a principle of defined exclusion. All concepts and characteristics would be surveyed, unless they met one of two exclusion criteria:

1. They were of such technical specificity as to be reasonably thought irrelevant to the needs of researchers seeking information through archival description.

   For example: Trim frames; parts' lists; materials reference and indication; angular dimensioning; tolerancing; machining and surface texture.

2. They were of such diplomatic detail as to be outweighed by the need to survey broadly across all concepts, rather than in depth within a lesser quantity.

   For example: Standard graphical conventions for generic elements; text; symbols; lines and terminations; tables and lists; sections and planes.

That this approach erred on the side of non-exclusion may be judged by the utility of the survey results. Of 642 individual variables that were surveyed, only 268 (41.8%) contributed data of sufficient importance to be included in the reported

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[321] See Introduction: 8.2.1 Consultation, 33.

results and findings.[322] The majority of variables, therefore, (58.2%) did not contribute sufficiently useful data to be reported.[323]

However, those variables that did not contribute data directly were not worthless. Some variables – derived from theory – were simply not present at all within the surveyed technical drawings.[324] Instances of other variables with great potential for aiding understanding were present in only very small numbers.[325] Other variables were found to be conceptually or practically difficult to employ, indicating their need for revision.[326] All these variables now exist for further consideration in similar future research.

3.1.5 A methodological approach to data definition

Here, I give a generic description of the construction of the individual disciplinary data definition models. The description highlights the practical application of a mixed methods approach – a modified form of standard content analysis.[327]

This mixed methods approach was conducted in two stages:

1. A deductive high-level initial overview of the literature, including 'already-agreed-on professional definitions' and prior knowledge,[328] to create a preliminary model.
2. An inductive extraction of detailed data from the literature, to create a detailed model.

Using standard content analysis in the first stage, the derived data increasingly populated the model. Conceptual groupings began to emerge. The literature search was then broadened, seeking wider and deeper theory to inform the construction of the model.

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322 See Results: 5. Selection of Results, *121*.

323 All 642 variables are listed at Appendix B, with an indication of those that did, and did not, contribute data to the reported results.

324 Including some concepts of certification signatures and dates, for example.

325 Drawing Office certification stamps, for example.

326 Some characteristics within Medium, and Changes, for example.

327 Adapted for a research question approach, rather than one based upon a hypothesis, and with some minor terminological differences: Bernard and Ryan, *Analysing Qualitative Data: Systematic Approaches*, 289-90.

328 Ibid., 55-6.

In the second stage, this literature was purposively selected to act simply as qualitative data sources. The two-fold aim of the content analysis at that point was to '*systematically and* objectively' [329] extract from texts:

- All instances of terms used for concepts and characteristics, but,
- Only those terms that were manifestly present – none were inferred through latent coding

The unit of analysis was at the level of a single word or phrase used as a term for a particular concept or characteristic.

It was there, at that detailed level of textual interpretation and data extraction, that the elements of grounded theory and content analysis became most mixed. It is difficult to describe that form of coding as anything other than a synthesis of both methods. [330] Within the framework of standard content analysis, data were extracted using grounded theory. The text was coded line-by-line, with key words and phrases marked, and potentially useful concepts identified. Terms were recursively and reflectively collected and located in the model. [331]

Data extraction continued until a sufficient range and depth of data was reached with which to move on to the Data Collection phase of the research. The key word is 'sufficient' – 'theoretical saturation' [332] was not reached. [333]

This approach exemplified the mixed methods debate at a very detailed, operational level. The synthesised use of grounded theory and content analysis

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329 Berg, *Qualitative Research Methods for the Social Sciences*, 306, citing O. R. Holsti, 'Content Analysis', in *The Handbook of Social Psychology*, G. Lindzey and E. Aronson, eds., 2nd ed., Vol. Two: 'Research methods' (Reading, MA, 1968), 601. The emphasis was made by Berg rather than by Holsti. Berg also cited an incorrect page number for this reference.

330 Content analysis and grounded theory have been described as 'two very different types of text analysis'. They 'reflect the two great epistemological approaches for all research: induction and deduction.': Bernard and Ryan, *Analysing Qualitative Data: Systematic Approaches*, 265.

331 Ibid., 271-3. I did not, though, use memos – a key feature of grounded theory. I instead continually revised the model through iterative induction and constant comparison.

332 Ibid., 266.

333 Nor could it ever have been, in the research time available. Methodologically, therefore, this approach could not be regarded as entirely fitting either the grounded theory or content analysis models for text selection and code creation.

elements was shown to produce useful practical outcomes, despite their epistemological differences.[334]

3.1.6 Pre-testing the concepts and characteristics

Following classical content analysis principles, the derived concepts and characteristics should have been tested on a few technical drawings from, or comparable to, those to be surveyed. Any problems that arose could then have been resolved before the technical drawings' survey. I did not adopt that normally sound advice. Considerable time had already been expended in developing the Data Definition Model; work needed to start on the survey. Furthermore, there was no guarantee that the very large number of concepts and characteristics to be tested would be present in those technical drawings selected for the test. This testing was therefore integrated within the technical drawings survey, as described later.[335]

3.1.7 An issue of language

In conclusion, the principal issue for the construction of the Data Definition Model emerged as one of language. It was necessary to consider in detail not just different disciplinary perspectives, but also the vocabularies with which they were expressed. Were that not the case, it would not have been necessary to construct separate disciplinary frameworks.

Traditional diplomatic literature, for example, lacked sufficient concepts for archives and records in aggregation. The archives and records literature, however, was not nearly so well developed in the articulation of concepts comparable with diplomatic genesis and tradition.

Directly related concepts could be found within technical drawings, expressed in completely different terms. The Signature-Date Block and Record of Changes, for example, provided concepts for a technical drawing's genesis and tradition. The

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334 Content analysis codebook development was regarded as a 'typical' product of inductive qualitative analysis: M. Q. Patton, *Qualitative Research & Evaluation Methods*, 3rd ed. (Thousand Oaks, CA: 2002), 453. Grounded theory was associated with that notion, both in that text, and more closely in M. B. Miles and A. M. Huberman, *Qualitative Data Analysis: An Expanded Sourcebook*, 2nd ed. (Thousand Oaks, CA, 1994), 58. Miles and Huberman did not make a specific connection to content analysis. Their description of codes and coding supported generic forms of qualitative analysis. Patton (453) considered content analysis to be a qualitative method. Neither text, therefore, addressed the mixed methods issues inherent in synthesising elements of quantitative content analysis and qualitative grounded theory.

335 See Research Design and Methodology: First data collection run, *110*.

Drawing Reference Code and Record of Issue indicated not single documents, but records related in aggregations.

The reconciliation of these disciplinary language issues resulted firstly in the construction of two complementary models. One model combined the idioms of diplomatic, archives, and records, while the other encompassed the quite dissimilar language of technical drawing. Ultimately, only a granular application of language, at the level of individual terms and phrases, enabled those two models to be mapped one to the other.

3.2 Representation of the research population

3.2.1 The research population

The population to be researched comprised technical drawings from British commercial vehicle manufacturers. Many enterprises were represented, across a large part of the twentieth century. Individual enterprises had been successively taken over, or otherwise amalgamated into what eventually became the Truck and Bus Division of British Leyland Motor Corporation Limited (BLMC), formed in 1968.[336] Following partial nationalisation in 1975, this enterprise became British Leyland Limited (BL Ltd).[337] Those enterprises represented in the technical drawings sample are illustrated at Figure 6, following.[338]

After BL Ltd's demise, the technical drawings, with other original records and printed and photographic material, eventually came under the management of the British Commercial Vehicle Museum (BCVM), Leyland, Lancashire. When this research commenced, in 2006, that material was undergoing a three-year project to appraise, select, and catalogue what was required for permanent archival preservation and public access. The project's location was within reasonable daily commuting distance of my research office.

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336 T. Dawson, ed., *The World of British Leyland* (nd c1971), 1-2.

337 University of Warwick, Modern Records Centre, 'British Leyland Limited' in *Archives Catalogues (*Warwick, 2011) [Online] http://dscalm.warwick.ac.uk/DServe/dserve.exe?dsqIni=DServe5.ini&dsqApp=Archive&dsqCmd=Show.tcl&dsqDb=Persons&dsqPos=0&dsqSearch=%28PersonName%3D%27british%20leyland%27%29 (accessed 01 Nov, 2011).

338 The enterprises noted within Figure 6 include only those identified from the drawn sample, and thus represent the sampled population, rather than the entirety of British Leyland's diverse enterprises.

Stored in rudimentary temporary premises, the material constituted more an artificial aggregation than an organic accumulation. The technical drawings were held in 122 assorted containers, including vertical and horizontal plan chests, filing cabinets, and wire cages. This diverse storage reflected the drawings' wide range of sizes and formats.[339]

The material's diverse provenances were clearly indicated by corporate names, logos, and records reference code series, for example. However, there were no useful finding aids to the entire aggregation, and only very limited anecdotal information about its origins and make-up. Some technical drawings' registers and index cards were available, but their entries could be related to very few drawings, and then only after considerable investigation.[340]

Two factors indicated that the majority of the material was associated with design and drawing office activities. Firstly, the activities represented included research, design, and development; specification and build; parts and materials; vehicle operation and maintenance; and sales, marketing, and publicity. Secondly, the clean condition of the materials was indicative of their use in a controlled environment such as a drawing office. They did not bear the oil and grease marks of the shop floor, nor the informal annotations of production-line workers.

Other corporate activities – governance, finance and staffing, for example – were only very patchily represented by the records within this aggregation.[341] However, many records were found to be held by archives services elsewhere,[342] revealing that this BCVM material had been orphaned. This situation typified the isolation of technical drawings from corporate records in other forms.

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339 The sizes of drawings in hard copy formats ranged from the equivalent of A4 to beyond A0. There were also microfilmed drawings on aperture cards.

340 Drawing registers were found marked for 'Leyland', 'Bathgate' [Leyland Scotland], and 'Austin'. Drawing index cards were found for Leyland and AEC enterprises.

341 Principally financial records of Charles H. Roe, Ltd, 1926-61, and some reports, financial records, and other records for Guy Motors Ltd, 1913–1960s. There were also smaller amounts of non-technical corporate records – essentially strays – for many other enterprises.

342 The principal accumulations are held within the British Motor Industry Heritage Trust, Heritage Motor Centre, Gaydon, 'BMIHT Business Records Collection' in *Catalogue of Business Records* (Kew, 2011) [Online] http://www.nationalarchives.gov.uk/a2a/records.aspx?cat=1036-bmihtbizreccoll&cid=0#0, (accessed 01 Nov, 2011); and the University of Warwick, Modern Records Centre, 'Mss 226' in *British Motor Industry Heritage Trust Collection* (Kew, 2011) [Online] http://www.nationalarchives.gov.uk/a2a/records.aspx?cat=152-mss226&cid=0#0, (accessed 01 Nov, 2011).

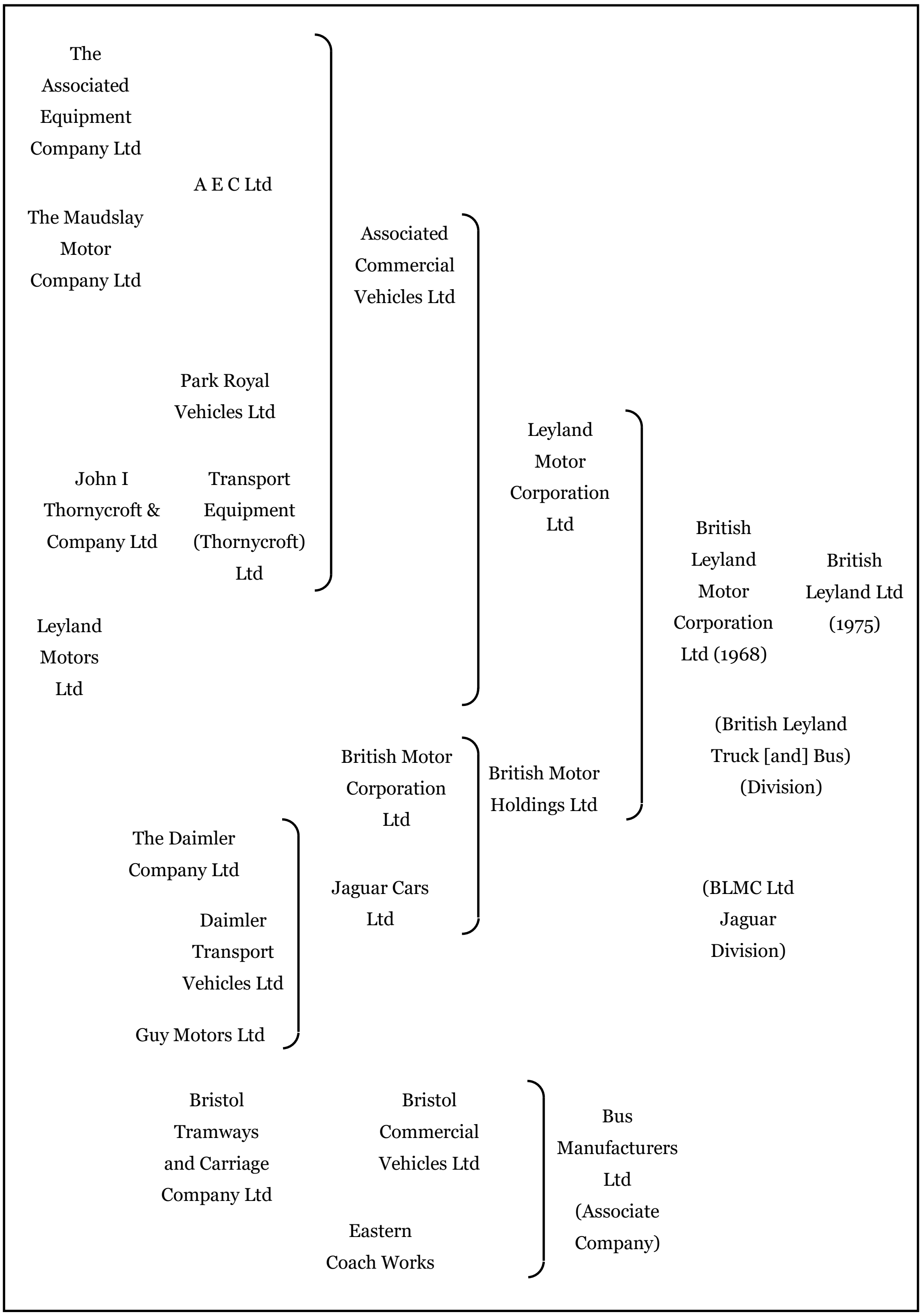

Figure 6: Schematic arrangement showing the relationships of the commercial vehicle manufacturers whose technical drawings formed the research sample [343]

343 Relationships arranged following: R. Church, *The Rise and Decline of the British Motor Industry* (Basingstoke, 1994), 77; Dawson, *The World of British Leyland*, 1-2.

Again typically, given the limited information for provenance and original order, the records' storage conditions, and the large formats of the technical drawings, their appraisal was difficult. The Project Archivist therefore examined the majority of the technical drawings one-by-one. Those that he selected for archival preservation were catalogued, and moved to appropriate facilities at the BCVM.

Many technical drawings were not so selected, and were put aside for destruction. I was granted access to draw a sample from that appraised-out residue during the last few last months of the BCVM project.[344] I could remove this sample to my research office. These drawings' lack of archival research values had no impact on their worth for my research, because those values were not a key factor to be analysed.

Indeed, I quickly realised that such drawings had potentially greater importance for this research than those that had been selected as archives. As a rejected residue, they contained all the selection and arrangement questions that archivists would face. By contrast, technical drawings that had been selected as archives would be 'sanitised' to a degree that might hide some processing questions from this research.

Other advantages accrued to the research from this serendipitous opportunity:

- Representative technical drawings would be immediately at hand in my research office, rather than having to be visited at locations remote to it.
- Far more detailed and reiterative investigation than had been anticipated would therefore be possible.
- The drawings could be used as a control sample for comparison with other similar samples, once a research methodology had been developed.
- This resource therefore enhanced the opportunities to develop new approaches to understanding technical drawings.

3.2.2 The research population in context

Because some attempt will be made later to generalise from the technical drawings sample, it will be helpful to place its parent population in context. Theoretically, a 'Total Global Population' would comprise all technical drawings of whatever subject, date, or place, ever created. We can, for convenience and

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344 See Acknowledgments, *xiv*.

sanity, define more practical populations. For illustration only, examples might range in scope to include technical drawings created or acquired within:

- Darlington Locomotive Works, 1883 to 1962
- USA military aircraft production during World War II
- Boulton and Watt steam engine manufacture in the eighteenth century
- British commercial vehicle manufacture in the twentieth century

The BCVM technical drawings population can be conceptualised in relation to such different scales of populations, as Figure 7, following, indicates. The only population with which this research had direct contact was the second last, which I term the BCVM Surviving Population.[345]

3.2.3 Pre-sampling survey

Within the 122 technical drawings' containers, all 64 plan chests were initially selected for sampling. They had not yet been processed by the Project Archivist, were the most accessible containers, and held the majority of the larger-sized hard-copy technical drawings. This accumulation is termed the BCVM Surveyed Population. A pre-sampling survey was undertaken on those 64 containers, to provide data that would enable a robustly representative sample to be designed and drawn.

Two key outcomes were required of the pre-sampling survey:

1. An indicative total number of drawings within the surveyed population
2. Indicative proportions for the enterprises represented within the population

That information would enable the proportion of population size to sample size to be estimated, so that a sample size correction factor could be applied if necessary. This survey would also better identify the diversity of enterprises that was known to exist. A more representative sample would be obtained if that diversity was accommodated by stratification in the sampling frame.[346]

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345 Other BLMC technical drawings may have survived elsewhere, hence this residue is termed the BCVM Surviving Population.

346 W. G. Cochran, *Sampling Techniques*, 3rd ed. (New York, 1977), 6, 89-90; E. K. Foreman, *Survey Sampling Principles* (New York, 1991), 99-101.

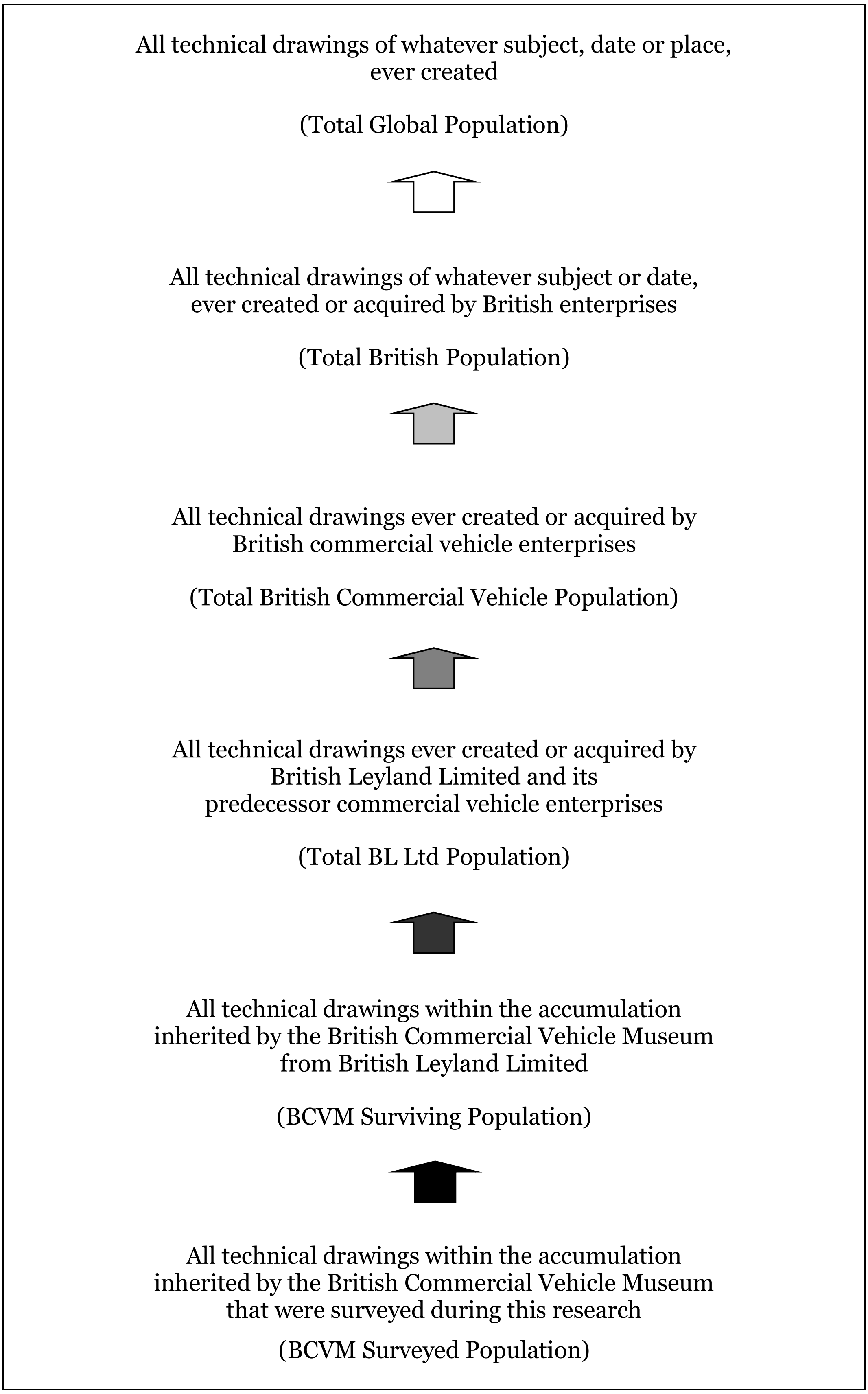

Figure 7: Conceptualised relationships of technical drawings' populations

The pre-sampling survey findings used to inform the sample design were, in summary:

- There were 1,914 gatherings of technical drawings [347] – first-stage sampling units
- There were some 19,000 individual technical drawings – second-stage sampling units
- They originated from at least thirteen vehicle manufacturing enterprises
- They were indicatively dated between the 1920s and the 1980s
- They were stored by size of drawing sheet
- Within each size, they were arranged in partially random and partially systematic order
- Systematic arrangements occurred within two large sub-populations, for AEC and Leyland enterprises
- No scheme of arrangement was available to guide sample selection

Examples of technical drawings of different genres and media were also identified during the survey, for later selection, and separate qualitative analysis.

3.2.4 Sample design

Within survey method, a sample must be designed and produced to represent the sampled population as closely as possible, within defined estimates of confidence. This is not necessarily as simple in practice as in theory – and sampling is a practical activity. [348] Some deviation from pure theory may be a pragmatic necessary, while always having regard to the effects upon statistical rigour.

This section describes and discusses how a sample was designed and drawn for the technical drawings' survey, using the results of the pre-sample survey.

Sample design parameters

Considerable study was necessary to arrive at the survey sample design parameters. Two related issues caused particular difficulty. The first was the choice of appropriately dimensioned confidence limits to be applied to the

347 One gathering was equivalent to the individual technical drawings normally contained within one drawer of a horizontal plan chest, or one folder in a vertical plan chest.

348 The place of sampling theory in this practical activity was introduced by Cochran, *Sampling Techniques*, 8-9.

statistical results of the technical drawings' survey. The second issue was the determination of an appropriate sample size. The two issues were linked – the more rigorous the confidence limits, the larger the required sample size. Other factors could also affect that relationship, according to particular survey circumstances and requirements. [349]

In summary, the design parameters chosen for this research's technical drawings' sample were:

Confidence in survey results:

- Confidence Interval +/- 5 percentage points
- Confidence Level 95%

Sample size:

- Theoretical 385 members
- Practical 400 members

Sample structure:

- Proportionally stratified
- Partly random
- Partly systematic
- With replacement
- Both single-stage and two-stage

Those choices provided the foundations for the validity of the results that were derived from the technical drawings' survey. The reasons for those choices are now explained.

Confidence in survey results

Non-sampling errors create unreliable results. They inhibit repeatability and generalisation. They occur when a drawn sample is not representative of the sampled population. [350] In this research, such errors were controlled and minimised through careful sample design and implementation.

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349 See, for example: Ibid., 72-88, especially 73-4, and P. S. Levy and S. Lemeshow, *Sampling of Populations: Methods and Applications*, 3rd ed. (New York, 1999), 70-5, 110-12, 175-9.

350 P. S. Mann, *Statistics for Business and Economics* (New York, 1994), 367-8; M. J. Panik, *Advanced Statistics from an Elementary Point of View*, (Burlington, MA, 2005), 7.

Sampling error, by contrast, cannot be controlled. The frequencies of occurrence of sample proportion statistics are used to estimate corresponding population proportion parameters, by means of inferential statistics.[351] Such statistical inference from a sample to a population is based upon probability, rather than certainty.

The consequent sampling error limits the confidence that can be placed in research results.[352] That error requires an interval estimate to be constructed around the point estimate of each sample statistic. A probabilistic statement then indicates the degree of confidence with which it can be assumed that the interval contains the corresponding population parameter.[353] Within this research, this probabilistic statement was expressed in terms of:[354]

- Confidence Interval (CI) – a point estimate bracketed by a lower and a higher value[355] – the Confidence Interval Limits. Measured in +/- percentage points.
- Confidence Level (CL) – the degree of confidence that the Confidence Interval contains the true population parameter. Measured as a percentage.[356]

The rationale for the confidence values chosen for this survey was as follows. In general, these values had to enable:

- Reliability of results from the sample analysis
- Inference from the sample to the sampled population
- Potential generalisation from the sample to wider populations

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351 Mann, *Statistics for Business and Economics*, 408-9.

352 Ibid., 366-7; Panik, *Advanced Statistics from an Elementary Point of View*, 7.

353 Mann, *Statistics for Business and Economics*, 408-11; Panik, *Advanced Statistics from an Elementary Point of View*, 7, 439-40.

354 Following, for example: Mann, *Statistics for Business and Economics*, 411, 441; S. Dowdy, S. Weardon and D. Chilko, *Statistics for Research*, 3rd ed. (Hoboken, NJ, 2004), 70-3. I consistently use the terms 'Confidence Interval' and 'Confidence Level' in the way here defined. In the literature's descriptions of statistical confidence, those terms, and others, were frequently found used in variously different ways.

355 In this context, statistical values as described and discussed *passim*.

356 It should be noted that the Confidence Level relates to the probability of any one Confidence Interval, constructed from each of all possible samples, containing the true population parameter. It is the Confidence Interval that moves with each sample, not the parameter. See, for example: S. Lemeshow and others, *Adequacy of Sample Size in Health Studies* (Chichester, 1990), 62-3, and C. Morris, *Quantitative Approaches in Business Studies*, 6th ed. (Harlow, 2003), 212.

More specifically, the aim of the survey was to determine which concepts and characteristics – hereafter, variables – were generic, or almost so, to the technical drawings under investigation. As a starting point, I therefore decided to identify all such variables that occurred in more than 90% of the drawings.

A point estimate of 95% for the occurrence of those variables, combined with a Confidence Interval of +/- 5 percentage points, would produce an interval estimate with:

- A Lower Confidence Interval Limit of 91% occurrence – the desired minimum level of occurrence
- An Upper Confidence Interval Limit of 100% occurrence

The Confidence Interval was therefore the most important confidence parameter to be fixed. Its value of +/- 5 percentage points accorded with practice reported not just in the limited archives literature,[357] but also more broadly.[358]

The choice of a value for Confidence Level was considered next. That value had not just to be appropriate to the Confidence Interval.[359] It had also to meet the more general requirements of reliability, generalisability and inference in respect of the survey results.

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357 S. Buchanan and S. Coleman, 'Deterioration Survey of the Stanford Universities Libraries Green Library Stack Collection', in *Preservation Planning Program Resource Notebook*, P. W. Darling and W. L. Boomgaarden, eds., [Revised Edition] (Washington, 1987), 256, [Online] http://www.eric.ed.gov/PDFS/ED282561.pdf (accessed 27 Sep, 2010); T. Chrzastowski and others, 'Library Collection Deterioration: A Study at the University of Illinois at Urbana-Champaign', *College & Research Libraries*, 50, 5 (Sep, 1989), 578; P. Eden and others, *A Model for Assessing Preservation Needs in Libraries: British Library Research and Innovation Report 125* (London,[1998]), 13; C. Creaser, 'Notes on Sampling': Appendix F to *A Model for Assessing Preservation Needs in Libraries*; I. Beck, 'Random Sampling used for Researching Preservation Conditions of the Documental Collection "Building License", of the Rio De Janeiro City General Archives', 32-3. Rio de Janeiro, 20-22 Sep, 2002. (ABRACOR, 2002) [Online] http://www.abracor.com.br/novosite/pdfs/xi_ing.pdf (accessed 19 Nov, 2010).

358 For example, in educational and social research, 5% [+/- 5 percentage points] was an 'acceptable margin of error' when using categorical variables, as were employed in this survey: R. V. Krejcie and D. W. Morgan, 'Determining Sample Size for Research Activities', *Educational and Psychological Measurement*, 30, 3 (1970), 607-10, J. E. Bartlett, J. W. Kotrlik and C. C. Higgins, 'Organizational Research: Determining Appropriate Sample Size in Survey Research', *Information Technology, Learning, and Performance Journal*, 19, 1 (Spring, 2001), 45.

359 'The researcher must…consider matching the precision range [Confidence Interval] and the Confidence Level. In general a small [Confidence Interval] will be paired with a higher confidence while a large [Confidence Interval] will be paired with a lower Confidence Level.' M. C. Drott, 'Selecting a Value for Confidence', in *Dr. Drott's Random Sampler: Using the Computer as a Tool for Library Management*. (M. C. Drott (Libraries Unlimited), 1996) [Online] http://testbed.cis.drexel.edu/sample/variability.html#conf (accessed 08 Aug, 2010).

This was a rather more pragmatic decision, which was not altogether helped by studying the literature. I did not feel comfortable with a Confidence Level value lower than 95%; the choice lay between either 95% or 99%. Finally, three separate reasons encouraged me to adopt a Confidence Level value of 95%.[360]

Firstly, five library and archives survey descriptions reported using a Confidence Level value of 95%.[361] Finer confidence limits were reported in two other cases.[362] More broadly, a 95% Confidence Level value was found reported to be that generally used for research in some comparable fields.[363]

Secondly, I did not feel in principle that the sample results would be so critical as to warrant a choice of 99%.[364] Finally, and somewhat pragmatically, the adoption of a 95% Confidence Level value[365] would result in a smaller sample size than if a 99% value was adopted.

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360 Notwithstanding the suggestion that that value's ubiquity has resulted more or less from statistical accident: A. Field, *Discovering Statistics Using SPSS*, 3rd ed. (London, 2009), 51.

361 National Archives and Records Service and Federal Bureau of Investigation, 'Appraisal of the Records of the Federal Bureau of Investigation: A Report to Hon. Harold H. Greene United States District Court for the District of Columbia', (National Archives and Records Service, 1981-2) Vol. 1, 3-5–3-6, [Online] http://jousting-at-windmills.org/fbi/appraisal/appFBI_taskforce1981v1.pdf (accessed 30 Apr, 2011); Buchanan and Coleman, 'Deterioration Survey of the Stanford Universities Libraries Green Library Stack Collection', 256; Chrzastowski and others, 'Library Collection Deterioration', 578; Eden and others, *A Model for Assessing Preservation Needs in Libraries*, 13; Creaser, 'Notes on Sampling', 72; Beck, 'Random Sampling used for Researching Preservation Conditions of the Documental Collection "Building License"', 33-4.

362 G. Walker, J. F. Greenfield and J. S. Simonoff, 'The Yale Survey: A Large-Scale Study of Book Deterioration in the Yale University Library', *College & Research Libraries*, 46, 2 (Mar, 1985), 132. A value of 99% was reported therein for the 'Confidence Interval'. It was though clear from the context that that figure related to what this research defines as the 'Confidence Level'. Elsewhere, R. Bond and others, 'Preservation Study at the Syracuse University Libraries', *College & Research Libraries*, 48, 2 (Mar, 1987), 146, reported a '95% confidence interval' with a '1% error rate'.

363 For example, in social science, education, and business research: Drott, 'Selecting a Value for Confidence'; Bartlett, Kotrlik and Higgins, 'Organizational Research', 45; A. Bryman, *Social Research Methods* (New York, 2001), 94; A. Bryman and E. Bell, *Business Research Methods*, 2nd ed. (Oxford, 2007), 192-3.

364 A 99% Confidence Level has been suggested as being appropriate when critical decisions are to be founded on research results, or when errors might 'cause substantial financial or personal harm': Bartlett, Kotrlik and Higgins, 'Organizational Research', 45. It has also been regarded as 'more common' than other values in the physical sciences: Drott, 'Selecting a Value for Confidence'.

365 There is obvious scope for confusion here between this 95% value for Confidence Level and the same value used for the required point estimate within the Confidence Interval. Hence the earlier emphasis on these concepts' definition and differentiation.

Sample size

The following parameters determined the size of sample that was appropriate to this research:

- The Confidence Interval was set to +/- 5 percentage points
- The Confidence Level was set to 95%
- Categorical variables were to be surveyed
- The population proportion value (variance) value was set to maximum (0.5)
- There was a very large population size in proportion to sample size
- One sample represented the entire population

The reasons for those factors, and the consequent sample size, are now briefly discussed.

While values for Confidence Interval and Confidence Level are to some extent a matter of choice, the decision does have important practical effects. The greater the confidence required in survey results, the larger the necessary sample size. Survey time and resources must increase accordingly. As a simple illustration, for every one sample undertaken at a 99% Confidence Level, more than one and a half similar samples could be processed at 95%, and almost two and a half samples at 90%. [366] However, if the confidence parameters are set too low, survey results will be unreliable, and incapable of valid inference or possible generalisation.

Different sample size formulae apply to continuous and categorical variables. Where both types of variable are present, the formula for categorical variables should be used. [367] This research primarily dealt with categorical variables.

The variance is a measure of the relative percentage of occurrence of a variable in a sample. For large samples, the variance of the sample proportion is a good estimator for that of the population. [368] The value for variance is critical to sample size, but, as in this case, is usually unknown before the survey takes place. This

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366 Based on M. C. Drott, 'Random Sampling: A Tool for Library Research', *College & Research Libraries* 30, 2 (Mar, 1969), 124, Table 1.

367 Bartlett, Kotrlik and Higgins, 'Organizational Research', 46. The authors also cited (44) Cochran's argument that researchers may wish to choose from a range of potential sample sizes in some circumstances: Cochran, *Sampling Techniques*, 81-2. This research used the formula for categorical variables, accepting the consequently larger sample size.

368 Foreman, *Survey Sampling Principles*, 16-19, 33-36.

research therefore necessarily adopted the common practice of using the most conservative value of variance – 0.5, or 50% – although it maximised the sample size.[369]

Both the BCVM Project Archivist and I believed the pre-sampling survey's population size estimate to be very conservative. That was later shown to be the case.[370] However, even that initial estimate of 19,000 technical drawings negated the need to apply a Finite Population Correction (FPC) factor to the sample size calculation. When the proportion of sample size to population size – the sampling fraction – exceeds 5%, an FPC factor can be applied to reduce the sample size.[371]

The appropriate sample size formula for this sample's parameters[372] produced an uncorrected sample size value of 385 technical drawings.[373] Consequently, the sampling fraction was very low, and use of the FPC factor was not appropriate.

The sample size for this design was, though, rounded up to 400 drawings, for practical reasons. There was a once-only opportunity to select from the BCVM technical drawings population. It was possible that during later data collection or analysis, a drawing or drawing element might not be amenable to survey, for

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369 Mann, *Statistics for Business and Economics*, 439; Bartlett, Kotrlik and Higgins, 'Organizational Research', 45. Bartlett and others followed Cochran's suggestion to 'estimate or guess the structure of the population assisted by some logical mathematical results': Cochran, *Sampling Techniques*, 78-81. Cochran himself suggested (80) that a 'serviceable estimate … can sometimes be made from relatively little information'.

370 See Research Design and Methodology: 3.2.5 Revision to population size estimate, *105*.

371 When sampling without replacement from a finite population: Panik, *Advanced Statistics from an Elementary Point of View*, 328. Panik gave 5% as the limit for this FPC factor, as did Mann, *Statistics for Business and Economics*, 371, 389, and Bartlett, Kotrlik and Higgins, 'Organizational Research', 46-7. The latter cited Cochran, *Sampling Techniques*, 24-5, although Cochran actually said that the proportion could be as high as 10% 'for many purposes'. Drott, 'Random Sampling: A Tool for Library Research', 120, also gave 10% as the FPC limit.

372 Formulae differ in detail. Within the following examples, the formula given by Mann and by Bartlett and others was used. See: Krejcie and Morgan, 'Determining Sample Size for Research Activities', 607-610; Cochran, *Sampling Techniques*, 75-6; Mann, *Statistics for Business and Economics*, 439; Bartlett, Kotrlik and Higgins, 'Organizational Research', 47.

373 Rounded up from a value of 384.16, because a fraction of a case cannot be surveyed: Levy and Lemeshow, *Sampling of Populations: Methods and Applications*, 72. Many sources, though, give a figure of 384. See, for example: Drott, 'Random Sampling: A Tool for Library Research', 124; Krejcie and Morgan, 'Determining Sample Size for Research Activities', 607-610; Bartlett, Kotrlik and Higgins, 'Organizational Research', 47.

some reason. The over-sample enabled fifteen cases to be discarded before statistical rigour would be compromised.[374]

Sample structure

The research being exploratory in nature, it was hoped to gain a general view of engineering drawings from the survey. The sample should therefore be designed to represent the BCVM Surviving Population as a whole. That approach would also best enable the sample to be cautiously generalisable to similar populations within vehicle engineering, and perhaps to be more broadly indicative of wider populations with similar profiles.

The sample design therefore used several techniques in combination to achieve the best possible representation of the population. The structure of the sample to be drawn therefore was:

- Proportionally stratified
- Partly random
- Partly systematic
- With replacement
- Both single-stage and two-stage

I now describe how those techniques of stratification, and random, systematic, and multi-stage sampling were applied.

<u>Stratification</u>

The pre-sampling survey had identified technical drawings from many different enterprises. Their boundaries were not at all clear-cut, and their groupings ranged considerably in size. A representative sample could not be drawn from one straight cut across the entire population. That approach would risk bias in the sample through under- or over-representation of drawings from any particular enterprise. Sample stratification was clearly called for.[375]

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374 Only 385 cases were required to achieve results within the survey's confidence parameters; the presence or absence of the additional fifteen cases had no practical effect.

375 See, for example: Cochran, *Sampling Techniques*, 89-96; Levy and Lemeshow, *Sampling of Populations: Methods and Applications*, 121-143.

I chose proportional stratification, because there was no basis upon which to employ optimum stratification. [376] The pre-sampling survey had identified thirteen principal enterprises, and there were very likely more to be discovered. There was little objective evidence upon which to decide which of those enterprises were of sufficient of interest to over-sample, and importantly, by how much other enterprises should be consequently under-represented.

The pre-sampling survey had enabled me to identify five discrete strata of drawings. A Sampling Frame – Table 5 and Table 6, following – formalised the make-up of the strata in the population, and the quantities of the strata members, such that a sample could be drawn.

There were only 400 drawings to collect from this c19,000-member population. The number of drawings to be collected from each stratum was proportional to the size of that stratum within the sampled population. The 'AEC' and 'Leyland Alpha' strata clearly contained significantly more drawings each than the other three, less well-defined, strata.

<table>
<tr><th>Enterprise</th><th>% of Total First-stage Sampling Units</th><th>Indicative Number of First-stage Sampling Units</th><th>Total Indicative Number of First-stage Sampling Units</th><th>Individual Numbers of Sampled First-stage Sampling Units</th><th>Total Number of Sampled First-stage Sampling Units</th></tr>
<tr><td>AEC</td><td>32.29%</td><td>618</td><td rowspan="5">1,914</td><td>13</td><td rowspan="5">40</td></tr>
<tr><td>Leyland Alpha</td><td>36.68%</td><td>702</td><td>15</td></tr>
<tr><td>Park Royal, Bristol</td><td>7.63%</td><td>146</td><td>3</td></tr>
<tr><td>Leyland Beta</td><td>9.82%</td><td>188</td><td>4</td></tr>
<tr><td>Other Enterprises</td><td>13.58%</td><td>260</td><td>5</td></tr>
</table>

Table 5: The Sampling Frame: First-stage sampling units: Gatherings of technical drawings

376 See: G. W. Snedecor and W. G. Cochran, *Statistical Methods*, 7th ed. (Ames, IA, 1980), 7, 434-5; Cochran, *Sampling Techniques*, 89-99.

Enterprise	% of Total Technical Drawings	Indicative Number of Technical Drawings	Total Indicative Number of Technical Drawings	Individual Numbers of Sampled Technical Drawings	Total Number of Sampled Technical Drawings
AEC	32.29%	6,180	19,140	129	400
Leyland Alpha	36.68%	7,020		147	
Park Royal, Bristol	7.63%	1,460		31	
Leyland Beta	9.82%	1,880		39	
Other Enterprises	13.58%	2,600		54	

Table 6: The Sampling Frame: Second-stage sampling units: Individual technical drawings

At that point, given the diversity of the population, I did consider whether the sample should be extended. There were two possible options if I did so:

- Draw larger samples – up to a full 400-member sample – from each individual enterprise that could be identified
- Use the optimum sampling technique within the smaller strata, to provide more information for the less well-represented enterprises

I decided not to take either option. While more 400-member samples would have provided a wider information base for the entire research, time for sample identification and collection was very limited. The Project Archivist's work could not stop while further sampling frames were constructed. Additional samples would also have magnified the overall research task.

Furthermore, the indicative quantity of technical drawings to be acquired for this research had already been agreed with the BCVM. It would not have been ethical to go beyond that agreement, and there was little time available for its renegotiation.

<u>Sampling techniques</u>
Two different combinations of sampling techniques were used to draw the stratified sub-samples. One approach was used for the two larger strata – 'AEC'

and 'Leyland Alpha'. These two strata accounted for almost 70% of the total sample to be drawn.

The second approach drew the sub-samples from the three smaller strata – 'Park Royal' and 'Bristol', 'Leyland Beta', and 'Other Enterprises'. These three strata made up the remainder of the sample – slightly more than 30%.

Both sets of techniques drew the samples in two stages, but in different ways, as now briefly described.

<u>Randomising the sample</u>
1,914 first-stage sampling units had been identified by the pre-sampling survey. Before sampling commenced, those units were intellectually disarranged. The units were then through-numbered in their new random order. This procedure was intended to break up any periodic arrangement that might have been present in the population. A sample could then be more validly drawn using systematic sampling techniques.

<u>Sampling the larger strata</u>
The AEC stratum is taken as an example of how the sub-samples were drawn from the two larger strata. Only 129 drawings were required to be drawn from a population estimated to be c6,180 drawings. The population was contained within 618 folders – first-stage sampling units.

To ensure that the sample was drawn from across the entire AEC population, systematic sampling was used to draw a first-stage sample. Thirteen folders were systematically selected.[377] These folders were found to contain a total of 417 drawings – an above-expected average of almost thirty-two drawings per folder.

To draw the second-stage sample, 129 random numbers were generated across the range 1–417. The first-stage sample was through-counted, and the appropriate drawings selected to make up the final sample for the AEC stratum.

377 The first folder drawn (#41) was randomly selected within the sampling interval of one to forty-seven. Every forty-seventh folder thereafter was then selected, to the end of the sequence, to produce the required thirteen first-stage sampling units.

Sampling the smaller strata

Each of the three smaller strata required significantly fewer drawings to be sampled than were drawn from the two larger strata. The 'Park Royal' and 'Bristol' stratum is taken as an example. Only thirty-one drawings were to be taken from an estimated 1,460 drawings within 146 first-stage sampling units.

Given this very low sampling fraction, only a systematic drawings-level approach was likely to ensure that samples were drawn from across the stratum. Thirty-one first-stage sampling units – plan chest drawers, in this case – were therefore systematically selected.[378]

The technique for drawing the second-stage sample differed from that employed for the larger strata. A random number (4) was drawn across the range between one and ten.[379] The fourth drawing from each of the thirty-one drawers was then selected as the sampled drawing, to produce the sample for this stratum.

Validity of the sample

The validity of the drawn sample can be considered. The principal risk was of bias in the sample caused by a periodic arrangement of technical drawings, which might affect the samples drawn by systematic sampling. That risk was largely countered by the initial intellectual rearrangement of the 1,914 first-stage sampling units. The samples from the larger strata were also less susceptible to that risk because their second-stage samples were drawn randomly.

The samples from the smaller strata were more vulnerable to systematic arrangement bias because both sampling stages used systematic sampling. However, these strata contained inherently less well-ordered drawings of diverse enterprises. They also made up less than one third of the total sample.

A separate risk of bias occasionally arose when the Project Archivist wished to preserve technical drawings that had been selected for sampling. In such cases, he followed agreed procedures to select alternative drawings. These interventions had minimal practical affect on the sample.

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378 The first drawer taken was #3, within the sampling interval of one to five. Every fifth drawer thereafter was then selected to the end of the sequence, to produce twenty-nine first-stage sampling units. The final two units were drawn using random sampling.

379 Maintaining the assumption that each first-stage unit held at least ten technical drawings.

It is therefore argued that the sample was drawn such that valid results could be derived from its survey.

Drawing the sample

The sample was drawn, within these described parameters, during the latter phases of the BCVM cataloguing project, between November 2006 and March 2007. A separate purposive selection of technical drawings was also made, to provide examples of as many different drawings' genres and media as could conveniently be taken. The sample and selections were removed to my research office for later survey.

3.2.5 Revision to population size estimate

The results of the larger strata sampling procedures enabled a better estimate to be inferred for the size of the BCVM Sampled Population. The following approximate drawings population sizes were indicated:

- AEC 19,776
- Leyland Alpha 27,568
- TOTAL <u>47,344</u>

Given that those two strata represented an originally estimated 68.97% of the total sampled drawings population (*N*), a revised estimated total *N* can be calculated, where:

$$N = \frac{47{,}344 \times 100}{68.97}$$

Total estimated population *N* of the
BCVM Sampled Population
therefore =
68,644 technical drawings

3.3 Data Collection Through Sample Survey

The technical drawings' data survey was the central research activity, carried out on the sample of technical drawings that had been drawn. A descriptive survey,[380] it was used to estimate the frequencies of occurrence of defined concepts and characteristics – the statistical variables – within the sampled population. Those variables that were found to be generic, or nearly so, would be investigated further, to assess their usefulness in making technical drawings more comprehensible. The results of the survey are reported in Chapter 4, and discussed in Chapter 5.

The survey was designed and conducted following published principles.[381] The sample had been designed to ensure the statistical validity of the survey results. They could be replicated, inferred to the sampled population within known confidence limits, and tentatively generalised more widely.

The concepts and characteristics for which data were to be collected had been initially defined, and would be refined during the survey itself.[382] In this section, I describe how, within the survey, those defined data were refined and collected with minimum error. The procedures that were employed, and now described, laid the foundations for robust survey results, effective statistical analysis, and inference. The procedures are first described conceptually. More practical aspects of data management are then described, in conclusion.

3.3.1 Data Collection

Data were collected solely from the 400-member sample of technical drawings. The outcome required from this Phase Four activity was a complete dataset of concepts, characteristics, lower level components, and their attendant terms, which was amenable to quantitative analysis. Data were derived from the technical drawings using content analysis – this time, in its standard form.[383]

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[380] A. J. Pickard, *Research Methods in Information*, (London, 2007), 96; K. Tanner, 'Survey Research', in *Research Methods for Students, Academics and Professionals: Information Management and Systems*, ed. K. Williamson, 2nd ed. (Wagga Wagga, 2002), 91.

[381] See, for example: Cochran, *Sampling Techniques*; Foreman, *Survey Sampling Principles*, 497; Levy and Lemeshow, *Sampling of Populations: Methods and Applications*, 525.

[382] See Research Design and Methodology: 3.1 Data Definition, *78*.

[383] Following, for example: Bernard and Ryan, *Analysing Qualitative Data: Systematic Approaches*, 289-90.

Granularity of collected data

Some conceptual components necessarily existed within every technical drawing – Information Form, and Primary Production Process, for example. Other components – Scale Indication, or Approved Signature, for example – were sometimes found, and other times not. Initially, therefore, it had been hoped that all survey data could be recorded simply at that level of 'Present' or 'Absent'. Such recording was thought sufficient to show the required frequencies of occurrence.

In practice, it was very often necessary to record data at more granular levels. Only then could data contexts be properly preserved, and similarities and differences in data presentation analysed. Ultimately, the knowledge that such contextualisation brought to understanding technical drawings would enable better guidance to be provided for archivists and researchers.

One important context was that of the position of a Data Element. That position could be defined either spatially or conceptually. [384] For example, a Data Element for the concept Drawing Reference Number might be found located in either the Top Left or Bottom Right standard positions of a technical drawing. Similarly, a signature could appear as either a Data Element within the Signature-Date concept, or within the Record of Changes concept. Recording such positions would enable the likely positions of individual elements to be given in practical guidance for archivists and researchers.

Such a practical need to accommodate contextual data was a major reason for the increased granularity in the technical drawings survey, and the burgeoning amount of data that was collected.

Collecting Data Values

A Data Value was recorded for every technical drawing component that was surveyed, at every level. Data Values were recorded in one of three ways – as a direct measurement of the component, as an exact transcription of the data found inscribed as the component's content, [385] or as a controlled term.

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384 Spatially, as a position within a standard position grid. Conceptually, as a position within a higher-level component, which was itself assigned a defined standard position.

385 Diplomatic analysis is concerned with the form of data, rather than the merit of its content. Nonetheless, in this exploratory research, I decided to capture textual data that existed within many Data Elements. I did not know what data would be important in analysis. I anticipated

For example, the Data Value for the width of a support was recorded as a millimetric measurement. A simple number was recorded for the value of the number of views inscribed upon a drawing. The Label Value of a Label Element was always recorded as a diplomatically exact transcription. So, too, were the values of Data Elements such as the name of the enterprise to whom a drawing was attributed. The importance of accurately recording such transcriptions is highlighted in discussion, later.[386]

Where Data Values were not manifestly present, it was necessary to record a controlled term. The simplest such Data Value term – 'Present' – was used to record the mere presence of a technical drawing component. Referring back to the previous examples of contextual data, a Data Value for the spatial position of a Drawing Reference Number could be recorded as 'Bottom Right'. A signature might be recorded as being 'Present' within the conceptual position 'Record of Changes'.

A particular merit of the Data Definition Phase lay in the large number of such controlled-term Data Values that could be pre-coded into the survey instruments.

Missing Data Values

A special type of controlled term was the Missing Data Value. Three types of Missing Data Values were defined: 'Absent', 'No Data', and 'Not Known'.

'Absent' was recorded in the following instances:

- Where a pre-defined Data Element was absent
- Where a pre-defined Label Element was absent

'No Data' was recorded in the following instance:

- Where a Data Element was present, but a corresponding Data Value was absent.

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having to work with large data volumes that were decontextualised from their technical drawings. Although those large volumes would of course be expanded by the addition of Data Values, their absence was, I thought, likely to cause constant confusion. In the event, Data Values proved to be essential to understanding the other data that I collected.

386 See, for example: Discussion: Deeper diplomatic analysis, *219*; Legal Name Forms for Rights Owner, *221*.

‘Not Known’ was recorded in the following instance:

- Where, exceptionally, it was not possible to determine the presence of particular data, whether it be a Data Element, Data Value, Label Element or an Element Value. For example, instances occurred of a reproduced technical drawing being so dark in places as to obscure the required detail. In other cases, some data were physically missing due to losses to the support.

Effect of Missing Data Values on sample size

Instances of ‘Absent’ and ‘No Data’ had no effect on the sample size, or on the subsequent statistical analysis. Their ‘non-presence’ correctly contributed to the calculation of frequencies of occurrence.

Instances of ‘Not Known’, by contrast, entailed a local reduction to the sample size for the relevant data. Such reductions were noted in the survey results and incorporated into the relevant statistical analysis. They had no material effect, however. It will be remembered that the required sample size was a minimum of 385 members. The sample was though overdrawn to 400 members, to allow for just such difficult cases. Fifteen sample members could therefore be lost before the validity of statistical analysis became affected. That degree of loss was not even approached during the survey.

3.3.2 Survey procedure

The Technical Drawings’ Survey was carried out in stages, between April 2007 and September 2009.

Data collection sets

A purposive selection had been made of the concepts and characteristics to be surveyed, to reduce their quantity to a manageable level. [387] Nonetheless, a very large volume of data remained to be collected from each of the 400 technical drawings. That was an impossibly large task to be carried out in one operation. The survey was therefore split into a number of smaller data collection sets and data collection runs.

[387] See Research Design and Methodology: 3.1.4 Purposive selection of concepts and characteristics for survey, *83*.

Eight sets of concepts and characteristics had been developed initially, to bring together those that ostensibly shared common characteristics. The practicalities of data collection prompted a change to that approach. The concepts were regrouped to bring together those whose data could be most easily collected concurrently. That change had no adverse effect upon data collection or analysis. The final data from each set were eventually all aggregated, in common form, into one dataset for the Technical Drawings' Survey.

First data collection run

All eight sets were subjected to at least two data collection runs; some more problematic data underwent a third run. Two concurrent activities were carried out during the first run – quantitative data collection and qualitative data testing.

Quantitative data were collected for the occurrence of the concepts and characteristics that had already been identified within the Data Definition Model. Concurrently, the utility of those concepts and characteristics was qualitatively tested as part of the content analysis that was being undertaken.[388]

In some cases, those existing concepts and characteristics needed to be changed, to a greater or lesser degree, to fit with the reality of the emerging survey data. In other cases, completely new characteristics – and, more rarely, concepts – had to be developed. In every case, data that were manifestly evident in a technical drawing were not inferred to mean something that they were not, just to fit a pre-existing definition.

The Data Definition Model was iteratively modified to reflect those changes to concepts and characteristics. The changes were made on the fly whenever possible. More complicated changes were sometimes held over until a convenient time, normally at the end of the run.

Once those new or changed concepts and characteristics had been incorporated into the structure of the Data Definition Model,[389] they, too, could be used to guide quantitative data collection. The technical drawings affected by those changes were always re-surveyed to capture such new quantitative data.

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[388] See Research Design and Methodology: 3.1.6 Pre-testing the concepts and characteristics, *86*.

[389] In content analysis terms, in a 'case-by-variable matrix': Ibid., 290, 293-4, 297-8.

Subsequent data collection runs

Once all held-over changes had been made, at the end of the first data collection run, a second run was carried out. The same approach was taken to any issues that arose. Where necessary, a complete or partial third and final data collection run was also carried out, to resolve any final problems. Each data collection set was deemed to be as complete and accurate as was practicable by the end of its third data collection run. The final run for each of the eight sets produced eight definitive sets of data, for aggregation into a Technical Drawings' Survey dataset.

Time taken for data collection

The time taken for each data collection run varied considerably.[390] Taking data collection as a whole process, an average total time of 50 minutes was spent collecting all the required data from each technical drawing.[391] This figure has some worth for planning similar data collection exercises in the future.

3.3.3 Bias, error risks, and mitigation

The main sources of error to be expected in the Data Collection phase of the research, in relation to data that were manifestly present, were:

- Failing to code data, because, for example, it was obscured, or simply overlooked
- Incorrectly coding data, for example through data entry errors

In addition to the above errors, latent data might have been incorrectly coded through incorrect inferences having been made, through either confirmation bias or other forms of researcher-induced bias.[392]

The principal defence against possible manifest data errors lay in the separation of data collection into comparatively small data collection sets and multiple collection runs. The sets were designed to be self-contained, internally coherent, and of a manageable size. The reiterative approach to the data collection runs

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390 Relevant factors included the complexity of the discovered data, and the degree to which concepts and characteristics had already been defined, or had to be created on the fly.

391 Some 330 hours were taken up with collecting all the survey data, and with concurrent code checking. That time was almost all contained within a period of some twenty-nine weeks, interspersed with other research work.

392 R. S. Nickerson, 'Confirmation Bias: A Ubiquitous Phenomenon in Many Guises', *Review of General Psychology*, 2, 2 (1998), 175-220; B. Allen and D. Reser, 'Content Analysis in Library and Information Science Research', *Library and Information Science Research*, 12, 3 (Jul - Sep, 1990), 258.

allowed issues to be resolved in a flexible way. Extensive notes were taken during data collection, rather than relying upon memory. That particularly helped to ensure that modifications to the Data Definition Model were retrospectively applied to all affected technical drawings, by re-survey.

Manifest data errors were perhaps most likely to arise from physical and intellectual fatigue. Despite the good office conditions, handling the large-format technical drawings required sustained physical effort over long periods. At the same time, countless thousands of individual data elements required careful extraction, interpretation and recording. Data collection was therefore carried out intermittently, over a period of some seven to eight months. It was then laid to rest before final checking and analysis, while other research work was carried out. That approach followed the suggestion that a single coder might 'ensure against' inconsistencies in coding by re-coding the same data 'after a span of time'.[393]

Latent coding would seem to be particularly at risk to 'researcher-induced bias' – for example, subtly [or unconsciously] influencing judgments made, to attain a desired research outcome.[394] However, I had no prior expectations of the results that the subsequent analysis of the data might bring. Any bias that I might have introduced could therefore only have been unconscious, undiscoverable, and hence irrecoverable. I do not think, though, that any such bias was introduced to any degree sufficient to invalidate the results.

4. Research design and methodological limitations

General limitations on the research have been previously discussed.[395] Here, I briefly discuss a single but important limitation that is inherent in the research design and methodology. It is the extent to which it is possible to generalise from the results of this research.

In essence, it is not possible to generalise these results reliably – nor any other results that are obtained through similar statistical methods. The statistical procedure of estimation only enables reliable inferences to be made from sample

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393 Ibid., 258.

394 Ibid., 258.

395 See Introduction: 8.2 Research Limitations, 32.

statistics to the populations that the samples represent. Those inferences are made within the confidence limits that are established for every individual sample.[396]

If such results are generalised to other populations, it is not possible to know how valid such generalisations might be. Clearly, generalisation to a population with a profile similar to that from which a sample has been drawn might produce more reliable indications than generalisations made to less analogous populations. Nonetheless, such generalisations are indicative, at best.

5. Data Management

Noteworthy matters of data management are briefly described in this chapter's final section, as part of the research aim to provide a generalisable methodology.

Data management techniques, tools and instruments had to be developed or acquired for use in the Data Collection phase. Five main issues influenced the development of the data management solutions:

- The large volume of data to be acquired and processed
- The statistical analysis techniques that the results would require
- Data version control and back-ups
- Data storage and long-term preservation needs
- Very limited time, finance, and other support for technical development

5.1 Data Analysis Software

SPSS Statistics[397] was chosen as the data analysis software. It would provide every analytical technique that the investigation would be likely to need. Although a proprietary software, data could be exported in formats suitable for long-term preservation.[398] It was freely available through institutional licensing.

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396 Bryman and Bell, *Business Research Methods*, 203.

397 During 2009, SPSS *Statistics* was briefly renamed PASW *Statistics*. At the time of writing (2010), it had been renamed IBM SPSS *Statistics*. The name SPSS *Statistics* has been used here to refer generically to the Base versions 15.0 – 17.0 that were used during this research.

398 Available formats for SPSS *Statistics* v17.0 included tab-delimited (*.dat), comma-delimited (*.csv), and Fixed ASCII (*.dat). Data definition files are required in addition to the data content files. Data can also be exported to MS Excel, and to other spreadsheet and database formats.

5.1.1 *SPSS Coding*

The SPSS codebook contained the complete set of coded variables that were defined, coded, and used in the survey. Those variables all derived from the concepts, characteristics, attributes, facets, and terms that had been determined in the Data Definition Model.

Each technical drawing's collected data was identified by a primary key termed 'Sample Number'. That was a simple running number, 1 to 400. Each 'Sample Number' corresponded to a more complicated 'IoP Number' [399] that had previously identified each individual drawing since sample selection. [400]

As far as possible, the survey was designed to ask only closed questions. [401] They were coded in the form of qualitative, categorical – or, hereafter – nominal variables. As far as possible, numerical response values were pre-coded into SPSS *Statistics*' 'Value Labels' data element.

The simplest type of nominal variable required only one of two response values, typically 'Absent' or 'Present'. Other nominal variables required far more than two response values – sixty-five values for one variable, for example. [402]

Two types of quantitative variables were also used. Discrete variables were typically used to record the numbers of views within a technical drawing, again using pre-coded response values when possible. Interval variables were used for linear dimensions, and dates. Some open-ended questions were also necessary. Responses were coded as textual string variables. [403]

The three types of missing data response values – 'Absent', 'No Data, and 'Not Known' – were coded '-9', '-7', and '-5' respectively. These negative values were used to differentiate them visually in data files from the very many positive response values that were used.

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399 'Instruments of Power' Project Number.

400 We are cautioned not to use SPSS case numbers, which are independent of case row data in SPSS databases: J. Pallant, *SPSS Survival Manual*, 3rd ed. (Maidenhead, 2007), 31. The use of AutoNumber in MS *Access 2003* was also avoided during data entry form development: J. L. Viescas, *Microsoft Office Access 2003 Inside Out* (Redmond, WA, 2004), 389.

401 Pallant, *SPSS Survival Manual*, 8-9.

402 Variable: Scale – Drawing – Given.

403 For example, a technical drawing title, or the name of the creating enterprise.

5.2 Data Entry

Data entry options fell between hard-copy survey instruments and keyboard inputting, or direct data entry via soft-copy data entry forms. Both would present their own benefits and problems. I opted for soft data entry forms.

While hard copy would be superficially easier to use with large format technical drawings, an additional layer of data entry risks would be incurred. Revisions to the data structure and data value tables would also be more difficult in hard copy. Bespoke direct entry data entry forms seemed to offer the best solution. There would though be a large time and work overhead in setting them up. [404] Again, a balance had to be struck. The aim was to not to produce a perfect solution, but a workable one that would facilitate reliable results.

The data entry forms had to capture and hold data in a format that was suitable for import into SPSS *Statistics*. Regrettably, a licence for the SPSS data entry tool *Data Entry Builder* [405] was not available, initially. MS *Access 2003* was therefore used to develop the first two data entry forms. [406] That was a difficult and time-consuming task. A licence then became available for SPSS *Data Entry Builder*, and the *Access* approach was gladly abandoned.

Forms' development using *Data Entry Builder* was also not without its problems, especially in the early stages. [407] However, much knowledge was gained throughout the forms development process, and a well-developed suite of data entry forms was finally used very successfully.

Again regrettably, by 2010, *Data Entry Builder* had been discontinued and was no longer supported. A renewal licence code was not available, and the suite of

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404 'A major part of the preliminary work [of survey data collection] is the construction of record forms on which the questions and answers are to be entered.' Cochran, *Sampling Techniques*, 6.

405 *Data Entry Builder* (final release v4.0.2) enabled both form design and data entry into designed forms. A reduced-functionality version, SPSS *Data Entry Station*, allowed only data entry into forms designed in *Data Entry Builder*. At the time of writing (2010) these products appeared to have been replaced by newer software within the IBM SPSS Data Collection Family: http://www.spss.com/software/data-collection/ (accessed 04 Mar, 2010).

406 The intent was not to create an *Access* database as such, but just to use its form design, data entry and data storage capabilities. The data would then be exported into SPSS *Statistics* for analysis in Text File format. Files in that format would also be used for long term data storage and preservation.

407 Initially, v4.0 was used, which frequently crashed during forms' creation. The problem was eventually traced to a bug, which was substantially corrected by v4.0.2.

data entry forms created for this research was no longer accessible. Data collection had fortunately been completed. The survey data had already been exported to other formats, which remained accessible. Had the product been withdrawn earlier in the research, the consequences could have been serious. [408]

5.3 Data back-up and version control

Data could not be collected from all 400 cases within one single data collection run. A discrete data file was therefore created for each partial run, each file building upon the previous one, until all 400 cases had been surveyed for each dataset. The advantage of this incremental file technique was that the immediately previous file provided a back up. Comparatively few data were therefore lost in the event of technical or other problems during any one data collection run. Each incremental file was also backed up, for additional protection. Finally, complete copies of all research data were regularly and periodically backed up to off-site storage.

Strict version control was maintained though explicit file naming and the use of File Properties, to indicate the data set, the progress of the data collection run, and the status of the file itself. [409]

[408] A well-recognised problem with proprietary software, for which no solution seemed to be available in this instance, despite considerable endeavour.

[409] For example: Working, Collected, Edited, Analysed, Back-up.

Chapter 4: Technical Drawings Survey: Results and Analysis

1. Introduction

This chapter presents the results of the technical drawings' data survey. The ways in which the raw data were converted into reportable results, though processing and analysis, is outlined. The means by which *post-hoc* Confidence Intervals were calculated is explained. So, too, is the way in which manifest and latent qualitative data were characterised.

Of the 642 surveyed variables, 268 provided data of sufficient importance to warrant formal reporting. The data from those variables have been aggregated into seventy-four sets of reported results. A short narrative accompanies each set.

The raw data for all 268 variables are reproduced at Appendix C, to enable verification of the analysed results and findings. The raw data for all 642 surveyed variables are contained within digital media at Appendix D.

Following this introductory section, this chapter prefaces and presents the results under the following headings:

- Raw survey data
- Data processing
- Data analysis
- Selection of results
- The results

The results presented in this chapter will be discussed in Chapter 5, in the context of the literature.

2. Raw survey data

A total of 642 unique variables were selected for survey. [410] Each variable contributed one value for each of the 400 cases in the data survey. The resulting

[410] With two additional variables – SAMPLENUMBER and IOPNUMBER – used for case identification. IOPNUMBER was a reference code originally allocated to a technical drawing

total volume of raw survey data therefore approximated to a little more than a quarter of a million individual databits. These databits ranged in size and complexity. Some were simple numerical counts of quantities, some were categorical controlled terms, while others were directly transcribed text strings.

It was realised at that time that the original coding of 'Absent', and 'No Data' as Missing Data Values was not appropriate to most of the analyses that would be required. Such Missing Data Values would be excluded from SPSS-generated analyses, whereas those values should be included. The categories 'Absent' and 'No Data' were therefore recoded as Valid Values for the relevant variables, leaving only 'Not Known' as a generally used Missing Value. This change had no effect on the validity of the collected data. It was a technical adjustment only, but one worthy of note for the benefit of similar future research. [411]

The third category of Missing Data – 'Not Known' – enabled a valid sample size to be determined for each individual variable. This category needed to be little used within those variables for which data could be generally determined. [412]

The raw survey data were processed and analysed, as now briefly described. The results of the analysed data are then reported in the remainder of the chapter. Findings are derived from those results during the discussion in Chapter 5.

3. Data Processing

Once collected within SPSS *Statistics*, the raw data underwent a number of data processing operations. First, an SPSS 'Frequencies' output was generated for all variables, to check for completeness of data collection. Next, all data were error checked. [413] Out-of-range values and other errors were resolved as necessary, normally by physically re-checking the data against the sampled drawing.

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during the sample survey. SAMPLENUMBER was a simpler running number, 0001 – 0400, allocated to the drawings in the final sample.

[411] For each variable, therefore, the number of cases considered for analysis equalled the sum of 400 minus any cases of 'Not Known'. Within each variable, the frequencies of occurrence for each value – including 'Absent' and 'No Data' – were calculated as a proportion of that sum.

[412] In contrast to those few variables for which data were generally difficult or impossible to determine – material colour, for example.

[413] Following Pallant, *SPSS Survival Manual*, 44-8.

The next step was to ensure that all the survey data that were to be statistically analysed were in quantitative form. Many data, derived from closed questions, were already coded as quantitative categorical variables. Those categories had been facilitated by the Data Definition Model, as previously noted.[414] At this stage, it was also possible to convert some qualitative text-string responses, to open-ended questions, into quantitative form. Other text-string responses were, though, required to remain in qualitative form.[415]

Finally, a further 'Frequencies' output was generated to confirm that all issues had been resolved, and that the survey data were now clean and fit for statistical analysis.

4. Data Analysis

Only descriptive statistics were required of the survey data. The final error-checked SPSS *Statistics* 'Frequencies' output files were used for those analyses.[416]

The first step was to determine the frequencies of occurrence of categories of data for and within each of the 642 survey variables. Those frequency results provided the starting point from which to consider which variables had provided data of potential research interest. Eventually, less than half of all the surveyed variables – 41.8% – would contribute data to the research's reported results and findings.

4.1 *Post-hoc* calculation of Confidence Intervals

It will be remembered that to be sufficiently of interest at first sight, a variable would have to produce useful data in at least 91% of the surveyed cases. A point estimate of occurrence of 95%, with a Confidence Interval (CI) of +/- 5 percentage points, at a Confidence Level (CL) of 95%, had therefore been chosen in the survey design. Those confidence limits assumed a sample size of not less than 385 cases.[417]

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414 See Research Design and Methodology: 3.1.1 Purpose of data definition, *78*.

415 Drawing Title, and Drawing Reference Code, for example.

416 Using PASW [SPSS] *Statistics* v17, within which the pre-programmed output only provided results to one decimal place, causing rounding errors for some results. All such instances were manually re-calculated for analysis to two decimal places.

417 See Research Design and Methodology: 3.2.4 Sample design, 93.

An individual *post-hoc* Confidence Interval (CI) was generated for each variable of interest, using the values for the surveyed frequency of occurrence and the sample size in each case. [418] Each individual frequency of occurrence, reported below, is accompanied by such a CI value, all at 95% CL. Those CI values are unexceptional for the results that were generated within the designed sample size. Where, in some cases, much smaller sub-sets of results were analysed, the Confidence Interval was wider, as was to be expected. The sample size from which those results were derived is reported in each case.

4.2 Statistical tests

No statistical tests were appropriate for these simple descriptive statistics. [419] Their limits of inference to their parent population are indicated by the individual variables' *post-hoc* Confidence Intervals at the 95% Confidence Level.

Statistical tests could be used by other researchers repeating this study, to assess the validity of the results. Tests could also be carried out between these data and any future data generated by similar surveys and analyses, to assess their degree of correlation. [420]

4.3 Qualitative analysis

Initial qualitative data analysis brought new understandings to some concepts and characteristics of data collection, in terms that had not been employed hitherto.

The concept of manifest data was now characterised as data that was explicit. It was precisely and clearly expressed by a technical drawing through possession of one or more of three characteristics:

1. Observable – including mere existence
2. Measureable – e.g. dimensions and quantities
3. Calculable – e.g. the Representative Fraction of a scale

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[418] Using PASW [SPSS] *Statistics* v17 PROPOR Extension to determine binomial confidence intervals for proportions at 95% CL, following, for example: Mann, *Statistics for Business and Economics*, 241-2, and Dowdy, Weardon and Chilko, *Statistics for Research*, 70-3.

[419] I am grateful to Dr Chris Stride for his advice on this point.

[420] For example, Binomial and Chi-Square Goodness-of-Fit tests: Mann, *Statistics for Business and Economics*, 494-9, 553-9, 583-9, and P. R. Kinnear and C. D. Gray, *SPSS 16 Made Simple* (Hove, 2009), 13, 20-2, 168-171, 202-12.

By contrast, the concept of latent data could be characterised in only one way, when certain conditions were fulfilled. Latent data:

- were not directly expressed by a technical drawing
- but were adjudged to be implicit within it
- through inferences founded upon manifest data
- expressed by one or more of the three manifest data characteristics above.

5. Selection of Results

Following analysis, 268 variables were considered to provide data of sufficient importance to be reported here. The data from those variables have been aggregated into seventy-four sets of concepts and characteristics, which also form the basis for the discussion in Chapter 5.

These results go beyond those for concepts and characteristics that were found to be generic, important as they remain to answering the research question. As will be seen below, and in later discussion, the absence of data that might be expected to have been found has produced research findings of at least equal importance.

5.1 Presentation of results

The principal aim was to present results for the presence or absence of concepts and characteristics. Usually, it was much less important to know what Data Value might attach to any particular concept of characteristic. For example, it was important to know whether technical drawings might generically bear a Drawing Reference Code that might assist with their contextualisation and intellectual arrangement. In the context of this research, it was much less important to report individual Data Values for the Drawing Reference Codes themselves.

A few higher-level results that are reported might appear to be trivial or self-evident. They are given, not just for completeness, but because they are often required to underpin lower-level results, and later discussion.

Percentage values for frequencies of occurrence are given to one decimal place, unless descriptively qualified in text. The particular qualifier ‘some’ indicates a rounding to the nearest whole number.

Many instances of textual data were found inscribed in UPPER CASE. To ease readability, they have been re-cast into Title Case, unless their original form is essential to the text.

The results are presented in a scheme of arrangement that is identical to that used in the discussion chapter. An explanation of the development of the scheme is properly located there, and no explanation is therefore given here. Each principal section of these results is, though, referenced to the appropriate part of the discussion.

6. The Results

6.1 Medium

Two specific concepts were considered within the general concept of Medium:

- Medium of Support
- Medium of Process

The rationale for, and development of, these concepts and their characteristics is discussed in Chapter 5. [421]

6.1.1 Support Medium

Frequency of occurrence 100%

It is axiomatic that every technical drawing within the dataset requires a medium of support. This derived variable is though necessarily stated to underpin the following individual characteristics of the Support Medium specific concept.

6.1.2 Support Medium – form – material

Frequency of occurrence 100%

Reliable identification of support materials could only be carried out at a high level, as discussed later. [422] Data Values for the materials of support, across all cases, were recorded as Cloths (44%, CI 39.2, 48.9), Synthetics (40.5%, CI 35.8, 45.4), Papers (12.5%, CI 9.5, 16.0), Not Known (3%, CI 1.7, 5.0).

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421 See Discussion: 3.1 Medium, *164*.

422 See Discussion: Identification of support materials in this research, *167*.

6.1.3 Support Medium – form – dimensions

Frequency of occurrence 100%

Three of the four facets surveyed within the dimensions attribute – short dimension, long dimension, and regularity of dimensions – all necessarily occurred in 100% of cases.

Many supports were rather irregular in their shape. The minimum and maximum short and long dimensions were therefore measured for each support, to the next highest millimetre.[423] Where a dimension was irregular, only the maximum value was finally recorded.

The support itself was recorded as irregular if the difference between the minimum and maximum values for a dimension exceeded 1% of the minimum value. This percentage was arbitrarily set as one that was thought reasonably likely to indicate support material cut from a roll, rather than having been supplied as a pre-cut flat sheet.[424] Within this definition, 15.3% (CI 12.0, 19.0) of all supports were irregularly dimensioned.

6.1.4 Support Medium – form – dimensions – indication

Frequency of occurrence 46.8%, CI 41.9, 51.6

The fourth dimensions facet was the presence or absence of a data element that indicated a drawing's nominal size. Such an element was present in 46.8% (CI 41.9, 51.6) of surveyed drawings.

6.1.5 Support Medium – form – orientation of layout

Frequency of occurrence 100%

This characteristic recorded the orientation of the support. In some rare cases, this orientation might not be the same as the orientation of the technical drawing upon it.[425] Almost all supports in this sample were in landscape orientation. Two were in portrait orientation, and one was square.

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423 It was very difficult to visually detect all such irregularities, especially for translucent synthetic supports. All dimensions were measured at least twice, normally at their extremities. Maximum variations might though occur at any point. Furthermore, if a support shape is trapezoidal, and thus irregular, two parallel dimensions may still be within the 1% limit.

424 See Discussion: Support size and dimensional regularity, *169*.

425 See Results: 6.2.1 Presentation Style – Drawing Orientation – layout, *127*.

6.1.6 Support Medium – form – material presentation

Frequency of occurrence 100%

This characteristic recorded whether the support material was presented in flat (94.5%, CI 91.9, 96.4) folded (5.5%, CI 3.6, 8.1) or rolled (0%) format. The data would have importance for archival storage and preservation purposes. However, the characteristic is comparatively unimportant here, and is not discussed further.

6.1.7 Process Medium – Primary Production

Frequency of occurrence 100%

The term 'primary' defines here the process first used to create any individual technical drawing as a unique information artefact, no matter what the drawing's status as a draft, definitive, or derivative.[426] The primary process thus encompasses all forms of production and reproduction.

It is axiomatic that a primary production process was used to create content within all 100% of technical drawings. It was, though, necessary to define and collect data for this characteristic. The data enable differentiation between the process used to initially create a technical drawing, and those processes that may be used later to amend, correct, annotate or otherwise change it.[427]

6.1.8 Process Medium – Primary Production – form

Frequency of occurrence 100%

The primary production processes used to create technical drawings' content were only manifestly observable at the attribute level. The processes were of two distinct forms – manual drafting (63.3%, CI 58.4, 67.9 of all cases) and reprography (36.8%, CI 32.1, 41.6 of all cases).

The manual drafting process most often used (48.5%, CI 43.6, 53.4 of all cases) was classified as simple drafting. Other manual drafting primary production processes – tracing, inking-in, and re-drawing – were recorded as having been

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426 See Discussion: Table 8: Definitions of Concepts of Document Status, *158*.

427 See Discussion: 3.1.7 Amendments and Corrections, *179*, 3.1.8 Annotations and Deletions, *180*.

used in 14.8% (CI 11.5, 18.5) of all drawings. However, this statistic may not be reliable, as discussed later. [428]

A smaller number of drawings (7%, CI 4.8, 9.8 of all cases) bore an indication of a proprietary type of reprographic process. [429] The type of process could not otherwise be determined with confidence, for reasons discussed later. [430]

6.1.9 Process Medium – Primary Production – form – material

Frequency of occurrence 100% [431]

This characteristic defines the material used in the medium of the primary production process. Almost equal proportions of the manually drafted drawings were created using either pencil (30.2%, CI 25.8, 34.8 of all cases) or ink (29.6%, CI 25.3, 34.3 of all cases) alone. They were used in combination for primary production in only some 3% of drawings. [432]

The generic term 'chemical' was used to denote the process material in those cases (36.9%, CI 32.3, 41.8 of all cases) where reprography was the primary process medium. The primary production process material could not be determined in two cases.

6.1.10 Process Medium – Primary Production – position

Frequency of occurrence 100%

The primary production content was found positioned on either the front (72%, CI 67.5, 76.2) or the back (28%, CI 23.8, 32.5) of its support. In 35% (CI 30.4, 39.8) of all cases, this content was not on the same side as the drawing frame. [433] In all but one of those 140 cases, the drawing frame was on the back of a translucent support, and the content on the front. [434]

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428 See Discussion: Problems of identification of manual drafting processes, *175*.

429 In various name forms, indicating either the OZALID or VELOGRAPH processes.

430 See Discussion: Problems of identification of reprographic processes, *176*.

431 398 cases for the three statistics within this characteristic.

432 There was some inconsistency in differentiating between the separate use of pencil and ink, and the combined use of same. The latter result may therefore be less than normally reliable.

433 See Results: 6.2.4 Presentation Style – Drawing Frame – position, *128*.

434 Calculated by a cross-tabulation of the preceding results against Support Medium – form – material, which showed cloth, tracing paper and synthetic supports to be those involved.

6.1.11 Process Medium – Amendments and Corrections – form

Frequency of occurrence 59%, CI 54.1, 63.7

The statistics reported for all Amendments and Corrections characteristics are based on one individual process – that of simple drafting, within the more general concept of manual drafting. Other individual processes within that general concept – inking-in, re-drawing, and re-tracing – are excluded, as discussed later.[435]

Their omission does not create major difficulties. The simple-drafted Amendments and Corrections comprise the very substantial majority of all such changes to the drawings – 208 cases out of 400 (52%, CI 47.1, 56.9). The excluded cases number only an additional twenty-eight. If they were included, they would raise the frequency of occurrence of Amendments and Corrections by only seven percentage points, to 59% (CI 54.1, 63.7). That proportion is still considerable lower than that considered generic within the wider results' analysis.

6.1.12 Process Medium – Amendments and Corrections – form – material

Frequency of occurrence 52%, CI 47.1, 56.9

Individual processes other than simple drafting are once more excluded from the following statistics for material, again with minor effect. The process material most commonly used for Amendments and Corrections was ink. It was found used on its own in 62.5% (CI 55.8, 68.9) of the 208 simple-drafted amendment cases (32.5%, CI 28.0, 37.2 of all 400 cases). Pencil was found used in isolation in 28.8% (CI 23.0, 35.3) of the simple-drafted amendment cases (15%, CI 11.8, 18.7 of all cases). Ink and pencil were used in combination in 8.2% (CI 5.0, 12.5) of simple-drafted amendment cases (4.3%, CI 2.6, 6.6 of all cases).[436]

6.1.13 Process Medium – Amendments and Corrections – form – material – colour

Frequency of occurrence 52%, CI 47.1, 56.9

Compared with the colours of media materials, there was much less difficulty in recording colour Data Values for Amendments and Corrections.[437] Almost

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435 See Discussion: Problems of identification of manual drafting processes, *175*.

436 One case of the use of pencil crayon was also recorded.

437 See Discussion: Problems of identification and interpretation of colour, *178*.

without exception, ink was recorded as black, and pencil as grey, whether used independently or in combination.[438]

Black was recorded as a colour used in 65.0% (CI 58.7, 71.0) of the 208 simple-drafted amendment cases, and for 36.8% (CI 32.1, 41.6) of all 400 cases. Grey was used in 34.1% (CI 28.1, 40.4) of simple-drafted amendment cases, and in 19.3% (CI 15.6, 23.3) of all cases.

6.2 Presentation Style

This section of the results encompasses intellectual concepts and characteristics for the layout and form of the structural components within a technical drawing. The rationale for this new general concept is discussed in Chapter 5, following.[439]

6.2.1 Presentation Style – Drawing Orientation – layout

Frequency of occurrence 100%

As noted above,[440] rarely, the layout orientation of a technical drawing might not coincide with the orientation of the support that bears it. This characteristic therefore records the layout orientation of the graphical content of the drawing. In this sample, though, the orientation of each drawing did coincide with that of its support. It was, almost without exception, landscape.

6.2.2 Presentation Style – Drawing Orientation – view

Frequency of occurrence 97.3%, CI 95.3, 98.5

Here, orientation of view is the Presentation Style characteristic that records the depicted view of right- and left-handed parts within the graphical content of a technical drawing. Conventionally, one such set of parts is portrayed ‘As Drawn’, while information for the other set is required to be inferred by taking an ‘Opposite Hand’ view.[441]

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438 Red ink was also used in one case, and red pencil crayon in one other. Because colours were sometimes used in combination, the sub-totals for each colour sum to more than the overall frequency of occurrence of 52%.

439 See Discussion: 4.1 Presentation Style, *181*.

440 See Results: 6.1.5 Support Medium – form – orientation of layout, *123*.

441 See Discussion: Orientation of view, *183*.

This characteristic was valid for 97.3% (CI 95.3, 98.5) of all surveyed technical drawings.[442]

6.2.3 Presentation Style – Drawing Frame

<u>Frequency of occurrence 100%</u>

At its simplest, a drawing frame is a rectangular border situated some small distance from the outer edges of the support, enclosing the graphical content of a technical drawing. It can also be a considerably more complicated concept, comprising numerous elements that give structure to the entirety of the drawing's graphical and textual content and contexts. All 400 surveyed technical drawings contained a drawing frame.

6.2.4 Presentation Style – Drawing Frame – position

<u>Frequency of occurrence 100%</u>

A drawing frame may be positioned on either the front or the back of a support. It is often positioned on the back of a translucent or transparent support, such that the frame can only be viewed in the correct orientation by looking through the support from the front. If positioned on the front, the drawing frame can be read directly in the correct sense. In this sample, 62.5% (CI 57.7, 67.1) of the drawing frames were found on the back of the support, the remainder (37.5%, CI 32.9, 42.3) on the front.

6.2.5 Presentation Style – Signature-Date Block[443]

<u>Frequency of occurrence 99%, CI 97.6, 99.7</u>

All but four of the drawings within this dataset (99%, CI 97.6, 99.7) contained one of two forms of Signature-Date Block.[444] A date data element accompanied each labelled signature data element in 53% (CI 48.1, 57.9) of all cases. In 46% (CI 41.2, 50.9) of all cases, only one date data element was labelled within a Signature-Date Block.

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442 It was not valid for eleven drawings whose Information Form was not appropriate to handed presentation styles, e.g. diagrammatic drawings and some technical sketches.

443 Often, only a set of initials was used for certification purposes in both the Signature-Date Block, and in the various forms of Changes and Issue Tables, reported later. It is, though, neither practical nor necessary in this research to distinguish certification by initials from certification by signature. Unless the context requires otherwise, the term 'signature' is therefore also used, hereafter, to encompass certification by initials.

444 Statistic derived from a cross-tabulation of data for Signatures and Dates characteristics.

6.2.6 Presentation Style – Title Block

Frequency of occurrence 95.5%, CI 93.1, 97.2

Almost all drawings (95.5%, CI 93.1, 97.2) contained a Title Block. Its form, and the characteristics that it contained, varied considerably with a technical drawing's provenance and Information Form. The most significant common characteristic of the Title Block was its position. In 92.4% (CI 89.4, 94.7) of the 382 cases where it existed, the Title Block occupied the full width of the bottom of the drawing. In almost all other cases, it occupied the bottom right-hand area. [445]

6.2.7 Presentation Style – Materials List

Frequency of occurrence 95.0%, CI 92.5, 96.8

A Materials List was present in 95.0% (CI 92.5, 96.8) of all drawings. [446] It bore a label element in all but two of those cases, and was almost always (95.5%, CI 93.1, 97.3) positioned within the Title Block. [447] A Data Value was present within 76.3% (CI 71.8, 80.3) of the Materials Lists [448] (72.4%, CI 67.9, 76.6 of all cases). [449]

6.3 Language and Script

This general concept goes far beyond the traditional diplomatic concept of natural language. It is chiefly concerned with the ways in which the content of a technical drawing is articulated through technical language concepts of Scale, Drawing Aspect, and Dimensioning. The development of these concepts is discussed in Chapter 5, following. [450]

6.3.1 Natural Language

Frequency of occurrence 100%

The natural language used in all cases was English.

6.3.2 Technical Language – Scale – Drawing – indication

Frequency of occurrence 67.3%, CI 62.5, 71.7

A scale indication was given on 67.3% (CI 62.5, 71.7) of all surveyed drawings, although its predominant form (58%, CI 53.1, 62.8) was as a textual note, to the

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445 In one case, it occupied a space around the entire drawing frame.

446 399 cases for this statistic.

447 379 cases for this statistic.

448 379 cases for this statistic.

449 399 cases for this statistic.

450 See Discussion: 4.2 Language and Script, *185*.

effect that the drawing was not to be scaled. A much smaller proportion of drawings (22.3%, CI 18.4, 26.5) displayed an indicated scale.[451] In 13% (CI 10.0, 16.6) of drawings, both a 'Do Not Scale' note and an indicated scale were found.[452]

6.3.3 Technical Language – Scale – Drawing – measured RF

Frequency of occurrence 88.3%, CI 84.8, 91.1

Although scales were so infrequently given on the drawings,[453] an indicative scale could be measured and calculated as a Representative Fraction (RF) in 92.7% (CI 89.7, 95.0) of technical drawings for which scaling was appropriate[454] (88.3%, CI 84.8, 91.1 of all cases). This RF was coded as the drawing's predominant scale.

Where possible, individual views on a drawing were coded with an RF scale if they differed from the predominant scale. This occurred in 15.7% (CI 12.4, 19.7) of scalable drawings[455] (15%, CI 11.8, 18.7 of all cases).

6.3.4 Technical Language – Scale – Plan – measured RF

Frequency of occurrence 93.2%, CI 90.2, 95.5

Plan views were given on 89.0% (CI 85.6, 91.8) of all 400 drawings.[456] A scale was indicated in only one case. An RF scale could be determined in 93.2% (CI 90.2, 95.5) of the cases that were appropriate for scaling[457] (82.0%, CI 78.0, 85.5 of all cases).[458]

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451 Usually displayed either as a ratio, or as text. Only one technical drawing contained a scale bar.

452 The two individual statistics therefore sum to more than 67.3%.

453 See Discussion: Problems when inferring scale data, *192*.

454 353 of 381 cases for this statistic. The Information Form of 19 technical drawings was not appropriate to scaling. In a further 28 cases, the data within a drawing were insufficient to enable a representative fraction scale to be calculated.

455 381 cases for this statistic, with the immediately preceding caveat. SPSS variable 'Number of Scales – Measured RF' showed that there were two scales in 55 cases, three scales in 3 cases, four scales in 1 case, and five scales in 1 case.

456 399 cases for this statistic.

457 351 cases for this statistic.

458 399 cases for this statistic.

6.3.5 Technical Language – Scale – Elevation – measured RF

Frequency of occurrence 91.9%, CI 88.4, 94.6

Compared with plan views, fewer elevation views were found on the surveyed drawings – 75.4% (CI 71.0, 79.5).[459] However, the proportion of RF scales that could be determined was similar – 91.9% (CI 88.4, 94.6) of drawings appropriate for scaling[460] (68.7%, CI 64.0, 73.1 of all cases).[461] Again, only one drawing indicated a scale.

6.3.6 Technical Language – Method of Representation – indication

Frequency of occurrence 21.3%, CI 17.5, 25.5

The orthographic projection system used was indicated on only 85 of the 400 surveyed technical drawings (21.3%, CI 17.5, 25.5).

6.3.7 Technical Language – Dimensioning

Frequency of occurrence 93.3%, CI 90.5, 95.4

Dimensioning existed within 373 of the 400 drawings in the sample (93.3%, CI 90.5, 95.4).[462]

6.3.8 Technical Language – Dimensioning – System – indication

Frequency of occurrence 56.5%, CI 51.6, 61.3

The form of dimensioning system used by a technical drawing was manifestly indicated in 60.3% (55.3, 65.2) of the 373 dimensioned drawings (56.5%, CI 51.6, 61.3 of all cases).[463] In all cases, the indication was textual, rather than symbolic, and most often made by a prominent note.

In those cases,[464] 12.1% (CI 9.1, 15.7) of drawings indicated the use of only imperial dimensions, 21.2% (CI 17.3, 25.5) used metric dimensions, and 27.1% (CI 22.8, 31.8) used both imperial and metric dimensioning. For all cases,[465] the

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[459] 399 cases for this statistic.

[460] 298 cases for this statistic.

[461] 399 cases for this statistic.

[462] Data collection and analysis for these concepts and characteristics was restricted to simple lateral dimensioning. It did not look deeper – into tolerancing or angular dimensioning, for example.

[463] 398 cases for this statistic.

[464] 373 cases for these three statistics.

[465] 398 cases for these three statistics.

results were 11.3% (CI 8.5, 14.7), 19.8% (CI 16.2, 24.0), and 25.4% (CI 21.3, 29.8) respectively.

6.4 Special Signs – Enterprise Logos and Trade Marks

This concept records logos and trademarks that appeared on the sampled technical drawings. These Special Signs comprised both graphical and textual elements, either separately or in combination.

6.4.1 Enterprise Logos and Trade Marks

Frequency of occurrence 21.5%, CI 17.7, 25.7

A logo or trademark was present in only 86 of all 400 cases (21.5%, CI 17.7, 25.7). Those 86 cases contained a total of 168 instances of logos or trademarks. One such special sign was present in 21 cases, two signs were present in 48 cases, and three signs in 17 cases.

Of those 168 logos and trademarks, 33 instances comprised a graphical element only, while 12 instances comprised a textual element only. The great majority, therefore – 123 instances (73.2%, CI 66.2, 79.7) [466] – comprised both a graphical and textual element in combination.

6.5 Changes

The new general concept of Changes subsumes and considerably extends the traditional diplomatic concept of Annotations. It therefore also includes concepts and characteristics associated with Changes and Issue Tables, Amendments and Corrections, and Deletions. The Changes concept is discussed in Chapter 5, following. [467]

6.5.1 Changes – Changes Table

Frequency of occurrence 78.6%, CI 74.4, 82.5 [468]

The Changes Table provides a structure for a formal record of changes made to a drawing after its initial production and authorisation for use. In this sample, 78.6% (CI 74.4, 82.5) [469] of technical drawings contained a Changes Table.

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466 168 cases for this statistic.

467 See Discussion: 4.4 Changes, *200*.

468 398 cases for this statistic.

469 398 cases for this statistic.

A label element was always present with a Changes Table, almost always with the Data Value 'Alteration[s]'.[470]

6.5.2 *Changes – Changes Table – Number of Changes*

Frequency of occurrence 40.7%, CI 36.0, 45.6[471]

Of the 313 drawings that contained a Changes Table, 51.8% (CI 46.2, 57.3) of the tables noted at least one change[472] (40.7%, CI 36.0, 45.6 of all cases).[473] Within a range of zero to seventeen recorded changes, the most frequently occurring number of changes (28.6%, CI 22.6, 35.3)[474] was one (13.8%, CI 10.7, 17.5 of all cases).[475]

6.5.3 *Changes – Changes Table – Certification – Data Values*

Changes within the Changes Table could be certified by a signature and a date. Not all the technical drawings within the sample contained changes requiring such certification. However, for those that did, the frequencies of occurrence of Data Values for certifying signatures were surprisingly low. Data Values for the signatures data element were present in only 29.0% (CI 24.2, 34.2)[476] of cases (22.8%, CI 18.9, 27.1 of all cases).[477] For the dates data element, Data Values were only slightly low – 48.9% (CI 43.4, 54.4)[478] of cases (38.4%, CI 33.8, 43.3 of all cases).[479] These issues are further analysed and discussed later.[480]

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470 Two cases = 'Modifications', one case = 'Revisions'.

471 398 cases for this statistic.

472 Changes discussed in these sections were made to the instance of the drawing under examination. They do not include changes displayed as part of a reproduction of an earlier instance of the drawing.

473 398 cases for this statistic.

474 192 cases for this statistic.

475 398 cases for this statistic.

476 314 cases for this statistic.

477 399 cases for this statistic.

478 313 cases for this statistic.

479 398 cases for this statistic.

480 See Discussion: 4.4.3 Analysis of the Record of Changes, *203*.

6.5.4 Changes – Changes-Issue Table

Frequency of occurrence 18.5%, CI 14.9, 22.5

In a further 18.5% (CI 14.9, 22.5) of cases, a Changes Table was also found integrated with an Issue Table, which was always labelled as such. [481] This combination produced what I term a Changes-Issue Table. The aggregated frequency of occurrence for both the Changes Table and Changes-Issue Table was 96.8% (CI 94.7, 98.2). [482]

Each following result for a Changes-Issue Table characteristic also includes a separate result for aggregated Changes Table and Changes-Issue Table frequencies of occurrence.

6.5.5 Changes – Changes-Issue Table – Number of Changes-Issues

Frequency of occurrence 9.0%, CI 6.5, 12.1

Within the seventy-four drawings that included a Changes-Issue Table, 48.6% (CI 37.5, 59.9) of the tables noted at least one change (9.0%, CI 6.5, 12.1 of all 400 cases). Within a range of zero to ten recorded changes, the most frequently occurring number of changes (32.5%, CI 19.6, 47.8) [483] was one (3.3%, CI 1.8, 5.3 of all cases).

The aggregated Changes and Changes-Issue Table results [484] showed that 51.2% (CI 46.2, 56.1) of both tables indicated at least one change to a technical drawing (49.5%, CI 44.6, 54.4 of all cases). [485]

6.5.6 Changes – Changes-Issue Table – Certification – Data Values

The frequencies of occurrence of Data Values for certifying characteristics in the Changes-Issue Table followed the pattern found for the Changes Table. Data Values for the signatures data element were present in only 30.1% (CI 20.5, 41.3) of cases [486] (5.5%, CI 3.6, 8.1 of all cases). [487] The frequency of occurrence of dates

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481 Very few drawings contained a stand-alone Issue Table; it is therefore not discussed individually.

482 This statistic is based on the 400 cases for the Change-Issue Table frequency, rather than on the 398 cases for the Changes Table frequency. It thus produces the lower aggregated statistic.

483 40 cases for this statistic.

484 387 cases for this statistic.

485 This statistic is based on the 400 cases for the Change-Issue Table frequency, rather than on the 398 cases for the Changes Table frequency. It thus produces the lower aggregated statistic.

486 73 cases for this statistic.

Data Values was again only slightly low – 45.9% (CI 34.9, 57.3), [488] (8.5%, CI 6.1, 11.5 of all 400 cases).

The aggregated results for the Changes and Changes-Issue Tables therefore produced a similar pattern. Signature Data Values occurred in only 29.2% (CI 24.8, 33.9) [489] of aggregated cases (28.3%, CI 24.0, 32.8 of all cases). [490] The aggregated frequency of occurrence for dates was 48.3% (CI 43.4, 53.3) [491] (46.8%, CI 41.9, 51.6 of all cases). [492] Again, these lower than expected frequencies of occurrence for certification values are further analysed and discussed later. [493]

In some cases, the Changes Table and Changes-Issue tables also contained marginal notes associated with initial production – 'Inked-in', and 'Approved', for example. [494] Such notes occasionally duplicated similar notes in the Signature-Date Block. The frequency of occurrence of those notes never exceeded 7.1% (CI 4.8, 9.9) for a single concept, [495] and was usually considerably less. The frequency of occurrence for all such cases of marginal notes combined still only achieved 16.1% (CI 12.8, 20.0). [496] Although these instances were low in number, their interaction with other concepts and characteristics is noteworthy.

6.5.7 Changes – Amendments and Corrections – quantity

Frequency of occurrence 52%, CI 47.1, 56.9

The Amendments and Corrections that are recorded here are those that were made, for each drawing, on that drawing only. They do not include any Amendments and Corrections made on any earlier versions from which that drawing had been derived. The frequency of occurrence of cases of technical

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487 399 cases for this statistic.

488 74 cases for this statistic.

489 387 cases for this statistic.

490 Missing values for the underlying statistics vary from zero to two cases. This statistic calculated to produce the worst-case – lowest – frequency of occurrence: zero missing values = 400 cases.

491 387 cases for this statistic.

492 This statistic again calculated for the worst case: zero missing values = 400 cases.

493 See Discussion: 4.4.3 Analysis of the Record of Changes, *203*.

494 Also: 'Issued', 'Redrawn', 'Stage IV', and a new concept – 'Retraced'.

495 397 cases for this statistic, across both Changes Tables and Change-Issue Tables.

496 397 cases for this statistic, across both Changes Tables and Change-Issue Tables.

drawings containing at least one Amendment or Correction (52%, CI 47.1, 56.9) was determined with the caveat noted previously.[497]

Where they were present, the number of Amendments or Corrections varied considerably, within the range one to ten. In some cases, the number could not be determined.[498] Two Amendments or Corrections were most frequently found (27.5%, CI 21.8, 33.8) in those cases where they could be counted[499] (14.5%, CI 11.3, 18.2 of all 400 cases).

6.5.8 Changes – Annotations – quantity

Frequency of occurrence 52%, CI 47.1, 56.9

The frequency of occurrence of cases of technical drawings containing at least one Annotation (52%, CI 47.1, 56.9) was coincidentally the same value as that for Amendments and Corrections, above. The number of Annotations on any one drawing ranged from one to five. In the majority of cases where they were present[500] (70.2%, CI 63.7, 76.1) only one annotation was normally found (36.5%, CI 31.9, 41.3 of all 400 cases).

6.5.9 Changes – Annotations – Data Values

Frequency of occurrence 52%, CI 47.1, 56.9

The annotation most often found was the term 'MF'. It was manifestly obvious in 74.0% (CI 67.8, 79.6) of the 208 cases where drawings contained annotations (38.5%, CI 33.8, 43.3 of all 400 cases). This annotation could also be inferred in a further 8.2% (CI 5.0, 12.5) of those 208 cases (4.3%, CI 2.6, 6.6 of all cases). The MF annotation, and others of substance, is discussed later.[501]

What were inferred as certification initials were found in 15.4% (CI 11.0, 20.8) of the 208 cases (8.0%, CI 5.6, 11.0 of all 400 cases). Invariably, they were found adjacent to a Record of Changes. In a few instances, the form of an annotation was such that it was either very difficult, or impossible, to distinguish between such certification initials and an MF annotation.

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497 See Results: 6.1.11 Process Medium – Amendments and Corrections – form, *126*.

498 In 25 cases (10.6%, CI 7.1, 15.0) where amendments and corrections existed (6.3%, CI 4.2, 8.9 of all 400 cases).

499 211 cases for this statistic.

500 208 cases for this statistic.

501 See Discussion: 4.4.5 Annotations and Deletions, *207*.

The only other extensively occurring form of annotation was that associated with a Drawing Reference Code. That form was present in 24.0% (CI 18.6, 30.2) of relevant cases (12.5%, CI 9.5, 16.0 of all 400 cases).

6.6 Archival Bond

The archival bond has been conceptualised as being different from context. It is integral to a record rather than external to it.[502] In technical drawings, the archival bond is manifested in the Drawing Reference Code. The concept of the Archival Bond is discussed in Chapter 5, following.[503]

6.6.1 Archival Bond – Drawing Reference Code – data element

Frequency of occurrence 100%

Up to four data elements for a Drawing Reference Code (DRC) were found within any one technical drawing in this sample. At least one data element existed in 100% of cases. In 76.3% (CI 71.9, 80.2) of all cases, a second data element was also found. A third data element was present in 37.3% (CI 32.6, 42.1) of all cases, and a fourth data element in 14.8% (CI 11.5, 18.5).

6.6.2 Archival Bond – Drawing Reference Code – label element

Frequency of occurrence 98%, CI 96.3, 99.1

A label element was associated with at least one Drawing Reference Code (DRC) data element in 98% (CI 96.3, 99.1) of all cases.

A total of 700 DRC label elements were present within the 400 cases. Across all those label elements, 92.7% (CI 90.6, 94.5) indicated that the Part Number of the item to which the drawing related was being used as the Drawing Reference Code. An element label indicating 'Drawing Number' was found in only 3.6% (CI 2.4, 5.1) of the 700 instances.

6.6.3 Archival Bond – Drawing Reference Code – position

Frequency of occurrence 100%

Across all 400 drawings, a Drawing Reference Code (DRC) was most commonly found (78%, CI 73.7, 81.8) in the bottom right area of a drawing. In those cases

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502 Duranti, 'The Concept of Electronic Record', in Duranti, Eastwood, and MacNeil, *Preservation of the Integrity of Electronic Records*, 19.

503 See Discussion: 4.5 Archival Bond, *208*.

where only one DRC was present in a drawing, it was almost invariably (98.5%, CI 93.3, 99.8) in a bottom right area position.[504]

The second-most frequently used position was diagonally opposite, in the top left area. A DRC was located there in 50.3% (CI 45.4, 55.1) of all 400 drawings, and in 55.4% (49.4, 61.2) of cases when a DRC was positioned in the bottom right area.[505]

A DRC could also be found frequently in the top right area (46.3%, CI 41.4, 51.1 of all 400 cases). In the fourth corner – bottom left – a DRC occurred in only 11.0% (CI 8.2, 14.3) of all 400 cases. Much less frequently, a DRC was found in other positions within a drawing.

6.6.4 Archival Bond – Drawing Reference Code – Data Value

Frequency of occurrence 100%

Data Values for a total of 908 Drawing Reference Codes (DRCs) were present within the sample's 400 cases. They were in either alpha-numeric or numeric-only form.

At least one DRC Data Value was present within every drawing. Where more than one DRC data element was present, their Data Values were identical in only 80.8% (CI 76.7, 84.4) of cases. Their Data Values were similar in a further 7.5% (CI 5.2, 10.4) of cases.[506]

6.7 Information Form

Information Form is defined as the concept that denotes a technical drawing's type or genre. The concept is discussed in Chapter 5, following.[507]

6.7.1 Information Form

Frequency of occurrence 100%

Latent data within each drawing's content was interpreted to code for the Information Form of the drawing, on two levels. At the higher level, the overwhelmingly predominant Information Form (89%, CI 85.7, 91.8) was

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504 68 cases for this statistic.

505 271 cases for this statistic.

506 See Discussion: Differences in Drawing Reference Code Data Values, *209*.

507 See Discussion: 4.7 Information Form, *211*.

Orthographic Projection (two-dimensional) drawing. The remaining few drawings were coded as one of five other Information Forms.

6.7.2 Information Form – Orthographic Projection

Frequency of occurrence 89.0%, CI 85.7, 91.8

Information Forms were further analysed within the predominant form of Orthographic Projection drawing. The most frequently occurring form (62.6%, CI 57.5, 67.5) inferred from the latent data in those cases [508] was the Single-part drawing [509] (55.8%, CI 50.9, 60.6 of all 400 cases). Almost all other cases of Orthographic Projection drawings (34.6%, CI 29.8, 39.6) [510] were types of Assembly drawing [511] (30.8%, CI 26.4, 35.4 of all cases).

6.8 Internal Articulation

Traditionally, the internal articulation of a document has been conceptualised as comprising three sequential groups of intellectual concepts and characteristics – the protocol, text, and eschatocol. While that sequence has been retained here, the make-up of the three groupings has been considerably altered, necessarily, to meet the needs of the graphical form of technical drawings. The new conceptualisations are discussed within Chapter 5, following. [512]

6.9 Protocol

Despite the presence of new concepts, those allocated to the protocol follow, as closely as possible, the arrangement used for more traditional forms of record.

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508 356 cases for this statistic.

509 Including Collective Single-Part drawings.

510 356 cases for this statistic.

511 Including Collective Assembly, Sub-Assembly, and Collective Sub-Assembly drawings.

512 See Discussion: 5. Internal Articulation, *217*. The concepts are discussed individually following that introduction.

6.9.1 Principal Enterprise

Frequency of occurrence 99%, CI 97.6, 99.7

The principal enterprise is defined here as that which was responsible for creating a technical drawing. An initial working assumption was made that the principal enterprise would be the one chiefly identified upon a technical drawing. [513]

The name of a principal enterprise was found indicated in 99% (CI 97.6, 99.7) of all 400 cases. The role of this enterprise was inferred to be a vehicle manufacturer in all but two of those cases. [514] An associated location of activity for the enterprise was found recorded in 57.8% (CI 52.9, 62.5) of all cases.

In 78.0% (CI 73.8, 81.9) of cases where a principal enterprise name existed, [515] it was positioned in the bottom left area of a drawing or its margin. It was otherwise found in a variety of locations, generally on the left or top edge of the drawing.

6.9.2 Rights Owner

Frequency of occurrence 68%, CI 63.3, 72.4

Data for this concept were drawn from statements of rights that were claimed in a technical drawing, or in the object that the drawing depicted. [516] The name of the enterprise claiming such rights [517] was present in 68% (CI 63.3, 72.4) of the drawings. These data provided manifest evidence of the role of each recorded enterprise as the claimed holder of intellectual property or contractual rights.

A location was associated with the enterprise name in 40.8% (CI 35.1, 46.6) of the rights statements [518] (27.8%, CI 23.5, 32.3 of all 400 cases). A year-date was also sometimes present, although some were only partial dates. A complete year-date

513 An initial working assumption, because it is accepted that this might not always be the case, particularly for some Information Forms of technical drawing. An architectural presentation drawing, for example, is likely to bear the client's name most prominently.

514 In these cases, a vehicle manufacturer's supplier.

515 396 cases for this statistic.

516 See Results: 6.10.6 Text – Final Clauses – Rights Statement, *145*.

517 Within this sample, these rights were always claimed by a corporate enterprise, and never by a natural person.

518 272 cases for this statistic.

could be manifestly found in only 8.5% (CI 5.6, 12.2) of those drawings bearing a rights statement [519] (5.8%, CI 3.8, 8.4 of all 400 cases).

6.9.3 *Drawing Title*

Frequency of occurrence 100%

A Drawing Title was present in 100% of cases. It was almost invariably positioned at Bottom Centre or Bottom Right of the drawing. [520] A Label Element identified this Data Element in only 21.3% (CI 17.5, 25.5) of cases. [521]

6.9.4 *Technical Drawing Subject – Activities*

Frequency of occurrence 100%

This concept recorded subject terms for the activities within which a technical drawing was created and used. [522] Such activities are different from the objects represented by technical drawings, whose results are given next. [523]

No surveyed technical drawing manifestly contained data to indicate its subject of activity. Subjects therefore had to be inferred from the content and contexts of each drawing. They were coded at two high levels, for illustration of method.

All drawings could be coded at both primary and secondary levels of subject activity. At the primary level, Commercial Vehicle Manufacturing was coded for in 100% of all cases. At the secondary level, the activity of Mechanical Engineering was coded for in 96.8% (CI 94.7, 98.2) of cases. The few remaining drawings were coded, at the same level, for Electrical Engineering, and Electro-mechanical Engineering.

6.9.5 *Technical Drawing Subject – Objects – Primary Level*

Frequency of occurrence 100%

This concept recorded terms for the objects that were represented by technical drawings. Again, for illustration of method, object terms were also recorded at two levels.

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519 272 cases for this statistic.

520 One case = Bottom Left, one case = Top Centre.

521 399 cases for this statistic.

522 The transactions that caused such records to be created within those activities are discussed at: Discussion: 4.8.1 Separation of concepts of business process and record production, *213*.

At the primary level, five object terms were provided for classes of Drawing Subject-Objects.[524] It was possible to use both manifest and latent data within each technical drawing to code for these primary-level terms. Data Values could therefore be coded for 100% of all cases at this level, placing a very substantial majority of cases (95.5%, CI 93.1, 97.2) in the Components class.

6.9.6 Technical Drawing Subject – Object – Secondary Level

Frequency of occurrence 79.8%, CI 75.6, 83.5

Coding for objects was not so easy at the secondary level. The Components class, for example, was divided into nine sub-classes, each representing a major structure or system within a commercial vehicle.[525] It was not always possible to code for sub-classes using the data – whether manifest or latent – available within a technical drawing. Across all cases, only 79.8% (CI 75.6, 83.5) of drawings could be coded for secondary-level subject-object terms. This problem is discussed further, below.[526]

6.9.7 Intended Use

Frequency of occurrence 83.8%, CI 79.9, 87.1

This concept defines the use to which the object represented within a technical drawing was intended to be put.[527] A Data Value was recorded for Intended Use in 83.8% (CI 79.9, 87.1) of surveyed drawings. A Label Element – which varied in its value [528] – was found for the concept in 94.5% (CI 91.9, 96.4) of drawings.

6.10 Graphics and Text

The core of a traditional document's internal articulation is represented in diplomatic by the central section 'Text'. For technical drawings, it is clearly

523 For the conceptual differences between subjects and objects, see Discussion: 5.1.6 Technical Drawing Subject, *225*.

524 Road vehicle, Railway vehicle, Other vehicles and equipment, Components, Associated equipment and records.

525 For example, Bodywork, Engine - Power Plant, Steering and Suspension.

526 See Discussion: Importance of and issues for object description, *228*.

527 It is important to distinguish this concept from that of Intended User, the concept that defines the person-role to whom a technical drawing is addressed. See Discussion: Manifest addressee person-roles, *224*.

528 See Discussion: 5.1.7 Intended Use, *229*.

apposite to restyle this section 'Graphics and Text'. The concept is discussed in Chapter 5, following.[529]

6.10.1 Graphics – Drawing Aspect – Number of Views – All Views – data element

Frequency of occurrence 98.5%, CI 96.9, 99.4

This concept considers the number of individual views – plan, elevation, or section views, for example – that are portrayed within a single technical drawing. Within all surveyed drawings, 98.5% (CI 96.9, 99.4) contained at least one view. The number of views presented by a single drawing varied within the range of one to twenty-four. Within those drawings containing a view,[530] the most commonly occurring frequencies were three views (29.2%, CI 24.9, 33.8) and two views (27.7%, CI 23.4, 32.2).

6.10.2 Graphics – Drawing Aspect – Number of Views – All Views – label element

Frequency of occurrence 45.2%, CI 40.3, 50.1[531]

In only 45.2% (CI 40.3, 50.1) of those cases was at least one label element found on a drawing to identify a view. The number of views that bore a label ranged from one to nineteen. The most commonly occurring frequencies, within those drawings containing a view,[532] were one view (20.1%, CI 16.3, 24.2) and two views (13.5%, CI 10.4, 17.1).

However, in only nine cases did the number of label elements match the number of views depicted. In the 97.7% (CI 95.9, 98.9) of drawings that depicted at least one view, therefore,[533] some views did not bear a label element to describe them.

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529 See Discussion: 5.2 Graphics and Text, *230*.

530 394 cases for these statistics.

531 394 cases for these statistics.

532 394 cases for these statistics.

533 394 cases for this statistic.

6.10.3 Graphics – Drawing Aspect – Number of Views – Orthographic Projection Plan Views

Frequency of occurrence 81.5%, CI 77.5, 85.1

This lack of labelling sometimes made discrimination between plan and elevation views very difficult. Based on my reading of the sampled drawings, I normally coded three indeterminate views as one plan and two elevations. On that basis, 91.6% (CI 88.3, 94.1) of the orthographic projection drawings within this dataset[534] depicted either one or two plan views (81.5%, CI 77.5, 85.1 of all 400 cases). Only six views bore a label.

6.10.4 Graphics – Drawing Aspect – Number of Views – Orthographic Projection Elevation Views

Frequency of occurrence 68.8%, CI 64.1, 73.1

Elevation views were present in 77.2% (CI 72.7, 81.4) of the orthographic projection drawings [535] (68.8%, CI 64.1, 73.1 of all 400 cases). The substantial majority of the relevant cases (95.6%, CI 92.7, 97.6) showed either one or two elevation views.[536] A label element was present for only three views.

6.10.5 Graphics – Drawing Aspect – Number of Views – Orthographic Projection Section Views

Frequency of occurrence 40%, CI 35.3, 44.9

There was a far greater range in the numbers of section views depicted – from one to fourteen. Such views appeared on some 44.9% (CI 39.8, 50.1) of all orthographic projection drawings [537] (40%, CI 35.3, 44.9 of all 400 cases). In contrast to the plan and elevation views described above, 80.6% (CI 74.0, 86.2) of drawings showing section views also bore labels for at least some of the views, while 75.6% (CI 68.6, 81.8) had labels for all the drawing's section views.[538] These label elements often provided specific information as to the type or purpose of the depicted section.

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[534] 356 cases for this statistic.

[535] 356 cases for this statistic.

[536] The small remainder depicted either three or four views.

[537] 356 cases for this statistic.

[538] 160 cases for these statistics.

6.10.6 Text – Final Clauses – Rights Statement

Frequency of occurrence 68.0%, CI 63.3, 72.4

A textual statement was found on 68% (CI 63.3, 72.4) of the drawings, stating the name, and sometimes the location, of the enterprise claiming rights in the drawing or in the object that it depicted.[539] The detailed data for this characteristic also provided the results for the Rights Owner concept, wherein they have already been reported.[540]

6.10.7 Text – Final Clauses – Scale Warning

Frequency of occurrence 58%, CI 53.1, 62.8

A textual note was found on 58% (CI 53.1, 62.8) of the drawings, warning that the drawing was not to be scaled.

6.11 Eschatocol

The concepts and characteristics associated with the initial certification of a technical drawing, and its authorisation for issue and use, have been conceived as being grouped within the eschatocol.

6.11.1 Eschatocol – Signatures – Drawn

Frequency of occurrence 99.3%, CI 98.0, 99.8

All but three technical drawings (99.3%, CI 98.0, 99.8) within this dataset bore at least one labelled data element to provide 'Drawn' certification by use of a signature.[541] At least one signature was present in 91.9% (CI 88.9, 94.3) of cases where such an element was provided[542] (91.2%, CI 88.2, 93.7 of all cases).[543]

The data for this characteristic, and for the other Signatures' characteristics immediately following, also provided results for Natural Person Roles, below.[544]

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539 Within this sample, these rights were always claimed by a corporate enterprise, and never by a natural person.

540 See Results: 6.9.2 Rights Owner, *140*.

541 Two such data elements were provided in seven cases. The term 'signature' again subsumes the term 'initials'.

542 396 cases for this statistic.

543 399 cases for this statistic.

544 See Discussion: 2.3 Concepts of person-roles, *159*.

6.11.2 Eschatocol – Signatures – Traced

Frequency of occurrence 66.8%, CI 62.0, 71.2

A formally labelled data element for 'Traced' certification was present in 53.8% (CI 48.9, 58.6) of drawings. In a further 13% (CI 10.0, 16.6) of cases, the label element was formed by a manuscript marginal note. In 51.3% (CI 45.3, 57.3) of cases where the 'Traced' data element existed,[545] at least one signature was present (34.3%, CI 29.7, 39.0 of all cases).

6.11.3 Eschatocol – Signatures – Checked

Frequency of occurrence 97.5%, CI 95.6, 98.7

There was a very high frequency of occurrence (97.5%, CI 95.6, 98.7) of the data element labelled 'Checked'. In 10.5% (CI 7.8, 13.8) of all cases, two such labels were present. Of those drawings that contained a 'Checked' data element,[546] 46.5% (CI 41.6, 51.5) bore one signature (45.2%, CI 40.4, 50.1 of all cases).[547] A second signature was present in 11.8% (CI 8.9, 15.2) of all cases.[548]

6.11.4 Eschatocol – Signatures – Passed

Frequency of occurrence 63.5%, CI 58.7, 68.1

A 'Passed' data element and label element was found in 63.5% (CI 58.7, 68.1) of all cases. Two such data and label elements occurred in 5.5% (CI 3.6, 8.1) of all cases. A signature was present in 60.7% (CI 54.6, 66.6) of those drawings where at least one 'Passed' element was present[549] (38.4%, CI 33.8, 43.3 of all cases).[550] In addition, 7.0% (CI 4.8, 9.9) of all cases[551] bore a second signature.

545 267 cases for this statistic.

546 387 cases for this statistic.

547 398 cases for this statistic.

548 399 cases for this statistic.

549 252 cases for this statistic.

550 398 cases for this statistic.

551 398 cases for this statistic.

6.11.5 Eschatocol – Signatures – Approved

Frequency of occurrence 61.5%, CI 56.7, 66.2

In 61.5% (CI 56.7, 66.2) of all cases, an 'Approved' data element was present and labelled. A signature was present in 49.8% (CI 43.6, 56.0) of those cases [552] (30.6%, CI 26.2, 35.2 of all cases). [553]

6.11.6 Eschatocol – Dates – Drawn

Frequency of occurrence 18.3%, CI 14.7, 22.3

Only infrequently (18.3%, CI 14.7, 22.3) was a date data element specifically associated with that labelled for 'Drawn' Signatures. A complete Data Value for Drawn date (day-month-year) was present in only 15.3% (CI 12.0, 19.1) of all drawings. [554] A partial date, including year, was present in an additional 1.8% (CI 0.8, 3.4) of all drawings. [555]

6.11.7 Eschatocol – Dates – Traced

Frequency of occurrence 6.8%, CI 4.6, 9.5

A formally labelled date data element for 'Traced' was found in only three cases. However, a complete date Data Value was found associated with the 'Traced' signature data element in 6.8% (CI 4.6, 9.5) of all cases. [556]

6.11.8 Eschatocol – Dates – Checked

Frequency of occurrence 23.5%, CI 19.5, 27.8

At least one labelled data element for 'Checked' date was found in 23.5% (CI 19.5, 27.8) of all drawings. [557] Considerably fewer drawings, though, (4.8%, CI 3.0, 7.2) bore at least one complete Data Value for a Checked date. [558]

6.11.9 Eschatocol – Dates – Passed

For completeness, it should be noted that a 'Passed' date element was almost invariably absent within the sampled technical drawings.

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[552] 245 cases for this statistic.

[553] 399 cases for this statistic.

[554] 399 cases for this statistic.

[555] 399 cases for this statistic.

[556] 399 cases for this statistic.

[557] Five cases had two Checked data elements.

[558] 398 cases for this statistic. Three cases had two date Data Values; one case had a partial date Data Value.

6.11.10 Eschatocol – Dates – Approved

Frequency of occurrence 22.8%, CI 18.8, 27.0

An ‘Approved’ date data element was found labelled in 22.8% (CI 18.8, 27.0) of all cases. A complete ‘Approved’ date value was present in 8.0% (CI 5.6, 11.0) of cases, and a partial date value, including year, in an additional 0.5% (CI 0.1, 1.6) of cases.

6.11.11 Eschatocol – Dates – Issued

Frequency of occurrence 33.8%, CI 29.3, 38.6

In 33.8% (CI 29.3, 38.6) of all drawings,[559] an ‘Issue’ date data element was present and labelled. A complete ‘Issue’ date Data Value was found in 22.8% (CI 18.9, 27.1) of all drawings.[560]

6.11.12 Eschatocol – Date – Omni

Frequency of occurrence 46%, CI 41.2, 50.9

A formally labelled ‘Date’ data element for what has been conceptualised here as an ‘Omni’ date[561] was present in 46.0% (CI 41.2, 50.9) of all cases. A complete ‘Omni’ date Data Value was present in 42.7% (CI 37.9, 47.6) of all cases. A partial Data Value, including year, was present in an additional 0.3% (CI 0.0, 1.2) of all cases.

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559 399 cases for this statistic.

560 399 cases for this statistic.

561 See Discussion: Signature-Date Block, *184*.

Chapter 5: Discussion

1. Introduction

The purpose of this chapter is to:

- Show how the results answered the research question
- Discuss how the results related to previous work reported in the literature
- Indicate areas where the results provide impetus for future work

This introductory section shows how the chapter's purpose will be met, under the following headings:

- The research question
- Depth of analysis
- Structure of the discussion

1.1 The research question

To contextualise the discussions in this chapter, it is helpful to re-state the research question, which was:

> How might traditional textual diplomatic theory be developed and applied to the examination of technical drawings, as an exemplar of graphical records, to enable their more efficient and effective archival interpretation and processing, and hence improve their availability for research use?

Arising from the research question, the research's aims and intended outcomes were, in summary, to discover, quantify, analyse, statistically estimate, and describe the physical and intellectual concepts and characteristics that had potential to enhance archivists' understanding of technical drawings.[562]

The research aims and outcomes were to be achieved through the development, implementation, and evaluation of a new methodology, based on diplomatic principles, whose efficacy for the present research use, and potential for wider application, was to be assessed.[563]

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[562] See Introduction: Table 1: Research Aims and Intended Outcomes, *15*.

[563] See Introduction: Table 1: Research Aims and Intended Outcomes, *15*.

1.1.1 Answering the research question

The answer to this research question lies on two levels – theoretical and practical. Intellectually, is it possible to develop traditional diplomatic theory in the way proposed? Practically, are diplomatic concepts suitable tools with which to investigate technical drawings? Would useful data be derived in that way?

Eisenhart raised salient points when contrasting theoretical and practical frameworks.[564] Theoretical frameworks might be academically set to a standard that is simply 'not functional' for practitioners.[565] Such theoretical 'solutions' are irrelevant to their needs. A practice-driven perspective, though, might merely encompass a narrow view of what works in only one situation. Yet that singular success might lead to it being imposed elsewhere, without any sound theory for explaining its conditions for success[566] – and without any guarantee of it.

This research, therefore, had to meet two central needs. It had to encompass both technical drawings and their archival environments, and do so in a way that enabled practical outcomes to be underpinned by appropriate theory.

This chapter answers the research question, and those two needs. In so doing, the discussion draws together the interrelationships and interdependencies of the concepts and characteristics whose individual results have just been reported. Some concepts and characteristics are further developed and synthesised; others are newly developed within the discussion.

The context of the discussion as a whole is maintained though reference to the literature. Points of concurrence and dissonance are noted and analysed. Areas

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564 M. A. Eisenhart, 'Conceptual Frameworks for Research circa 1991: Ideas from a Cultural Anthropologist; Implications for Mathematics Education Researchers'. Blacksburg, Virginia, 16-19 Oct, 1991. (North American Chapter of the International Group for Psychology of Mathematics Education, 1991).

565 Ibid. In response, Lester suggested that that might not be a problem with theoretical frameworks *per se*. It might though arise if researchers adopted a research tradition other than that customary to a discipline: F. K. J. Lester, 'The Nature and Purpose of Research in Mathematics Education: Ideas Prompted by Eisenhart's Plenary Address'. Blacksburg, VA, 16-19 Oct, 1991. (Virginia Polytechnic Institute and State University, 1991). That thought was of course very relevant to this research. I am grateful to Dr D. Canada for his kind assistance with these references, sourced from drafts of his doctoral dissertation: D. Canada, *Re: Your Dissertation: Elementary Preservice Teachers' Conceptions Of Variation* (Pers Comm, 15 Jul, 2010).

566 Eisenhart, 'Conceptual Frameworks for Research circa 1991', 208.

where further work would be beneficial are highlighted. So, too, are areas where the results or the methodology have potential for wider application.

1.2 Depth of analysis

The depth of analysis undertaken varied with the concept or characteristic under investigation. In principle, my aim was to examine issues at one or two levels below which an archivist would expect to have to go when sorting, arranging or describing technical drawings. That lower depth would enable me to aggregate up results and findings to the higher practical level.

For illustration, concepts for Method of Representation were defined only at a high level that I perceived to be appropriate to the need. Drawing Aspect, though – the concept with which Method of Representation was closely related – was necessarily investigated in considerable depth and detail.[567] A detailed analysis was made of legal name forms for Principal Enterprise, and Rights Owner.[568] By contrast, it was difficult to attain consistent and reliable identification of primary production processes, especially reprographic processes, at anything but a high level.[569]

There is no doubt that diplomatic analysis could have been carried out to greater depths within many of the concepts and characteristics that were investigated. For example, comparative analysis could no doubt identify variations in the form of technical drawing templates. Such differences would signify dissimilar provenances and periods of production. Forms of script, and even the detailed use of punctuation, could help with the relative dating of technical drawings.[570]

Such depth was not warranted in this exploratory research. It would provide a narrow focus, when the need was for breadth of coverage. That breadth would provide a rounded picture of a technical drawing from an archival perspective. It would enable future work to concentrate on areas of detail where necessary.

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567 See Discussion: Drawing Aspect, *195*.

568 See Discussion: Legal Name Forms for Rights Owner, *221*.

569 See Discussion: Identification of primary production processes, *174*.

570 See Discussion: Deeper diplomatic analysis, *199*.

1.3 Structure of the discussion

The structure of this discussion can only follow the structure of diplomatic criticism in the broadest terms, in that it proceeds from the physical to the intellectual.[571] Some traditional diplomatic concepts have had to be reconceptualised. They can then accommodate aspects of records and recordkeeping that did not exist when diplomatic was originally formulated – principally, records' creation by reprographic reproduction. This reinterpretation will now be briefly explained.

1.3.1 Extrinsic and intrinsic elements in reprographically reproduced records

This research had to consider the production of copies of technical drawings by reprographic reproduction, rather than by traditional manual drafting. Some diplomatic concepts traditionally regarded as extrinsic elements – Script, Special Signs, and Annotations – are as observable in a reprographic reproduction as in an 'original' document. In such circumstances, therefore, those concepts fail the essential test that had traditionally caused them to be classified as extrinsic elements.[572] At the same time, diplomatic concepts that had traditionally been classified as intrinsic elements – Entitling, Dates, and Final Clauses, for example – are also as observable in a reprographic reproduction as in an 'original' document.

In consequence, when records are created by reprographic reproduction, it is not possible to use diplomatic's traditional means of differentiation between extrinsic and intrinsic elements. This difficulty is additional to, and conceptually different from, that experienced by the application of traditional diplomatic theory to records in electronic environments.[573] The problem warrants detailed examination in future research.

1.3.2 Physical and intellectual concepts in this research

In this research, the need was only to develop a structure that would best enable discussion of the findings related to the technical drawings survey. The terms 'physical concepts' and 'intellectual concepts' are therefore used in place of

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571 See, for example: Duranti, *Diplomatics: New Uses for an Old Science*, 151-8.

572 See Literature Review: 2.5 Diplomatic concepts of extrinsic and intrinsic elements, *48*.

573 Ibid.

'extrinsic' and 'intrinsic' respectively.[574] The intent of the two former terms is similar to that of the two latter, traditional diplomatic, terms. A 'physical concept' is one whose characteristics are present only in an 'original' document. If that document is reprographically reproduced, the physical characteristics of the 'original' and of the 'reproduction' will be different.[575]

While there is no direct correspondence between the two sets of structural terms, diplomatic's traditional terms are not deprecated. Rather, the present choice of terms enables the concepts used within this interpretation to be more readily distinguished from those that have been used traditionally.

1.3.3 Foundational concepts in this discussion

It has, though, been necessary to discuss four concepts – genesis and tradition, document status,[576] person-roles,[577] and dates – sooner than would normally be the case in diplomatic criticism. All four are intellectual concepts that must be defined before they are encountered within other individual concepts and characteristics. I have termed them 'Foundational Concepts'. This is only a labelling and repositioning of convenience, for the purposes of this discussion, not an intellectual change to diplomatic theory.

This chapter therefore continues with the following principal sections:

- Foundational concepts and characteristics
- Physical concepts and characteristics
- Intellectual concepts and characteristics
- Internal articulation

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574 The traditional diplomatic concept of 'Medium', for example, is now subsumed within that of 'Physical Concepts'. There are other differences that are noted within this discussion. Hence the present interpretation does not exactly correlate with the similarly termed concepts of 'Physical Form' and 'Intellectual Form' that were used, for example, in: The Preservation of the Integrity of Electronic Records [UBC Research Project]. 'Template 1: What is a Record in the Traditional Environment?', and InterPARES 1 Project: Authenticity Task Force, 'InterPARES 1 Project: Appendix 1: Template for Analysis'.

575 For example, the original support medium material might be 'paper', and that of the reproduction, 'synthetic film'. The original size of support might also be different from that upon which the reproduction was made.

576 For example, draft, original, and copy documents.

2. Foundational Concepts and Characteristics

The 'Foundational Concepts' that are necessarily discussed here first are:

- Genesis and tradition
- Document status
- Person-roles
- Dates

2.1 Genesis and Tradition

Genesis and tradition are two different but sequential diplomatic concepts. The diplomatic concept of genesis has been defined in terms of the 'moment of action' and the 'moment of documentation' – *actio* and *conscriptio*. Two sets of routines flowed from those moments, either in sequence or in parallel. That genesis continued from the inception of the act that produced a document, up to the moment of its final execution as a complete document. [578]

The procedure governing the moment of documentation for medieval documents has been seen as being formalised in office routines. The sequence of activities varied according to the nature of the office and the document being prepared. Typically, it would include the creation first of a draft, then of a fair copy. Perhaps after registration, the document was validated. It was then ready for delivery, to those it concerned, through the final activity – *traditio*. [579]

This *traditio* is an exemplar of the broader concept of tradition within diplomatic. The tradition of a document encompasses its different forms of status over time, for example, as a draft, original, and as extracts and copies in various forms. [580] Those forms of status have been regarded as constituting the degree of perfection that a document enjoys as a representation of its original form. [581]

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577 In diplomatic terms, the concept 'Qualification of signature'.

578 Duranti provided an extensive explanation of the concept of genesis as an 'elaboration of routines' within: Duranti, *Diplomatics: New Uses for an Old Science*, 108-13.

579 This simplified summary of characteristics of genesis is derived from the analysis given by Duranti: Ibid., 112-3 and n.9. Although Duranti regarded that analysis as unconvincing, and developed a much more elaborate scheme, what is used here is quite adequate for the present need.

580 Delmas, 'Manifesto for a Contemporary Diplomatics', 451.

581 Duranti, *Diplomatics: New Uses for an Old Science*, 48 and n.32; 49-50; 165 and n.11.

A document's diplomatic status has also been distinguished from two further concepts, the document's 'form of transmission' and 'method of transmission'.[582] The former concept concerned the medium of the information carrier on which a document was received by an addressee. The latter concept, of less interest here, denoted the process of communication by which a document was transmitted by one party to another.[583]

2.1.1 Genesis and tradition in technical drawings

The data that were necessary to determine a technical drawing's genesis and tradition were not manifestly obvious within the sampled technical drawings. Rather, they were subsumed within other concepts that are described and discussed elsewhere in this chapter:

- Primary Production Processes[584]
- Clause of Corroboration – Signature-Date Block[585]
- Changes[586]
- Amendments and Corrections[587]
- Stage of Realisation[588]

Genesis and tradition have therefore been only briefly considered here, as a necessary preface to the discussion of a new application of the concept of document status. That application has been developed in this research to help simplify the interpretation of the concepts that have hitherto been encompassed within genesis and tradition.

2.2 Document status

I now describe and compare two concepts of document status. The first is derived from existing diplomatic theory. The second concept has been developed within this research.

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582 Duranti considered the concepts of 'tradition' and 'transmission' to be synonymous in diplomatic terms: Ibid., 165, 48 n.32.

583 Ibid., 163-4.

584 See Discussion: Importance of primary production processes identification, *173*.

585 See Discussion: Clause of Corroboration – Signature-Date Block, *233*.

586 See Discussion: 4.4.1 Importance of the Changes concept, *201*.

587 See Discussion: 3.1.7 Amendments and Corrections, *179*, 4.4.4 Amendments and Corrections, *206*.

588 See Discussion: 2.1 Genesis and Tradition, *154*.

2.2.1 Diplomatic concepts of document status

The concepts of draft, original, and copy documents are central to diplomatic theories of genesis and tradition. Duranti, for example, discussed at length the variations in document status that might arise through different circumstances of document creation, maintenance, and use. [589]

Importantly for this research, Duranti noted that she would 'not illustrate the methodology involved in the identification of the sequence of copies of the same document'. Such a methodology would only be suited to medieval documents. A new methodology to identify the tradition of 'modern and contemporary material' had yet to be developed. Duranti suggested that it would be an 'extremely difficult and probably a sterile exercise'. Nonetheless, in the past such an exercise had 'contributed significantly' to diplomatic techniques for determining the reliability of documents. [590]

2.2.2 A new conceptualisation of document status

This research has arrived at a new conceptualisation of document status, which can be considered both in its own right, and also be applied to understandings of diplomatic genesis and tradition.

Earlier, a conceptualisation of engineering drawing was described from the literature. [591] Three strands of thought have been developed from that conceptualisation. They form a new conceptualisation of engineering drawing production. That conceptualisation, in turn, leads to a new set of concepts for document status.

Firstly, engineering drawings can be conceived as a form of self-communication. These design drafts were used by engineering designers to reduce their thoughts, iteratively, to a final design solution. It was principally a mental activity, where the designer's own written records would not communicate a solution sufficiently well to others to enable it to be implemented.

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589 Ibid., 48-53. See also pp. 165-6.

590 Ibid., 53-4. See also this point in relation to Discussion: 4.4.1 Importance of the Changes concept, *201*.

591 See Literature Review: 4.1 Conceptualisation of engineering drawing, *62*.

Secondly, engineering drawings can be conceived as a form of internal communication. They were the design and drawing office master records – the definitive 'Instruments of Power' that documented a design solution as the outcome of design activity. As such, they embodied all the manifest and latent power and authority of their creators – overtly, that of corporate enterprises rather than of individual employees.[592]

Should the design solution have required later modification, it would have incurred further design activity and, at its conclusion, further definitive drawings. These engineering drawings might have been created by engineering designers, but were more usually drafted by others, acting on designers' own drawings or on other instructions. The art involved in this activity was that of technical skill in drafting, rather than that of the engineer in designing.

Thirdly, engineering drawings can be conceived as a form of mass communication. They enabled a design solution to be communicated to those who were to implement it. As expendable working drawings, they were derivatives of the definitive master records. They were created on the instructions of designers, drafters, or others, by those who were skilled in the reproduction processes involved. Where that process involved tracing or hand copying, considerable artistic skill was required. While that had little to do with engineering design knowledge, it helped maintain the iconic power of a technical drawing, even in derivative form.

With the advent of reprographic reproduction processes, technical drawings lost much of their iconic status. Visible indications of power and authority were far less apparent in monochrome derivative drawings. Rather, power and control was to be maintained through increasingly sophisticated drawings' management systems. As will be seen later, though, evidence for the practical application of such systems has raised unexpected questions.[593]

Two sets of conceptualisations can be derived from this model. While they are created in the context of engineering drawing, I argue that both sets of concepts

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592 See Introduction: 2.2 Instruments of Power, *4*.

593 See Discussion: Implications of the authorisation findings, *253*.

can be more generally applied to other types of technical drawings, and, more broadly, to records of all types.

Firstly, within the functions of engineering design and production,[594] three stages of activity can be defined. So, too, can the forms of engineering drawings that result from the transactions within those activities, as illustrated in Table 7:

Activity	Process	Records
Design Evolution	Self communication	Drafts
Design Recording	Internal Communication	Definitives
Design Dissemination	Mass Communication	Derivatives

Table 7: Derivation of Concepts of Document Status

Secondly, the engineering drawing outputs of those three stages can also be defined as three specific concepts within a general concept of document status for a technical drawing, as illustrated in Table 8:

Drafts	Forms of self-communication, comprising imperfect and incomplete documents, typically accruing as tangible expressions of a designer's thoughts
Definitives	Forms of internal communication, comprising perfect and complete documents, typically retained by or on behalf of their creators, for internal reference and reproduction
Derivatives	Forms of mass communication, comprising reproductions of definitive documents, typically issued to instruct or enable actions to be taken

Table 8: Definitions of Concepts of Document Status

594 See Discussion: 4.8 Stage of Representation, *212*.

The use of these three specific concepts of document status does not preclude the derivation and use of more particular individual concepts of document status within them. Indeed, other concepts and characteristics that enable more granular expressions of document status will be described later.[595] The three basic forms of record that are defined here are also particularly linked, later, to the new concept of Stage of Representation.[596]

However, the purpose of this new conceptualisation is to simplify the means by which the genesis and tradition of technical drawings can be described. The concept of document status provides a framework within which defined forms of record are clearly associated with the defined activities that produced them.

2.3 Concepts of person-roles

The somewhat unattractive term 'person-role' is defined here as the capacity in which a natural or legal person acts, either substantively or in relation to a document or record. Either form of person might act in one or more person-roles.

The concept of a person-role equates to the diplomatic concept of a qualification of signature. Technical drawings' person-roles are derived from the certification activities that are indicated within a Signature-Date Block.

Person-roles are relevant to the following concepts that are discussed for technical drawings within the main body of this chapter:

- Principal Enterprise Role[597]
- Addressee[598]
- Primary Production Certification[599]

2.3.1 Diplomatic concepts of person-roles

Different diplomatic sources provide somewhat differing definitions of persons and their roles in relation to records. Definitions for those of interest to this

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595 See, for example: Discussion: 4.4 Changes, *200*, wherein the different forms of change that can accrue to a document are specified. See also: Discussion: 3.1.5 Primary production processes, *171*, which describes the processes by which a derivative might be produced.

596 See Discussion: 4.8 Stage of Representation, *212*.

597 See Discussion: 5.1.2 Principal Enterprise – Role, *220*.

598 See Discussion: 5.1.4 Addressee, *223*.

599 See Discussion: 5.3.1 Primary Production Certification, *232*.

research are therefore summarily synthesised here – Author, Writer, Addressee, Countersigner, and Scribe. The first three of these roles are considered necessary for a document to come into existence. [600]

Later, these diplomatic concepts will be mapped to the individual concepts of person-roles derived for technical drawing primary production certification activities. [601]

Author

The author is the natural or legal person responsible for the creation and issue of a document. Usually, the same person is also responsible for the act or event of which the document is the outcome. Unless the author is also the writer, their signature and qualification may not appear as an attestation. Their name may though appear elsewhere – in the entitling, for example. [602]

Writer

The writer of a document is the natural person responsible for its intellectual form, and for the articulation of its content. The writer's signature and its qualification are usually present as an attestation, and may be accompanied by a date. The writer may be the same person as the author, or be an agent of the author. The role of writer is not, though, that of scribe. [603]

Addressee

The term addressee denotes the natural or legal person to whom a document is directed. The addressee may or may not coincide with the addressee of the act put into being by the document, or referred to by the document. Nor does the addressee have to be the same person to whom a document is transmitted or delivered. [604]

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600 Ibid., 83-4.

601 See Discussion: 5.3.3 Individual Certification Concepts, *237*.

602 Ibid., 84, 142-3.

603 Boyle, 'Diplomatics', 80; Duranti, *Diplomatics: New Uses for an Old Science*, 86-7.

604 The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 1: What is a Record in the Traditional Environment?', 2; Duranti, *Diplomatics: New Uses for an Old Science*, 85-6.

Countersigner

Traditionally, a document may be validated by one or two countersigners. A single countersigner thus confirms that a document physically and intellectually conforms to established procedures, and that it is appropriately signed. Where employed, the role of the second countersigner is more executive than administrative. It is to ensure that the document conforms to the will of the author. The signature of this second countersigner will be manifestly qualified; that of the first may not. [605]

Scribe

A scribe is a natural person who contributes in a non-executive capacity to the production of a document, for example, as a copyist or clerk. The role of a scribe is not that of a writer. A scribe's signature may appear as an attestation, and may be joined with a qualification. [606]

2.3.2 Technical drawings' concepts of person-roles

Individual concepts of person-roles can be derived from five principal technical drawing certification activities that are indicated within Signature-date Blocks. [607] They are Drafter, Tracer, Checker, Passer, and Approver. Their roles are largely self-explanatory, and will be elaborated upon later. [608]

2.4 Concepts of dates

Providing an appropriate date for any document rests upon understanding what the date purports to record. Two specific dating concepts may be defined within a general concept of dating:

- Dates relating to acts and events
- Dates relating to documentation of those acts and events

This discussion will draw on diplomatic and archival knowledge to develop individual date concepts within both specific concepts. These new concepts will

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605 Ibid., 87-8.

606 Following Boyle, 'Diplomatics', 80; Duranti, *Diplomatics: New Uses for an Old Science*, 87-8.

607 See Discussion: Clause of Corroboration – Signature-Date Block, *233*.

608 See Discussion: 5.3.3 Individual Certification Concepts, *237*.

be mapped, later, to those date concepts deduced for technical drawing primary production certification activities. [609]

Dates are relevant to so many of the concepts discussed within this chapter that it is impractical to refer to those concepts here.

2.4.1 Diplomatic concepts of dating

Diplomatic's concept of *datatio* encompasses both a chronological date and a topical date. [610] Only the chronological date is of concern here. The topical date – the geographical location of document dating – is relevant elsewhere. [611]

As with the qualification of signatures, diplomatic theory differs in its interpretation of date concepts. Again, though, a brief synthesis can be made to arrive at relevant definitions. Four date concepts have been identified within traditional diplomatic analysis – *Actum*, *Scriptum*, *Factum*, and *Datum*.

- *Actum* The date of the act – *actio* – or event with which a document is associated [612]
- *Scriptum* The date on which a document was written [613]
- *Factum* The date on which a document was executed [614]
- *Datum* The date on which a document was issued, and hence the date an act was transmitted [615]

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609 See Discussion: 5.3.3 Individual Certification Concepts, *237*.

610 The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 2: What is a Complete Record in the Traditional Environment?', 1; L. Duranti, 'CEI - Charters Encoding Initiative*: Datatio*: Comments' (Charters Encoding Initiative, 2007) [Online] http://www.cei.lmu.de/element.php?ID=61 (accessed 06 Nov, 2011).

611 See Discussion: Differentiating forms of names and locations, *218*.

612 InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES)', 7; Z. Hunyadi, 'The Identification of a Forgery: Regularities and Irregularities in the Formulae of the Charters Issued by the Székesfehérvár Convent by the Knights of St John of Jerusalem (1243-1353)', in *Dating Undated Medieval Charters*, M. Gervers, ed., (Woodbridge, 2000), 143. These attributes of *Actum* do not have direct relevance to dates within technical drawings, and the concept is not considered further here.

613 InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES)', 7.

614 Ibid.

615 Ibid.; Hunyadi, 'The Identification of a Forgery', 143.

2.4.2 Archival concepts of dating

Important concepts of dating have also been identified within archival theory and practice, and should not be ignored:

- Date of Creation of a record [616]
- Date of Accumulation of a record [617]
- Date of Copyright in a record [618]
- Date of Change to a record, to create a new version [619]
- Date of Reproduction of a record, to create a copy [620]
- Date of Representation of a record's content [621]

3. Physical concepts and characteristics

Within this research, I considered physical data to be as potentially valuable as any other form of evidence that could be gleaned from a technical drawing. [622] Following the reconceptualisation of physical and intellectual concepts in this research, all physical concepts and characteristics have been gathered together within the diplomatic concept of Medium.

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616 International Council on Archives, *ISAD(G): General International Standard Archival Description*, 15, cl. 3.1.3; Bureau of Canadian Archivists, 'Chapter 1: General Rules for Description', 1–33-4, cl. 1.4B; Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings', 6–16, cl. 6.4B.

617 International Council on Archives, *ISAD(G): General International Standard Archival Description*, 15, cl. 3.1.3; Bureau of Canadian Archivists, 'Chapter 1: General Rules for Description', 1–32, cl. 1.4A6, and 1–65, cl. 1.8B8a; Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings', 6–34, cl. 6.8B10a.

618 Bureau of Canadian Archivists, 'Chapter 1: General Rules for Description', 1–42, cl. 1.4F4. Occurrences of copyright date occurred too infrequently in this sample to merit discussion.

619 International Council on Archives, *ISAD(G): General International Standard Archival Description*, 15, cl. 3.1.3; Bureau of Canadian Archivists, 'Chapter 1: General Rules for Description', 1–41, cl. 1.4F1; Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings', 6–16, cl. 6.4B1.

620 International Council on Archives, *ISAD(G): General International Standard Archival Description*, 15, cl. 3.1.3; Bureau of Canadian Archivists, 'Chapter 1: General Rules for Description', 1–32, cl. 1.4A5, and [1–35], cl. 1.4B3.

621 Developed from Ibid., 1–33, cl. 1.4A7, and 1–62, cl. 1.7D4. I define the Date of Representation as the date of the object depicted by a drawing. For example, a part made in 1925 as an initial sample might be drawn in 1926 when accepted for use in production. The drawing's Date of Representation is 1925, and its Date of Creation is 1926.

622 As others have previously asserted. See, for example: Boyle, 'Diplomatics', 82-3, and C. Heald, 'Is there Room for Archives in the Postmodern World?', *American Archivist*, 59, (Winter, 1996), 101, cited by E. Ketelaar, 'Tacit Narratives: The Meanings of Archives', *Archival Science*, 1, 2 (Jun, 2001), 139, n.42.

A particular approach was taken to the investigation of physical concepts and characteristics. The methodology rested upon the use of only the five physical human senses. This approach was adopted with a view to assisting archivists who might not have ready access to conservation resources. A sensory approach, if viable, would also negate the need to subject technical drawings to conservation analysis to assist their intellectual processing.

It must be stated now that this approach produced unexpectedly disappointing results. Nonetheless, these findings must be reported and discussed equally with the other research findings.

It is unlikely that many archivists would possess the skills required to derive detailed physical data for technical drawings' media, without some form of external assistance. While reference literature was available, the research found that it did not sufficiently help with a sensory approach to investigating physical concepts and characteristics in depth. At this stage of research, specialised – sometimes very specialised – conservation science resources are required to answer the questions that were posed.

3.1 Medium

The term medium is used within this discussion in a broader sense than that traditionally found within diplomatic theory.[623] Here, I define medium as a general concept for a physical carrier of information. Within that general concept, I define two specific concepts of medium:

- Support Medium — the medium used as a support for a technical drawing
- Process Medium — the medium used in a process to create a technical drawing

Closely associated with these concepts of medium are the concepts of the materials of which the media are made. I define the general concept of material, in this context, as that 'which imparts certain characteristics' to the medium.[624]

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[623] For example, as 'the material carrying the message', medium has been conceived as being only the material of the support: Duranti, *Diplomatics: New Uses for an Old Science*, 135.

[624] Adapting B. P. Bergeron, *Dark Ages II: When the Digital Data Die* (Upper Saddle River, NJ, 2002), 59 ff, cited by R. Pearce-Moses, 'Medium' in *A Glossary of Archival and Records Terminology*, R. Pearce-Moses, ed., (Chicago, 2005) [Online] http://www.archivists.org/glossary/term_details.asp?DefinitionKey=399 (accessed 09 May, 2011).

Hence, forms of material are recorded as attributes that partially characterise the two specific concepts of medium:

- Support Material — the material of the medium used as a support for a technical drawing, e.g. paper, cloth
- Process Material — the material of the medium used in a process to create a technical drawing, e.g. pencil, ink

3.1.1 Potential benefits and limitations of identification of medium

An initial premise was that identification of the materials used in a technical drawing's media of support and primary production process would help to identify the form of the production process itself. Knowledge about such physical data could also help inform archivists about other aspects of a technical drawing – Genesis and Tradition, Dates, or the Stage of Realisation, for example.

The purpose of this part of the research was therefore to determine what key diagnostic characteristics an archivist might be able to derive from the media used to create a technical drawing, using only the five physical senses. This sensory approach was not very successful. The merit of this part of the discussion therefore lies with the identification of two areas:

- Some practical limits for archivists seeking to interpret technical drawings through the physical characteristics of drawings' media
- Potential for conservation science research to develop resources to assist archivists and researchers in this area

3.1.2 Scope of the discussion for medium

With the above caveats, I now discuss the following aspects of medium:

- Support materials
- Support dimensions, layout, and presentation
- Primary production processes
- Support and process materials' colour
- Amendments and Corrections
- Annotations and Deletions

3.1.3 Support materials

This section discusses the importance of the identification of materials used for technical drawing supports, and the difficulties that were experienced in making such identifications.

Importance of support material identification

Duranti noted that identification of the material of the support medium was one of the most important original aspects of traditional diplomatic analysis. Over time, though, common forms of writing materials came into widespread use. Much of the relevance of those traditional materials to diplomatic analysis was then lost. [625]

The present research found that potential remained for the identification of a support's material to be an important diagnostic tool. The materials normally found used were types of paper, cloth, and, from the mid-twentieth century, synthetic film. All three basic types existed in a variety of forms, [626] which might assist with technical drawings' interpretation in three ways:

- The choice of material is often associated with the point of gestation that a technical drawing has reached – the Stage of Realisation. For example, early pencil drafts might be schemed onto detail paper. Finished drawings requiring reproduction would be drafted onto translucent materials such as tracing paper or tracing cloth. Where durability of the drawing was important – for long-term record purposes, for example – tracing cloth and polyester-based materials were regarded as suitable. [627]
- The material used might also be associated with a particular reproduction process materials supplier, whose dates of operation might help to date the drawing. Within the technical drawings sample, there are, for example, four variations of the OZALID trade name for diazotype copying processes.
- Support material could also give an indication of a drawing's date or period, if it was undated. For example, many identifiable forms of tracing paper have been used since the mid-nineteenth century. The introduction of tracing cloth in Britain has been dated to 1846. By 1953, 'sheet plastics materials' were starting to replace such cloth supports. [628]

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625 Duranti, *Diplomatics: New Uses for an Old Science*, 135 – although that situation had reversed for media which supported records in electronic formats.

626 For a useful summary table, See British Standards Institution, *BS 1192:1969 Building Drawing Practice*, 2nd revised ed. (London, 1969), 63-5.

627 British Standards Institution, *BS 308:1943 Engineering Drawing Office Practice*, 1st revised ed. (London, 1943), 42; British Standards Institution, *BS 1192:1969 Building Drawing Practice*, 63-5.

628 British Standards Institution, *BS 1340-43:1946 Drawing Papers (Tracing, Detail and Cartridge)*; British Standards Institution, *BS 1192:1953 Drawing Office Practice for Architects and Builders*, 1st revised ed. (London, 1953), 36; Price, *Line, Shade and Shadow*, 49, 76-89.

An associated characteristic of support materials was present only in the negative, in this sample. No drawing bore the oil, grease or dirt marks that would be highly indicative of it having been used in manufacturing, repair, or similar operational activities. The absence of such matter therefore indicated that the drawings from this sample had been retained within drawing offices or similar controlled records' environments. [629]

Identification of support materials in this research

The literature had already indicated that identification of support media might not be as simple as I had first thought. Nonetheless, I hoped that support media materials could be identified to greater degrees of granularity than the three basic types of paper, cloth and synthetic film – to determine the actual material of the medium.

In practice, reliable identification of the support materials was even more difficult than had been anticipated. Only those manifest attributes that could be positively identified through observation could be recorded. [630] For example, the literature indicated that the material used for cloth supports was very probably cotton. [631] The cloth support materials in the sample could not, though, be identified with the knowledge and tools that were available.

Similarly, synthetic supports were only recorded at a generic level, because of the difficulty of identifying some synthetic materials. [632] With hindsight, some could have been confidently recorded as either cellulose acetate or polyester. Only the unidentified remainder need then have been categorised as unknown synthetics.

In some cases, there was also difficulty in differentiating between forms of paper, particularly between sensitised and unsensitised paper. For example, a large number of supports manifestly carried diazotype reprographic content. Very few,

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[629] For intellectual characteristics adducing to the same conclusion, see Discussion: 4.4.5 Annotations and Deletions, *207*.

[630] See Results: 6.1.2 Support Medium – form – material, *122*.

[631] T. R. Nelb, 'Identification and Preservation Maintenance of Common Visual Media and Supports', in *Architectural Records: Managing Design and Construction Records*, W. Lowell and T. R. Nelb (Chicago, 2006), 130, and Price, *Line, Shade and Shadow*, 49, 89, citing B. L. Hamann, 'The Examination and Treatment of Railway Engineering Drawings on Tracing Cloth: Report Submitted in Partial Fulfillment of the Requirements for the Degree of BSc in Archaeological Conservation'. (Institute of Archaeology: University of London, 1989).

though, bore a marking to indicate that their material form was paper specially prepared for that process.[633] The materials of twelve supports could not be identified at all.[634]

Problems of identification of support materials

Three problems combined to create the identification difficulties:

- Some support media were impregnated and / or surface coated with base materials that hindered identification of the support material
- Some reproduction processes also introduced characteristics that tended to mask the support materials to which they were applied[635]
- Some support materials were breaking down in different ways, evidenced by, for example, embrittlement, stickiness or grittiness

Such problems combined, in some cases, to make impossible even a basic identification of the material. Even destructive testing of some research examples proved fruitless.[636] That approach could not of course be applied to technical drawings required for archival preservation.

Although some detailed descriptions and excellent images of support materials were available,[637] they were not found sufficient to enable positive identification. No matter how good an image, a two-dimensional surrogate of a three-dimensional support could not provide the necessary sensory attributes of sight, touch, and even smell that were key to material identification. I concluded that to make confident identifications, I required physical reference materials with which to make side-by-side comparisons with technical drawings' supports.

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632 This problem is particularly discussed separately, below: Problems of identification of synthetic support materials, *169*.

633 See Discussion: Problems of identification of reprographic processes, *176*.

634 These twelve supports all derived from one enterprise. Their appearance indicated that they encompassed three or four different types of media. All the supports were coated with base materials to the extent that it was not possible to determine the material of the support. It may have been paper, tracing paper, or even synthetic.

635 For example, discolouration: M. Vilela, L. M. Ferreira, and J. Vieira, 'Discolouration of Architectural Photoreproductions', *Restaurator*, 27, 1 (2006), 1-8.

636 C. Williamson, *Drafting Films* (Pers Comm, 04 Feb, 2008).

637 Kissel and Vigneau, *Architectural Photoreproductions*, 125; *Price, Line, Shade and Shadow*, 359.

Problems of identification of synthetic support materials

Synthetic support materials proved to be the most difficult to identify. No coherent resource could be found that would enable their identification without the use of technical resources. [638] Yet the need for physical reference materials to compare with synthetic supports was particularly strong. They had fewer sensory attributes than paper or cloth supports.

Attempts were made to procure a reference set of identified synthetic support materials, to compare with the materials in the technical drawings sample. Fourier Transform Infrared (FTIR) analysis was identified as the most appropriate means by which such reference materials might be obtained. Despite some FTIR spectra being made available, [639] this approach was not successful. It also went against the research principle of using only human sensory observations. Future research would be useful within the field of conservation science.

3.1.4 Support dimensions, layout, and presentation

Observation of the physical concepts defined within a technical drawing's support can provide clear and direct evidence for other less tangible intellectual concepts, for example, provenance, date of creation, and original order. That utility in four physical concepts is summarily discussed here:

- Support size and dimensional regularity
- Support size indication [640]
- Support layout
- Material presentation

Support size and dimensional regularity

The sizes of drawing sheet used by an enterprise were unlikely to change rapidly over time. Considerable investment would have been required in suitably sized

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[638] I am most grateful to the following for their kind assistance and advice regarding this issue: P. Owen, W. Cantwell – University of Liverpool, C. Williamson – Smile Plastics Ltd., S. Lambert – Plastics Specialist Subject Network.

[639] I am most grateful to The National Archives (K. Ntanos and C. Williams) for facilitating this work.

[640] This is an Intellectual Concept, properly situated within Presentation Style, but is necessarily included here to facilitate discussion.

drawing boards and storage equipment. [641] The sizes of drawing sheets could therefore provide a starting point for identifying drawings of common provenance.

Within the period covered by this investigation – the 1920s to the 1980s – the dimensioning of standard drawing sheet sizes changed from imperial to metric measurements. The change was formally introduced into British Standards from 1961, led initially by pressure from architectural rather than engineering interests. [642]

Again, within that period, technical drawings' support media were available in standard-width rolls.[643] Drawing sheets of any required length could therefore be cut off within the drawing office. Smaller-width sheets could be cut to minimise waste, [644] while multiple widths could be joined to form very large sheets. Cut sheets, including those pre-printed with an enterprise's standard technical drawing template, could also be supplied from external sources.

The survey results showed that 15.3% (CI 12.0, 19.0) of supports within the sample exhibited irregularity in their dimensions. [645] Such dimensional irregularity is not likely in an externally supplied, pre-cut, drawing sheet. Rather, it is indicative, I argue, of support media being cut to size within a drawing office.

I therefore contend that technical drawings of common provenance can be indicated through a comparison of the sizes and dimensional regularity of their drawing sheets.

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641 The extent to which the size of supports used was related to the capabilities of reprographic reproduction equipment is arguable. Generally over time, such equipment was able to process increasingly larger support sizes, but the cost to enterprises of upgrading the equipment would have been a limiting factor. More fundamentally, though, reprographic equipment would not be required to process support sizes larger than could be conveniently used by drawing offices.

642 British Standards Institution, *BS 3429:1961: Specification for Sizes of Drawing Sheets*; British Standards Institution, *PD 5617: Amendment No. 1 to BS 3429:1961 - Sizes of Drawing Sheets* (London, 1965).

643 Widths ranged from 30 to 72 inches. See, typically: British Engineering Standards Association, *BS 308:1927 Engineering Drawing Office Practice*, 7, cl. 1; British Standards Institution, *BS 308:1943 Engineering Drawing Office Practice*, 6, cl. 1.a; British Standards Institution, *BS 1340-43:1946 Drawing Papers (Tracing, Detail and Cartridge)*, 9, cl. 2; British Standards Institution, *BS 1342:1962 Specification for Detail Drawing Paper*, 5, cl. 3a.

644 As was well illustrated in: British Standards Institution, *BS 1192:1944 Architectural and Building Drawing Office Practice*, (London, 1944), 5, Fig. 1.

645 The principles used to define this regularity were described at Results: 6.1.3 Support Medium – form – dimensions, *123*.

Support size indication

Sorting and arranging such large-format records is not, though, very convenient. An alternative, diplomatic, approach was available in almost half of the surveyed drawings – those that bore a marking to indicate their drawing sheet size.[646]

The approach is illustrated by technical drawings of the AEC and Maudslay enterprises. Ninety-two AEC Ltd drawings used the form of marking 'DRAWING SIZE 4'.[647] The same form of marking was found used on the only two drawings for The Maudslay Motor Co. Ltd. This correlation therefore provided useful evidence for a link between Maudslay and AEC, and some indication of these drawings' date – the two enterprises merged in 1945.[648]

Support layout and material presentation

Two further physical concepts also provide indications of technical drawings' common provenance. The concepts are simple, but valuable in being ubiquitous. They are, firstly, the orientation of support layout – landscape, portrait, or, square;[649] and secondly, material presentation – flat, folded, or rolled.[650]

3.1.5 Primary production processes

The medium of the primary production process is defined here as a carrier of information that is separate from the medium of support, previously described. In this specific context of medium, the primary production process is that which is first used to create each and every individual instance of a technical drawing. The process therefore applies equally to draft, definitive, or derivative technical drawings.

By definition, the primary production process does not pertain to any changes made to a drawing after its initial production, and which are considered later.[651] However, the media and materials used for primary production may usefully be compared with those used for such changes. In combination, they provide data

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646 See Results: 6.1.4 Support Medium – form – dimensions – indication, *123*.

647 'DRAWING SIZE 8' was also found in 16 cases for AEC enterprises alone.

648 Church, *The Rise and Decline of the British Motor Industry*, 77.

649 Landscape, portrait, square. See Results: 6.1.5 Support Medium – form – orientation of layout, *123*.

650 Flat, folded, rolled. See Results: 6.1.6 Support Medium – form – material presentation, *124*.

651 See Discussion: 4.4 Changes, *200*.

that equate to the physical attributes of diplomatic Script as it has previously been conceptualised.[652]

Forms of primary production processes

The medium of a primary production process can take one of two forms:

- Manual drafting used to create new content upon a support
- Reprography used to reproduce existing content onto a new support

Within these two specific forms of primary production processes, individual forms can be conceptualised, for example:

- Manual drafting – e.g. Simple drafting, Re-drawing, Inking-In, Tracing
- Reprography – e.g. Blueprinting, Diazotyping, Gel-lithographing, Printing

Materials of primary production processes

The material of the medium used for the primary production of a technical drawing is an important diagnostic indicator of the process employed. Pencil is clearly associated with manual drafting. The diverse chemical media used in some reprographic processes are classified here generically as 'Chemical'. Ink can be employed in some other forms of reprography, as well as in manual drafting.[653]

The primary production process, and the material used for it, is sometimes specifically associated with a particular material for the support medium.[654] In reprography, for example, blueprints could only be produced onto opaque paper or cloth.[655] The sepia diazo process, by contrast, was used to create images onto translucent cloth and synthetic film.[656]

Within manual drafting processes, lightweight detail paper was considered a practical medium for initially working up designs in pencil. Ink drafting onto

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652 'different hands, typefaces or inks': Duranti, *Diplomatics: New Uses for an Old Science*, 135-6, 140.

653 For the circumstances under which specific process materials were recommended for and used in manual drafting, See British Standards Institution, *BS 308:1943 Engineering Drawing Office Practice*, Appendix II, 42, para a; Price, *Line, Shade and Shadow*, 27-32, 95-106.

654 See, for example: Kissel and Vigneau, *Architectural Photoreproductions*, 125.

655 Ibid., 31.

656 Ibid., 63.

more durable tracing cloth, and later, polyester-based film, was recommended for final designs requiring reproduction and / or long-term preservation.[657]

Almost without exception within the sample, ink was used for all forms of manual drafting[658] onto cloth supports.[659] While pencil was the sole process material employed for original drafting onto detail paper, it was also found used, unremarkably, with all other forms of support materials present within the sample.[660] Reprographic processes were predominantly used with cloth and synthetic supports.[661] The process materials used to create the technical drawings in this sample were broadly proportioned equally. Approximately one third of cases each used pencil, ink, or reprographic chemicals.[662]

Importance of primary production processes identification

It was anticipated that knowledge of a technical drawing's form of primary production process would assist with its interpretation in four ways:

1. The process used is often indicative of the point of gestation that a design has reached – the Stage of Production.[663] For example, manual drafting processes are normally used to create draft design and definitive final-design drawings. Designs are implemented through the issue of reprographically reproduced derivative drawings.
2. The process and materials used can similarly help to indicate a technical drawing's Stage of Representation,[664] and its diplomatic Genesis and Tradition.[665]
3. The process used is normally chosen to create a drawing on a support material that is appropriate to the needs of its intended user, as inferred or indicated by an Addressee.[666]

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657 British Standards Institution, *BS 308:1943 Engineering Drawing Office Practice*, 42; British Standards Institution, *BS 1192:1969 Building Drawing Practice*, 63.

658 Manual drafting processes are here defined as including Simple Drafting, Inking-in, Tracing, and Re-drawing.

659 One of 118 cases used a tracing paper support.

660 Synthetic films (68 cases), detail paper (19), cloth (17), tracing paper (13), paper (1).

661 Synthetic films (88 cases), cloth (32), paper (12), tracing paper (3).

662 See Results: 6.1.9 Process Medium – Primary Production – form – material, *125*.

663 See Discussion: 4.8.3 Stage of Realisation through the Stage of Production, *215*.

664 See Discussion: 4.8.3 Stage of Realisation through the Stage of Production, *215*.

665 See Discussion: 2.1 Genesis and Tradition, *154*.

4. As the use of different reprographic processes has changed over time, identification of such a process can help to date a drawing. For example, aniline printing was generally replaced by blueprinting, which was in turn superseded by diazotyping. [667]

Identification of primary production processes

As was the case for support materials, the results showed that consistent and reliable identification of primary production processes was more difficult than had been anticipated. [668] Identification of reprographic reproduction processes was particularly difficult, even with the benefit of excellent reference texts. [669]

As shown in Figure 8, following, when seeking to identify primary production processes, it is necessary to differentiate between:

- Manual drafting of content onto a clean, non-printed drawing sheet
- Manual drafting of content onto a clean, pre-printed drawing sheet template [670]
- Reprographic reproduction of content on a clean, non-printed drawing sheet onto another clean, non-printed drawing sheet
- Reprographic reproduction of content on a clean, non-printed drawing sheet onto a clean, pre-printed drawing sheet template
- Reprographic reproduction of content on a clean, pre-printed drawing sheet template onto a clean, non-printed drawing sheet

Technical drawings might exhibit other process combinations. For example, manual and reprographic production processes were frequently found combined within the surveyed drawings. Such cases were importantly indicative of changes to content subsequent to primary production. They are considered later. [671]

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666 See Discussion: 5.1.4 Addressee, *223*.

667 Kissel and Vigneau, *Architectural Photoreproductions*, 25-43.

668 See Results: 6.1.8 Process Medium – Primary Production – form, *124*.

669 For example, Ibid.; Batterham, *The Office Copying Revolution*, 200; Price, *Line, Shade and Shadow*, 359. The last-mentioned appeared after this work had been very substantially completed.

670 See Discussion: 4.1.2 Technical drawing templates and drawing frames, *183*.

671 See Discussion: 4.4 Changes, *200*.

Problems of identification of manual drafting processes

Identification of manual primary production processes raised one particular problem. Manifest data, indicating that a drawing had been Traced, Inked-in, or Re-drawn, were found in inconsistent positions and forms across the sampled drawings. In analysis, it was found that these data could not be adequately differentiated from similar processes that had been recorded as being used for amendments and corrections.[672]

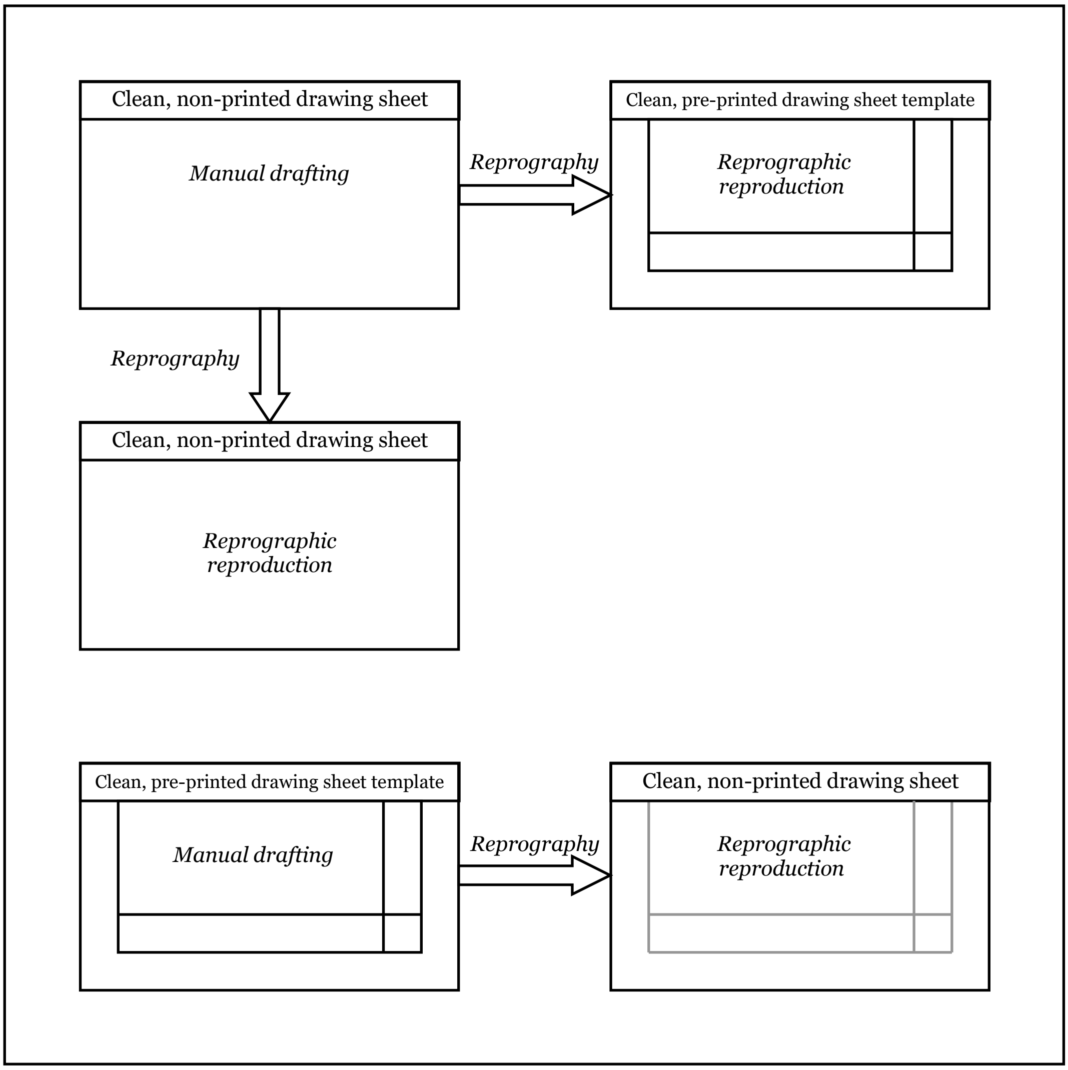

Figure 8: Forms of Primary Production Processes

It was therefore not possible to determine a reliable frequency of use of these individual processes for primary production. However, it was not considered that

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672 See Discussion: 4.4.4 Amendments and Corrections, *206*.

these detailed data merited further investigation because of their low frequencies of occurrence. Such instances constituted only 23.3% (CI 18.4, 28.8) [673] of cases within the specific form of manual drafting (14.8%, CI 11.5, 18.5 of all 400 cases).

Problems of identification of reprographic processes

The reprographic processes were by far the most problematic. I had hoped to have been able to identify them individually, particularly as an aid to dating the technical drawings. However, even after considerable observation, I was often unable to identify the reprographic process used, confidently. I therefore simply recorded each case of reprography as that specific form of primary production process – at a higher level of analysis than was really useful.

The observable characteristics of reprographic processes were, in general, irresolvably tied up with those for the support materials. Colour, which was a significant diagnostic characteristic, posed particularly intractable problems. It is separately discussed, below. Another important diagnostic attribute was whether reprographic content had been reproduced on the front or the back of a support. Determining that by observation alone was also sometimes problematic, as noted, following.

The literature was again excellent in its depth and detail. However, I found for a second time that two-dimensional surrogates, lacking sensory attributes such as touch and smell, were insufficient to enable positive identifications of processes in many cases. Once more, a reference set of examples would have greatly helped to identify the reprographic production processes found in the sample.

Front-back reprographic reproduction

The side of the support upon which an image is reprographically reproduced, in relation to a normal view of the reproduced image, can be indicative of either the reprographic process used, the intended use of the derivative drawing, or both. [674]

In practice, it was sometimes found very difficult to determine whether a drawing had been reproduced on the front or the back of synthetic support materials in particular. It could only be positively determined by scraping off some of the base

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[673] 253 cases for this statistic.

[674] See Results: 6.1.10 Process Medium – Primary Production – position, *125*. The traditional terms *recto* and *verso* are inappropriate to these indeterminate circumstances.

layers that carried the image. That would of course be an inappropriate action for archival technical drawings.

3.1.6 Support and process materials' colour

Colour was ostensibly the easiest observable facet of support and process materials' characteristics. It was also potentially the most diagnostically informative, especially for reprographic processes. [675] However, the literature advised that many colour variations could be found across, and even within, such processes. [676] Consistent interpretation and description of colour data across the technical drawings' sample was therefore essential, to minimise the risk of misidentification of reprographic processes in particular.

It was regrettable, then, that colour data could not be reliably collected, as will be explained below.

Forms of support and process materials' colour

The individual facets of colour relevant to this research were those of:

- a support material whose natural colour had not been modified by the application of base layers or reprographic processes. Normally the colour of support materials used only for manual drafting processes.
- a support material whose natural colour had been modified by carrying reprographic content, but not by having had base layers applied to facilitate the reprographic process. Areas of support not carrying reprographic content still show the support's natural colour. [677]
- a support material whose natural colour had been modified by the application of base layers applied to facilitate a reprographic process. The layers might have been applied to only one side of the support, allowing comparison with its natural colour on the other side. [678] However, the base layer might bleed through to give a false colour indication.
- a support material whose natural colour had been modified by both the application of base layers applied to facilitate a reprographic process, and by

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675 Kissel and Vigneau, *Architectural Photoreproductions*, 13-22.

676 Of which the ubiquitous diazotype was an excellent example likely to be encountered often by archivists: See Ibid., 37-43.

677 For example, the gel-lithograph process: Ibid., 91-5; Price, *Line, Shade and Shadow*, 211-14.

678 For example, the diazotype process: Kissel and Vigneau, *Architectural Photoreproductions*, 37-9, 43.

the process itself.[679] Again, areas of support unaffected by either the base layers and / or the process might still show the support's natural colour, but bleed-through might again give a false colour indication.

- a line colour used by a manual drafting or reprographic primary production process,[680] to create drawing content.
- a line colour used before a primary production process to create a pre-printed drawing sheet template.[681]

Problems of identification and interpretation of colour

Small numbers of drawings could be compared side-by-side, and subjective colour values ascribed. This method quickly became impractical when trying to consider all 400 drawings within the sample. Even not-so-subtle differences in colour, which were obvious side-by-side, were not so clearly differentiated when separated across the hundreds of drawings within the dataset.

Once more, a reference dataset was required. Commercial retail paint charts were used, and the technique found sound in principle. Rigorous and repeatable colour data recording would, though, require a more authoritative form of standard colour chart. Munsell,[682] Pantone,[683] and British Standards resources were investigated. It was not possible, though, to identify a standard colour chart that was reasonably accessible or affordable.[684]

Moreover, advice was received that colour was now best described by reference to colour systems, rather than by use of colour charts.[685] The CIE L*a*b* system

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679 Again, the diazotype process, for example: Ibid., 41.

680 Line colour was a key element for the identification of reprographic processes in Kissel and Vigneau's comprehensive 'Flowchart for...Identification': Ibid., 13-22.

681 This contributes to understanding of the genesis of primary production content. See Discussion: 4.1.2 Technical drawing templates and drawing frames, *183*.

682 x-rite, Inc, 'Munsell Color' (x-rite, Inc., nd) [Website] http://www.xrite.com/top_munsell.aspx (accessed 02 Jun, 2011); Munsell Color Science Laboratory, 'Welcome to the Munsell Color Science Laboratory' (Rochester Institute of Technology, nd) [Website] http://www.cis.rit.edu/mcsl/ (accessed 02 Jun, 2011).

683 Pantone United Kingdom, 'Pantone United Kingdom' (Home Page) (Pantone LLC, nd) [Website] http://www.pantone.co.uk/pages/pantone/index.aspx (accessed 02 Jun, 2011).

684 Only one such chart within British Standards was affordable, but its range of colours was found to be too limited for this application: British Standards Institution, *BS 5252F:1976 British Standard Framework for Colour Co-Ordination for Building Purposes: Colour Matching Fan* (London, 1976). I am grateful to the University of Liverpool for this special purchase for this aspect of the research.

685 A. Phenix, [*Describing*] *Colour* (Pers Comm, 25 Sep, 2007).

was recommended, but a reflectance spectrophotometer would be required to make colour measurements. [686] Because that method would run against the research need for non-technical sensory observations, colour value measurement was not progressed further.

Consistent and statistically reliable data for colour therefore could not be collected for support and reprographic process materials. This was a regrettable gap in an otherwise comprehensive research dataset. The lack of reliable colour data contributed considerably to the problems of identifying support and reprographic process materials, previously described.

3.1.7 Amendments and Corrections

Discussed here are the physical characteristics of the medium of the processes used to amend or correct a technical drawing. Intellectual characteristics, associated with the concepts of changes to a drawing, are considered later. [687]

Amendments and corrections are not primary production processes. By definition, they amend or correct content that has been created by an earlier primary production process. That process might have been manual drafting or reprography. Where a technical drawing has been created by the primary process of reprography, an amendment or correction is only considered here to be such if it has been made to the reprographically reproduced content. Amendments and corrections that exist only as part of the reprographic reproduction are considered only to be relevant, in this context, to the earlier content that has been reproduced.

The intent of this differentiation is to assist with the better definition of a technical drawing's diplomatic status, genesis, and tradition. [688]

Amendments and corrections were normally found to be made by the process of simple manual drafting. [689] The same observations can be made of that process's

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686 CEI: Commission Internationale de l'Eclairage, 'CEI: [International Commission on Illumination]' (CIE Central Bureau) [Website] http://www.cie.co.at/ (accessed 02 Jun, 2011).

687 See Discussion: 4.4.4 Amendments and Corrections, *206*.

688 See Discussion: 2.1.1 Genesis and tradition in technical drawings, 155.

689 See Results: 6.1.11 Process Medium – Amendments and Corrections – form, *126*. In a small number of cases, they were also made by a small piece of material bearing the amendment or correction being pasted onto the drawing. These instances were not recorded.

materials as were made previously for primary production. [690] Material colour was though much more easily recordable, being a line colour produced by manual drafting rather than reprography. [691]

Theoretically, there should no longer be the same correlation between process and support materials. When an amendment or correction has to be applied to a technical drawing, the material of its support has already been established in primary production. This was indicated within this sample by the use of ink to make amendments or corrections on synthetic supports. [692]

3.1.8 Annotations and Deletions

In contrast to data that amend or correct a technical drawing's primary content, annotations are defined here as the inclusion of data additional to that existing in primary content. This section merely notes, for completeness, that data for the physical characteristics of annotations were collected within the concept of Medium. The data were not of sufficient importance to merit discussion here. The intellectual characteristics of annotations are summarily discussed within the concept of Changes, later. [693]

Physical characteristics of Deletions were present within some surveyed technical drawings. They were of no importance and are noted here only for completeness.

4. Intellectual Concepts and Characteristics

This principal section discusses those diplomatic concepts and characteristics that can be investigated equally well in both 'original' documents and in reprographic reproductions of those documents. Some of these concepts and characteristics will have been regarded, in traditional diplomatic analysis, as

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690 See Results: 6.1.12 Process Medium – Amendments and Corrections – form – material, *125*. The media and materials used for amendments and corrections may usefully be compared with those used for primary production. Together, they provide data which equate to the physical attributes of diplomatic Script as it has been conceptualised elsewhere. See Discussion: 3.1.5 Primary production processes, *171*.

691 See Results: 6.1.13 Process Medium – Amendments and Corrections – form – material – colour, *126*.

692 Thirty-eight cases used hand-drafted ink, sometimes in combination with pencil, for amendments and corrections on synthetic supports. Only nine cases did so for primary production.

693 See Discussion: 4.4.5 Annotations and Deletions, *207*.

extrinsic elements. As previously discussed, they are regarded in this research as intellectual concepts.[694]

As well as those traditional diplomatic concepts, other concepts discussed here have been derived from late twentieth-century diplomatic theory.[695] Some concepts have also been newly developed within this research.

Intellectual concepts of a general nature are necessarily discussed first. They can then more easily inform understanding of the discussion that follows for the intellectual concepts of a technical drawing's internal articulation – the protocol, graphics and text, and eschatocol.

The intellectual concepts and characteristics are therefore discussed in the following order:

- Presentation Style
- Language and Script
- Changes
- Archival Bond
- Contexts
- Information Form
- Stage of Representation
- Internal Articulation

4.1 Presentation Style

The term Presentation Style is used here to define a new general concept that was developed within this research. While knowledge of this concept's rationale is essential to understanding other parts of the general discussion, the components themselves merit only summary description.

The new general concept of Presentation Style encompasses more specific intellectual concepts and their characteristics that govern the layout and form of the structural components that make up a technical drawing. Some concepts and characteristics within Presentation Style have been found previously included

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694 See Discussion: 1.3 Structure of the discussion, *152*.

695 Typically from theory developed within the UBC and InterPARES projects. See, for example: Duranti, 'The Concept of Electronic Record', 12-20; Duranti and Thibodeau, 'The Concept of Record in Interactive, Experiential and Dynamic Environments', 15-20.

within a conceptualisation of diplomatic Script.[696] Layout and formatting are considered comparable to the orientations of a technical drawing, and to the position and form of its primary production content. The traditional 'correspondence between paragraphs and conceptual sections of the text'[697] is directly analogous to the structure provided by technical drawing templates and drawing frames.

The present conceptualisation therefore more logically separates elements that are associated with the physical form of a document from those that are concerned with the articulation of content through Language and Script – considered later.[698]

Presentation Style is distinct from the concepts and characteristics of Medium, whose Data Values may change when derived versions of drawings are created. The Data Values of the intellectual characteristics of Presentation Style will, by contrast, be preserved when derived versions are created by reproduction processes other than manual copying and transcription – essentially, reprographic reproduction processes.

The following concepts within Presentation Style are now summarily discussed:

- Technical drawing orientations
- Technical drawing templates and drawing frames, including:
  - Title Block
  - Signature-Date Block
  - Materials List

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696 'layout, pagination, formatting' and 'paragraphing': Duranti, *Diplomatics: New Uses for an Old Science*, 135-6, 140. The concept of Presentation Style here is not intended to be related to the concept of Presentation Features within: InterPARES 1 Project: Authenticity Task Force, 'InterPARES 1 Project: Appendix 1: Template for Analysis', 1.

697 Duranti, *Diplomatics: New Uses for an Old Science*, 136.

698 See Discussion: 4.2 Language and Script, *185*.

4.1.1 Technical drawing orientations

Two specific concepts are defined within the general concept of the orientation of a technical drawing:

- The orientation of the layout of a drawing [699]
- The orientation of the view of a drawing [700]

Orientation of layout

Drawing layout has been characterised within the traditional diplomatic concept of Script as *carta transversa* and *carta non transversa*. [701] This concept of 'Orientation of layout' enables the orientation of layout of a technical drawing upon a support to be differentiated from the orientation of layout of the support itself. [702]

Orientation of view

The second orientation concept is quite different. It can be used when 'handed' objects are represented in a technical drawing. For example, a right-handed object is depicted 'As Drawn', while data for the left-handed object are required to be inferred as 'Opposite Hand'. This concept can be considered analogous to *ductus* – the direction of writing – within the traditional diplomatic concept of Script.

4.1.2 Technical drawing templates and drawing frames

The technical drawing template's complexity ranged from a simple drawing frame to a highly structured lattice of inter-related components. Such diversity in a template's structural content and layout makes it a very useful first indicator of a technical drawing's Information Form. [703] Some form of drawing frame was present in 100% of all surveyed cases. [704]

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699 See Results: 6.2.1 Presentation Style – Drawing Orientation – layout, *127*.

700 See Results: 6.2.2 Presentation Style – Drawing Orientation – view, *127*.

701 InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES)', 3.

702 See Discussion: Support layout and material presentation, *171*.

703 For example, a single-part or an assembly drawing. See Discussion: 4.7 Information Form, *211*.

704 See Results: 6.2.3 Presentation Style – Drawing Frame, *128*.

Data Values for the front-back positioning of a technical drawing template can be used with similar data for primary production content.[705] Those data have greater diagnostic potential in combination than in isolation – for example, for a drawing's Primary Production Processes, Intended Use, Genesis, and Tradition.

Within this sample, the template components that were found to be generic, or nearly so, were a Signature-Date Block, Title Block, and a Materials List – discussed next.

Signature-Date Block

Discussed here are the structural attributes of the Signature-Date Block. Its internal components and contents, and accompanying marginal notes where present, are considered later.[706]

Although the form and contents of the Signature-Date Block varied widely across the dataset, two general forms were found.[707] To distinguish between those two forms, I applied a new term to each, as now explained.

In 46% (CI 41.2, 50.9) of all cases, only one data element was labelled for date within a Signature-Date Block.[708] That date data element was typically positioned below the individually labelled signature data elements, and was not manifestly associated with any one of them. This I termed an 'Omni[bus]' date – hence an 'Omni' form of Signature-Date Block.

The second form of Signature-Date Block was normally internally structured so as to have a data element for date accompanying each data element that was labelled for signature. This form occurred in 53% (CI 48.1, 57.9) of all cases. I termed it a 'Non-Omni' form of Signature-Date Block.

Title Block

In British Standards for engineering drawings, the major component of a technical drawing's layout was the Title Block. Its structure varied considerably

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[705] See Results: 6.2.4 Presentation Style – Drawing Frame – position, *128*.

[706] See Discussion: Clause of Corroboration – Signature-Date Block, *233*.

[707] See Results: 6.2.5 Presentation Style – Signature-Date Block, *128*.

[708] See Results: 6.11.12 Eschatocol – Date – Omni, *148*.

according to the purpose for which the drawing was to be used.[709] In this sample, the Title Block was almost always positioned either across the full width of the bottom of the drawing, or in the bottom right-hand corner.[710]

Materials List

The Materials List is noted here only because the survey results showed it to be almost generic.[711] The concept's practical importance to the research was very low, and it was therefore not considered further.

4.2 Language and Script

The concepts of Language[712] and Script were closely related within traditional diplomatic theory, but each had its own separate characteristics. While great importance was traditionally attached to both concepts, their perceived relevance waned over time.[713]

As will be seen in the discussion below,[714] I regard Language as the key to understanding technical drawings. I have therefore reconceptualised the traditional diplomatic concepts and characteristics of Language and Script. I conceive that Language can be considered as a means by which knowledge is communicated. Script can then be considered as a lower-order means by which Language is expressed.

Following that reconceptualisation, I regard Language as the means by which the content of a technical drawing is communicated. Script, in technical drawings, is the textual or graphical expression of that language.[715] That expression makes Script a more tangible concept than that of Language. The characteristics of Script are however very granular, and inextricably tied up with other concepts and characteristics within technical drawings. It is the concept of Language that is

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709 Compare, for example, the structures illustrated by: British Standards Institution, *BS 308:1953 Engineering Drawing Practice*, 2nd revised ed. (London, 1953), 8-12, Figs 2-6.

710 See Results: 6.2.6 Presentation Style – Title Block, *129*.

711 See Results: 6.2.7 Presentation Style – Materials List, *129*.

712 The term 'Language' is hereafter formed as a Proper Noun when used to denote the diplomatic concept of Language. 'Script' follows the same convention.

713 Duranti, Diplomatics: *New Uses for an Old Science*, 135-8.

714 See Discussion: 4.2.2 Language, *187*.

715 More generally, the ways in which Script is expressed vary according to the form of production process by which a record is created or changed. In audio-visual recordings, for example, Script can be conceived as being the means by which images or sounds are expressed.

crucial to understanding technical drawings – a concept that is therefore brought back to prominence in this conceptualisation of diplomatic theory.

This section clearly separates the two concepts of Language and Script. The new treatment of the diplomatic concept of Script is briefly discussed first. Essentially, most of the characteristics of Script are conceptually relocated to those concepts with which they have close ties.

I then discuss Language in more detail. Specifically, I bring forward some problems of technical language literacy that might be faced by archivists, and then suggest how they can be overcome. Finally, I define and discuss three individual concepts of Language in the context of technical drawings.

This section therefore discusses the following aspects of Language and Script:

- Script
- Language
- Technical Language – Scale
- Technical Language – Method of Representation and Drawing Aspect
- Technical Language – Dimensioning

4.2.1 Script

An indicated above, I have conceptually relocated most of the characteristics of the diplomatic concept of Script. I argue that this relocation is not theoretically problematic. Each relocated characteristic of Script now resides alongside other characteristics that have similar attributes and facets. In each case, they are grouped together within a relevant diplomatic concept. These relocations are indicated at the relevant places within this chapter. [716]

I also contend that this general approach to the diplomatic concept of Script might be applied to any other Information Form of document, especially those that use other forms of non-textual language. Typically, such Information Forms would include traditional forms of accounting or scientific records, musical scores, and audio-visual recordings.

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[716] Within the concepts of Process Medium, Presentation Style, and Changes. The characteristics remaining within Script are all of intellectual form – types of script, forms of punctuation, and abbreviations and initialisms. They are not sufficiently important to merit further discussion here.

4.2.2 Language

Diplomatic conceptualisations of Language

Having discussed characteristics within Script, those within Language can now be considered. They, too, are embedded within other concepts, albeit at a higher level and with a wider scope than the characteristics of Script.

Within the concept of Language, the characteristics of vocabulary, composition, and style contributed to the diplomatic convention of the *ars dictaminis*. That documentary rhetoric provided rules that were meant to guide the drafting of every type of document. Specific expressions of language became established as formulae, modelled in *formularia* for the guidance of document writers. [717]

Those diplomatic rules and examples for the creation of medieval documents have been mirrored since the twentieth century by British and international standards for technical drawing.

The conceptualisation of Language within diplomatic exemplifies the difficulty of rigidly defining concepts in terms of extrinsic and intrinsic elements. Language was originally regarded as an intrinsic element. The language used formed part of the internal articulation of a document. Later theorists reconceived Language as an extrinsic element, which could only be accurately analysed within an original document. [718]

I have already clearly separated the concepts of Language and Script. In those terms, Language provides the means by which a document's content is intellectually articulated. The intellectual concept of Language is as truly represented in reprographically reproduced technical drawings as it is in the drawings that are so reproduced. Language is therefore amenable to diplomatic analysis in both forms of document. I further argue the same case for other Information Forms that are reprographically reproduced.

Added weight is given to this argument by the necessary location of the Language characteristic of formulae within the intellectual content of a technical drawing. In late twentieth-century diplomatic theory, formulae have been associated with

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[717] Ibid., 137.

[718] See Literature Review: 2.5 Diplomatic concepts of extrinsic and intrinsic elements, *48*.

Script.[719] However, I consider them to be part of the Language of technical drawing. They are analogous to standard forms of articulation with which technical drawing language was expressed in the research sample.[720]

Definitions of Language

Diplomatic's original natural language concept is considerably extended here to encompass forms of technical language. The general concept of Language is defined as comprising two specific concepts:

- Natural Language – The system of spoken or written communication used by a particular country or people in their day-to-day affairs[721]
- Technical Language – The system of written communication used by a particular community to develop, record, and transmit technical ideas through technical drawing

Individual natural and technical languages may be accrued to both these specific concepts.

Technical language literacy

Natural Language need not be considered further here.[722] The textual forms of natural language description are though inadequate to define and communicate three-dimensional technical ideas through a two-dimensional medium. Rather, visual forms of communication, using special signs and symbols,[723] have been developed. Once learned, such technical languages are as readable as words on a page.[724] They are not, though, common to most archival practice and experience. Yet 'From a diplomatic point of view, the study of the Language of the document

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719 Duranti, *Diplomatics: New Uses for an Old Science*, 137.

720 For example, 'Do Not Scale Drawing', 'As Drawn', and 'Opposite Hand'.

721 Adapted from the definition of 'language, n. (and int.)' in *OED Online*, Mar 2011 ed. (Oxford University Press, 2011) [Online] http://www.oed.com (accessed 12 Apr, 2011).

722 Nor was Natural Language studied from the perspective of linguistics in traditional diplomatic analysis of documents. Rather, special features of language expression were the focus: InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES)', 7. See also Discussion: Solutions for technical language literacy, *189*.

723 In this context, they are not to be regarded as special signs and symbols in the sense of diplomatic analysis.

724 Baynes and Pugh, *The Art of the Engineer*, 15; Belofsky, 'Engineering Drawing: A Universal Language in Two Dialects', 24.

is important to establish the provenance and the date of the document.'[725] This can be as true for technical languages as for the natural languages more usually encountered by archivists.

Problems for technical language literacy

A variety of technical languages and dialects exists to impede intellectual access to a technical drawing by archivists and researchers. Yet I contend that it is not necessary to be a technical linguist to be able to understand a technical drawing sufficiently for archival management and research purposes. Rather, what is first required is a clear understanding of just how much needs to be known about such languages. That follows the general principles of this research.

Many forms of technical language have been created on different levels, deriving their meanings from diverse cultures and social contexts. In the present context, both internationally and domestically, different enterprises and their drawing offices 'created and reflected local and national dialects of [technical drawing] language'.[726] The forms of language employed were aligned to the ways in which technical drawings were intended to be interpreted and used.[727] One of the most 'significantly divergent' approaches to technical drawing language existed at the articulation level – the adoption of first- or third-angle projection.[728] Finally, there have been attempts to draw together this diversity of technical drawing language through national and international standards. Those standards might, though, encompass a grammar and vocabulary as intellectually inaccessible to the archivist and non-specialist researcher as the technical drawings with which they are faced.

Solutions for technical language literacy

It is not, though, knowledge of such technical languages *per se* that will help archivists and researchers to better understand technical drawings. It is how

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725 InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES)', 7.

726 Brown, 'Design Plans, Working Drawings, National Styles', 236. A similar point was also made in the entirely different context of diplomatic analysis: Duranti, *Diplomatics: New Uses for an Old Science*, 138.

727 Brown, 'Design Plans, Working Drawings, National Styles', 195-6, 235-6. Brown brought considerable insight to this topic.

728 Belofsky, 'Engineering Drawing: A Universal Language in Two Dialects', 24. Belofsky's entire paper concerns this fundamental issue of technical drawing practice.

those languages articulate information about particular concepts and characteristics that can potentially enable a better understanding. In common with the general approach to this research, the problem of technical language literacy was broken down. Discrete areas of concern were identified, guided by diplomatic theory.

From this conceptualisation, and the survey results, I have identified three Technical Language concepts that were sufficiently generic to be potentially of importance to archivists and researchers:

- Scale
- Drawing Aspect
- Dimensioning

These individual Language concepts are considered generically, rather than being tied to specific forms of articulation such as are found, for example, in British Standards. This is in keeping with the general approach to this research.

4.2.3 Technical Language – Scale

The results showed that the technical drawings within the sample were normally drawn to scale.[729] At the same time, relatively few drawings bore an indication of the scale(s) to which their depicted views had been drawn.[730] Rather, the majority of drawings contained the instruction, in terms analogous to a Clause of Prohibition, 'Do Not Scale Drawing'.[731] The reasons for perhaps surprising situation are two-fold:

- dimensional instability of the material of the support, leading to expansion and / or shrinkage, which would alter a directly-read scaled measurement.[732]

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729 See Results: 6.3.3 Technical Language – Scale – Drawing – measured RF, *130*.

730 See Results: 6.3.2 Technical Language – Scale – Drawing – indication, *129*.

731 See Results: 6.10.7 Text – Final Clauses – Scale Warning, *145*. Nonetheless, the BS 308 series always recommended that an indication of scale should be given. The inclusion of a warning against scaling was only first mentioned in 1967, in connection with microfilming: British Standards Institution, *Supplement No.1 to BS 308:1964 Engineering Drawing Practice: The Preparation of Drawings Suitable for Microfilming* (London, 1967), 4, cl. 27. The next edition retained the requirement for an indicated scale, the warning against scaling being a discretionary addition: British Standards Institution, *BS 308:Part 1: October 1972 Engineering Drawing Practice: General Principles*, 4th revised ed. (London, 1972), 28, cl. 10.1.

732 See, for example: British Standards Institution, *BS 308:1943 Engineering Drawing Office Practice*, 42, App. IIb; British Standards Institution, *BS 1192:1969 Building Drawing Practice*, 63, App. A.

- imprecise enlargements and reductions to drawings when reprographically reproduced, especially when working copies are made from microfilms of original drawings.[733]

This meant that even though a technical drawing had been drafted to scale, and a scale indication given, the dimensions of represented parts must not be directly measured from a drawing, using a calculation of scale. Rather, all necessary dimensions must be explicitly stated on the face of the drawing.[734]

Importance of scale indication

That does not mean that the concept of scale is unimportant. No matter how it might have been used originally, a researcher will find knowledge of the scale of a technical drawing to be of particular interest. That would especially be the case when making decisions to travel to view drawings based on remote access to their archival descriptions.

Scale could be recorded in archival description simply as a single or predominant scale for a technical drawing as a whole. Where more than one scale is used for different Drawing Aspect views, though, connecting each view to a scale would provide a more detailed description of a technical drawing. It should not be inferred that only drawings at larger scales, showing greater detail, are of more archival research value than those at smaller scale. Drawings at smaller scales, showing a whole artefact, assembly, or arrangement, might be of equal research interest.

Inferring scale data

The survey results showed that a scale value was rarely indicated.[735] A scale value therefore had to be calculated in a single consistent form in this research – the Representative Fraction.[736] Data collection for this characteristic was therefore very time consuming. Very often, Representative Fractions had to be inferred by

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733 British Standards Institution, *Supplement No.1 to BS 308:1964 Engineering Drawing Practice*, 4, cl. 27.

734 Brown argued, in a North American context, that this contributed to the subordination and direct control of production workers though technical drawings: Brown, 'When Machines Became Gray and Drawings Black and White', 45, 52-3, n.75.

735 See Results: 6.3.2 Technical Language – Scale – Drawing – indication, *129*.

736 See, for example: Procter and Cook, *Manual of Archival Description*, 203, cl. 22.4C2 Item 2; Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings', 6-13, cl. 6.3B1.

measurement of a drawn line and calculation against the line's stated dimension. Nonetheless, Representative Fractions could be calculated sufficiently often for scale to be regarded as a potentially useful generic concept.[737]

Problems when inferring scale data

Data collection highlighted the need for some caution to be taken when inferring a scale. Occasionally, an individual element of a representation was not at the same scale as could be generally and reasonably deduced for the rest of the representation. If that element had been chosen in isolation for a calculation of scale, that calculation would be wrong.

Such an incongruity can result from a number of factors. In the surveyed drawings, for example, some dimension lines were found broken, so that large but uncomplicated features could be represented out of scale. Some amended dimension lines were found to have been foreshortened, to fit within the available drawing space. While such amendments were obvious when manually drafted, they did not stand out when viewed in reprographically reproduced derivatives. In a few other cases, a dimension was found given for which no obvious explanation could be found, other than it being a drafting error.

All these potential irregularities of scale representation call into question the means by which scale is represented in archival description. It cannot be expected that archival processing time will be available to seek out every possible source of scaling error, even if they could be recognised. It is therefore appropriate to record as 'Indicated' a scale manifestly given within a technical drawing. A scale that has been inferred though calculation should be so noted, as 'Calculated'.[738]

A range of issues has therefore militated against the concept of scale in technical drawing. It is as if scale has been used as a technical language of convenience to govern the physical dimensions of a technical drawing itself. Dimensions rule

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737 See Results: 6.3.3 Technical Language – Scale – Drawing – measured RF, *130*; 6.3.4 Technical Language – Scale – Plan – measured RF, *130*; 6.3.5 Technical Language – Scale – Elevation – measured RF, *131*.

738 Following: Ibid., 6-14, cl. 6.3B1.

over scale, both intellectually and practically. Technical drawings might therefore be more properly regarded as dimensioned, rather than scaled, drawings.[739]

4.2.4 Technical Language – Method of Representation and Drawing Aspect

This section introduces the languages of representing objects within technical drawings. The discussion focuses on the language normally used to create images in technical drawings – orthographic projection. That language is differentiated from that of pictorial representation, which might also be found used.[740]

Newly developed concepts of Method of Representation and Drawing Aspect[741] are introduced. I explain how, through them, terminology can be used to inform a generic understanding of drawings' graphical content. Defined terms can then be applied to the description of views within technical drawing images.[742]

Developing these new concepts of Method of Representation and Drawing Aspect was a sizeable task whose outcomes can only be summarised here.

Archival understanding of graphical content

Despite a record's content being extraneous to diplomatic analysis,[743] the graphical content of a technical drawing cannot be ignored. No matter what textual information might exist in other concepts and characteristics, graphical content is normally this form of record's reason for existence.

Yet for the non-specialist, this image can be one of the most difficult areas of a technical drawing to understand. At the same time, it is not the content in itself that archivists need to understand. Rather, they have to know how that graphical

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739 Engineering drawings were regarded as 'scaled drawings' in Heap, 'Engineering Drawings - their Selection, Storage and Use', 39.

740 Orthographic projection and pictorial representation fulfil two different purposes. Rarely, a small pictorial representation might be found within an orthographic projection drawing, to illustrate a particularly complicated feature, for example. No such instances were found in this sample. Other forms of representation, including layout and installation drawings, technical sketches, and diagrammatic drawings, are considered later. See Discussion: 4.7 Information Form, *211*.

741 Derived from the term 'Aspect', used in architectural drawing description: Bingham, *Cataloguing Guide*, 12.

742 And also, later, for the concept of Information Form. See Discussion: 4.7.2 Determination of Information Form, *212*.

743 Duranti, *Diplomatics: New Uses for an Old Science*, 43.

content is represented. That information can then be communicated to researchers, through archival description.

It is therefore not necessary for archivists to comprehend fully all the technical detail of such an image before they can effectively process the record. Rather, what is required is an appreciation of what the image represents, and how it is represented, in more general and generic terms. For example, does it show a side view of a complete object, a detailed view of a part, or an exploded view of a multi-part assembly?

How such views might be determined and described in archival settings is now discussed though the concepts of Method of Representation and Drawing Aspect. These two concepts separate out terms that elsewhere have been conceptually combined, but which actually operate on quite different levels.[744] At the same time, I have also clearly separated the concept of Drawing Aspect from that of Orientation of View,[745] discussed earlier.[746]

Method of Representation

This general concept encompasses the specific concepts of drawing systems used to draft different forms of image within technical drawings. Only two such specific concepts need be considered here:[747]

- Orthographic projection
- Pictorial representation

Through orthographic projection, views of a three-dimensional object are projected onto a two-dimensional plane such as a technical drawing. It is the

744 For example, within the concept of 'Aspect' are terms that indicate a direction of view, e.g. plan, section; and terms that indicate a drawing system, e.g. axonometric, isometric: Bingham, *Cataloguing Guide*, 12.

745 Exemplifying an avoidance of conflict with existing use of the terms 'Orientation' and 'Aspect': Getty Vocabulary Program, ed., 'Orientation' in *Art & Architecture Thesaurus (AAT)* (Los Angeles, CA, 1983-) [Online] http://www.getty.edu/vow/AATFullDisplay?find=orientation&logic=AND&note=&english=N&prev_page=1&subjectid=300056297 (accessed 12 Jun, 2011).

746 See Discussion: Orientation of view, *183*.

747 Further concepts are introduced later, when the Method of Representation is presented as the means by which a technical drawing's Information Form is described. See Discussion: 4.7 Information Form, *211*.

> most widely used method of representing technical objects in all fields of technical drawing...and is thus considered to be the accepted technical language.[748]

In pictorial representation, by contrast, a three-dimensional image of an object is created by projecting a single view of the object onto a drawing plane.[749] Such technical illustrations are commonly used where difficulty might be experienced in the interpretation of an orthographic projection drawing. They are often used to illustrate products and objects in parts catalogues, and in operating and maintenance manuals, for example.

Indication of Method of Representation

Drawings drafted using orthographic projection have used one of two drawing systems:[750]

- First angle projection
- Third angle projection

The difference between projection systems is fundamentally important to reading a technical drawing, yet within this dataset, comparatively few drawings indicated the system in use.[751] However, a researcher whose level of interest requires knowledge of which system has been used is very likely to be able to identify it.

While pictorial representation can use a larger number of systems, knowledge of the system used has little practical importance for the archival management of technical drawings. It is not considered further here.

Drawing Aspect

A technical drawing may contain one or many graphical representations of the object that it was created to portray. Whichever form of representation has been used, each individual view requires a descriptive term by which it can be denoted,

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748 British Standards Institution, *BS EN ISO 5456-2:1999: Technical Drawings - Projection Methods - Part 2: Orthographic Representations* (London, 1999), iii.

749 Adapted from British Standards Institution, *BS EN ISO 5456-4:1999: Technical Drawings - Projection Methods - Part 4: Central Projection* (London, 1999), iii.

750 The reasons behind those two 'dialects' of the engineering drawing language were examined in Belofsky, 'Engineering Drawing: A Universal Language in Two Dialects', 23-46, and Mori and Belofsky, 'Engineering Drawing: A Universal Language in Two Dialects - Comment and Response', 853-857.

751 See Results: 6.3.6 Technical Language – Method of Representation – indication, *131*.

for example in archival description. I use the term Drawing Aspect for the general concept that encompasses specific and individual forms of view. Terms for specific forms of view correspond to those used for the specific concepts of the Method of Representation – orthographic projection and pictorial presentation. Within each specific form of view are the individual concepts and characteristics whose terms can be used for description.

Orthographic projection

Two-dimensional orthographic projection drawing normally requires more than one view to be drawn of an object, for it to be fully represented. Within the specific concept of orthographic projection, for example, individual forms of view include plan view, elevation view, section view, and detail view. Each individual view may be further characterised. Forms of plan view, for example, include a top-down view and a bottom-up view. Section views include cross sections and half sections.

Pictorial representation

Within technical drawing as considered here, views are much less often created through the specific concept of pictorial representation. Drawings showing such three-dimensional representations are normally confined to a single view. It may be exploded, to show the relationship of parts within an assembly. Cut-away and X-ray views are used to reveal otherwise hidden parts or portions within an assembly or structure. Such technical illustrations, typically used in parts catalogues, and vehicle maintenance and operating manuals, are not the focus of this research, and are therefore not considered further here.

Problems of identifying Drawing Aspect

It is inherent in two-dimensional orthographic projection drawing that multiple views are normally necessary to depict an object effectively. In this sample, two and three views occurred most frequently. [752] It is helpful to researchers for archival descriptions to state the number and form of views that a technical drawing depicts.

[752] See Results: 6.10.1 Graphics – Drawing Aspect – Number of Views – All Views – data element, *143*.

However, the sample results showed that orthographic drawing views were very often not labelled. Almost without exception, each case where multiple views were depicted lacked at least one individual label. More than half of the cases of orthographic drawings bore no view label at all.[753]

Determining the difference between a plan view and elevation view was especially difficult.[754] Quite often, it was impossible to decide which was a plan view, and which a front, side or end elevation. Furthermore, views of single parts in particular might not be related to the as-fitted orientation of the drawn object. This is recognised to be a problem generally within engineering drawing:

> Unless an article can be oriented to give a definite front view, the draftsman has no option but to make an arbitrary choice.[755]

This relative lack of label elements places something of an interpretation burden upon archivists describing this aspect of a technical drawing. Again, though, it must be emphasised that archivists need only understand how the graphical content has been represented – not, in this particular context, what it represents. How that content is represented is described using terms within the newly developed concept of Drawing Aspect. That concept, by being founded in the acknowledged language of engineering drawing, enables appropriate descriptions to be written.

4.2.5 Technical Language – Dimensioning

The general concept of dimensioning has developed considerably within the date range of the technical drawings in this sample. In 1927, the first relevant British Standard devoted less than a single page of text to dimensioning.[756] By 1972, two

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753 See Results: 6.10.2 Graphics – Drawing Aspect – Number of Views – All Views – label element, *143*.

754 See Results: 6.10.3 Graphics – Drawing Aspect – Number of Views – Orthographic Projection Plan Views, *144*, 6.10.4 Graphics – Drawing Aspect – Number of Views – Orthographic Projection Elevation Views, *144*.

755 Simmons and Maguire, *A Manual of Engineering Drawing Practice*, 30. See also: W. E. Walters, 'Three-Dimensional Engineering Drawing', *Engineering Drawing and Design*, 2, 1 (1948), 3, and Simmons, Maguire, and Phelps, *Manual of Engineering Drawing*, 29.

756 British Engineering Standards Association, *BS 308:1927 Engineering Drawing Office Practice*, 8.

of the standard's three parts were devoted solely to the topic.[757] Dimensioning and tolerancing had acquired a language of their own.

In theory, such developments potentially offer extensive opportunities for interpreting technical drawings. Detailed diplomatic and palaeographical analysis should be able to identify how those conventions were interpreted by different enterprises – and even individuals – over time. They might then help with assessments of drawings' provenance, and relative date and original order.

As to be expected, dimensioning was used in a sufficient number of drawings to be considered a near-generic concept.[758] Available time, though, permitted only one fundamental characteristic to be surveyed, as an illustration of the opportunity. That chosen was the manifest indication of the dimensioning system in use on a drawing – imperial or metric.[759] Those drawings that bore such data, and which were also dated, were then analysed for patterns related to the dimensioning system, provenance, and date. Although the results needed to be treated with some caution,[760] some patterns were discernable that are illustrative of the potential of this form of analysis.

Within those cases that were dated, and which also manifestly indicated the dimensioning systems in use, all those for Thornycroft enterprises, between 1945 and 1965, used only the imperial system.[761] Unsurprisingly, given their date-range of 1972 to 1980, British Leyland drawings with similar qualifications almost exclusively used the metric system.[762]

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757 British Standards Institution, *BS 308:Part 2:October 1972 Engineering Drawing Practice: Dimensioning and Tolerancing of Size*, 4th revised ed. (London, 1972); British Standards Institution, *BS 308:Part 3:October 1972 Engineering Drawing Practice: Geometrical Tolerancing*, 4th revised ed. (London, 1972).

758 See Results: 6.3.7 Technical Language – Dimensioning, *131*.

759 See Results: 6.3.8 Technical Language – Dimensioning – System – indication, *131*.

760 The analysis relied upon only manifest data that stated the dimensioning system in use. It became apparent that more comprehensive and better-quality data could have been gleaned by observation of the dimensioning practice itself within each drawing. Time precluded this rework.

761 34 cases. One later case (#0182, in 1972) indicating the use of the metric system, post-dated Thornycroft's amalgamation into British Leyland.

762 31 cases. Only four cases used imperial dimensioning, between 1972 and 1974.

Drawings for AEC enterprises, by contrast, for the much broader period 1929 to 1968, used both imperial and metric dimensions.[763] There was, though, no gradual change from imperial to metric within this period, as might be expected. Rather, metric dimensioning was indicated to be in use from the earlier date.

Deeper diplomatic analysis

More detailed levels of diplomatic analysis of dimensioning data offer potential to differentiate between drawings where other evidence is deficient. Diagnostic characteristics include, for example, the use of vulgar or decimal fractions, leading zeros, decimal markers and thousands' markers, and the forms of unit abbreviations.[764] Furthermore, while this analysis has concentrated only on simple linear dimensioning, other dialects of the dimensioning language offer similar opportunities.[765] Such a vast potential could not be realised within the time available for this research, but remains open to future investigation.

4.3 Special Signs – Enterprise Logos and Trade Marks

A comparatively small number of technical drawings contained logos and trade marks. These special signs comprised both graphical and textual elements, either separately or in combination.[766] All such special signs could be reproduced reprographically, defining the concept as an intellectual one.

The correspondence of logos and trade marks to specific diplomatic concepts is arguable. In technical drawings, the purpose of logos and trade marks was obviously more than incidental embellishment – they were stylistic expressions of a Principal Enterprise's corporate identity. However, they were not normally found especially associated with certification concepts. Their role would not

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763 102 cases.

764 Compare, for example, the usages in British Engineering Standards Association, *BS 308:1927 Engineering Drawing Office Practice*, 8, cl. 7; British Standards Institution, *BS 308:1943 Engineering Drawing Office Practice*, 23, cl. 12.a-c; British Standards Institution, *BS 308:1953 Engineering Drawing Practice*, 36, cl. 13.a-c; British Standards Institution, *BS 308:1964 Engineering Drawing Practice*, 3rd revised ed. (London, 1964), 35, cl. a-c; and British Standards Institution, *AMD 480 Amendment Slip No.3 to BS 308:1964 Engineering Drawing Practice* (London, 1970).

765 For example, angular dimensioning, and dimensional tolerancing.

766 See Results: 6.4.1 Enterprise Logos and Trade Marks, *132*.

therefore seem to be manifestly equivalent to the diplomatic special sign of validation.[767]

These special signs could, though, be diplomatically analysed to useful effect. Two examples indicated administrative change within an enterprise. In the first case, the simple 'Leyland' logo was crossed out in six drawings. In two of those cases, 'Leyland Vehicles' logos and trade marks were present.[768] In the four other cases, those for 'British Leyland Truck + Bus Division' were present.[769]

In the second case, the continuity of the stylised original 'Leyland' letter 'L' was traced through to the 'British Leyland Truck [and] Bus Division' logos. It also highlighted a difference in form within these latter elements – the use of either a '&' or a '+' as the conjunction.

Despite the small number of cases bearing these special signs, an important general point can be made from them. The logos and trade marks can be considered, in miniature, as analogous to technical drawings themselves. Despite the apparent difficulties of analysing ostensibly graphical data, workable approaches can be developed and useful results derived at both these micro and macro levels of analysis.

4.4 Changes

The Changes concept subsumes and extends the traditional concept of diplomatic Annotations. This new general concept is scoped to include the intellectual concepts and characteristics associated with changes made to a technical drawing after it has been created through a Primary Production Process. Related physical concepts and characteristics are located within the concept of Medium, and were discussed earlier.[770]

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767 Duranti, *Diplomatics: New Uses for an Old Science*, 138 and n.11, and 149 n.26. This use of logos and trade marks is an issue of corporate culture that bears further investigation. To what extent might such embellishments have been intended to function beyond expressions of corporate identity – as promotional and marketing tools, for example?

768 Cases #0236, #0249.

769 Cases #0218, #0226, #0228, #0235.

770 References are made to these physical concepts from within the discussions of their intellectual counterparts, below.

The Changes concept therefore includes:

- Record of Changes
- Amendments and Corrections
- Annotations and Deletions

Because Primary Production Processes include forms of reprography, the creation of a derivative drawing by such a process is not of itself regarded as a change. Changes concepts and characteristics therefore relate only to changes made by manual drafting processes. However, those concepts and characteristics apply equally to changes that have been made to draft, definitive, or derivative drawings.

4.4.1 Importance of the Changes concept

Consequently, the Changes concept affords a vital role in a situation where reprographic reproductions of records are possible. It enables changes that only exist as part of a reprographic reproduction to be clearly differentiated from those that have been created by manual processing. It is those latter changes that are the subject of this concept – those changes that directly affect the instance of the record under consideration. By contrast, changes that are merely shown as part of a reprographic reproduction are of no interest within this concept. They would only be of interest within the instance of the record where they appeared as manual process changes.

This conceptualisation allows the archivist and researcher to consider properly the genesis and tradition of the instance of the record with which they are faced. It avoids confusion with any earlier instance of the record that might have been created for a different purpose, certainly at a different time, and, possibly, even within a different enterprise. As such, the Changes concept addresses Duranti's view that identification of the sequence of copies of the same record was only relevant to documents of the medieval period. [771] I argue that this new general concept fills that gap in knowledge. [772]

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771 Ibid., 53-4.

772 See also this point in relation to Discussion: 2.2 Document status, *155*.

4.4.2 Record of Changes

The Record of Changes is defined as a specific concept that encompasses different individual forms of a formal record of changes that might exist in a technical drawing. Within the sample, three such forms of a record of changes were found. Each was defined as an individual concept of Change:

- Changes Table
- Issue Table
- Changes-Issue Table

These three individual concepts now are briefly described, followed by a wider discussion of the analysis of the Record of Changes.

Changes Table

The form of the Changes Table was found to vary considerably across drawings of different dates and provenances.[773] In general, its sophistication generally increased over time during the twentieth century. As a formal record, even the simplest Changes Table might be expected to certify a change to a drawing by containing characteristics for a Note of Change, its date, and a certifying signature.[774] That would parallel the level of certification normally found within the Signature-Date Block, discussed later.[775]

However, certification within the Signature-Date Block – controlling primary production – is conceptually broken down into discrete activities. Individual person-roles and associated dates can therefore be identified and mapped to diplomatic and archival concepts. No such granularity was found in the Changes Table. It was therefore not possible to associate Changes Table signatures and dates with diplomatic and archival concepts.[776]

Issue Table

The concept of Issue involved the release of a complete and certified technical drawing from the drawing office, for the production of the item that it defined. A drawing might have been Issued after its initial completion, or following later

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773 See Results: 6.5.1 Changes – Changes Table, *132*.

774 See, for example: British Standards Institution, *BS 308:1943 Engineering Drawing Office Practice*, PLATE 4.

775 See Discussion: Clause of Corroboration – Signature-Date Block, *233*.

776 See Discussion: 2.3 Concepts of person-roles, *159*; 2.4 Concepts of dates, *161*.

changes to it.[777] Every time that a drawing was re-Issued, it was given an incremented Issue number or letter code.

As with the Changes Table, the form of the Issue Table varied. It would, though, typically contain, with the Issue Code, a Note of Change and its date.[778] The Issue Code was sometimes also used to modify a Drawing Reference Code.

By definition, the date recorded in an Issue Table mapped to the diplomatic date concept of *Datum* – the date on which a document was issued.[779] That date is also therefore a technical drawing's 'effective date' in respect of a change occasioned by a re-Issue of the drawing subsequent to its primary production.[780]

Very few drawings in this sample contained an Issue Table but not a Changes Table.[781] The stand-alone Issue Table is therefore not considered further.

Changes-Issue Table

A Changes Table and an Issue Table were sometimes found co-located and intellectually inseparable.[782] I have termed this concept a Changes-Issue Table. Because they were so closely related, especially within the later-dated drawings of the sample, their combined results are next discussed at the level of the Record of Changes. This concept is usefully generic by virtue of the very high frequency of occurrence of a Changes Table, either in isolation or in combination with an Issue Table.

4.4.3 Analysis of the Record of Changes

In practice, many Records of Changes examined in this dataset were found to omit even some of the basic characteristics that were expected within their formal table structures. Many drawings did bear data within the Notes of Change characteristic. Accompanying signatures and dates were, though, often quite

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777 I am grateful to Bernard Champness for his advice on this point: B. Champness, *Re: Archival Research and Technical Drawings* (Pers Comm, 24 May, 2010).

778 See, for example: British Standards Institution, *BS 308:Part 3:October 1972 Engineering Drawing Practice: Geometrical Tolerancing*, 67, App. G. This example lacks the certifying signature characteristic, which was also found to be uncommon in the admittedly very small number of stand-alone Issue Tables within this sample.

779 See Discussion: 2.4.1 Diplomatic concepts of dating, *162*,

780 Following Duranti, *Diplomatics: New Uses for an Old Science*, 139, n.14.

781 Results' reporting is therefore not appropriate for this concept.

782 See Results: 6.5.4 Changes – Changes-Issue Table, *134*.

loosely associated with them, if present at all. Furthermore, the interpretation of those characteristics was not always simple.[783] As was indicated above, for example, save for Issue Date, the signature and dates concepts within the Record of Changes could not be correlated with those from diplomatic and archival theory.

It was not always absolutely clear that all data within a Changes or a Changes-Issue Table actually referred to a change within the drawing. For example, the first Note of Change in some cases appeared simply to be a note of a previous drawing or part number. This did not constitute a change to the drawing itself. However, no consistency of approach was found overall. All such data within a Changes or a Changes-Issue Table were therefore enumerated as Notes of Changes.

Sometimes, it was also difficult to determine whether capitalised initials accompanying a Note of Change were intended to have a certification function, or whether they were intended to function as the annotated abbreviation ‘MF’, indicating that the drawing had been microfilmed. Where there was doubt, they were coded as Certification Signatures.

However, the clear indications given by the results of the analysis of this aspect of the Records of Changes cannot be discounted by such difficulties. Two important issues became apparent during the analysis of the data for the Records of Changes. Both inspired uncertainty about the certification of these technical drawings as controlled records. These issues were:

- The incomplete authorisation of many of the revisions within the Record of Changes
- The apparent post-production revision of drawings that were only incompletely authorised or not authorised for production at all

Incomplete authorisation within the Records of Changes

On an aggregated case basis, the results showed a surprisingly low incidence of certifying signatures, compared with the frequency of occurrence of changes

[783] These Changes and Change-Issue data have therefore been coded to the greatest degree of accuracy possible, using ‘Not Known’ if absolutely necessary, but there may be some over-counting.

recorded in the Records of Change. The incidences of certifying dates were just slightly lower than those for the changes themselves.[784]

The low frequency of occurrence of certification Data Values was further analysed at the individual case level. Only outcomes for the aggregated Records of Changes are given here. Almost exactly half of all drawings (49.5%, CI 44.6, 54.4) contained a known quantity of Notes of Change within a Record of Changes.[785] Only 28.3% (CI 22.4, 34.8) of those drawings also contained a corresponding number of both certifying signatures and dates. A further 46.5% (CI 39.6, 53.4) of cases bore only the correct number of dates. Just 2.5% (CI 1.0, 5.4) of relevant cases contained only the correct number of signatures. In 22.7% (CI 17.3, 28.9) of cases, neither the quantities of signatures nor dates corresponded with the number of changes.

The implications of these low levels of certification are discussed later.[786] These results also indicated markedly lower levels of certification within the Record of Changes than was found within the Signature-Date Block, discussed later.[787]

Post-production changes to drawings not authorised for production
Changes to a drawing are commonly required throughout its life, synonymous with that of the product that it depicts. They typically attend to problems found during initial product prototyping, revise designs to ease production, or incorporate modifications during a product's use in service.

It is therefore axiomatic that to bear an entry within its Record of Changes, a drawing should have been first authorised for use following its initial creation. Yet a correlation of the data for the Records of Changes with that for a drawing's initial authorisation for issue and use found this often not to be the case. The analysis was difficult and time-consuming, and the precise relationships of some certification characteristics were not entirely clear. Nonetheless, the magnitude of the unexpected result cannot be entirely explained away by those factors.

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784 See Results: 6.5.6 Changes – Changes-Issue Table – Certification – Data Values, *134*.

785 See Results: 6.5.5 Changes – Changes-Issue Table – Number of Changes-Issues, *134*.

786 See Discussion: Implications of the authorisation findings, *253*.

787 See Discussion: 5.3.4 Combined Certification Concepts, *248*.

Of those drawings that contained at least one Note of Change,[788] some 47% did not also contain, in their Signature-Date Block, a complete set of certifying signatures and dates for their initial creation.[789] However, within some 37% of those drawings, the Notes of Changes were themselves fully certified in the Record of Changes by a signature and a date. This is a considerably higher proportion than was noted above for the Record of Changes generally – some 28%.

The conundrum revealed by this analysis is, therefore, that technical drawings that have not been fully authorised for initial use have had subsequent changes to them fully certified. That indicates that they had indeed been in use before being changed. Although noteworthy, further analysis of these results cannot be undertaken here. Their implications are considered later, within a discussion of primary production certification and authorisation.[790]

4.4.4 Amendments and Corrections

The intellectual characteristics of Amendments and Corrections have been relocated here to the general concept of Changes. The physical characteristics of Changes were considered earlier, within Medium.[791] Previously within diplomatic theory, corrections to documents have been placed within Script.[792]

As its name implies, the specific concept of Amendments and Corrections is composed of two individual concepts. An amendment is defined here as a change to a technical drawing that reflects some form of development. For example, the design of the depicted object might evolve, or the name of the client for whom the object was intended might change. A correction, by contrast, is a change made to rectify some error in the drawing, typically caused by an error in drafting. The use of both amendments and corrections would be expected to be reflected by an entry in a drawing's Record of Changes.

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788 198 cases.

789 Because of the noted uncertainties, the percentages given in this paragraph are indicative values for which statistical confidence limits are not appropriate.

790 See Discussion: Implications of the authorisation findings, *253*.

791 See Discussion: 3.1.7 Amendments and Corrections, *179*.

792 Ibid., 135-6, 140; InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES)', 3, 9.

Within the dataset, 52% of all drawings contained at least one simple-drafted amendment or correction.[793] They were spatially and conceptually located across the drawings. Although not sufficient to be regarded as a generic concept, this is a high frequency or occurrence. It warns that often, a technical drawing cannot be accurately interpreted by only cursory examination. Closer inspection is required to ensure that data recorded from it are the most current. The date of final certification, for example, may well be superseded by a later amendment – sometimes decades later. Knowledge of such changes to data contributes to understandings for a technical drawing's genesis and tradition.[794]

Furthermore, amendments or corrections are not always fully recorded in a Record of Changes – as the immediately preceding discussion made clear. Indeed, they might not be always recorded at all. Of the 208 cases that contained simple-drafted amendments or corrections, some 17% did not contain any Changes data in their Record of Changes.[795]

4.4.5 Annotations and Deletions

The concept of Annotations has traditionally been a substantially singular one within diplomatic. A wide range of characteristics has been defined within annotations, particularly in diplomatic's new conceptualisation for more modern records.[796] An annotation might be accompanied by some form of certification – usually a signature or initials, and a date.

The importance of the concept of Annotations is not intended to be diminished by its relocation here as a specific concept within the general concept of Changes. It still remains a discrete concept whose definition remains aligned to its traditional purpose.

Annotations were present in a little more than half the drawings within this sample.[797] However, one form of annotation predominated – the marking 'MF', which was inferred to mean that the drawing had been selected for

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793 That figure excludes other forms of manual drafting, which would raise the frequency of occurrence to 59%. See Results: 6.5.7 Changes – Amendments and Corrections – quantity, *135*.

794 See Discussion: 2.1.1 Genesis and tradition in technical drawings, *155*.

795 35 of 208 cases: 16.8%, CI 12.2, 22.4.

796 Duranti, *Diplomatics: New Uses for an Old Science*, 139-40.

797 See Results: 6.5.8 Changes – Annotations – quantity, *136*.

microfilming.[798] That annotation was noteworthy only for the confusion that it caused between itself and authorisation initials adjacent to the Record of Changes, as noted earlier.[799]

Some of the other annotations specifically noted that a technical drawing was a 'Master', or a 'DO' [Drawing Office] copy, or otherwise indicated that it was a controlled record. Conversely, no annotations were identified as having been made outside a drawing office – by production-line workers or contractors, for example.[800]

Intellectual characteristics of Deletions were present within some surveyed technical drawings. As with their physical counterparts, they were of relatively little importance, and are not considered further.

4.5 Archival Bond

The transformation of a document to a record has been conceptualised through the archival bond. That bond denotes the necessary links between a record, its creator, the activities in which it participated, and other records.[801]

It has been argued that to preserve the archival bond, records' selection as archives should be carried out at levels of aggregation that allow the records' relationships to be preserved.[802] That cannot, though, be used as an argument for not using diplomatic analysis as a means of understanding forms of document – including technical drawings. Unless individual documentary forms are understood, at least on an exemplar basis, informed decisions cannot be made about their disposition as records in aggregations.

Only an intellectual bond enables knowledge of a record's original necessary links and intellectual order to be preserved. A physical bond, such as might be established in traditional records' storage systems, is too fragile to meet the same

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798 See Results: 6.5.9 Changes – Annotations – Data Values, *136*.

799 See Discussion: 4.4.3 Analysis of the Record of Changes, *203*.

800 For physical characteristics adducing to the same conclusion, see Discussion: Importance of support material identification, *166*.

801 The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 1: What is a Record in the Traditional Environment?', 4; Duranti, 'The Concept of Electronic Record', in Duranti, Eastwood, and MacNeil, *Preservation of the Integrity of Electronic Records*, 11 and nn.11, 12, 13; 19 and nn.34, 35.

802 Ibid., 62, n.34.

need.[803] An intellectual archival bond can be established at the time of a record's creation and original use by application of a unique reference code to the record.[804] In the present case, I have defined the archival bond as being manifested by a technical drawing's Drawing Reference Code.

4.5.1 Drawing Reference Code

Each technical drawing normally bears a reference code that is unique to its particular content. The form of code is usually either numerical or alpha-numerical, and frequently includes special characters such as hyphens and slashes. In this sample, almost every Drawing Reference Code was labelled as a Part Number.[805]

Up to four Drawing Reference Code data elements were found within any one technical drawing in this sample. They were located in a variety of positions, and at least one Data Value was always present.[806] Such abundance of data for a single concept makes it generically very useful. However, the data showed the Drawing Reference Code to be a concept with potential to both benefit and hinder archival interpretation.

Differences in Drawing Reference Code Data Values

The results showed that where more than one Drawing Reference Code (DRC) was present in an individual technical drawing, there were discrepancies between the codes in some 20% of cases. Those discrepancies might call into question the presumption that a Drawing Reference Code would always provide the necessary archival bond between records.

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803 A bond has been considered 'implicit in the physical arrangement of [traditional] records': Ibid., 19. Yet the storage of technical drawings by size of support, for example, immediately establishes artificial physical connections that will often bear no relation to the drawings' intellectual relationships.

804 That requirement is considered, rightly, as essential for records in intangible electronic formats. The perceived need to promote that point seems to have occasioned the less valid argument for physical connections in tangible records: Ibid., 19. The need for a manifest intellectual link had, though, already been made elsewhere: H. MacNeil, 'Conceptualizing an Authentic Electronic Record: The Development of a Template for Analysis'. Vancouver, 17 Feb, 2001. (Vancouver, 2001). [Online] http://www.interpares.org/documents/interpares_symposium_2001.pdf (accessed 13 May, 2011).

805 See Results: 6.6.2 Archival Bond – Drawing Reference Code – label element, *137*.

806 See Results: 6.6.1 Archival Bond – Drawing Reference Code – data element, *137*, 6.6.3 Archival Bond – Drawing Reference Code – position, *137*, 6.6.4 Archival Bond – Drawing Reference Code – Data Value, *138*.

Many forms of discrepancy could be reasonably resolved, however. For example, the DRC suffixes 'RH' and 'LH' related to 'As Drawn' and 'Opposite Hand' views. Numerical or alphabetical suffixes might also indicate an Issue Code. In other cases, a drawing creator's Drawing Reference Code for an object might be matched by a supplier's or a client's own code for that object. Finally, a drawing's depicted object might have been modified so much as to warrant the application of a completely new Drawing Reference Code.

Sorting and arrangement by Drawing Reference Code

It is often impractical to physically sort and arrange large-format technical drawings. During this research's pre-sampling survey, a usable degree of intellectual order was achieved through electronic sorting of the drawings using only abbreviated forms of their Drawing Reference Code. [807] The greater the investment in data entry for Drawing Reference Codes, the more granular the level of sorting that can be achieved. Theoretically, diplomatic analysis of the form of individual Drawing Reference Codes would enable the most detailed degree of sorting to be achieved.

4.6 Contexts

In contrast to the concept of Archival Bond, which is integral to a record, contexts are external to it. [808] No concept of context appeared manifestly as such within a sampled technical drawing. This discussion is therefore necessary brief, despite the importance of the concept.

Nonetheless, data that contributed to two concepts of context were present within other concepts and characteristics. [809] Those concepts were derived from a late twentieth-century conceptualisation of diplomatic contexts – albeit for records in electronic formats. [810]

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807 Letter-code series and number ranges, for example.

808 Ibid.; Duranti, 'The Concept of Electronic Record', in Duranti, Eastwood, and MacNeil, *Preservation of the Integrity of Electronic Records*, 19.

809 As indicated by MacNeil, 'Conceptualizing an Authentic Electronic Record: The Development of a Template for Analysis', 9. I do not, though, follow MacNeil's stated relationships between diplomatic concepts and contexts.

810 InterPARES 1 Project: Authenticity Task Force, 'InterPARES 1 Project: Appendix 1: Template for Analysis', 5-6.

A technical drawing's provenancial context was indicated by concepts of Principal Enterprise,[811] Rights Owner,[812] Special Signs[813] and Final Clauses.[814] Concepts within the Stage of Representation,[815] and certification and authorisation within the Signature-Date Block[816] and Record of Changes,[817] were indicative of procedural contexts.

4.7 Information Form

Because a technical drawing often has more than one purpose, ascribing a single function to a drawing is often difficult.[818] In archival description standards, this problem has sometimes resulted in the conflation of high-level descriptive concepts for technical drawings.[819]

4.7.1 Definition of Information Form

I have attempted to separate out these concepts. Here, I define Information Form as the concept that denotes a technical drawing's type, genre – or, most appropriately, its form.[820] Examples include 'single-part drawing', 'exploded assembly drawing', and 'diagrammatic drawing', Elsewhere, I have introduced and described other concepts with similar intent.[821]

All drawings inherently have an Information Form, making it a generically useful concept.[822] It is also one with potential to be of particular interest to researchers seeking specific forms of information. The Information Form concept is therefore

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811 See Discussion: 5.1.1 Principal Enterprise – Name and location, *218*.

812 See Discussion: 5.1.3 Rights Owner – Name and location, *220*.

813 See Discussion: 4.3 Special Signs – Enterprise Logos and Trade Marks, *199*.

814 See Discussion: 5.1.3 Rights Owner – Name and location, *220*.

815 See Discussion: 4.8 Stage of Representation, *212*.

816 See Discussion: Clause of Corroboration – Signature-Date Block, *233*.

817 See Discussion: 4.4.2 Record of Changes, *202*.

818 Baynes and Pugh, *The Art of the Engineer*, [Exhibition Catalogue], 4.

819 See, for example: Procter and Cook, *Manual of Archival Description*, 202, cl. 22.4C2.1 – 'type'; International Council on Archives, *ISAD(G): General International Standard Archival Description*, 22, cl. 3.3.1 – 'documentary form'; Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings', 6–8, cl. 6.1B4. – 'nature of archival unit', cl. 6.1C. – 'general material designation'.

820 Information Form here equates to the diplomatic conceptualisation of a document type-name: Duranti, *Diplomatics: New Uses for an Old Science*, 152. For typical traditional type-names, See Boyle, 'Diplomatics', 82-3.

821 See, for example: Discussion: Drawing Aspect, *195*, 4.8 Stage of Representation, *212*.

822 See Results: 6.7.1 Information Form, *138*.

intended to provide one means by which technical drawings can be clearly and unambiguously described, to enhance research access.

4.7.2 Determination of Information Form

No technical drawings within the sample gave a reliable manifest indication of their Information Form. A few drawings did include a drawing type-name within their Drawing Title. Such names were not, though, consistent in either their application or appropriateness.[823] Nor would they be expected to be so, especially across technical drawings of diverse provenances.

A technical drawing's Information Form had therefore always to be inferred, and standardised descriptive terms defined and applied. The concept chosen by which that inference would be made was central to the purpose of a technical drawing – the Method of Representation of its content.[824] At the highest level of Information Form, a technical drawing would therefore be described by terms that included, for example, 'orthographic projection drawing', 'pictorial representation drawing', 'technical sketch', and 'diagrammatic drawing'.

The next lower level of Information Form identified a drawing in terms that were intended to be most useful to research access. The Information Form that was present in the substantial majority of cases is used for illustration.[825] It was the two-dimensional orthographic projection drawing – the classical form of engineering drawing. Almost two-thirds of those cases were forms of Single-Part drawing – again, a classical form. Some one-third comprised forms of Assembly drawing, while the remaining few orthographic projection drawings were General Arrangements.

4.8 Stage of Representation

This general concept has also been developed to try to overcome the conflation of concepts in the literature.[826]

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823 For example, 'Arrangement', 'Assembly', 'Installation', 'Sketch', 'Layout', 'Outline'.

824 See Discussion: Method of Representation, *194*.

825 See Results: 6.7.2 Information Form – Orthographic Projection, *139*.

826 See, for example, the conflation of usages in: Bingham, *Cataloguing Guide*, 11, 12, 23. See also: Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings', 6-9, cl. 6.1E2., and Procter and Cook, *Manual of Archival Description*, 199, 202 – 'Type'.

4.8.1 Separation of concepts of business process and record production

In common with Gawne,[827] I recognised that confusion still remained between the business processes within which technical drawing was an activity, and the technical drawings that were the products of transactions within that activity. Therefore, I defined a new general concept – the Stage of Representation – to encompass two specific concepts:

- Stage of Production – denoting the business processes
- Stage of Realisation – denoting the resultant records

The Stage of Production is defined here as the concept that indicates a temporal sequence of stages within a production process. Three high-level Stages of Production are defined – the business processes of Design, Production, and Post-production. Intermediate stages are normally defined within those main stages.

Technical drawings are created within a Stage of Realisation that is bound to a Stage of Production. The drawings are realised by technical drawing activities within those business production activities. As illustrated by Table 9, draft and definitive technical drawings are normally produced during the design stage, and derivative drawings during production and post-production stages. These three forms of record were defined earlier, within the concept of Document Status.[828]

Stage of Representation		
Stage of Production		**Stage of Realisation**
Engineering Design	Design Evolution	Drafts
Engineering Design	Design Recording	Definitives
Engineering Production and Post-Production	Design Dissemination	Derivatives

Table 9: Relationships of Stages of Production to Stages of Realisation within the Stage of Representation

[827] Gawne, 'Cataloguing Architectural Drawings', 178.

[828] See Discussion: Table 8: Definitions of Concepts of Document Status, *158*.

Stage of Realisation terms for technical drawings will, though, be most usefully determined at the intermediate stages of business production activities and related technical drawing activities. Therefore, the Stage of Realisation is defined here as the concept that indicates a development stage within a technical drawing activity. Such development stages are the steps that constitute transactions within a business activity.[829] Every such step therefore equates to a Stage of Realisation. Each step, as a transaction, realises a record – a technical drawing. The record is therefore appropriately identified in terms of the technical drawing transaction that produced it.

This conceptualisation is particularly appropriate because of the disparate ways in which technical drawings have been found described in this context. Many different terms have been found in use across industries and countries.[830] That is especially so for records associated with intermediate Stages of Production.

A few examples will briefly illustrate the two concepts and their relationship within the Stage of Representation. It will then be realised that a descriptive term applied to a technical drawing for its Stage of Representative could often not be adequately substituted by a term for a business process Stage of Production.

Within the Design Stage of Production, two forms of technical drawing that might be realised are a Sketch Design Drawing and a Detailed Design Drawing. Similarly, Production Control Drawings or Working Drawings might be realised within the Production Stage of Production. In the Post-production Stage of Production, As-built and Maintenance drawings might be realised.

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829 Following: British Standards Institution, *PD ISO/TR 15489-2:2001 - Information and Documentation - Records Management - Part 2: Guidelines* (London, 2001), 9, cl. 4.2.2.2, and 11, cl. 4.2.4.2.

830 The range of terms, including those for ostensibly similar or identical concepts, can only be illustrated. See, for example: Baynes and Pugh, *The Art of the Engineer*, 14-19; Getty Vocabulary Program, 'Hierarchy Display - Drawings by Function' in *Art & Architecture Thesaurus (AAT)* (Los Angeles, CA, 1983-) [Online] http://www.getty.edu/vow/AATHierarchy?find=drawings&logic=AND&note=&page=1&subjectid=300034362 (accessed 14 May, 2011); British Standards Institution, *BS 6100-1.5.7:1988 Incorporating Amendment No.1: Glossary of Building and Civil Engineering Terms - Part 1: General and Miscellaneous - Section 1.5 Operations; Associated Plant and Equipment - Subsection 1.5.7 Drawings* (London, 1992), 1-2, cl. 157 2; Daniels and Peyceré, 'Glossary of Specialized Terms for Archives of Architecture', 133-137.

4.8.2 Determining the concept of record production – Stage of Realisation

Terms for a Stage of Realisation, then, rather than a Stage of Production, should be used to describe technical drawings. Every technical drawing has a Stage of Realisation. However, as has been confirmed by this survey, there are normally no manifest data that directly indicate a technical drawing's Stage of Realisation. A Data Value for the concept must therefore be inferred from other concepts and characteristics present within a drawing. The concept of Stage of Realisation can, in turn, contribute to the concept of Genesis and Tradition. [831]

Two completely different approaches to determining a drawing's Stage of Realisation were considered. The first looked at the problem intellectually, through the concept of Stage of Production. The second approach analysed a technical drawing's physical concepts and characteristics. It must be stated at the outset that neither approach was able to provide sufficiently useful data for the interpretation of a drawing's Stage of Realisation, even at the highest level. The two approaches are briefly described to indicate the problems encountered, and the scope for future work.

4.8.3 Stage of Realisation through the Stage of Production

Determining the records that derive from business processes requires that those processes first be sufficiently understood. Therefore, the Stages of Production within which technical drawings were created had to be known. Only then could appropriate Stage of Representation terms be assigned to individual cases.

This approach did not work for the sampled drawings. It will be remembered that the drawings were an artificial amalgam of diverse provenances. No useful contextual information was available about the different business processes under which they had been produced. Business processes could therefore only be surmised theoretically and generically. Based on the previously noted abundant diversity of terms, even a workable terminological structure could not be developed to any level of detail.

For a Stage of Production approach to succeed, it would have focus on the technical drawings and business processes of individual enterprises. However, it

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[831] See Discussion: 2.1.1 Genesis and tradition in technical drawings, *155*.

might only be possible to determine business processes from the records themselves, if contextual information had not survived. Such an approach would follow the principles of 'special diplomatics'. Findings from individual enterprises could be compared, and gaps in knowledge identified. Complete findings might be aggregated up into more general models applicable to particular contexts – of industry or country, for example.[832] This approach should be considered in future work.

4.8.4 Stage of Realisation through physical concepts and characteristics

From the beginning of this research, it was believed that the diplomatic analysis of a technical drawing's physical concepts and characteristics might significantly help to indicate its Stage of Realisation. The premise to be tested during research was that support and process media and materials were very often closely related to a technical drawing's Stage of Realisation.

The examples used previously for comparison with Stages of Production can be used again for this brief illustration.[833] A Sketch Design Drawing might well be drafted in pencil on thin detail paper or tracing paper. A Detailed Design Drawing might be pencil drafted – and perhaps inked-in – on more substantial tracing paper or cartridge drawing paper.

Production Control Drawings or Working Drawings would likely be issued from a Drawing Office as reprographically reproduced derivatives, possibly on sensitised papers. As-built drawings, providing a long-term and durable record of production, would probably be created with ink on tracing cloth, or later on synthetic support materials.

In the event, these premises could not be tested. The reasons lay in the inability sufficiently to determine Data Values for the physical concepts and characteristics that were most relevant to the Stage of Realisation concept. Those problems, previously discussed, lay within the concepts of support and process media and

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832 Duranti, *Diplomatics: New Uses for an Old Science*, 126-8. I am grateful to Professor Duranti for her additional advice on this point.

833 See Discussion: 4.8.1 Separation of concepts of business process and record production, *213*.

materials.[834] They do not require further explication here. Their failure to contribute to the Stage of Realisation concept, though, supports the case for future work in the area of physical concepts and characteristics.

5. Internal Articulation

Diplomatic analysis of traditional textual documents normally follows the internal articulation of the document from top to bottom, beginning to end. A core set of the concepts and characteristics that present the articulation will be common to all documents. Others will only appear in specific forms of document. Traditionally, these intellectual concepts and characteristics have been formed into three sequential groups – protocol, text, and eschatocol.

This diversity in the existence of concepts and characteristics, and the ways in which they are presented, are considered to be key to distinguishing one form of document from another.[835]

The sequential grouping has been retained in the analysis of technical drawings. A much more circuitous route around the drawing has been necessary, though, to populate the groups. That journey illustrated the need for one of the key aims for this research – to identify physically where potentially useful intellectual concepts and characteristics might normally be found within a technical drawing.

The important concepts and characteristics that were found for the internal articulation of technical drawings are now discussed, group by group.

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834 See Discussion: 3.1.1 Potential benefits and limitations of identification of medium, *165*, 3.1.3 Support materials, *165*, 3.1.5 Primary production processes, *171*, 3.1.6 Support and process materials' colour, *177*.

835 Ibid., 141-2, 150. I have conceptualised such identification as determining a technical drawing's Information Form. See Discussion: 4.7 Information Form, *211*.

5.1 Protocol

The concepts allocated to the protocol of a technical drawing are those that align as closely as possible to the concepts found in more traditional textual forms of record. The following concepts are discussed:

- Principal enterprise
- Rights owner
- Addressee
- Drawing title
- Technical drawing subject
- Intended use

5.1.1 Principal Enterprise – Name and location

The principal enterprise is defined here as the corporate legal body – the legal person – responsible for the creation, reception, or maintenance of a technical drawing. This concept's purpose is to identify a definitive form of name for such a principal enterprise, and the geographical place of creation, reception, or maintenance for the technical drawings for which it was responsible. The concept therefore corresponds to the diplomatic concept of *intitulatio* – the entitling. [836]

Differentiating forms of names and locations

Drawings' data for principal enterprise names was effectively ubiquitous, making it a usefully generic concept. [837] The Data Values varied in complexity. Simple abbreviated forms, for example, 'A.E.C. Ltd', could be compared with structured statements of corporate hierarchies, for example, 'British Leyland, Truck & Bus Division, Leyland Motors Ltd. Leyland Lancashire'. Some names, for example, 'British Leyland, Transport Equipment (Thornycroft) Ltd. Basingstoke', encompassed three stages of administrative change within one name, together with a location of activity.

Other data for locations associated with principal enterprises, although occurring less frequently, were formed with similar variations. Simple place-names –

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[836] Ibid., 142-3; Hunyadi, 'The Identification of a Forgery', 139.

[837] See Results: 6.9.1 Principal Enterprise, *140*.

‘Lowestoft’ and ‘Coventry’, for example – could be compared with other instances of location Data Values that comprised full postal addresses, including postcode. [838]

It is understood that the legal address of an enterprise might not be the location at which technical drawing activities were carried out. However, the available locational data sometimes indicated that a ‘works’ address was being given. [839] Where such evidence is available, those locations might be considered appropriate to the topical dating of technical drawings. [840]

These data therefore have archival management and research values beyond immediate indications of technical drawings’ provenance. The different forms of enterprise name, and location of activity, enable phases of corporate existence to be differentiated, even if they cannot immediately be dated.

Deeper diplomatic analysis

Deeper diplomatic analysis can facilitate more granular differentiation of such data. Corporate identity, endeavour, and ownership are expressed though the inscription of the creator name on a technical drawing. Its form changes over time, perhaps as much due to changes in design style, as to changes of corporate legal existence.

Even changes in the style of punctuation within a name might provide useful indications of change over time, and allow better restoration of records’ original order. Such changes might not even result from a deliberate change of design style, but simply from the supply of drawing sheet templates from a different printer. They might also be indicative of the personal characteristics of individual drawing drafters, inkers-in, and tracers who operated at different periods.

The possibilities can be illustrated through an example for ‘A.E.C. Limited. Southall. Middx.’ Within a set of fourteen drawings for nominally the same name and location, the presence or absence of a full stop (.) at various positions created four different Data Values. [841] A larger set of technical drawings for ‘Leyland

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838 For example, Cases #0132, #0325.

839 For example, Cases #0160, #0262.

840 See Discussion: 2.4.1 Diplomatic concepts of dating, *162*.

841 Exemplified by cases #0041, #0076, #0122, #0125.

Motors Ltd. Leyland. England.' exhibited similar characteristics, together with some diversity in the use of upper- and lower-case letters. [842]

5.1.2 Principal Enterprise – Role

The capacity – role – in which the enterprise operated in respect of the drawings was not so manifestly obvious. This characteristic of *intitulatio* normally had to be inferred from the data. An enterprise might not necessarily be the creator of a technical drawing. During the course of its activities, the enterprise could have received the drawing, or have otherwise held or maintained it. Only rarely was this enterprise role manifestly obvious in respect of the drawing itself.

Consequently, determination of the business activities – the business role – of the enterprise responsible for the creation of the drawing was equally subjective. That business role needed to be inferred. It is considered shortly. [843]

5.1.3 Rights Owner – Name and location

The concept of rights ownership lacks an individual position within the structure of diplomatic criticism. It is discussed here because the concept immediately follows that for Principal Enterprise, with which some comparisons of data are made.

The rights owner is defined here as the natural or legal person named upon a technical drawing as claiming either copyright in the drawing, or contractual rights in the product that it depicted. [844] Invariably in this sample, the rights were claimed by corporate enterprises, in formal statements that could be considered analogous to Clauses of Prohibition and Clauses of Injunction. [845] The concept of rights owner was therefore investigated, to judge its potential as a source of information for a drawing's corporate provenance.

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842 Within 97 cases, there are 9 versions of the name form, exemplified by cases #0240, #0271, #0273, #0277, #0282, #0285, #0296, #0331, #0337.

843 See Discussion: 5.1.6 Technical Drawing Subject, *225*.

844 Although corporate logos and trade marks were also present in some drawings, these were the only two rights that were manifestly claimed.

845 Following the definitions of Final Clauses given in Duranti, *Diplomatics: New Uses for an Old Science*, 147-8. I am grateful to Caroline Williams for her advice on this point.

A number of initial assumptions were necessarily made, whose veracity would be tested by the survey results:

1. The enterprise making the rights claim was very probably responsible for the drawing's creation.
2. The enterprise making the rights claim was also likely to be the enterprise within whose records the drawing was found.
3. A statement of rights ownership was likely to contain the legal form of name for the enterprise claiming the rights.
4. The legal name form would potentially be more definitive for an enterprise than other name forms that might be found – trading names, for example.
5. A statement of geographical location might be found co-located with such a legal name form.
6. A corporate location given for legal purposes might not necessarily be the same as the location at which a technical drawing had been created.

Notwithstanding all those assumptions, and a non-generic frequency of occurrence, survey data for the Rights Owner concept did produce a remarkable degree of useful information. [846] Occasionally, it included a date. Principally, though, the data were informative about enterprise name forms, as is now discussed.

Legal Name Forms for Rights Owner

The forms of names given for Rights Owner and Principal Enterprise were diplomatically analysed within each case where both concepts occurred. The two name forms were then compared.

Ostensibly, these two separate sets of Data Values would identify the same legal person – albeit that the concepts performed different purposes. While the Rights Owner name specifically identified the claimant of rights, the Principal Enterprise name provided a less specific, but usually more visibly assertive, statement of corporate identity. Nonetheless, the two names might be expected to be very similar, if not identical.

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[846] See Results: 6.9.2 Rights Owner, *140*.

This proved not to be the position in this sample. Of 272 cases containing Data Values for both concepts, 266 were compared. [847] They comprised drawings from three enterprises – A.E.C., Leyland, and British Leyland. All three cases provided clear evidence of valid differences between the given Data Values for the names of Rights Owner and Principal Enterprise. I use the case of Leyland as an example of how this evidence for enterprise names might be maximised within the diplomatic concept of Script. [848]

Legal Name Forms for Leyland Enterprises
A sub-set of 97 cases contained technical drawings for Leyland enterprises, pre-dating its re-incorporation as BLMC. Eighteen different forms of Principal Enterprise Name were found in this sub-set. Three distinct enterprises could be identified from those name forms – 'Leyland Motors Ltd.', 'Leyland Vehicles', and 'Leyland Bus'.

The most commonly occurring Principal Enterprise Name forms were those for 'Leyland Motors Ltd.' If differences in diplomatic form – punctuation and case – were discounted, all those instances could be reduced to a single form – nominally, 'Leyland Motors Ltd., Leyland, England.'

All Principal Enterprise Name forms 'Leyland Vehicles' and 'Leyland Bus' were in common form. Their differences lay in the attachment to most name forms of a variety of location of activity suffixes, for example, 'Leyland Bus Farington', and 'Leyland Vehicles Workington'. [849]

There were only three forms of Rights Owner Name within the 97-case sub-set. Two of them, 'Leyland Motors Ltd[.]' were differentiated only by the full stop. The third name was 'Leyland Vehicles Limited'.

The name forms for Rights Owner and Principal Enterprise were compared. Discounting the previously noted diplomatic form differences, the name form

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847 Four cases contained elements of inferred data, and were therefore excluded. The remaining two cases, for one enterprise not otherwise represented, would not have provided a meaningful sample.

848 See Discussion: 4.2.1 Script, *186*.

849 These suffixes included one clearly identifiable instance of a formerly independent enterprise – Eastern Coach Works – taken over by Leyland Vehicles: case #0244.

‘Leyland Motors Ltd[.]’ correlated between Rights Owner Name and Principal Enterprise Name in 100% of 75 cases.

The Rights Owner Name form ‘Leyland Vehicles Limited’ matched not only all fourteen instances of Principal Enterprise Name ‘Leyland Bus’, but also all eight instances of Principal Enterprise Name form ‘Leyland Vehicles’.[850]

These analytical reductions clearly indicated that just two Leyland enterprises encompassed the eighteen different versions of Principal Enterprise Name form originally encountered. ‘Leyland Vehicles Limited’ was now suggested as a comparable enterprise to ‘Leyland Motors Limited’. This modified an earlier view prompted by the otherwise scant evidence for the former enterprise. It also suggested ‘Leyland Bus’ to be a subordinate enterprise within ‘Leyland Vehicles Limited’.

5.1.4 Addressee

Within the concept of addressee – *inscriptio* – are the characteristics of the name, title, capacity, and address of the natural or legal person to whom a document is directed.[851] The surveyed technical drawings have revealed few manifest data that could characterise an addressee in those terms.[852] Indeed, the concept of addressee appears almost entirely invisible within technical drawings. Because diplomatic theory demands that all documents must have an addressee,[853] this apparent absence must be considered.

I have therefore defined the addressee as a general concept, within which are two specific concepts that recognise the problem. They are defined in relation to the capacity – person-role – within which an addressee acts:

- Latent addressees
- Manifest addressees

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850 In both cases, whether or not the Principal Enterprise Name had a location of activity suffix.

851 The Preservation of the Integrity of Electronic Records [UBC Research Project], ‘Template 2: What is a Complete Record in the Traditional Environment?’, 1; L. Duranti, 'CEI - Charters Encoding Initiative*: Inscriptio*: Comments' (Charters Encoding Initiative, 2007) [Online] http://www.cei.lmu.de/element.php?ID=50 (accessed 06 Nov, 2011).

852 Results’ reporting is therefore not appropriate for this concept.

853 ‘There is no document without an addressee because documents result from actions and any action falls on somebody’: Duranti, *Diplomatics: New Uses for an Old Science*, 86. See also: Discussion: 2.3 Concepts of person-roles, *159*.

Both such forms of addressee can be conceived as being the addressee to whom a technical drawing is directed. They are not mutually exclusive within a single technical drawing. I now briefly explain these two specific concepts and individual person-role concepts within them.

Latent addressee person-roles

Earlier, I conceptualised how different forms of engineering drawings – draft, definitive, and derivative – could be conceived as the products of three different forms of communication – self-communication, internal communication, and mass communication. [854] Different forms of drawing therefore spoke to different forms of audience.

Those audiences are conceived here as three different forms of addressee, each of whom has an individual diplomatic capacity or person-role. These three forms of addressee are the natural self, the legal person possessing the records, and wider external populations. This latter form of addressee might comprise one or more natural or legal persons, or different numbers of both forms of person.

The extent of information that can be gleaned is likely to be different for each of those three individual person-role concepts. In each case, though, the information that is available will depend upon the interpretation of data that are largely latent in nature. They will exist both in isolation and in combination across concepts.

Manifest addressee person-roles

Very rarely within this sample, manifest data have been found to indicate a more specific intended user of a technical drawing. Bodybuilders, Coachbuilders, and Drillers can be cited as examples. [855] Such intended users are expressed in terms of generic person-roles. They are though more concrete forms of individual addressee than can be inferred from within the three latent forms.

5.1.5 Technical Drawing Title

Diplomatic theory has regarded a title or subject to be part of the minimum requirements for a complete traditional graphical record, to enable identification

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[854] See Discussion: 2.2.2 A new conceptualisation of document status, *156*.

[855] Typically, cases #0036, #0092, #0107, were entitled for those person-roles.

of the record's content. [856] A title has also been regarded as a necessary element of a technical drawing's archival description. [857]

I do not disagree – a technical drawing's formal title should be recorded in archival description. It provides a necessary intellectual link between a record and its descriptive surrogate. However, the results from this survey have shown that the title given on the face of a technical drawing very often did not clearly describe the drawing's content.

While the title might have *accurately* described the content, it did so without any internal context by which that content could be understood. Compare, as illustration, forms of titles such as 'Elbow', 'Distance Piece' and 'Longitudinal', with the very much less common but more explanatory forms 'Arrangement of Illuminated Sign on "Nippy" Special Cab', and '"Reliance" Body Outline Showing Access Flaps Etc'.

Therefore, although a drawing title was present in every drawing within the sample, that ubiquity is less useful than at first sight. [858] Data other than a technical drawing's formal title must be used to give a clearer indication of what a technical drawing's content concerns. [859] Those data might necessarily have to be inferred, but are important – especially to remote researchers with access only to a textual description of a graphical record.

5.1.6 Technical Drawing Subject

The concept of technical drawing subject can fill gaps in knowledge that were indicated within two concepts discussed earlier.[860] I define the general concept of technical drawing subject as encompassing two specific concepts:

- Technical Drawing Subject – Activities
- Technical Drawing Subject – Objects

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856 The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 2: What is a Complete Record in the Traditional Environment?', 2.

857 Procter and Cook, *Manual of Archival Description*, 199-200; Bureau of Canadian Archivists, 'Chapter 6: Architectural and Technical Drawings', 6-6, cl. 6.1B1. – 'formal title proper'.

858 See Results: 6.9.3 Drawing Title, *141*.

859 See Discussion: 5.1.6 Technical Drawing Subject, *225*.

860 Firstly, a principal enterprise's business activities – its business role. See Discussion: 5.1.2 Principal Enterprise – Role, *220*. Secondly, a technical drawing's content. See Discussion: 5.1.5 Technical Drawing Title, *224*.

These two distinctly different concepts address, head-on, a problem that is apparent in the understanding of subject classification and indexing. It is one that the archives and museums domains, in particular, often conceptualise in different ways. What are perceived as objects by museums, for example, are often described as subjects within archives. Different forms of terms are then used to describe essentially the same subject or object, obstructing cross-domain information retrieval. [861]

Simple terminological schemes for both subjects and objects were developed to test such differences using the drawings under investigation. [862] For illustration, subject terms included the activities of 'Commercial Vehicle Manufacturing', and 'Mechanical Engineering'. [863] Object description included 'Road Vehicle' as a higher-level term, [864] and 'Engine' as a lower-level term. [865] Within separate authority lists, proper names would include 'Reliance' – the brand name of a motor vehicle, and 'A.E.C. Limited' – the legal name of a commercial vehicle manufacturer. [866]

The distinction between subject description and object description can thus be clearly recognised, with the aim of developing well-founded cross-domain data standards. Indeed, were it not for the perceived need to promote this distinction, these two concepts would have been simply termed here 'Subject' and 'Object'.

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861 See, for example, two ostensibly subject-based thesauri, which also include many object terms, especially at their lower levels: UNESCO, ed., *UNESCO Thesaurus* (University of London Computer Centre, 2004) [Online] http://www2.ulcc.ac.uk/unesco/index.htm#brow (accessed 22 Apr, 2011); UK Archival Thesaurus Project, ed., *UK Archival Thesaurus* (University of London Computer Centre, 2004) [Online] http://www.ukat.org.uk/index.html (accessed 22 Apr, 2011). Contrast with the Getty Art & Architecture Thesaurus, which explicitly includes both an Activities Facet and an Objects Facet within its highly developed structure: Getty Vocabulary Program, 'Hierarchy Display' in *Art & Architecture Thesaurus (AAT)* (Los Angeles, 1983-) [Online] http://www.getty.edu/vow/AATHierarchy?find=&logic=AND&note=&english=N&subjectid=300000000 (accessed 22 Apr, 2011).

862 In archival description generally, it is expected that thesauri, terms, or authority lists would be used that were appropriate to the subjects, objects, and proper names found in the records being described.

863 See Results: 6.9.4 Technical Drawing Subject – Activities, *141*.

864 See Results: 6.9.5 Technical Drawing Subject – Objects – Primary Level, *141*.

865 See Results: 6.9.6 Technical Drawing Subject – Object – Secondary Level, *142*.

866 The differences between subjects, objects, proper names, and related concepts in this context are well described in: British Standards Institution, *BS 8723-2:2005: Structured Vocabularies for Information Retrieval. Guide. Thesauri* (London, 2005), i-59. See especially: 2-4, cl. 6.1.1.

Importance of and issues for subject description

Diplomatic theory is firm that the subject or title of a graphical record is part of the minimum requirements for content articulation. [867] A subject annotation applied during a record's post-execution handling phase might also contribute to a 'complete and effective document'. [868]

In archival description, the subject of a record has, though, been regarded as but one element of a record's scope and content – even a discretionary one 'if the title of the item is clear enough'. [869] Such minimal usage reflects a view that subjects are elements of secondary finding aids, or of indexes, rather than being part of the principal structural representation file for an archival accumulation. [870]

As I have argued above, technical drawings' titles are very often not clear enough for effective research access. [871] However, I do not agree that that inadequacy is best overcome by the use of a supplied title, as has been recommended. [872] To replace a manifest title with a supplied title is to break a vital intellectual link between a record and its surrogate description. [873]

Rather, inadequate manifest data for the description of a technical drawing's content should be supplemented by data inferred for the subjects and objects that are represented. As a general rule, such subject and object data should be transformed into controlled terms within a suitably structured thesaurus or simpler terms list. Controlled terms can then be used as vital access points for

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867 The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 2: What is a Complete Record in the Traditional Environment?', 2.

868 Duranti, *Diplomatics: New Uses for an Old Science*, 139-41.

869 See, for example: International Council on Archives, *ISAD(G): General International Standard Archival Description*, 22, cl. 3.3.1; Bureau of Canadian Archivists, 'Chapter 1: General Rules for Description', 1-62, cl. 1.7D4.

870 See, for example: Procter and Cook, *Manual of Archival Description*, 9.

871 See Discussion: 5.1.5 Technical Drawing Title, *224*.

872 International Council on Archives, *ISAD(G): General International Standard Archival Description*, 14, cl. 3.1.2; Bureau of Canadian Archivists, 'Chapter 1: General Rules for Description', 1-16, cl. 1.1B2.

873 If a manifest title does not exist, there is of course no such link to break, so this point is moot. However, all cases within this sample did manifestly contain a drawing title.

researchers, especially those remote from the records that such access points would describe.[874]

By describing activities, subject data can also contribute data to other elements of archival description – a principal enterprise's business role, for example.[875]

Importance of and issues for object description

Object data particularly offered an opportunity to associate a drawn object with a particular vehicle, engine, or assembly. It thus contextualised the drawing as part of a physical production process, rather than just as part of a more abstract design process, or, even more intangibly, a records management process.

The representation of objects at a high level – complete vehicles, engines, major assemblies, and systems, for example – could usually be readily distinguished. Contextualising lower-level parts, though, was sometimes less easy. Consequently, 20% of objects could not be individually classified using the manifest and latent data discussed thus far. Specialist knowledge was required, which this approach had hoped to avoid.

Some of that specialist knowledge would be within the compass of an archivist, researcher, or some other person familiar with the subject of the drawings. Further subject indexing would be therefore be possible within the scope of that knowledge.

Other specialist knowledge would only have existed within the contexts of the drawings' creation and use. Much of that knowledge had to be considered lost. However, that problem was to some extent alleviated by a further concept that had not initially attracted much research attention. It was the concept of Intended Use, the next to be discussed.

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[874] P. Garrod, *The Subject in Question: The Case for Developing a UK Archival Thesaurus* (University of London Computer Centre, [2002]) [Online] http://www.ukat.org.uk/downloads/case03.pdf (accessed 24 Jun, 2010); mda Waterways Terminology Working Group, 'Introduction' in *mda Waterways Object Name Thesaurus* (mda, 2002) para 1.2, [Online] http://www.collectionstrust.org.uk/waterw/intro.htm#Introduction (accessed 22 Apr, 2011).

[875] See Discussion: 5.1.2 Principal Enterprise – Role, *220*.

5.1.7 Intended Use

This concept was a surprising discovery within the sampled technical drawings. It has no real parallel within diplomatic theory. Intended Use recorded whole-part relationships of tangible objects, rather than of records. As noted immediately above, contextualising depicted objects might be difficult at more detailed levels of interpretation. Intended Use data can help to assess the relevance of individual drawings, in relation to a product or assembly of which their depicted objects are a part.

As such, the concept of Intended Use could be considered within diplomatic theory as analogous to other characteristics of the 'administrative context of the action'. [876] Intended Use would therefore be regarded as part of the protocol of a technical drawing, albeit not one that has been previously conceptualised in diplomatic.

Importance of Intended Use

Although Intended Use Data Values were not sufficiently present to be considered generic, they occurred very frequently. [877] Often, they particularly enhanced the data within those 20% of drawings for which an object term could not be classified in detail. [878] Of those drawings, 81.3% (CI 71.7, 88.6) [879] contained Intended Use data that indicated a higher-level context.

Those higher-level contexts took several different forms. Within the drawings that depicted objects as individual parts or assemblies, the whole object was often a vehicle, engine or other major assembly. The type or brand of vehicle could therefore sometimes be directly identified – 'Victory 2', 'Railcar', or 'M.O.S. Winch', for example. In other cases, a reference code was given, which would enable comparative analysis of drawings.

The larger whole was sometimes inferred to be the geographical location of a customer, within whose enterprise such products would become part. Recorded

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876 Which characteristics have been cited as including the 'indication of the persons involved...and subject'. A more specific analogy to the diplomatic concept of notification would be tenuous: Duranti, *Diplomatics: New Uses for an Old Science*, 142, 146.

877 See Results: 6.9.7 Intended Use, *142*.

878 See Discussion: Importance of and issues for object description, *228*.

879 80 cases for this statistic.

locations ranged from 'Liverpool' and 'Manchester' to 'Stockholm', 'Jo'burg' and 'Kowloon'. In these particular cases, the Intended Use concept might be regarded as an attribute of a nominal inscription within a contractual document. As such, it would be analogous to the address element within the diplomatic concept of *inscriptio*.[880]

Label elements

The label elements used to denote the data collected for the Intended Use concept differed across the drawings of different enterprises within the sample. This indicated the need for some caution when interpreting the data. Label elements such as 'Used On' and 'Model' could be confidently taken to mean that a depicted object was, indeed, intended for the use described by the concept's whole-object Data Value.

Whole-object data appearing under the label elements 'First Used' and 'First Used On', by contrast, could not be so confidently associated with a depicted object. As those labels implied, such instances of a drawing might depict an object that had been designed originally in a different production context.

The label elements 'Designed For' and 'Originated For' less certainly indicated either of the above-noted possibilities. Data Values recorded under the label element 'Remarks' contained similar forms of Data Values to those others discussed here. In some cases, two forms of 'Intended Use' label elements were present within the same drawing.

5.2 Graphics and Text

In the diplomatic analysis of traditional textual documents, the text is the core of the document – its reason for being. It either records the 'will of the author', or provides evidence for, or memory of, an act.[881] Reflecting the content of the sampled technical drawings, this central section of diplomatic criticism has been termed here 'Graphics and Text', where graphics predominate.

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[880] Ibid., 144.

[881] Ibid., 145.

This *corpus* is usually of essential importance to research.[882] Indeed, the whole purpose of the present investigation is to develop ways in which that core content can be made more understandable and accessible. However, as Duranti noted,[883] the text offers no more to diplomatic criticism than do the other concepts of internal articulation. This research has found that a similar conclusion can be drawn when the 'text' is predominantly graphical. The sampled technical drawings contained only two traditional diplomatic concepts within this central section – one graphical, the other textual.

The graphical content can be regarded as the technical drawing's diplomatic disposition – *dispositio*. That concept has been described as the 'expression of the will or judgement of the author'.[884] The phrase is very apt to the depiction of design decisions expressed through technical drawing. For the technical drawings within this research, the concept of Graphics-Views forms the diplomatic disposition.

The graphical content of a technical drawing is made up of one or more views. How those views are formed has already been discussed within the concepts of Method of Representation and Drawing Aspect.[885] All that is required within the graphical *corpus* is to record the numbers and forms of views that are present within the graphical content.[886]

The forms of views should be described using controlled terms from a defined terminological structure, informed by any label elements that are present for the views. Interpretation of what the graphical content represents, for which

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882 Boyle used both *corpus* and *contextus* to denote this component of a document: Boyle, 'Diplomatics', 84. The term *corpus* seems more appropriate.

883 Duranti, *Diplomatics: New Uses for an Old Science*, 145.

884 Ibid., 147. The UBC Project also specifically associated graphical content in traditional records with the diplomatic concept of disposition: The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 2: What is a Complete Record in the Traditional Environment?', 2.

885 Wherein the relevant results were reported. See Discussion: 4.2.4 Technical Language – Method of Representation and Drawing Aspect, *193*. See also Discussion: Orientation of view, *183*.

886 See, for example: Results: 6.10.3 Graphics – Drawing Aspect – Number of Views – Orthographic Projection Plan Views, *144*; 6.10.4 Graphics – Drawing Aspect – Number of Views – Orthographic Projection Elevation Views, *144*; 6.10.5 Graphics – Drawing Aspect – Number of Views – Orthographic Projection Section Views, *144*.

specialist subject knowledge might be necessary, is not required. That information is supplied through other concepts, as previously discussed.[887]

Within the sampled drawings, the only textual concept of note in the *corpus* was that of Final Clauses – *clausulae*.[888] Those clauses – of prohibition or injunction – were sufficiently noted earlier.[889]

5.3 Eschatocol

Technical drawings are necessarily controlled records. Control of a drawing's content is a vital part of ensuring that the drawing is fit for its intended use. I have previously considered concepts and characteristics associated with the control of changes to drawings.[890] Here, I introduce discussion of similar concepts and characteristics for the initial certification of a technical drawing. I have conceived them all as being within a general concept of Primary Production Certification.[891]

Locating discussion of the Primary Production Certification concept here is an inevitable consequence of following the standard structure of diplomatic analysis. Intellectually, the Primary Production Certification concept within the surveyed technical drawings was coincidentally coterminous with the diplomatic concept of eschatocol. The physical position of the certification components within a technical drawing – near to the bottom – also mirrored their location in more traditional forms of record.

5.3.1 Primary Production Certification

Looking at the fitness of records from a diplomatic perspective, both Duranti[892] and MacNeil[893] considered the influences that bureaucracy had brought to bear

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887 See Discussion: 5.1.5 Technical Drawing Title, *224*; 5.1.6 Technical Drawing Subject, *225*, 5.1.7 Intended Use, *229*.

888 See Results: 6.10.6 Text – Final Clauses – Rights Statement, *145*; 6.10.7 Text – Final Clauses – Scale Warning, *145*.

889 See Discussion: 5.1.3 Rights Owner – Name and location, *220*.

890 See Discussion: 4.4 Changes, *200*.

891 For the avoidance of doubt, the term 'certification' means here the certification of technical drawings, not the objects that they depict.

892 Duranti drew upon S. Raffel, *Matters of Fact: A Sociological Inquiry* (London, 1979), 124. Duranti regarded it as a 'turning point' in her approach to diplomatic: Duranti, *Diplomatics: New Uses for an Old Science*, 10, 70-3.

on records' production. Through bureaucracy, facts and acts were translated into records. Means were then developed to assess how well records could stand for such facts and acts. The approach considered here is that of an assessment of the completeness of a record by the application of signatures and dates to it.

The diplomatic concept most appropriate to the application of signatures and dates within technical drawings is that of *subscriptio* – here termed 'attestation'. [894] This general concept includes the specific concepts of attestation by signatures, qualification of signatures, and dates. The concept has been traditionally introduced in diplomatic by a Clause of Corroboration, which also has an analogy within technical drawings – the Signature-Date Block.

The following diplomatic concepts are therefore now discussed in relation to technical drawings:

- Clause of Corroboration – Signature-Date Block
- Signatures of Attestation
- Qualification of Signatures
- Dating of Signatures

That discussion lays the foundations for consideration of concepts of certification and authorisation within technical drawings, and of the sometimes surprising issues that the survey results revealed.

Clause of Corroboration – Signature-Date Block

The purpose of a Signature-Date Block within a technical drawing is to provide a certified record of completion of identified activities within the drawing's primary production process. Those stages might include, for example, initial drafting, tracing, checking of work carried out, and approval for issue and use. Completion of a drawing production activity is normally certified by a signature, and is often accompanied by a date.

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893 MacNeil, *Trusting Records: Legal, Historical and Diplomatic Perspectives*, 104-111, 115-6. MacNeil also drew upon Weber's ideal-type of bureaucracy: M. Weber, *On the Methodology of the Social Sciences*, trans. and ed. E. A. Shils and H. A. Finch (Glencoe, IL, 1949).

894 Following Duranti, the term 'attestation' is used, rather than 'subscription': L. Duranti, 'CEI - Charters Encoding Initiative: *Subscriptio*: Comments' (Charters Encoding Initiative, 2007) [Online] http://www.cei.lmu.de/element.php?ID=63 (accessed 06 Nov, 2011).

Those identified activities, signatures, and dates are normally found co-located within a single structural area of a technical drawing – the Signature-Date Block. This concept can be considered analogous to the vestiges of a diplomatic Final Clause – the Clause of Corroboration. That clause often begins the eschatocol, especially in 'solemn, official and legal documents' that might again be thought comparable with technical drawings.

In both technical drawings and more traditional forms of document, the form of the Clause of Corroboration varies 'according to time and place'. Although that form is not a narrative one in technical drawings, it is 'usually formulaic and fixed' for any one particular enterprise at any one period of time. Irrespective of differences in form, though, the concept's purpose is the same – to provide means by which the record is validated, and its authenticity guaranteed. [895] The concept also provides evidence for a technical drawing's genesis and tradition. [896]

A Signature-Date Block was almost always present within each drawing of this diversely composed dataset. [897] Label Elements defined five principal certification activities within it – Drawn, Traced, Checked, Passed, and Approved. [898] Sometimes, the activities were indicated by manuscript marginal notes, rather than by formal labels. Each activity is considered as an individual concept of primary production certification. They are discussed later. [899]

Signatures of Attestation

Central to the eschatocol is the specific concept of attestation. It involves the application of individual subscriptions by the principal persons who take part in the production and issuing of a document. In the surveyed technical drawings, the subscriptions were usually found as sets of initials, rather than signatures. [900] These attestations were not qualified in the normal diplomatic sense, that is, by

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895 Following *Duranti, Diplomatics: New Uses for an Old Science*, 148.

896 See Discussion: 2.1.1 Genesis and tradition in technical drawings, *155*.

897 See Results: 6.2.5 Presentation Style – Signature-Date Block, *128*.

898 Although data were also collected for a further nine similar concepts, none had frequencies of occurrence greater than 5%. They are therefore not considered further.

899 See Discussion: 5.3.3 Individual Certification Concepts, *237*.

900 But as previously noted, the term 'signature' has been used to subsume such uses of initials within the Signature-Date Block.

the title or capacity of the signatory. [901] Rather, they were qualified by one of the terms used to denote an individual certification activity within a technical drawing's primary production.

Qualification of Signatures

Within diplomatic theory, the qualification of signature refers to the title or position of a signatory to a document. It thus denotes the role played by that person in the document's production. [902] The sampled drawings solely recorded natural persons as attestors.

As previously discussed, at least three principal person-roles have been considered necessary for the creation of a record – the author, the writer, and the addressee. [903] However, the sampled drawings manifestly only indicated the need for the roles of author and writer to contribute to primary production certification activities. The addressee was not required to participate. [904]

Other person-roles might though be involved. One of the bureaucratic means for assessing a record as a fact permits a record-writer to report only one portion of that fact. Alternatively, more than one person could be required to report the same fact. Such reporting is certified by signatures. In diplomatic terms, the signature carried 'special resonance'. It made the reporter responsible for the record. The signature's 'sanctioning function [was] reinforced' when more than one person was required to sign a record. [905] This plurality of signatures is a key component of technical drawings' certification, and is examined later. [906]

Dating of signatures

Both diplomatic and archival concepts of dating were described earlier. [907] In what have been termed contemporary documents, dates have been regarded as being usually found in the protocol. That contrasted with their position, in

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901 Ibid., 149.

902 Following Ibid., 83-4, 87-8, n.9.

903 See Discussion: 2.3 Concepts of person-roles, *159*.

904 For the role of the addressee in technical drawings, see Discussion: 5.1.4 Addressee, *223*.

905 Ibid., 71-2; MacNeil, *Trusting Records: Legal, Historical and Diplomatic Perspectives*, 107-8.

906 See Discussion: 5.3.3 Individual Certification Concepts, *237*.

907 See Discussion: 2.4 Concepts of dates, *161*.

medieval and early modern documents, in the eschatocol.[908] In technical drawings, the normal physical location of the Signature-Date Block – near the bottom of the drawing sheet – justifies dates being both physically and intellectually positioned within the eschatocol.

In this research, problems were often encountered when trying to determine the purpose of the dates concepts found in a technical drawing's Signature-Date Block. As noted previously, two forms were found, termed 'Non-Omni' and 'Omni'.[909] In the 'Non-Omni' form of Signature-Date Block, date concepts for primary production certification could be physically and intellectually linked to the qualifications of signatures. Such technical drawings dates' concepts included Drawn, Traced, Checked, Passed, Approved, and Issued.

However, almost half of all cases used the 'Omni' form of Signature-Date Block. That form contained only one date data element. It was physically positioned below all the data elements for qualification of signature, but had no manifest intellectual relationship with any of them. An explanation to this problem is postulated later.[910]

5.3.2 Common Issues for Primary Production Certification

The five individual concepts of primary production certification within the Signature-Date Block that will be discussed in detail are the:

- Drawn concept
- Traced concept
- Checked concept
- Passed and Approved concepts

Issues that are common to all or most of these individual concepts are now noted. There then follows consideration of those matters that are peculiar to individual certification concepts.

Three key common issues became apparent during the analysis of the Signature-Date Block certification concepts:

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908 Duranti, *Diplomatics: New Uses for an Old Science*, 143 and n.20.

909 See Discussion: Signature-Date Block, *184*.

910 See Discussion: Findings from survey results – Passed and Approved, *247*.

1. The degree of sophistication of certification employed by an enterprise was evidenced by the presence or absence of individual certification concepts within a technical drawing's Signature-Date Block.
2. The degree to which certification of an individual drawing was carried out was evidenced by the presence or absence of Data Values for individual certification concepts within a technical drawing.
3. The frequencies of occurrence of certification concepts must be analysed in the combinations in which they occurred, rather than as individual concepts.

Three further common issues also became evident:

1. The presence or absence of a Data Value for a signature was important; its transcription was not. [911]
2. By contrast, the Data Value for a date was as important as its presence or absence. [912]
3. A 'Non-Omni' date was clearly associated with a single certification concept, while an 'Omni' date was associated with several certification concepts.

5.3.3 Individual Certification Concepts

Issues peculiar to the following individual primary production certification concepts within the Signature-Date Block are now discussed:

- Drawn concept
- Traced concept
- Checked concept
- Passed and Approved concepts

Drawn concept

Qualification of Signature – Drawn

Consideration of the 'Drawn' qualification of signature immediately raises a question about the power and authority relationships between the persons involved. Conceptually, a technical drawing might be drawn in two different ways: [913]

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[911] A transcribed and / or diplomatically analysed signature recorded and compared during archival processing would, of course, have clear potential to provide an additional level of evidence of provenance.

[912] Particularly in providing evidence for change over time.

[913] See Literature Review: 4.1 Conceptualisation of engineering drawing, *62*.

- As the direct graphical expression of original thought, for example by a designer-engineer.
- As the indirect graphical expression of original thought, for example by a drafter-technician following directions from a designer.

Both those circumstances of creation must also be further contextualised. All technical drawing primary production and certification activities were carried out by persons who were acting, in one role or another, as agents for an author. They were not acting as individuals, but for the legal person who employed them. [914]

Developing the first two propositions, there are therefore two finer points to consider within the 'Drawn' concept:

- Natural persons undertook the physical activities of primary production and certification
- Notwithstanding those persons' status, for example as designer-engineer or drafter-technician, they were always acting as an agent for an author

The activities required of this role are of a higher order than those of a copyist, or, in diplomatic terms, a Scribe. Only the diplomatic person-role concept of Writer meets both the key criteria for the role required to certify a technical drawing as 'Drawn'. The concept combines the direct practical role of drafter with the indirect conceptual role of agent. [915]

However, the theory upon which the role of Writer as agent was defined exemplified only a direct relationship between writer and author. As has been shown here, the drafter-technician acts as an agent for the author only indirectly, through the designer-engineer. Even the designer-engineer might act only indirectly as agent, through higher levels of management.

I argue that this example of indirect writer-as-agent relationship to an author is likely to be replicated in wider contexts of record production. In the present case, it is exemplified by natural persons as intermediaries between writer and author.

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914 This is invariably the situation for all the drawings within this dataset. It might be also be considered the most likely scenario for the creation of most technical drawings within manufacturing industry. It is in contrast to architectural drawings, which might be more often created by an architect acting as an individual, albeit perhaps as principal in an architectural practice.

915 See Discussion: 2.3.1 Diplomatic concepts of person-roles, *159*.

It is not inconceivable, though, that such intermediaries might also include legal entities. That would be the case, for example, when one legal person sub-contracts to another the performance of acts leading to the creation of records.

Within the 'Drawn' concept, therefore, the qualification of signature is that of a Writer. It attests to the fact that the action recorded in the technical drawing conforms to the will of the author. That author is the legal person for whom the Writer is indirectly acting as agent. Almost invariable within this sample, that legal person will be the Principal Enterprise. [916]

Date – Drawn

The individual concept of a 'Drawn' date maps exactly to the diplomatic concept of *Scriptum*. [917] In the context of this primary production activity, it is the date on which the drafting of a technical drawing was certified as carried out or completed. Again, within this 'Drawn' context, these two concepts also clearly coincide with the archival dating concept of Date of Creation. [918]

A 'Drawn' date is certified as such within a technical drawing by a signature whose qualification attests, as Writer, to the 'Drawn' concept.

It should be noted that a 'Drawn' date is not necessarily always the first to be correctly applied – or applied at all – to a technical drawing. Dates produced by manual drafting, for example, might be traced from another drawing, rather than being first drawn. Reprographically reproduced drawings cannot bear a 'Drawn' date that correctly reflects the date of their creation.

Findings from survey results – Drawn

A 'Drawn' signature was present sufficiently often within the sampled technical drawings for it to be considered a generic concept. [919] This signature of attestation

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[916] The only exceptions are the very few cases where technical drawings created by other persons have been received and / or maintained as records of the Principal Enterprise.

[917] See Discussion: 2.4.1 Diplomatic concepts of dating, *162*.

[918] See Discussion: 2.4.2 Archival concepts of dating, *163*.

[919] See Results: 6.11.1 Eschatocol – Signatures – Drawn, *145*.

contributes to the data required for an assessment of the degree of certification that an individual technical drawing enjoys. [920]

A ‘Drawn’ date, by contrast, was rarely specifically associated with a ‘Drawn’ signature. [921] Largely, this was due to the absence of a separate ‘Drawn’ date data element within ‘Omni’ date Signature-Date blocks. Based on this sample’s results, therefore, it will not usually be possible to determine the date of original creation for a technical drawing.

Traced concept

Qualification of Signature – Traced

The role of the tracer, as the name implies, is to trace over a technical drawing. This production activity might be required for a number of reasons. It could improve a drawing’s presentation or quality of communication. Tracing could also produce a derivative drawing on a more durable and permanent medium of support, or one that was amenable to a reprographic reproduction process. [922]

Whatever the purpose of this primary production activity, it was carried out in a non-executive capacity. The role of the Tracer was akin to that of a copyist. It was not coincident with the role of Writer. As such, the diplomatic person-role concept of Scribe provides an appropriate analogy to that of Tracer. [923]

Within a technical drawing’s ‘Traced’ concept, therefore, the qualification of signature is that of a Scribe. The relationship of a Scribe with a technical drawing’s author is similar to that of a Writer, but at a further remove – the Tracer acts as an agent for a Writer. Importantly, the Tracer does so in an administrative, non-executive, role.

Date – Traced

Notwithstanding that a ‘Traced’ technical drawing is produced by a Scribe in a non-executive role, that manual production activity creates a new record – the

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920 This assessment is considered later. See Discussion: 5.3.4 Combined Certification Concepts, *248*.

921 See Results: 6.11.6 Eschatocol – Dates – Drawn, *147*.

922 Poole, *Engineering Drawing for Technician Engineers*, 2; Price, *Line, Shade and Shadow*, 88.

923 See Discussion: 2.3.1 Diplomatic concepts of person-roles, *159*.

tracing. The creation of the new record means that the diplomatic date concept of *Scriptum* is equivalent to the technical drawing 'Date–Traced' concept.

It will be remembered that *Scriptum* was also equated with a 'Drawn' date. [924] That is not problematic. Mapping technical drawing date concepts with those for diplomatic is founded on the individual characteristics of those concepts. Correspondence is possible in all individual contexts where comparable characteristics exist in technical drawing and diplomatic date concepts.

The situation for the correspondence of the 'Date–Traced' concept with archival date concepts is different. The new record that has been created by the activity of tracing is of course a derivative. The appropriate archival date concept is therefore that of Date of Reproduction. [925]

A 'Traced' date is certified as such within a technical drawing by a signature whose qualification attests, as a Scribe, to the 'Traced' concept.

Given that a 'Traced' technical drawing is a new record, the 'Traced' date should always be, in theory, the first to be correctly applied to such a record. As was the case for 'Drawn' dates, reprographically reproduced drawings cannot bear a 'Traced' date that correctly reflects the date of their creation. [926]

Findings from survey results – Traced

Neither a 'Traced' signature nor even a 'Traced' signature data element were sufficiently present in this sample to be regarded as a generic concept. [927] Where present, however, the signature would contribute to the data required to assess a technical drawing's degree of certification. [928]

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924 See Discussion: Date – Drawn, *239*.

925 See Discussion: 2.4.2 Archival concepts of dating, *163*.

926 This point is obviously common to all cases where dates are reprographically reproduced in derivative technical drawings, and is therefore not reiterated for other date concepts.

927 See Results: 6.11.2 Eschatocol – Signatures – Traced, *146*.

928 Considered later. See Discussion: 5.3.4 Combined Certification Concepts, *248*.

A ‘Traced’ date Data Value was very rarely present.[929] Within this sample, therefore, it was not normally possible to determine the date of creation of a technical drawing when tracing was the primary production process.

Checked concept

Qualification of Signature – Checked

The general role of a ‘Checker’ is to ensure the accuracy of a technical drawing. To do so, a ‘Checker’ may operate in a number of more specific roles. Two roles that are relevant here are the checking of technical drawings that have been ‘Traced’ and / or ‘Drawn’.

Within this discussion, I classify the ‘Checked’ certification concept as the lowest level of what I term Authorisation Concepts. They include those concepts whose names clearly indicate that they involve some form of supervision of technical drawing primary production.

Within diplomatic person-role concepts, that of ‘Countersigner’ maps most closely to the role of ‘Checker’. Two roles were noted within the concept of ‘Countersigner’ – one administrative, the other executive.[930] The executive role more closely maps to that of ‘Checker’ in technical drawings. The role of ‘Checking’ is not administrative; it is always to ensure that a technical drawing conforms to the will of the author. That is the case even when two ‘Checker’ roles are signified within technical drawings. One checks the ‘Drawn’ activity, the other the ‘Traced’ activity.[931]

Within a technical drawing’s ‘Checked’ concept, therefore, the qualification of signature is that of a ‘Countersigner’. This certification activity encompasses both executive and authorisation roles. However, the ‘Countersigner’ as ‘Checker’ is still acting as an agent for a technical drawing’s author.

Date – Checked

There is no direct correlation between a technical drawing’s ‘Date-Checked’ concept and any diplomatic date concept. That is particularly so when two

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929 See Results: 6.11.7 Eschatocol – Dates – Traced, *147*.

930 See Discussion: 2.3.1 Diplomatic concepts of person-roles, *159*.

931 Poole, *Engineering Drawing for Technician Engineers*, 2-3.

separate 'Checked' dates have been employed – one associated with checking 'Drawn' activity, the other related to 'Traced'.

An argument could be proposed for *Factum* to be most analogous to 'Date-Checked'. Its strongest point would only be that both *Factum* and 'Date-Checked' occupy similar positions in their respective specific concepts of dating. [932] There is no correlation between the 'Date-Checked' concept and any archival date concepts. [933]

Nonetheless, a 'Checked' date might still be certified as such within a technical drawing by a signature whose qualification attests, as a 'Countersigner', to the 'Checked' concept.

<u>Findings from survey results – Checked</u>
A single 'Checked' data element was effectively generic within the sampled drawings. [934] Less than half of those cases contained a signature, though. A second 'Checked' data element and / or signature rarely occurred. That it did so, albeit infrequently, provides some empirical data for the 'Checker' role supervising both the 'Drawn' and 'Traced' activities.

A 'Checked' date data element was rarely present, and a 'Checked' date value very rarely so. [935] Both 'Drawn' and 'Traced' date values appeared more frequently than those for a 'Checked' date. From the results from this sample, therefore, it will not normally be possible to date this first stage of technical drawing authorisation.

Passed and Approved concepts
<u>Qualification of Signature – Passed and Approved</u>
The roles of those who 'Pass' or 'Approve' a technical drawing vary with the control procedures that are applied to drawing production. They may differ, for example, with a drawing's provenance or form. [936]

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932 *Actum*, *Scriptum*, Factum, *Datum* and *Drawn*, *Traced*, Checked, *Passed / Approved*.

933 See Discussion: <u>2.4.2 Archival concepts of dating</u>, *163*.

934 See Results: <u>6.11.3 Eschatocol – Signatures – Checked</u>, *146*.

935 See Results: <u>6.11.8 Eschatocol – Dates – Checked</u>, *147*.

936 Champness, *Re: Archival Research and Technical Drawings*.

Both 'Passed' and 'Approved' concepts have been encountered separately, and in combination, within the individual drawings in this dataset. Where both appeared together, the 'Passed' concept invariably preceded that for 'Approved'. Although their precise purposes might have differed, both concepts operated at a higher level than the 'Checked' concept.

The 'Passed' and 'Approved' concepts are therefore both considered together here as Authorisation Concepts. I say that where only one such concept appears, its certification by signature denotes that the technical drawing is complete and fit for issue and use. Certification expresses the will of the drawing's author. Where both concepts appear, that condition is achieved only by the certification by signature of the 'Approved' concept. [937]

Diplomatic's executive person-role of 'Countersigner' maps most closely to both the 'Passed' and 'Approved' concepts in technical drawings. [938] Within both those concepts, therefore, the qualification of signature is that of a 'Countersigner'. In either role, a 'Countersigner' might be close to acting directly as an agent for an author, rather than indirectly. That would be especially the case for those acting in the role of an 'Approver', and / or when employed within smaller enterprises.

Date – Passed and Approved

I have defined both 'Passed' and 'Approved' concepts as those whose certification denotes that a technical drawing is complete and fit for issue and use. Their date concepts are complicated by the technical drawing production concept of 'Issue', previously discussed in brief. [939]

The 'Issue' concept was found only in comparatively late engineering drawing standards and sampled drawings. [940] It allowed for a technical drawing to record the date upon which it was issued for use. That date could not be earlier than the

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937 I do not say that the 'Passed' concept need also be similarly certified in such cases. At this level of discussion, I infer it to be subsumed within the certification of the 'Approved' concept.

938 See Discussion: 2.3.1 Diplomatic concepts of person-roles, *159*.

939 Issue was defined as an individual concept within Changes. It was, though, often conflated with other Changes' concepts, and appeared insufficiently in isolation to make its further discussion useful at that point. See Discussion: Issue Table, *202*.

940 The first 'Issue' date recorded in the sample was 1951. The first mention in relevant standards was in 1953: British Standards Institution, *BS 308:1953 Engineering Drawing Practice*, 12, Fig. 6.

date upon which the drawing had been 'Passed' or 'Approved'. It could be coincident with the last such date of authorisation, or be later than that date.[941]

In diplomatic dating concepts, *Datum* signifies the date on which a document was issued, and hence the date that an act was transmitted.[942] The concept of *Datum* is therefore not quite coincident with those of 'Passed' and 'Approved'. *Datum* signifies a completed act of issuing, while the latter two concepts denote only a completeness and fitness that enables issuing.

Factum, by contrast, signifies the date on which a document was executed.[943] Where technical drawings pre-date the concept of 'Issue', it is difficult not to relate the date concepts of 'Passed' and 'Approved' to that of *Factum*. The 'Passed' and 'Approved' dates might be certified as such by a signature whose qualification attests as a 'Countersigner'. The later of those two dates might be regarded as giving the 'effective date' of a technical drawing in respect of its primary production.[944]

There is no clear correlation between a 'Passed' or 'Approved' date and any archival date concepts as presently defined.[945] However, an extension of the archival concept of 'Date of Accumulation' provides a possible parallel. That concept's role is to provide for the date on which a record enters into an accumulation of records.[946]

I have already argued that the certification by signature of a technical drawing as 'Passed' or 'Approved' denotes that the drawing is then complete and fit for issue and use. I now extend that argument, and say that that certification also denotes that the technical drawing's completeness and fitness for use enables it to enter a relevant accumulation of records. The later of the 'Passed' or 'Approved' date, therefore, is equivalent to the archival date concept of 'Date of Accumulation'.

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941 'Just because a set of drawings has been completed does not mean that they will to used to make a product': Champness, *Re: Archival Research and Technical Drawing*s.

942 See Discussion: 2.4.1 Diplomatic concepts of dating, *162*.

943 See Discussion: 2.4.1 Diplomatic concepts of dating, *162*.

944 Following Duranti, *Diplomatics: New Uses for an Old Science*, 139, n.14. When changes were subsequently made to a drawing, a later effective date would of course apply.

945 See Discussion: 2.4.2 Archival concepts of dating, *163*.

946 In practice, that date might hitherto have been considered appropriate only to those records that are received by a recordkeeper, rather than those created by a recordkeeper.

Where technical drawings also contain an 'Issue' date, the diplomatic date concept of *Datum* provides a true analogy. There is, though, no correspondence between the 'Issue' concept and any archival date concepts.[947] The 'Issue' date gives the 'effective date' of a technical drawing's primary production.[948]

There only now arises the question of which diplomatic person-role would provide an appropriate qualification of signature for an 'Issue' date. In diplomatic terms, the person issuing the sampled technical drawings was the *intitulatio*. That issuer was always a legal person, the Principal Enterprise.[949]

Very rarely, an inked stamp was found impressed on a technical drawing. The stamp could be considered as having some equivalence with an author's or issuer's subscription sign.[950] The impressions contained a principal enterprise's name, full address, and the date that the drawing was 'Issued' by the Drawing Office.[951]

By far the more usual form of 'Issue' dating was similar to the forms described for other technical drawing date concepts. Again, a natural person physically issued the technical drawings while as an agent acting for the legal person. With the evidence available, it is not possible to map a diplomatic person-role to a technical drawing's 'Issue' date concept. Certainly, the role cannot be that of Author, because that role has been delegated to the agent whose role is sought.

Nor are the roles of Writer or Countersigner appropriate to this 'Issue' activity.[952] Possibly, a Scribe might 'Issue' a technical drawing. However, a Scribe could only do so in a non-executive capacity, while acting as an agent for a more senior representative of the author. It is that more senior agent-role that remains undefined here.

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947 See Discussion: 2.4.2 Archival concepts of dating, *163*.

948 Following Ibid., 139, n.14. Again, later changes would create a later effective date.

949 See Discussion: 5.1.1 Principal Enterprise – Name and location, *218*.

950 Ibid., 138 and n.11; InterPARES 1 Project: Authenticity Task Force, 'Lineage of Elements Included in the Template for Analysis (Pre-InterPARES)', 3.

951 Typically, cases #0130, #0140, #0152, for Bristol Commercial Vehicles Ltd. These very low-frequency results are not otherwise reported.

952 That is not to say that a natural person cannot undertake more than one role, but the concern here is with roles rather than persons.

Findings from survey results – Passed and Approved

A data element was present for both the 'Passed' and 'Approved' concepts in some two-thirds of all sampled drawings. However, less than one-third of all drawings then bore an 'Approved' authorisation signature. Somewhat more than one-third of all drawings were authorised as 'Passed'.[953] These low frequencies of occurrence for technical drawings' authorisation concepts were surprising. They are discussed further, below.[954]

The frequencies of occurrence of manifestly labelled 'Passed' and 'Approved' date data elements were even lower than those for their signatures. An 'Approved' date data element was rarely present, and a complete date value very rarely so. The 'Passed' date concept was almost invariably absent from the sample.[955]

Although a more recent concept, an 'Issue' date data element and Data Value was present more frequently than those for the 'Passed' and 'Approved' concepts combined.[956]

These findings therefore indicate surprisingly low frequencies of occurrence for both date concepts and date values at the highest levels of technical drawings' authorisation. However, these results are based only on labelled certification concepts that manifestly associated a qualification of signature to a date. They occurred within the 'Non-Omni' Signature-Date Blocks.[957]

It will be remembered that approaching half of all the sampled drawings bore only a single certification date data element, within an 'Omni' Signature-Date Block. In a very large proportion of those cases, a date value was also present. The drawings bore no manifest indication that enabled those single dates to be associated with any particular certification activity.

It is now reasonable to propose that the 'Omni' dates were associated with the highest level of authorisation activity that was available within a drawing's

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953 See Results: 6.11.4 Eschatocol – Signatures – Passed, *146*, and 6.11.5 Eschatocol – Signatures – Approved, *147*.

954 See Discussion: 5.3.4 Combined Certification Concepts, *248*.

955 See Results: 6.11.9 Eschatocol – Dates – Passed, *147*, and 6.11.10 Eschatocol – Dates – Approved, *148*.

956 See Results: 6.11.11 Eschatocol – Dates – Issued, *148*.

957 See Discussion: Signature-Date Block, *184*.

'Omni'-type Signature-Date Block. Normally, that was either the 'Passed' or the 'Approved' concept.[958] No evidence has been seen that provides a closer physical or intellectual relationship with any other concept, within or outwith the Signature-Date Block. That association would substantially increase the frequencies of occurrence of dates associated with Authorisation Concepts.

These largely qualitative considerations of certification and authorisation are now approached more quantitatively, to try to answer the questions raised by them.

5.3.4 Combined Certification Concepts

This section takes up the puzzling question of the low levels of certification and authorisation indicated above. It does so through further quantitative analysis of the individual certification and authorisation concepts, largely as they were found used in combination. This part of the discussion comprises the following sub-sections:

- Authorisation Issues
- Authorisation Concepts
- Authorisation Analysis
- Implications of the Authorisation Findings

Authorisation Issues

I have defined the 'Checked', 'Passed', and 'Approved' primary production certification concepts as Authorisation Concepts. The latter two concepts are of importance for denoting that a technical drawing is complete and fit for issue and use. Within the sample, the low frequencies of occurrence of signatures for those concepts is surprising. Accompanying dates also appeared in surprisingly few cases. However, the situation for dates was complicated by the concepts of 'Issue' date and 'Omni' date.

Yet the drawings within this sample indicated that they were from enterprises' drawing office accumulations.[959] They might therefore be expected to be definitive records, and thus be the most highly controlled and certified of all forms of technical drawings.

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[958] In 11 cases, 'Checked' was the highest available authorisation concept.

[959] This inference is based on internal evidence from the drawings, and information received from former employees.

It was possible, of course, that some drawings were merely drafts, concepts, and ideas, whose production had not proceeded to completion. Yet many also contained changes data within their Record of Changes.[960] This indicated that they had indeed been completed and issued for use – despite their incomplete primary production certification.

This completely unexpected finding warranted further investigation. If confirmed, it had potential to provide a new perspective on the control and management of technical drawings as records. The presence or absence of certification signatures and dates would be expected to provide key evidence for the authenticity and reliability of such records. This was an issue at the heart of the research's principal investigation method – diplomatic analysis.

The further investigation was necessarily undertaken without knowledge of the actual certification procedures used by individual enterprises. As has been noted, the form and use of Signature-Date Blocks differed across enterprises. Some Signature-Date Blocks were found with manuscript certification label elements appended to them. This indicated that procedures did not always conform to those allowed for by the drawings' integral certification concepts. No doubt, practices also changed over time.

The deeper analysis required was both complicated and time-consuming. Nonetheless, some useful findings were finally produced, which are now discussed.

Authorisation Concepts

The individual certification concepts were initially separated into two categories:

- Non-Authorisation Concepts
- Authorisation Concepts

The Non-Authorisation Concepts were those involved with the conceptual and physical primary production of a technical drawing:

- Drawn
- Traced

[960] Which changes were also often incompletely certified. See Discussion: 4.4.3 Analysis of the Record of Changes, *203*.

The Authorisation Concepts included those whose terminology clearly indicated that they involved some form of supervision of the Non-Authorisation Concepts. They were:

- Checked
- Passed
- Approved

The concept of Issue is not included here. That concept, as defined, was implemented only following the completion of these primary production activities, rather than being part of them.

The Authorisation Concepts, in particular, appeared in different frequencies and combinations across the dataset.[961] The combinations of those concepts, and their frequencies of occurrence were:[962]

• Checked, Passed	34.1% (CI 29.6, 38.9)
• Checked, Approved	32.1% (CI 27.6, 36.8)
• Checked, Passed, Approved	29.0% (CI 24.7, 33.7)
• Checked [Only]	3.0% (CI 1.7, 5.1)
• Other combinations[963]	1.8% (CI 0.8, 3.4)

It was obvious from this analysis that whatever individual combination of Authorisation Concepts was used, a general hierarchy of use seemed to exist. It ranged from Checked at the lowest level, through Passed, to Approved at the highest level.

Attention now turned to the use to which those Authorisation Concepts had been put. That would be shown by the presence of a signature attesting to the completion of the relevant activity, and by associated dates. It was therefore necessary to analyse the Data Values present for Authorisation Concepts within each drawing.

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961 It is important to note that this refers to the concepts themselves, and not to Data Values that might have been attached to them.

962 396 cases for these statistics.

963 Other combinations or individual concepts, all with very low frequencies of occurrence, which are not considered further.

The data analysed thus far clearly indicated that certification and authorisation procedures differed in drawings across the sample. That was largely because the sample deliberately contained drawings of many different provenances. Yet there were sufficient drawings of similar provenance for valid comparisons to be made of certification and authorisation practices. The outcomes were still puzzling.

Within one enterprise, for example, a substantial number of technical drawings had been authorised, at their highest available level, by a 'Passed' signature and date.[964] It was difficult to understand inconsistencies at the lower levels of certification. Some drawings had been certified by signature as either 'Drawn' and 'Checked', 'Traced' and 'Checked', or 'Drawn', 'Traced', and 'Checked'. None of those instances was problematic. Those which were so had been certified as either only 'Drawn', only 'Traced', or both 'Drawn' and 'Traced'. In no cases had they also been certified as 'Checked'.

Technical drawings of a different enterprise contained both the 'Passed' and 'Approved' certification concepts.[965] A sizeable number had been authorised by signature at the highest level – 'Approved'. Yet comparatively few of those drawings had also been authorised as 'Passed'. The absence of an 'Approved' certification for a drawing that has been 'Passed' can be indicative merely of an incompletely authorised drawing. Yet the absence of 'Passed' certification from an 'Approved' drawing of similar provenance is much less easy to explain.

Such complications made the overall analysis of the combinations of concepts and Data Values very protracted. A limit to this aspect of the investigation had to be imposed. The analysis therefore necessarily considered a technical drawing to be complete and fit for issue and use only if it bore a signature for the highest level of Authorisation Concept that it employed. For the overwhelming majority of cases, that was either Passed or Approved.[966] The presence of accompanying dates was analysed in tandem with the Authorisation Concepts.

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964 64 cases for AEC Ltd enterprises.

965 35 cases for Leyland and British Leyland enterprises.

966 4 cases where Checked was the highest level of Authorisation Concept have been included in the analysis.

Authorisation Analysis

The analysis of the certification Data Values confirmed the initial suspicions that had prompted this deeper investigation. It also prompted definition of a third certification category – Incomplete Authorisation.

The aggregated results for the Authorisation Concepts, where they represented the highest level of certification possible for a drawing, were: [967]

- **Completely Authorised: Signed and Dated 53.3% (CI 48.4, 58.2)**

Aggregated results were also calculated for those cases where the highest level of Authorisation Concept that had been certified was not the highest level that was possible for the drawing. To these were added those cases that bore a signature, but not a date, for the highest level of Authorisation Concept employed. These cases therefore represent incompletely authorised drawings: [968]

- Complete Authorisation Concept: Signed but not Dated 6.8% (CI 4.6, 9.6)
- Incomplete Authorisation Concept: Signed and Dated 14.1% (CI 11.0, 17.8)
- Incomplete Authorisation Concept: Signed but not Dated 4.5% (CI 2.8, 6.9)
- **TOTAL Incompletely Authorised: 25.5% (CI 21.4, 30.0)** [969]

Finally, aggregated results were calculated for cases where Data Values existed only for Non-Authorisation Concepts. These cases represent completely non-authorised drawings: [970]

- Non-Authorisation Concept: Signed and Dated 13.9% (CI 10.7, 17.6)
- Non-Authorisation Concept: Signed but not Dated 4.8% (CI 3.0, 7.2)
- Non-Authorisation Concept: Dated but not Signed 0.8% (CI 0.2, 2.0)
- Non-Authorisation Concept: neither Signed nor Dated 1.8% (CI 0.8, 3.4)
- **TOTAL Non-Authorised: 21.2% (CI 17.4, 25.4)** [971]

The apparent precision of these results must be mediated. They are still founded on a statistically robust sample. The findings provide a clearer and sharper view

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967 396 cases for these statistics. Aggregated results from the Approved, Passed, and above-noted Checked concepts.

968 396 cases for these statistics. Aggregated results from the Approved, Passed, and Checked concepts.

969 Independent SPSS PROPOR calculations: sub-totals do not sum.

970 396 cases for these statistics. Aggregated results from the Drawn and Traced concepts.

971 Independent SPSS PROPOR calculations: sub-totals do not sum.

of certification and authorisation practice than did the qualitative analysis that prompted this deeper investigation.

Nonetheless, some less rigorous assumptions and accommodations have had to be made in this part of the analysis. [972] These particular results therefore should be regarded as broad indicators, rather than precise conclusions.

Implications of the authorisation findings

Here, I discuss the findings for primary production certification, together with those for the certification of Changes, presented earlier.[973] Both are considered within the context of late twentieth-century diplomatic and records' theory. [974]

Only a little more than half of the drawings within this dataset bore what would normally be considered appropriate authorisation as a record – a signature and accompanying date, certifying completeness, and fitness for issue and use.

The corollary of this unexpected result is that the remainder of the technical drawings would not be expected to have been regarded and used as authoritative records. Yet strong evidence has already been presented, within the earlier discussion of the Records of Changes, that many of them were. [975] That is an even more surprising finding. It is perhaps indicative of the innate power of technical drawings, derived both from their corporate contexts of creation and their inculcated iconic status. [976]

Furthermore, the general occurrence of certification signatures within the Records of Changes was also surprisingly lower than the incidence of noted

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972 For example, a small number of very low-frequency results have been disregarded. Although the 'Issue' date was defined as following these concepts, rather than being part of them, some inter-relationship between them was previously evidenced within the Records of Changes. The necessary conflation of the 'Passed' and 'Approved' concepts, and the frequent presence of the 'Omni' date concept, will have also introduced some unquantifiable uncertainty into the results.

973 See Discussion: 4.4.3 Analysis of the Record of Changes, *203*.

974 The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 3: What is a Reliable Record in the Traditional Environment?', 1; British Standards Institution, *BS ISO 15489-1:2001 - Information and Documentation - Records Management - Part 1: General*, 7, cls. 7.2.3, 7.2.4; InterPARES 2 Project and others, 'InterPARES 2 Project: A Framework of Principles for the Development of Policies, Strategies and Standards for the Long-Term Preservation of Digital Records', 6-7, (C4).

975 See Discussion: Post-production changes to drawings not authorised for production, *205*.

976 See Introduction: 2.2 Instruments of Power, *4*.

changes.[977] The data provided no explanation for these seeming anomalies in certification and authorisation.

The situation is both burdened and relieved by diplomatic theory.[978] A record's reliability is said to be established at the time of its creation. That reliability signifies that the record is an accurate representation of the facts to which it attests. A degree of trustworthiness is thus bestowed upon a record, emanating from three factors:

- The degree of completeness of the record
- The degree of control of its creation procedure, and / or
- The record author's reliability

Once a record has been created, it should subsequently be protected from unauthorised alteration to preserve its integrity. An authentic record is one that it purports to be, and is as reliable and accurate as it was when first created.

Many of the technical drawings in this sample struggle to meet such tests. As has been seen from the certification and authorisation results and their analysis, many technical drawings are not complete. Signatures and / or dates are missing in many cases. This degree of incompleteness indicates a less than satisfactory degree of control exercised over certification.[979] Other than using these factors as indicators, there does not seem to be any way, at this remove, of assessing the reliability of the technical drawings' authors.

Using those criteria from modern diplomatic and records' theory, therefore, relatively few of the technical drawings in this sample could be regarded as reliable records. It is important to note, though, that the present need is not for prospective conditions to control current records' reliability and accuracy. Rather,

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977 See Discussion: Incomplete authorisation within the Records of Changes, *204*.

978 Following: The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 3: What is a Reliable Record in the Traditional Environment?', 1; InterPARES 2 Project and others, 'InterPARES 2 Project: A Framework of Principles for the Development of Policies, Strategies and Standards for the Long-Term Preservation of Digital Records', 6-7, (C4).

979 Where the degree of control is cited in relation to 'creation procedure'. I argue that it is equally appropriate to the change procedure – the creation of changed content: The Preservation of the Integrity of Electronic Records [UBC Research Project], 'Template 3: What is a Reliable Record in the Traditional Environment?', 1.

those assessments are to be applied retrospectively to records being appraised for archival preservation.

Within diplomatic theory of the early twenty-first century, assessing the accuracy and hence the reliability of records relied upon three assumptions.[980] Firstly, and not unreasonably, the use of inaccurate records was assumed to be harmful to business interests. Secondly, it was assumed that records were accurate when created. Thirdly, records were assumed to be both accurate and authentic because their creator relied upon them when used in the normal course of business.

Nevertheless, as has been illustrated here by the sample results, there is no clear evidence that all records were accurate when created and used. Some of the incompletely authorised technical drawings were no doubt drafts, inaccurate almost by definition. Some drawings that bore changes surely did so to eliminate other inaccuracies. Perhaps some inaccurate drawings had already been issued for use. And, of course, other technical drawings will have been complete, reliable, accurate and authentic.

Authenticity is not at issue here. However, the certification and authorisation data cannot always indicate which technical drawings were complete, reliable, and accurate, and which were not. What the results do show is that those qualities cannot be assumed merely by the existence of a technical drawing that bears indications of use in the business of its creator. Further investigation is required of these 'Instruments of Power'.

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980 InterPARES 1 Project: Authenticity Task Force, 'Requirements for Assessing and Maintaining the Authenticity of Electronic Records' (InterPARES 1 Project, 2002) [Online] http://www.interpares.org/book/interpares_book_k_app02.pdf (accessed 08 Sep, 2007); InterPARES 2 Project and others, 'InterPARES 2 Project: A Framework of Principles for the Development of Policies, Strategies and Standards for the Long-Term Preservation of Digital Records', 6. Although these assumptions were made within the context of electronic records, their generality is difficult to contest.

Chapter 6: Conclusions

1. Introduction

This chapter presents the conclusions that have been drawn from the research. Claims for contributions to knowledge are then set out, followed by a note of areas where future research is indicated.

The conclusions are introduced by short re-statements of the position that existed before this research commenced. Summaries are set out for the research problem, and for the potential of diplomatic theory to address the problem. The research problem was encapsulated within a Research Question, which was to be investigated and answered through defined aims and objectives. Finally, the purpose of each of the thesis chapters is summarised. That for the Literature Review is presented last, together with a summary of the gaps in knowledge derived from the literature.

The chapter therefore introduces the conclusions under the following headings:

- The research problem
- A potential solution
- The Research Question; aims and objectives
- Summary of the thesis chapters
- Conclusions from the literature

Two sets of conclusions are then presented. The first set is reported within the framework of the three research aims and intended outcomes that were established in Chapter One. The conclusions assess how far the outcomes have answered the Research Question. The extent to which the research was successful in that regard is thus clearly indicated. The second set comprises other substantial conclusions that are drawn more generally from the research.

Both sets of conclusions contribute to the claims for contributions to knowledge that are then set out. The conclusions also provide some of the indications for future research that then follow.

1.1 The research problem

This research was stimulated by problems that archivists face when trying to make technical drawings available for research use. There are two key difficulties – one physical, the other intellectual. Technical drawings are normally physically large. Moreover, they are often found in bulk – sometimes overwhelmingly so. Different versions of drawings are often found mixed together in manually drafted and reprographically reproduced forms. Intellectually, attempts to interpret technical drawings can be confounded by their structural complexity, both as individual documents, and in aggregation. Usable original finding aids for aggregations might not survive with the drawings.

Technical drawings are a difficult form of record to interpret. They are drafted using special technical languages, whose dialects and accents differ with contexts of production. Combined with the problems of physical size, bulk, multiple versions and loss of contexts, technical drawings can present complex problems to archivists. Understandably, other forms of record can be thought to offer more cost-effective opportunities for archival processing, public access, and research use. An imbalance is thus created in the archives that are available for British industry and engineering.

1.2 A potential solution

The research problem was multi-faceted. Yet the key information necessary to process a technical drawing archivally was no different from the information required for any other form of record. A potential path to a solution lay in developing means to make technical drawings more comprehensible to archivists. The structural complexity of technical drawings could be reinterpreted though more familiar concepts, in more archivally relevant language.

Diplomatic's granular approach to document analysis offered a way forward. A well-developed structure of concepts and characteristics had long existed for the critical analysis of textual documents. Diplomatic theory had also been extended to records in electronic formats. Its further extension to the analysis of technical drawings, as an exemplar of graphical records, was worthy of investigation.

By diplomatically analysing a statistical sample of technical drawings, it might be possible to determine concepts and characteristics that were always, or almost always, found within the drawings. Those concepts and characteristics could then be qualitatively assessed, to determine those that might help to make technical drawings more comprehensible to archivists. Once appropriately interpreted, such generic and useful concepts and characteristics would provide a new theoretical foundation for understanding technical drawings. In consultation with archivists and researchers, practical guidance could then be developed. These value-laden records could then be archivally processed more easily, and made more readily accessible for research use.

1.3 The Research Question; aims and objectives

The path to this potential solution was signposted by the Research Question. The way forward along the path was developed as a set of three research aims and related outcomes. Each aim was supported by a number of operational objectives and their related outputs. The success in attaining the research aims, and hence answering the Research Question, would be measured by the delivery of the intended research outcomes.

The conclusions reached for each of those three intended outcomes are presented below. They are followed by two further conclusions that have been drawn for other matters of substance that arose during the research. The scene is set for those conclusions by a brief summary of the purposes and conclusions of the chapters that form the thesis thus far. Within that summary, that for the Literature Review is given separately, last. The picture given by the literature before the research commenced can then be compared more closely to the position attained at the conclusion of the research.

1.4 Summary of the thesis chapters

The introductory chapter described the historical context of technical drawings. It highlighted their values as both ‘Instruments of Power’ and archival research resources. Problems encountered in making archival technical drawings available for research were described, and a potential solution outlined. The Research Question, aims, and objectives were set out, and key definitions provided. The research’s scope and limitations were explained. The foundations for the research were thus laid.

Chapter 3 described and discussed how the research design and methodology would meet the needs of the Research Question and its aims. A mixed methods research design was justified, within a theoretical framework of diplomatic. Key areas of the research design were described in sufficient detail to enable their replication. The extent to which the research results could be statistically inferred and generalised was set out. Data management issues, and measures taken to minimise bias and other error risks, were noted. The detail within Chapter 3 was therefore sufficient to enable both the replication of the results of this research, and the application of the research design and methodology in future research.

The results of the technical drawings' data survey were presented in Chapter 4. They were prefaced by brief descriptions of how the raw survey data were processed and analysed to produce those results. The basis for the selection of results for discussion was set out.

The results were developed into findings, and discussed, in Chapter 5. This is the heart of the thesis. Discussion was importantly prefaced by an explanation of how diplomatic's traditional concepts had had to be developed. A chief area of theoretical development accommodated the presence of reprographically reproduced records. That was an issue ubiquitous to records created since the nineteenth century, rather than one specific to technical drawings. However, modifications to theory had also had to be made to meet the needs of those graphical record forms. A small set of foundational concepts was also defined as a necessary enabler of the discussion, rather than as a further development of diplomatic theory.

The diplomatic concepts of extrinsic and intrinsic elements were set aside in favour of more appropriate physical and intellectual concepts. Findings for physical concepts were discussed first, followed by those for general intellectual concepts. The findings for those intellectual concepts that were specific to a technical drawing's internal articulation were then discussed. The chapter concluded with the development and discussion of important and unexpected findings – the low levels of certification and authorisation that the survey results had shown for technical drawings' issue, use, and revision. The Bibliography follows this concluding chapter. A separate volume presents the technical drawings survey data, within four appendices.

1.5 Conclusions from the literature

The Literature Review had three aims. Firstly, it should identify knowledge, and gaps in knowledge, relevant to the scope of the research. Secondly, the reviewed literature should underpin the individual disciplinary data definition models that were to form the Interdisciplinary Data Definition Model (DDM). Thirdly, the literature should contribute data to populate those models.

The literature for diplomatic was most blessed with theory. Relevant theory was less apparent in the literature for archives and records, and technical drawings. That situation reflected the practical nature of technical drawing in particular. Some reviewed archives and records literature was specific to archival technical drawings, while some was more general in nature. In both cases, that literature was also largely concerned with applied theory and practice, rather than pure theory.

1.5.1 Technical drawings

The essential starting point within the literature review for 'technical drawings' was to seek a well-founded definition for the general concept itself. One such was found in British Standards. Two more specific concepts, for 'engineering drawings' and 'architectural, building, and construction' (ABC) drawings could then be defined from *RAD2008*.

The literature then reviewed for technical drawings first examined that for engineering drawings. A clear distinction was drawn, from the literature, between engineering drawings and the engineering design activities that produced the drawings. That section of the reviewed literature laid the foundations for a new conceptualisation of document status that was developed in this research.

The British literature that was available for engineering drawings' original contexts of production and use was very limited. It was much more descriptive than theoretical. Some theoretical understanding of the contexts of engineering drawing production could be drawn, though, from an American perspective.

Rather more British literature was available for ABC drawings' original contexts of production and use. Those contexts were, though, quite dissimilar to those for engineering. Comparable business processes within British engineering design and drawing offices have yet to be analysed in the archival literature, presenting a gap in knowledge.

British Standards for both engineering drawings and ABC drawings contributed to the development of the Interdisciplinary DDM. Other more specialised standards also contributed knowledge for physical concepts, such as media of support, and reprographic reproduction processes.

1.5.2 Technical drawings as archives

The literature for technical drawings in archival settings was sparse, necessitating an international Anglophone review. Literature for ABC drawings predominated over a very thin *corpus* for engineering drawings. The ABC literature that dealt with physical aspects of technical drawings – media of support and reproduction processes – could, though, be particularly usefully applied to engineering drawings.

An extensive trawl of the archival literature enabled many intellectual concepts within technical drawings to be identified, and to contribute to the Interdisciplinary DDM. However, considerable dissonance was found in the ways in which similar concepts were defined and / or labelled. Despite some highly developed vocabularies, there was very clear potential for their mis-application in archival description. That was especially the case when using apparently appropriate terms in a context of description that was different from the one for which the terms had been developed.

Even within ABC drawings, descriptive practice and terminology differed across the international boundaries of the literature. Terminological imprecision was especially remarked upon in the literature. No coherent vocabulary existed for archival engineering drawings, indicating a gap in knowledge.

No guidance was found for the special knowledge required to archivally process and describe engineering drawings. Even *RAD2008*'s well-developed scheme conflated engineering and architectural drawings within a special section of its rules. The lack of such specialist guidance for engineering drawings in archives, particularly in British contexts, represents a further gap in knowledge.

The artificiality of differentiating between engineering drawings and other forms of engineering record was asserted in the literature. At the same time, the practical difficulties of making engineering drawings accessible, to provide an accurate and balanced selection of records, were also noted.

1.5.3 Diplomatic

The first three hundred years of literature for diplomatic theory were devoted to textual documents. Theoretical applications were then developed for records in aggregations, and for records in electronic formats. The literature of both eras was used extensively to contribute to the Interdisciplinary DDM.

A very few accounts described diplomatic's use for other forms of record, including photographs. However, no literature applied diplomatic theory to graphical records such as technical drawings – indicating a gap in knowledge.

Of particular relevance to this research was the assertion that much greater precision was brought to terminology by diplomatic than by archival science. Archival description could benefit from diplomatic's terminological exactitude.

1.5.4 Archives and records – general theory and practice

The general archives and records literature contributed relatively little to the research, beyond a high-level conceptualisation of a record. As this literature was used only to complement that for diplomatic, its slimness was not important.

1.5.5 Summary of gaps in knowledge

The following gaps in knowledge were therefore indicated by the literature:

- L-1 Analysis of historical business processes within British engineering design and drawing offices.
- L-2 A coherent vocabulary for the archival description of engineering drawings.
- L-3 Specialist guidance for archivally processing and describing engineering drawings in archives, particularly in British contexts.
- L-4 Application of diplomatic theory to the analysis of technical drawings, as an exemplar of graphical records.

How those gaps in knowledge were addressed by this research is considered later within the conclusions. [981]

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[981] See Conclusions: 4.1 Gaps in knowledge from the literature, answered by this research, *286*.

2. Delivery of the Research Outcomes

This principal section presents conclusions about the delivery of the three intended research outcomes. Those outcomes were derived from the research aims, which were, in turn, formulated to answer the Research Question. Each outcome is first considered individually, as a measure of how successful the investigation has been in answering the Research Question, through the aims and outcomes. These conclusions are informed, where appropriate, by evidence for the attainment of operational objectives and outputs.

Outcome One presents conclusions about the research design and methodology that were developed within this investigation. Those developments essentially provided the means by which an answer to the Research Question could be sought. These conclusions are therefore logically presented before those that more directly relate to the question itself.

Outcome Two provides the setting for those Research Question conclusions. They are gathered into three sets. The first conclusions consider the quantitative and qualitative validity of the research results. Secondly, conclusions are drawn about the potential utility that the reported concepts and characteristics have for enhancing archivists' understandings of technical drawings. Finally for this outcome, conclusions are made for the unexpected findings about technical drawings' certification and authorisation.

Outcome Three's conclusions are made for two further, related, aspects of the research design and methodology. The first conclusions concern the ability of the research design and methodology to enable replication of this research's results. Secondly, conclusions are drawn for the generalisability of the research design and methodology to future research applications. Both those requirements were embedded in the research design and methodology that enabled the delivery of statistically robust and replicable results. The conclusions for this outcome are therefore drawn chiefly from those concerning the validity of those results, within Outcome Two.

The conclusions for each Outcome are summarised at the end of each section, and are indicated in text thus: (C*n*-*n*).

2.1 Aim and Outcome One

Aim: Using the lens of diplomatic theory, develop means by which technical drawings can be made more comprehensible to archivists.

Outcome: Developed a new research design and methodology, using diplomatic, archives, and records theory, to discover, quantify, and analyse the intellectual and physical concepts and characteristics of technical drawings.

2.1.1 Introduction

Conclusions are first drawn for the mixed methods approach to the development of the research design and methodology, which used a perspective of diplomatic theory. More specific conclusions are then made for the ways in which four problems of archival understanding were addressed. Conclusions for two special areas of methodological novelty are then presented.

2.1.2 Mixed methods with a diplomatic perspective

No single philosophical position was identified for the diverse disciplines that were involved in this research. Nor could a single philosophical position embrace the research methods and techniques that were employed. A research design that included a mixed methods methodology was therefore appropriate to the needs of this research. This methodology is not novel; it merely theoretically formalises long-established research practice in diverse fields. [982]

The principles of both the research design and the methodology were already established in the literature. The 'Sequential Exploratory Strategy' provided a suitable model for the research design. Apart from its practical suitability, the strategy could be implemented within an explicit theoretical framework. That particular feature therefore enabled this research's chosen perspective – diplomatic – to be readily accommodated within the research design. [983]

The research's methodological approach followed that of the mixed methods' 'Complementary Strengths Thesis'. Philosophical incommensurability in

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[982] See Research Design and Methodology: 2.1 Situating the Research Design, *71*.

[983] See Research Design and Methodology: 2.2 Conceptualising the Research Design, *73*.

components of the methodology was countered by the research design. There was a clear separation of epistemologically different methods within the design. At the same time, the complementary strengths of each methodological component's paradigmatic position could be realised. [984]

In general terms, therefore, both the design and methodology used in this research were founded on published principles and practice, and were appropriately employed. (C1-1) Their novelty lay only in their application to research within the ARM discipline. That such an application is novel is perhaps also surprising. From the experience of this research, a mixed methods methodology can be argued as being entirely appropriate to research in a discipline such as archives and records management, where working across disciplines is inherently ubiquitous. [985] (C1-2)

2.1.3 Four problems of archival understanding

Here, conclusions are presented for the ways in which four problems of archival understanding were addressed within the design of the research and its methodology – special graphical conventions, specialist subject knowledge, latent data, and contextual information. [986]

Minimise the need for archivists to understand special graphical conventions

Closely associated with the need for interdisciplinary working is the issue of the double hermeneutic. [987] Archivists have to describe and disseminate, in ways that can be widely understood, information that derives from diverse disciplines. To be able to produce such finding aids, guides, and other descriptive models, archivists must first be able to understand the ways in which those other disciplines model their own information.

The problem of understanding those other information models was determined to be one of language. The research scoped the problem by conceptualising three forms of technical language that were used to create technical drawings. All three

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[984] See Research Design and Methodology: 2.1 Situating the Research Design, *71*.

[985] See Research Design and Methodology: 1. Introduction, *70*.

[986] See Introduction: Table 2: Research Objectives and Intended Outputs for Aim and Outcome One, *16*.

[987] See Research Design and Methodology: 1. Introduction, *70*.

forms of language – Scale, Drawing Aspect, and Dimensioning – were expressed in forms of Script that used special graphical conventions. [988]

A means was therefore developed that enabled those technical languages to be translated into a single language that would be more familiar to archivists – the language of diplomatic. The success of that aspect of the research design and methodology is shown by the utility of the Interdisciplinary Data Definition Model that was developed. This first special area of methodological novelty is described separately, below. [989]

The importance to diplomatic of both Language and Script has been said to have waned over time. [990] Based on the findings of this research, though, I conclude that the concept of Language was central to the successful diplomatic analysis of technical drawings. (C1-3) The language used was based on that of diplomatic, rather than on that of technical drawing. (C1-4)

Minimise the need for archivists to possess specialist subject knowledge
The need to understand special graphic conventions – and the resolution of that problem – is closely linked to a further problem of archival understanding. It is the perceived need for archivists to possess specialist subject knowledge, to be able to interpret technical drawings appropriately.

Here, the focus is on the graphical *corpus* of a technical drawing – the content whose depiction was the reason for creating the drawing. Clearly, this is a most important area for an archivist to understand, and for a researcher to be informed about. Yet a technical drawing's graphical content is often the concept that is most unyielding to understanding. [991]

I have concluded, though, that it is not the specialist subject matter as represented by graphical content that needs to be understood by archivists, to be

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988 See Discussion: 4.2 Language and Script, *185*.

989 See Conclusions: 2.1.4 The Interdisciplinary Data Definition Model, *268*.

990 Duranti, *Diplomatics: New Uses for an Old Science*, 135-8.

991 See Discussion: 5.2 Graphics and Text, *230*.

able to inform researchers usefully. (C1-5) Specialist subject information is provided through other concepts, as previously discussed.[992]

Rather, it is the way in which that graphical content is represented, in broad and generic terms. (C1-6) The information that is required for archival processing is therefore of the type: how many views are depicted, by what Method of Representation, and by what forms of Drawing Aspect?

Those conceptualisations have been fully developed and described within this research.[993] The use of controlled terms from defined vocabularies – based, for example, on the Interdisciplinary Data Definition Model – will both prompt data discovery, and help standardise content description. (C1-7)

Enable archivists to interpret latent data

The first two special problems discussed above drew conclusions for problems caused by manifest data. Here, conclusions are presented for the converse situation – where technical drawings' data are latent. The conclusions concentrate on latent data for intellectual concepts and characteristics. Issues associated with physical latent data are discussed below.[994]

As concepts and characteristics were developed and defined during the research, it became clear that those for which data had to be inferred presented a specific problem. A means was required to inform archivists that such latent data existed in technical drawings, to help them understand the data's potential importance, and to enable them to extract and record the data. (C1-8)

Instances where a concept contains or relies upon latent data have been discussed at the appropriate points within the preceding chapter. They include concepts as diverse as Addressee Person-Role,[995] Subject,[996] and Stage of Realisation.[997] Any

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992 See Discussion: 5.1.5 Technical Drawing Title, *224*; 5.1.6 Technical Drawing Subject, *225*, 5.1.7 Intended Use, *229*.

993 See Discussion: 4.2.4 Technical Language – Method of Representation and Drawing Aspect, *193*.

994 See Conclusions: 2.1.5 Physical concepts and characteristics, *270*.

995 See Discussion: Latent addressee person-roles, *224*.

996 See Discussion: 5.1.6 Technical Drawing Subject, *225*.

997 See Discussion: 4.8.2 Determining the concept of record production – Stage of Realisation, *215*.

means developed to assist archivists with interpreting and understanding latent data would therefore have to be widely scoped.

A starting point exists in the Interdisciplinary Data Definition Model developed in this research. It provides a source of controlled terms, which, as noted in the preceding section, can also be used as prompts for data discovery. (C1-9) The model could usefully be developed in future research, and complemented by practical guidance to understanding archival technical drawings. Such guidance would also advise archivists about the existence and potential importance of latent data within technical drawings. (C1-10)

This research has therefore provided a foundation to enable archivists to interpret latent data better, but more development work is required in future research.

Enable archivists to interpret contextual data
No data for contexts was manifested as such within the sampled technical drawings. Such data did, though, exist within many other concepts.[998] The discovery and interpretation of contextual data therefore constituted a particular instance of latent data. (C1-11)

2.1.4 The Interdisciplinary Data Definition Model

The way in which the Research Question was to be answered was through the identification of concepts and characteristics that were both generic and useful. The starting point for the journey towards that answer was the development of an Interdisciplinary Data Definition Model (DDM).[999] Initially, the model had to contain data for concepts and characteristics that were sufficient to populate serviceable survey instruments. At that stage, therefore, the model needed to be satisfactory, rather than complete.

It will be remembered that the Interdisciplinary DDM was created from individual disciplinary data definition models. The way in which those individual models were developed was an example in miniature of the mixed methods methodology that was adopted for the research as a whole. A balance was struck

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998 See Discussion: 4.6 Contexts, *210*.

999 See Research Design and Methodology: 3.1.3 The Interdisciplinary Data Definition Model, *80*.

between two methods of accruing data to those models, at both micro and macro levels.

Micro-level data accrual to a model was an activity entirely separate from later data collection within the technical drawings' survey. In this initial data definition phase, high-level data for concepts and characteristics were first deduced from an overview of the literature. An outline model was created. Detailed data were then inductively extracted by a thorough bottom-up analysis of the literature, to create a detailed model.

That micro mixed methods approach successfully used a combination of content analysis and grounded theory, despite their different epistemological origins. Objections on grounds of incommensurability have been countered, above.[1000]

That initial phase was theoretical. Its micro approach can be compared with a second, macro, phase of data accrual to the model. In that macro phase, empirical data primarily collected for quantitative analysis were also used qualitatively, to modify the Interdisciplinary DDM iteratively.

The success of that two-phase mixed methods approach was evidenced by the utility of the Interdisciplinary DDM. The model was made possible by a use of mixed methods methodology that enabled epistemological issues to be reconciled. It can therefore be concluded that a mixed methods approach can be successfully used in such circumstances. (C1-12)

However, the general success of the approach to developing the Interdisciplinary DDM rested – as with the research in general – upon the concept of language.[1001] The discipline from which any particular concept or characteristic was derived was of no account. What did matter was the language used to describe the concept or characteristic. (C1-13)

Essentially, the language of the model had to be one that was understandable to archivists. That understanding was achieved by reducing concepts and characteristics to fine degrees of granularity, to the point where terminology

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[1000] See Conclusions: 2.1.2 Mixed methods with a diplomatic perspective, *264*.

[1001] See Conclusions: Minimise the need for archivists to understand special graphical conventions, *265*.

became common across disciplines. The granular data were then re-aggregated, using the theoretical perspective of diplomatic. Concepts were thus created that could be described in language familiar to archivists. (C1-14)

The final Interdisciplinary DDM therefore represented an interdisciplinary body of knowledge, expressed in a meaningful archival language. The methodology by which that model was created depended upon a granular approach to language that enabled interdisciplinary differences in terminology to be successfully reconciled.

2.1.5 Physical concepts and characteristics

In this research, equal importance was attached to investigating both physical and intellectual concepts and characteristics. Methodological conclusions associated with intellectual concepts and characteristics have been given above. Here, quite different conclusions are presented for physical concepts and characteristics. It must be said at the outset that the overall conclusion for this component of the methodology is one of disappointment. There was a relative lack of success in deriving useful information from these physical features of technical drawings.

The key part of the methodology adopted for investigating physical concepts and characteristics was that their data should be derived by archivists who were using only their five physical human senses. That approach would negate the need for specialist conservation resources to help with the intellectual aspects of archivally processing and describing technical drawings. [1002]

Technical drawings' physical concepts and characteristics were investigated not just to provide first-order data for the physical make-up of a drawing. More importantly, physical data were also intended to be used to help inform archivists about other, far less tangible, concepts – a drawing's Genesis and Tradition, the date or period of a drawing's creation, or its Stage of Realisation, for example. [1003]

The three physical concepts for which investigation was most important, and also most problematic, were the medium of a drawing's support, the medium of the

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[1002] See Discussion: 3. Physical concepts and characteristics, *163*.

[1003] See Discussion: 3.1.1 Potential benefits and limitations of identification of medium, *165*.

process used to create a drawing, and colour. Concepts of material were closely associated with the two concepts of medium. The concept of colour was key to the determination of Data Values for the concepts of both medium and material.

Within media of support, identification of synthetic materials was most difficult.[1004] Most processes of reprographic reproduction were far harder to identify reliably than were the manual production processes.[1005] However, differentiating between manual drafting during primary production, and manual drafting during subsequent amendments and corrections, was also problematic.[1006] The consistent identification of colour was an intractable problem across almost all the physical concepts and characteristics.[1007]

Each of those three areas of investigation produced a similar finding, from which a common conclusion can be drawn. For reliable data to be collected, it was essential to have physical reference sets of examples of the medium, process, material, or colour that was being investigated. Such examples could then be compared side-by-side with the technical drawing being analysed. (C1-15)

Despite some excellent reference texts, printed two-dimensional surrogates did not provide the physical attributes of sight, feel, and smell that the research found to be necessary for reliable identification by sensory means. (C1-16)

A conservation science approach was not considered to be a generally practicable means of routinely discovering physical data from technical drawings, for two reasons. Firstly, that approach would normally require specialist facilities and equipment – for example, to carry out FTIR analysis, or to measure colour values. Such specialised resources would likely not be available within the reasonable reach of many archivists, even those whose offices included conservation studios. Secondly, a conservation science approach might entail the testing – sometimes destructively – of examples of the media and materials requiring analysis. That would clearly not be appropriate for technical drawings selected for archival preservation. (C1-17)

1004 See Discussion: Problems of identification of synthetic support materials, *169*.

1005 See Discussion: Problems of identification of reprographic processes, *176*.

1006 See Discussion: Problems of identification of manual drafting processes, *175*.

1007 See Discussion: Problems of identification and interpretation of colour, *178*.

Based on the results of this research, it must be concluded that many archivists might be hard pressed to derive understandings from the physical concepts and characteristics of technical drawings, through use of their five senses alone. (C1-18) The use of reference texts did not provide the sensory attributes necessary to facilitate that approach. However, the specialist resources required of a conservation science approach were not likely to be routinely available to many archivists.

Those gloomy conclusions do not, in my view, totally negate the use of physical concepts and characteristics as an approach to understanding technical drawings. The conclusions certainly do not diminish the principle that such physical features contain Data Values of importance for enabling understanding. (C1-19) Physical concepts and characteristics remain as important as their intellectual counterparts. [1008] That is notwithstanding a view that the relevance of some physical aspects of diplomatic analysis had diminished for records supported by traditional forms of media. [1009]

What these conclusions do highlight is the need for future research within the area of conservation science, as indicated later. [1010] (C1-20)

2.1.6 Research design and methodology conclusions – summary

The following conclusions can be summarised for Outcome One, from those presented above:

C1-1 A mixed methods research design and methodology was appropriate to this research, philosophically and practically.

C1-2 Mixed methods research design and methodology is appropriate to ARM research more generally.

C1-3 The concept of language was central to the successful diplomatic analysis of technical drawings.

C1-4 The language successfully used was based on that of diplomatic, rather than on that of technical drawing.

[1008] Following Boyle, 'Diplomatics', 82-3, and Heald, 'Is there Room for Archives in the Postmodern World?', 101, cited by Ketelaar, 'Tacit Narratives', 139, n.42.

[1009] By contrast, the support media for records in electronic formats *are* considered important: Duranti, *Diplomatics: New Uses for an Old Science*, 135.

[1010] See Conclusions: 5. Indications for future research, *287*.

C1-5 Archivists do not need to understand the specialist subject matter that is represented by the graphical content of a technical drawing, to be able to inform researchers usefully.

C1-6 Archivists do need to be able to inform researchers about the ways in which such specialist subject matter is represented.

C1-7 The use of controlled terms from defined vocabularies will both prompt data discovery, and help standardise technical drawings' content description.

C1-8 A means is required to assist archivists to discover, interpret, and use the latent data that exist in technical drawings.

C1-9 The Interdisciplinary Data Definition Model developed in this research provides a starting point for controlled terms (C1.7) and for assisting archivists with latent data problems (C1.8).

C1-10 The Interdisciplinary Data Definition Model, and complementary practical guidance to understanding archival technical drawings, could usefully be developed in future research.

C1-11 The discovery, interpretation, and use of contextual data constitutes a particular instance of latent data.

C1-12 The successful use of a mixed methods methodology, at a detailed level, was evidenced by the utility of the Interdisciplinary Data Definition Model.

C1-13 The general success of the approach to developing the Interdisciplinary Data Definition Model rested upon the concept of language.

C1-14 The theoretical perspective of diplomatic was used within the Interdisciplinary Data Definition Model when aggregating granular data for terminology into a language understandable to archivists.

C1-15 To aid archivists' identification of physical concepts and characteristics when using only their physical senses, physical reference sets of examples of the matter being investigated are essential.

C1-16 Printed two-dimensional surrogates did not provide the physical sensory attributes necessary for reliable identification of physical concepts and characteristics.

C1-17 A conservation science approach is not a generally practicable means by which archivists could routinely discover physical data from technical drawings.

C1-18 Many archivists might be hard pressed to derive understandings from the physical concepts and characteristics of technical drawings, through use of their five senses alone.

C1-19 Physical concepts and characteristics still retain realisable Data Values of importance for understanding technical drawings.

C1-20 The means by which the Data Values of technical drawings' physical concepts and characteristics might be realised rests with future conservation science research.

2.2 Aim and Outcome Two

Aim: Implement and evaluate [means by which technical drawings can be made more comprehensible to archivists] using an exemplar statistical sample of technical drawings.

Outcome: Statistically estimated, and described, concepts and characteristics that were effectively generic within the sampled technical drawings, and which had potential to enhance archivists' understanding.

2.2.1 Introduction

Two sets of conclusions that are directly relevant to this aim and outcome go to the heart of the research question. A further set of conclusions can also be drawn, for unexpected findings that accrued while that fundamental question was being addressed. This section therefore presents conclusions under three headings:

1. Statistically estimated concepts and characteristics
2. Concepts and characteristics and their utility for understanding
3. Unexpected findings for certification and authentication

2.2.2 Statistically estimated concepts and characteristics

The ability of the research to conclude that certain concepts and characteristics have potential to aid understanding of technical drawings is predicated upon fulfilling a prior sequence of conditions:

- The comprehensiveness of coverage of the concepts and characteristics identified within the Interdisciplinary Data Definition Model (DDM)
- The appropriateness of the concepts and characteristics that were purposively selected for the technical drawings' survey
- The composition of the population from which the survey sample was drawn
- The robustness of the sample as a representation of its parent population
- The rigour of survey data collection
- The appropriate derivation of frequencies of occurrence
- The statistical confidence in the survey results

Conclusions for each of these conditions will now be summarily drawn. They will then be aggregated into a general conclusion for this section, upon which the validity of the conclusions drawn in the succeeding section must inevitably rest.

The content of the Interdisciplinary DDM was aligned to the profile of the technical drawings that were to be surveyed in this research. The model was theoretically informed by directly relevant British Standards, and by wider literature. [1011] Empirical data from the surveyed technical drawings also contributed to the model. [1012] The Interdisciplinary DDM was therefore more than sufficiently comprehensive in its coverage of relevant concepts and characteristics. (C2-1)

The need for purposive selection of concepts and characteristics for the technical drawings' survey introduced unplanned subjectivity into the research. Yet the selection of appropriate concepts and characteristics from the Interdisciplinary DDM was critical to the research's success. Grounds for exclusion were therefore defined, to try to reduce the subjectivity in selection. The high proportion of selected concepts and characteristics that did not produce useful data (58.4%) indicates, it is argued, that this approach was successful. [1013] (C2-2) The choice of concepts and characteristics could also be reviewed in future similar research. (C2-3)

[1011] See Research Design and Methodology: 3.1.2 An interdisciplinary approach to data definition, *79*.

[1012] See Research Design and Methodology: 3.3.2 Survey procedure, *109*.

[1013] See Research Design and Methodology: 3.1.4 Purposive selection of concepts and characteristics for survey, *83*.

The technical drawings population that was sampled comprised engineering drawings from British commercial vehicle manufacturers. Dating from the 1920s to the 1980s, they chiefly depicted general mechanical engineering subjects and activities. The survey statistics, results, and findings can be directly inferred to that technical drawings' population. (C2-4)

Such research outputs might only be generalised with decreasing validity and reliability to other technical drawings' populations. It is not possible, based on a single sample, to say to what degree such generalisation might be possible. The greater the distance that inferences are drawn from technical drawings of different subject, date, or county of origin, for example, the greater the potential for invalidity and unreliability. (C2-5)

The degree to which the technical drawings sample truly represents its parent population cannot be tested, that population having been destroyed. It was with that once-only opportunity in mind that the sample was design and drawn, as robustly as possible, following published principles. [1014] The research and its results have thrown up no reasonable grounds for suspicion that the sample is not robust. Statistical comparison could be made with the results of similar research, in the future, to assess their level of correlation. (C2-6)

The techniques employed for survey data collection were designed to maximise rigour, and minimise opportunities for error and bias. [1015] Well-designed survey instruments were initially populated with pre-defined Data Values, reducing the risk of data entry errors. Data were collected in sub-sets of variables, in multiple runs, to enable problems to be resolved in a controlled manner. Extensive back-ups were maintained. No qualitative measures can definitively indicate the total accuracy of such data. The survey could be replicated, though, for so long as the sample remains available, and the two sets of results compared. (C2-7)

The principal results required of the survey data were frequencies of occurrence of concepts and characteristics. Following initial data processing and error checking, all such frequencies were calculated using SPSS *Statistics*. This process was unproblematic. Confidence intervals were also calculated using SPSS, again

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[1014] See Research Design and Methodology: 3.2.4 Sample design, *93*.

[1015] See Research Design and Methodology: 3.3.1 Data Collection, *106*.

without difficulty.[1016] There are no reasonable grounds to indicate that those procedures produced errors in the reported results. (C2-8)

The greatest uncertainty amongst all the conclusions thus drawn for the statistically estimated concepts and characteristics is that for the purposive selection of the concepts and characteristics to be surveyed. It has however been shown that that selection erred considerably on the side of caution. The conclusion that the approach adopted was successful must be sustained.

The quantitative conclusions are more straightforward. The methods and procedures employed were rigorous and robust, and no reasonable grounds for error have been indicated. The general conclusion must be, therefore, that the reported results are valid, and that they can be reliably inferred to the population from which they were derived.

2.2.3 Concepts and characteristics and their utility for understanding

Conclusions can now be drawn about the potential utility of the reported concepts and characteristics for enhancing archivists' understandings of technical drawings. As well as underlining the outcomes of this research, these conclusions provide a starting point for future consultation with archivists and researchers.

This section's conclusions are considered under two headings:

- Generic concepts and characteristics
- Non-generic concepts and characteristics

Generic concepts and characteristics

Of the seventy-four concepts and characteristics whose results were reported, thirty-four (46%) occurred in 91% of more of cases, and were considered to be potentially useful. One other generic characteristic was not considered useful.[1017]

Those generic concepts and characteristics would provide information of importance to technical drawings' archival selection, arrangement, description, and research use. (C2-9) Intellectual information includes, for example, that for drawing provenance, subject matter, depicted content, scale, original referencing,

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[1016] See Results: 4. Data Analysis, *119*.

[1017] Materials List – see Discussion: Materials List, *185*.

and Information Form. Despite the problems of determining physical data, support and process media and materials can be identified at a high level. Data for support dimensions, orientation, and format are also ubiquitous.

However, this research has gone beyond the mere identification of generically useful concepts and characteristics. It has described, for example, where they might be most commonly found located within a technical drawing. The forms in which concepts and characteristics might be found, and the labels by which they might be indicated, have also been set out in this research. The identification and extraction of latent data has been discussed. Such interpretations provide underpinning for the practical application of this research – in published guidance, for example. (C2-10)

Non-generic concepts and characteristics
Results are reported for forty concepts and characteristics (54% of all those reported) that, while not generic, were considered to have potential importance, or were otherwise noteworthy. Although these concepts or characteristics were not generic within this sample, some might be more common in other technical drawings' populations.

Those non-generic concepts or characteristics can contribute to understanding in several ways. Firstly, they can be valuable in their own right. In this sample, for example, data was very sparse for enterprise logos and trade marks. The data that did exist, though, ably illustrated that diplomatic analysis could derive useful information about a technical drawing at a micro level. [1018]

Secondly, data from non-generic concepts and characteristics can contribute to that already provided by their generic counterparts. For example, non-generic data for legal name forms of Rights Owners enabled generic data for Principal Enterprise names to be interpreted more accurately – again using diplomatic analysis. [1019]

These two examples merely illustrate the utility of the non-generic concepts and characteristics identified within this research. Because of that utility, (C2-11) and

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[1018] See Discussion: 4.3 Special Signs – Enterprise Logos and Trade Marks, *199*.

[1019] See Discussion: Legal Name Forms for Rights Owner, *221*.

because they might be more commonly found elsewhere, (C2-12) the reporting and discussion of these non-generic concepts and characteristics, and their consideration in future research, is justified. (C2-13)

2.2.4 Research question conclusions – summary

The following conclusions can be summarised for Outcome Two, from those presented above:

C2-1 The Interdisciplinary Data Definition Model was more than sufficiently comprehensive in its coverage of relevant concepts and characteristics.

C2-2 The purposive selection of concepts and characteristics for the technical drawings' survey was successful.

C2-3 The choice of selected concepts and characteristics could be reviewed in future similar research.

C2-4 The survey statistics, results, and findings can be directly inferred to the sample's parent population of technical drawings.

C2-5 The broader the inferences made to wider populations, the greater the potential for invalidity and unreliability in the conclusions drawn.

C2-6 The results of this research could be statistically compared with the results of similar future research, to assess their level of correlation.

C2-7 This survey could be replicated, for so long as the research sample remains available, and the two sets of results compared.

C2-8 There are no reasonable grounds to indicate that the statistical procedures produced errors in the reported results.

C2-9 The identified generic concepts and characteristics would provide information of importance to technical drawings' archival selection, arrangement and description, and research use.

C2-10 Theoretical underpinning has been provided for the reported concepts and characteristics, and can be used in the practical application of the research.

C2-11 Identified non-generic concepts and characteristics also have importance for understanding technical drawings.

C2-12 Concepts and characteristics that were not generic within this sample might be more common in other technical drawings' populations.

C2-13 The reporting and discussion of the identified non-generic concepts and characteristics, and their consideration in future research, is justified.

2.3 Aim and Outcome Three

Aim: Ensure that the [means by which technical drawings can be made more comprehensible to archivists] will enable:

- replication of the results of this research
- comparable work to be undertaken on other exemplars of technical drawings, in future research
- indicative generalisation of results, with appropriate caution, to other technical drawings' populations.

Outcome: Developed and sufficiently described a research design and methodology that was able to deliver statistically robust and replicable results, and be successfully applied to the analysis of other technical drawings.

2.3.1 Introduction

At first sight, it might be thought that this aim and outcome goes beyond the needs of the research. That is not the case. The aim applied conditions upon the research design and methodology that generally enabled the delivery of robust and reliable results from this research.

Because of that approach, it was easily possible to ensure that a solid foundation had been laid from which future research could proceed. That foundation exists both in the research design and methodology, and in the results that they facilitated in this research.

Most of the conclusions that can be drawn for this outcome have already been developed within Outcome Two. Conclusions for this section are therefore only summarised, under the following two headings:

- Research results
- Research design and methodology

2.3.2 Research results

This research's results were intended to:

- Be statistically robust and replicable
- Provide a benchmark for comparison with the results of similar future research on other samples of technical drawings

- Be capable of indicative generalisation, with appropriate caution, to other technical drawings' populations

That those objectives were achieved is evidenced by the following previously formed conclusions:

C2-4 The survey statistics, results, and findings can be directly inferred to the sample's parent population of technical drawings.

C2-7 This survey could be replicated, for so long as the research sample remains available, and the two sets of results compared.

C2-6 The results of this research could be statistically compared with the results of similar future research, to assess their level of correlation.

C2-5 Broader inferences can only be tentatively made to wider populations, and with decreasing validity and reliability as the distance to them increases.

C2-8 There are no reasonable grounds to indicate that the statistical procedures produced errors in the reported results.

2.3.3 Research design and methodology

This outcome was designed to deliver a research design and methodology that was:

- Conceptually and statistically robust
- Practically amenable to implementation
- Replicable, scalable, and generalisable

That those objectives were achieved is chiefly evidenced by the conclusions drawn for the research results, immediately above. The following two previously drawn conclusions are also relevant:

C2-3 The choice of selected concepts and characteristics could be reviewed in future similar research.

C2-10 Theoretical underpinning has been provided for the reported concepts and characteristics, and can be used in the practical application of the research.

Only two new conclusions need be drawn here for these aspects of research design and methodology:

C3-1 This research design and methodology is capable of scaled generalisation to the analysis of other samples of technical drawings.

C3-2 If the subject of technical drawings was substantially different from those surveyed here, the Data Definition Model would require modification by the addition of data for appropriate concepts and characteristics.

3. Other conclusions

Two other conclusions, which derive more generally from the research, are presented here under the following headings:

- Development of diplomatic theory
- Certification and authorisation of technical drawings

3.1 Development of diplomatic theory

This research introduced a number of new concepts to aid the interpretation of technical drawings. Those developments were made within the research's overarching theoretical perspective of diplomatic. The reconceptualisation of the traditional diplomatic model was a consequence of the interpretation aim, rather than a goal in itself.

However, the structure of diplomatic criticism that has traditionally been used for textual analysis cannot adequately cope with records that can be reprographically reproduced.[1020] (C4-1) Modifications to the structure of diplomatic criticism were therefore most often made in this research to accommodate that reproduction ability. Changes to accommodate the graphical nature of technical drawings were more often made at lower levels of conceptualisation and characterisation.

In summary, diplomatic theory was modified and extended in the following ways. Structurally, the traditional concepts of extrinsic and intrinsic elements were set aside. They were replaced by concepts based on physical and intellectual characteristics within records. The intent was to establish diplomatic concepts that could effectively operate in a records environment that included the possibility of reprographic reproduction. Without that capability, it seemed impossible to apply diplomatic theory to technical drawings successfully.

[1020] Technical drawings are, of course, merely one form of such records.

Therefore, the unique physical concepts and characteristics that existing only in an 'original' document were all now conceptualised within the single general diplomatic concept of Medium. All other concepts and characteristics were of an intellectual nature. They could exist in both an 'original' document, and in 'copies' of it – two concepts deprecated in this research, as discussed below.

Those intellectual concepts and characteristics were conceptualised within a number of higher-level, general, diplomatic concepts. Most of those general concepts were newly developed, while containing many lower-level concepts and characteristics from traditional diplomatic theory. Of particular note is the concept of Language, much extended, and thus brought back to prominence within diplomatic theory. The traditionally important diplomatic concept of Annotations retains its importance, but is subsumed within a larger general concept of Changes.

The concept of Document Status is presented as a practical simplification of traditional Genesis and Tradition. Terms such as 'original' and 'copy' are thus replaced by terms that clearly associate a document or record with a defined stage of business activity. Further concepts, associated with the form of a record, and its intended use, are also clearly defined.

As noted at the beginning of this section, these changes to diplomatic concepts were not originally intended – certainly not on the scale with which they have been developed. However, the message that was clearly coming from the documents under survey could not be ignored. Existing theory did not suit the reality, and the reality in the records could not change. The models developed in this research therefore inductively followed the data, as MacNeil had argued for in her critiques of the UBC Project and InterPARES 1.[1021] This approach also took heed of Eisenhart's warning not to develop a theoretical 'solution' that was unrelated to reality. To do so would simply produce results that were, at best, irrelevant to practitioners.[1022]

In this research, therefore, theory has been developed as an integral part of practical research. Those developments were substantially aligned to the

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[1021] See Literature Review: 2.4.2 Methodological issues, *47*.

[1022] Eisenhart, 'Conceptual Frameworks for Research circa 1991', 205-6.

existence of records capable of being reprographically reproduced. That research has been shown to have produced valid results. The successful delivery of those results therefore clearly shows that the developments to diplomatic theory successfully achieved their intent. The utility of the new diplomatic theory has been demonstrated. (C4-2)

It is clearly understood, of course, that this research's results reflect only one population of technical drawings, albeit those of a general engineering nature. Further research, on dissimilar samples of technical drawings, would enable results to be compared, case by case. More general theory could thus be developed, over time, from a growing body of knowledge. (C4-3)

3.2 Certification and authorisation of technical drawings

As well as providing answers to the Research Question, the investigation also led to some unexpected findings about the certification and authorisation of technical drawings. These findings related to two conceptual areas – the Record of Changes, and the Signature-Date Block. [1023]

Within the Signature-Date Block, barely more than half of the surveyed drawings contained what would normally be considered appropriate authorisation as a record – a signature and accompanying date. The substantial remainder would not therefore be expected to have been regarded and used as authoritative records. Yet some of those drawings bore authorised notes of changes in their Record of Changes. That indicated that the drawing had been in use, despite it being incompletely authorised for use after its creation. Such a high level of anomalies in technical drawings' certification and authorisation for use was completely unexpected, (C4-4) and warrants further investigation in separate research. (C4-5)

This finding also leads to a reaffirmation that diplomatic criteria should be applied appropriately to the circumstances in which records are found. For example, conditions set for the prospective control of current records' reliability

[1023] See Discussion: 4.4.3 Analysis of the Record of Changes, *203*; 5.3.4 Combined Certification Concepts, *248*.

and accuracy are not appropriate to the retrospective determination of those qualities in records being appraised for archival preservation. [1024] (C4-6)

3.3 Other conclusions – summary

The following conclusions can be summarised from those presented above:

C4-1 The structure of diplomatic criticism that has traditionally been used for textual analysis cannot adequately cope with records that can be reprographically reproduced.

C4-2 Diplomatic theory developed in this research has been substantially aligned to the existence of records capable of being reprographically reproduced. The utility of that new theory has been demonstrated by the successful delivery of the results that rested upon the theory.

C4-3 Further research, on dissimilar samples of technical drawings, would enable more general theory to be developed from a growing body of knowledge.

C4-4 An unexpectedly high level of anomalies in certification and authorisation was found in the sampled technical drawings.

C4-5 The high level of anomalies in certification and authorisation warrants further investigation in separate research.

C4-6 Diplomatic criteria for the prospective control of current records' reliability and accuracy are not appropriate to the retrospective determination of those qualities in records being appraised for archival preservation.

4. Contributions to knowledge

Contributions to knowledge are claimed for this research under two headings:

- Known gaps from the literature, answered by the research
- Other contributions to knowledge made as a result of the research

[1024] See Discussion: Implications of the authorisation findings, 253.

4.1 Gaps in knowledge from the literature, answered by this research

This research has substantially filled two of four gaps in knowledge that were identified from the literature, and has laid the foundations to address a third gap, as follows: [1025]

1. Diplomatic theory has been successfully developed and applied to the analysis of technical drawings, as an exemplar of graphical records. (L-4, C1-3, 1-4, 1-14, 2-4, 2-9, 2-11)
2. A coherent vocabulary for the archival description of engineering drawings has been developed as an Interdisciplinary Data Definition Model. This model is amenable to development and extension to wider genres of technical drawings. (L-2, C1-7, 1-9, 1-10, 2-1, 3-2)
3. Theoretical underpinning has been provided for the future drafting of specialist practical guidance for the archival processing and description of archival engineering drawings. (L-3, C1-9, 2-10)

4.2 Other contributions to knowledge made as a result of the research

Other claims for contributions to knowledge are made as follows:

1. Diplomatic theory has been successfully developed and applied to records that are capable of being reprographically reproduced. The traditional structure of diplomatic criticism has been substantially modified to accommodate that fundamental change to the records' environment. (C4-1, 4-2)
2. New certification and authorisation concepts have been developed for technical drawings, to enable their reliability as records to be better assessed.[1026]
3. The mixed methods research design and methodology, as described, provides an exemplar for ARM research more generally. [1027] (C1-1, 1-2, 3-1)
4. The design and implementation of the survey sample, as described, provides an exemplar for sampling complicated records' populations in ARM practice.[1028]

[1025] See Conclusions: 1.5.5 Summary of gaps in knowledge, *262*.

[1026] See Discussion: 5.3.1 Primary Production Certification, *232*, 5.3.4 Combined Certification Concepts, *248*.

[1027] See Research Design and Methodology: 2. A 'Mixed Methods' Research Design, *71*.

5. Indications for future research

The following gaps in knowledge, identified during the research, indicate areas offering potential for future research:

1. Consultation with archivists and researchers about the utility of selected concepts and characteristics that were identified during this research, to precede the drafting of specialist guidance to understanding archival technical drawings. (L-3, C1-10)
2. Creation of standard sets of references for technical drawings' media of support, processes of reproduction, and colour, to assist archivists with the interpretation and archival processing of technical drawings. (C1-19, 1-20)
3. Research of dissimilar technical drawings' populations, to enable more general theory to be developed from a growing body of knowledge. (C4-3)
4. Analysis of historical business processes within British engineering design and drawing offices, to enable better understandings of the forms of technical drawings that were created and revised. (L-1)
5. Further investigation of the high level of anomalies in certification and authorisation found in technical drawings. (C4-4, 4-5)
6. Further investigation of selected non-generic concepts and characteristics identified in this research, because of their utility and their potential to occur more commonly in other technical drawings' populations. (C2-11, 2-12, 2-13)
7. Further investigation of diplomatic concepts for records that are capable of being reprographically reproduced. (C4-1)

[1028] See Research Design and Methodology: 3.2 Representation of the research population, *87*.

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