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Archivalization of Science Archives: New Techniques in Making Science Archives Understandable.¹

*Patrick van den Nieuwenhof**

Abstract: How can archivists analyse science archives? Science archives are like DNA for the human body: unique and essential. The analysis of DNA and science archives is a very difficult process. Archivists in a scientific environment need to develop new techniques complementary to the traditional methodologies. In this paper an overview of these old and new techniques will be given. It will also show how these techniques can be worked out in practice.

The research I am currently working on is based at the Belgian Nuclear Research Centre (*StudieCentrum voor Kernenergie* – SCK) in Mol (Belgium) and is financed by the Flemish Scientific Research Fund.² The project is coordinated by Prof. Frank Scheelings of the Institute of Archival Science and Records Management in Brussels. *The focus of the research is the development of new methodologies for detecting and analysing science archives.* But first I will briefly go into what the SCK does.

The Nuclear Energy Study Centre (*Studiecentrum voor Kernenergie* - SCK-CEN) is a public institution founded in 1951. It is the largest independent institution for applied scientific research in nuclear sciences in Belgium. The SCK-CEN came into being to promote nuclear science in general and the nuclear industry in particular. In particular, its work covers:

¹ This article is based on a presentation given at the International scientific archives conference, “Future proof: delivering scientific archives in the twenty-first century”, University of Edinburgh, 9-11 april 2003, <http://www.bath.ac.uk/ncuacs/Edinconference.htm>

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² For more information about the Centre: <http://www.sckcen.be>

- 1) Safety of nuclear reactors and nuclear reactor fuel
- 2) Radio protection
- 3) Safe conditioning of radioactive waste and its storage
- 4) Accounting and physical control techniques, as well as chemical analysis techniques for fissile and other sensitive materials
- 5) Resistance of nuclear infrastructure to acts of aggression

The SCK-CEN also investigates applications of nuclear energy, does scientific and technical studies, and provides services to the nuclear industry.

As already mentioned, the purpose of this article is the development of new techniques for analysing scientific archives. Why?

The dominant paradigm of the archivist is still to design and control an archive management plan for the storage of authentic documents. On the other hand, the complexity and dynamism of our world have dramatically increased in a relatively short period of time. Various views on the future of our society are sometimes diametrically opposite one another. The Canadian media theoretician, Marshall McLuhan, introduced the concept of “the global village” as a result of the widespread use of the radio in the 1920s, which enabled people to be informed more quickly and accurately of what was happening in the rest of the world. The term “global village” now refers to the “community of *netizens*” on the worldwide web. It is a “digital society” where everybody is connected to everyone else online, such that geographic boundaries are no longer relevant. This form of society creates the impression that everything is manageable and controllable as a result of globalisation.³ The “casino society” of Castells gives a completely different picture: we are less clear about what buttons we have to press in what order to achieve a given effect. In such a “casino society” we no longer know what information will be important tomorrow, and this information literally comes from everywhere with increasingly short average validity periods. The complexity and analytical frameworks are increasing and give society a picture that is no longer unequivocal.⁴

The scientific world has not escaped these developments. Before the Second World War, science could count on the confidence of the people and the idea of progress dominated scientific debate, but since the development of the atom bomb, for example, mistrust has increased. We only have to think of the various frauds that came to light over the last decade, the science war that came to a head - better known as the “Sokal affair”, and the increasing public demand for accountability. The scientific world responded to this by developing quality manuals, building up a clear communications policy, conducting a risk man-

³ McLUHAN (M.), POWERS (B.R.), *The Global Village: Transformations in World Life and Media in the 21st Century*, Reprint 1992, New York, 240 p.

⁴ CASTELLS (M.), *The information age: economy, society and culture*, 1998, Oxford, 3 vols.

agement policy, and setting up ethics commissions.⁵ This development, which had its high point in the 1990's, did not pass the SCK by.

Three years ago the SCK started the research programme, "The integration of social aspects into nuclear sciences and technology". A number of "human" or "social" scientists were recruited to study certain aspects. They are currently working on five fields of research, and there are consultations in three horizontal think tanks. The fields of research are:

- How sustainable can nuclear energy be?
- How are group thinking and ethics influencing nuclear waste decision-making?
- How can integration problems in nuclear law (medical, environmental) be solved?
- How can a safety culture and safety perception be clarified through interaction?
- How can we make our value judgements explicit?

These issues often require an interdisciplinary, multidisciplinary and trans-disciplinary approach. Hence three horizontal think tanks have been set up, i.e.:

- Ethical choices in radiological protection
- Expert culture
- Involvement of relevant players

Thus so far, a few developments on a social and scientific level. But what about the world of archivists. They are consciously or unconsciously influenced by these external factors. Since the publication of Derrida's "Archive Fever" in 1998, many question marks have been placed on the foundations and principles of archivistics, and also on the social position of archivists. For Derrida, it is not so much the text or document that is important. Through deconstruction, Derrida describes the "black holes" in the textual information of a document. In so doing, the traces that lie at the basis of a document can be retrieved.⁶ In the same line of thought, Arlet Farge in "*Le goût de l'archive*"⁷ and Marie-Ann Chabin in "*Je pense donc j'archive*"⁸ give a modified view on the use of the term "archive" and the significance of archives for society. These are just a few publications that give critical thoughts on the archiving practices of today.⁹

⁵ CORNELIS (G.), *Zoeken naar oplossingen. Inleiding tot het probleemgericht denken*, 2000, Brussel, VUBPress, 158 p.

⁶ DERRIDA (J.), *Archive fever: a freudian impression*, 1998, University of Chicago Press, 114 p.

⁷ FARGE (A.), *Le goût de l'archive*, 1989, Seuil: Paris, 152 p.

⁸ CHABIN (M.-A.), *Je pense donc j'archive*, 2000, L'Harmattan, 207 p.

⁹ Other interesting articles are: BROTHMAN (B.), The past that archives keep: memory, history, and the preservation of archival records, In: *Archivaria*, 51, 2001, p. 48-80. COOK (T.), Archival science and postmodernism: new formulations for old concepts, In: *Archival Science*, 1, 2001, p. 3-24. KETELAAR (E.), Tacit narratives: the meanings of archives, In: *Archival Science*, 1, 2001, p. 131-141. MACNEIL (H.), Trusting records in a postmodern world, In: *Archivaria*, 51, 2001, p. 36-47.

The theoretical differences between modern and post-modern archivistics form the subject of the next part of this article.

Modern machine view versus post-modern organic view¹⁰

In the machine or mechanical view, the organisation is considered to be an efficient working system, built up from components that work together flawlessly and automatically. The characteristics of the organisation are: simple routine work and lots of rules. Coordination is largely done through bureaucratic vertical structures, where standardisation of work is the main objective. This viewpoint can best be compared to a Greek temple: the superstructure controls the operation of the organisation, the pillars are the departments through which the vertical communications flow.

The organic idea sees the organisation as an open system that survives by acquiring resources from its environment, and by continually adapting itself to changing environmental requirements. In ever-changing links, complex, non-routine operations are done in mutual harmony. In contrast to the machine view, it is not the top that plays an important coordinating role, but the support staff and middle management. The organic model can be drawn in the form of a grid. Both vertical and horizontal structures are in alternating/flexible relationships with one another. Power and influence are distributed in a similar type of organisation. The search for solutions and results leads to the formation of working groups that bring together people with knowledge of the matter at hand. Decisions are not made by senior management per se.

Modern view: organisation = basis
Post-modern view: individuals = basis¹¹

An organisation is a group of people who combine their forces within a more or less stable play of social contacts. Throughout history, four elements have always played a role in economic affairs:

- raw materials
- labour
- capital
- knowledge.

In a knowledge economy such as ours, the knowledge factor plays an increasingly important role in the functioning of an organisation. But even there, specific problems also often lurk. The knowledge production factor, which

¹⁰ SHEPHERD (E.), YEO (G.), *Managing records. A handbook of principles and practice*, 2003, London, p. 30-71.

¹¹ WEGGEMAN (M.), *Kennismanagement in de praktijk*, 2000, Schiedam, p. 14-25 and MacKENZIE OWEN (J.), *Is Kennismanagement voorbij ?*, In: *Pentascopie*, 2002, p. 61-65.

originally was the preserve of the top, has descended to the floor in increasing numbers of organisations. Because of the increase in the use of this production factor, attention on its management has greatly increased. Knowledge starts with the individual, an organisation as such does not generate knowledge, but facilitates it. In other words, knowledge is packaged into the minds of people. This knowledge is not the property of the organisation, and as it were, it goes out of the door at the end of working day. If, for whatever reason, the people did not feel like coming back the next day, the organisation would come to a standstill. Archiving individual files and their contextualisation is a priority in this post-modern approach.

Modern focus on ICT management Post-modern focus on human development management ¹²

In the current world of archiving, file management is often narrowed down to ICT tools. This school of thought is mainly directed at codified knowledge. It is based on the stock approach, where it is assumed that knowledge can be objectively transferred. Archive management is consequently aimed at managing (storing, updating and accessing) information in databases. Implicit knowledge has to be continually externalised in order to be made available to others in a person-independent way. Technology thus plays an important role here.

In the post-modern context, more attention is paid to what is called “human talent development”. This school of thought is mainly directed at implicit knowledge: experiences, skills and attitude. ICT only plays a facilitating role here.

Modern sequential thinking Post-modern non-sequential thinking ¹³

Sequential thinking is based on a linear, time related process, which is mainly played out in two-dimensional space. Thinking is done in stages: first this action and only then the next.

On the other hand there is non-sequential thinking where the time dimension is minimised. The spatial aspect comes to the foreground. A scientist or scientific research group takes on simultaneous actions at certain points in time. Instead of a two-dimensional space you come to a three-dimensional, sometimes virtual space, where it is less easy to model processes.

¹² KLING (R.), Learning about information technologies and social change: the contribution of social informatics, In: The Information Society, 16, 2000, p. 217-232.

¹³ CARDIN (M.), Archives in 3D, In: Archivaria, 51, 2001, p. 112-136.

Modern universal thinking
Post-modern time and space reflection ¹⁴

Modern thinking is based on universal values and standards. Certain frameworks can be applied to everything and at all times, irrespective of socio-cultural structures. Under the influence of post-modern philosophers, this has been called into question and the emphasis placed more on a diversification in time and space. The “cookbook” concept fits in with this thinking. The same starting situation can result in a different end product under the influence of human and cultural factors.

Modern focus on explicit and embedded knowledge
Post-modern focus on implicit knowledge¹⁵

Literature generally identifies three types of knowledge: embedded, explicit and implicit or tacit knowledge.¹⁶

Embedded knowledge differs substantially from the other two forms of knowledge. It follows on from the historic formation of information and knowledge. This form is found, for example, in processes, products, services, structures, methods and techniques. Concrete examples in the SCK can be found in the QA procedures. Although a QA procedure seems to be imposed from above as an enforced measure, it is often a continuation of certain activities according to processes that evolved and were accepted historically, except that it now also takes on an extra legal legitimacy.

Explicit knowledge is expressed in a formal and systematic language, and appears in the form of data, formulae, reports, publications, articles, books, etc., and last but not least, *archives*. It is a tangible information source that is stored and communicated on paper or on a digital medium. Archives have a prominent role in this category. In contrast to other explicit information sources, an archive is primarily a process-related or contextual primary information source. In other words: a book can be stored anywhere as an entity, an archived record on the other hand is unique and relative. Unique because it is always the expression of a certain action, activity or process. Relative because an archived record is always in relation to another archived record.

Implicit knowledge/tacit knowledge is in the minds of people and is particularly difficult to formalise. It always involves subjective understandings, intuitively

¹⁴ GREENE (M.A.), BOLES (F.), *The archivist's new clothes; or, the naked truth about evidence, transactions, and recordness*, 2001, Unpublished paper, 52 p.

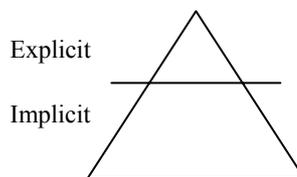
¹⁵ WEGGEMAN (M.), *Kennismanagement in de praktijk*, 2000, Schiedam, p. 42.

¹⁶ HALES (S.), *Dimensions of knowledge and its management*, 2001, 6 p., http://www.insighting.co.uk/resources_articles.htm

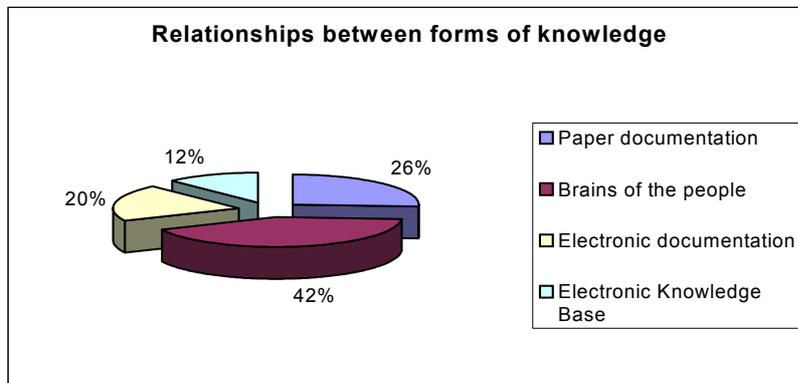
tions, skills, experiences, etc. In many cases, it is an unconscious memory mechanism, such as with the use of languages. Our speech mechanism is largely based on the unconscious recall of a number of language conventions. Our daily lives, and certainly also our functioning in a scientific environment are based on conventions where we no longer dwell on what we use. It can thus be both personal and collective tacit, intangible knowledge. The motto “If only we knew what we know” summarises very well what is meant by “tacit knowledge” in KM.

What is the ratio between these different types of knowledge? The implicit component of knowledge is much bigger than the explicit, as shown by the schematic presentation below. Indeed, an individual or group of people know more than what they can tell, precisely because of the unconscious mechanisms and conventions. Later a framework will be given to make part of this implicit knowledge explicit.

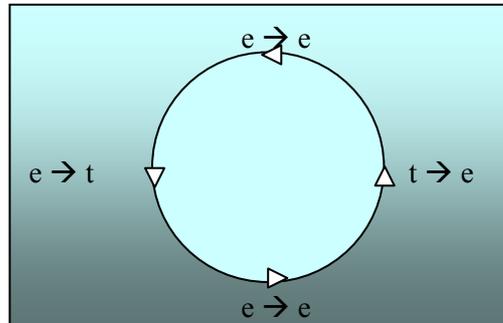
The Knowledge Iceberg



More specifically, figures on the ratios between explicit and implicit knowledge are given in the diagram below



In many cases a strict dividing line cannot always be drawn. What are important is the way in which the different forms relate to one another and the way in which the one passes into the other. It is a continuous process of interaction and cross-fertilisation. The diagram below shows this on an abstract level.



This form of knowledge transfer is the best known. In the past, a great deal of effort was made in this respect by archivists, document managers, librarians and documentalists, in short information professionals. First on paper and then to an increasing extent with computers. The development of intranet, the Internet, knowledge portals and sophisticated search engines rapidly provide the information-seeking citizen/scientist with explicit information.

For example: knowledge centre portal

$t \rightarrow t$

Communication between scientists is one of the most important methods of transferring knowledge. Informal consultation points such as coffee breaks, day-to-day contact with colleagues, meetings, lunches, etc, result in an exchange of knowledge, the size of which is difficult to estimate. Within KM, there are techniques for increasing and facilitating this form of knowledge transfer, for example by setting up “Communities of Practice or Interest”.

For example: developers community portal

$t \rightarrow e$

From tacit knowledge to explicit knowledge, is the process of externalising knowledge, in other words from a person to a tangible medium. This can be done spontaneously, for example by keeping a logbook. The importance of verbal testimony has been taken seriously over the last decade. It is no longer just the major stories, but also individual stories are gaining in importance. Evidence of this is the many “oral history” projects. In this respect we can refer to the project done at the NASA Johnson Space Center. More than 200 employees and former employees were interviewed. What KM is currently experimenting with is the process of “bringing out/eliciting”, not so much from historical considerations but also to detect and further distribute knowledge to a new generation of employees. An expert interviews another expert in order to draw out what they know. This is very often done when one of the two is retir-

ing. This knowledge transfer involves the knowledge and experiences that a person acquired during his career, which should not be lost. The interviews are often unstructured, and the interviewee is free to talk about his experiences.

For example: In the SCK there is currently the HADES project, an underground laboratory for storing highly radioactive waste under a clay layer. Pioneers who gave birth to the concept are now approaching retirement age, and their considerable know-how would otherwise be lost with them. The importance of an oral history project is once again underlined by the unique nature of this laboratory.

e → t

This process is closely linked to the concept of “picking it up as you go along”. Individual employees take training courses (explicit knowledge), but often only process this knowledge for themselves, and in so doing new tacit knowledge is created.

More important for science archivists, however, are the “stories” or “intangible” elements, which belong to archives as a reflection of scientific research. Understanding science archives is not an easy matter, and will often come to a dead stop if the archivist limits himself to just classifying and describing documents for this type of archive. Traceability and understandability of information require more than just a catalogue. Trails, stories, and relevant anecdotes can be detected and made explicit by using new techniques. While the transfer from tacit to explicit knowledge is rather informal, and does not use explicit knowledge as a basis, the transfer from explicit to tacit knowledge does indeed use explicit knowledge in order to detect understandings, experiences, trails, stories and contextual data. With what method can this be done? In KM, a number of people are researching and developing “storytelling”, but more about that later.¹⁷

Methodological repercussions¹⁸

What are the repercussions on a methodological level? Very many theoretical frameworks in archivistics and archive management are based on the idea of the “global village”. Mechanical models of the organisation are used, which fail to acknowledge an organisation as a complex ecosystem whose operation cannot be fully predicted and described. In archivistics, archive and file forma-

¹⁷ NONAKA (I.), The Knowledge-creating company, In: Harvard Business Review on Knowledge Management, 1998, Harvard Business School Press, p. 21-45.

¹⁸ This part is based on: DENNING (S.), The squirrel. The seven highest value forms of organizational storytelling, 2002, 150 p., <http://www.stevedenning.com/squirrel.htm>. SNOWDEN (D.), Storytelling: an old skill in a new context, In: Business Information Review, 1999, 16, 1, p. 30-37. SNOWDEN (D.), From storytelling to narrative, In: Knowledge Management, 2002, 5, 4.

tion are traditionally analysed according to the method of standardisation. The study of institutions, or the analysis of functions, tasks and actions (for example, according to PIVOT) are used as a basis, and then document analysis methods brought in from a political level are added to this (L. Duranti). Standards, criteria, requirements and directives for analysing archive formation and designing archive management systems have been developed since the start of the 1990's. Examples of this are the ISO 15489 standard, the DoD standard, Moreq, etc. Control and planning archive management are the hobbyhorse of these archive theoreticians. Within this "evidence and accountability" paradigm, documents are almost exclusively considered as evidence of a certain action. Keeping this evidence and guaranteeing its reliability are the main concerns of this school of thought. Despite the merits of these analytical methods, they do give rise to sharp criticism from the post-modern point of view. But what is the alternative from a post-modern point of view? Post-modern literature presents a number of techniques that are currently being tested in an experimental phase. A number of examples are given below.

Role-playing. Remember that knowledge usually comes from analysing the bad news, which can mean mistakes. Who really wants to talk about their mistakes? When we tell stories about ourselves, we are often so busy presenting a public identity, our social mask of being the competent individual who does not make stupid goofs, let alone admit them and that we never get around to discussing the mistakes and difficulties that constitute the source of true knowledge. If you can give individuals a throwaway identity by asking them to play a role, it can enable them to convey the truth of what actually happened.

Conduct a "what if" discussion. What if we had done this? What if we had not done that? This frees up everyone to talk, not about what actually happened with all the emotional attachments associated with having made mistakes, but about what might have happened. Here we are in the world of imagination, where things can be a lot more agile, freewheeling and open, because we are not risking any of the capital we have invested in our protective self-image. Even though we are talking about something that did not actually happen, it can shed light on what did happen, and on how things could be different in the future. In the process, we reveal the story of what we really know.

Mix thinking and doing in a kind of cycle. You try something and it does not work properly. You think about it and then imagine how it could be different. You try that out and see what happens. It seems to be working better. So you try it again and you see what happens. Your practical experience leads to reflection on what worked, which leads to the construction of a story that leads to further active experimentation

One of the new techniques is *storytelling*, which we will now look at further.

Storytelling

On first sight, working with “stories”, “tales”, etc., would seem to be a rather strange idea. But as has turned out in the past, strange ideas are sometimes the ones that work and yield new results. At a very early age we were all confronted with stories, but it was quickly made clear to us that they should not be taken seriously. This was and is the case in primary school, but once again in a “scientific” environment. Hard facts, traceability, evidence, formal logical reasoning, objectivity are radically different to stories. Knowledge resulting from scientific research is not based on stories, but on analysis, calculation, verification, etc. Storytelling is rather associated with amusement, imagination, etc., in brief, a pleasant pastime. But stories are more important than is generally accepted. Stories are an important field in neurology, anthropology, psychology, sociology, history, cultural studies, natural sciences and even in mathematics. In archivistics, it is increasingly recognised that stories can and must play an important role in analysing archives. An article recently appeared by Prof. Ketelaar “Tacit narratives: the meanings of archives”. In this article, the author argues that when archives are made accessible, the meanings that the archive formers and users give to these documents should also be considered. In this way, an archive is never really closed or static. The interpretation and reinterpretation are just as important as the record itself. In other words, storytelling is not just another “primitive” use that must be replaced by modern computer controlled analytical methods.

Applications of storytelling

The use of storytelling has different, often divergent areas of application. KM literature identifies various forms of storytelling, each with its own purpose:

- To communicate a complex idea and spark action
- To get people working together in a group or community
- To tame the grapevine and neutralise negative gossip
- To communicate who you are
- To transmit values
- To lead people into the future
- To share information and knowledge

In the scope of this research, we are concentrating on the last form. The objectives of this type of storytelling or “knowledge transfer story” are of a dual nature:

- 1) A mechanism for detecting and opening up knowledge
- 2) A mechanism for creating meaning

Criteria for a knowledge transfer story

Before starting with the knowledge transfer procedure, a number of data has to be set out that could impact on the “story”, and which also interpret and document it. The table below shows the questions that first have to be answered.¹⁹

<p>1) To what extent do the work and context of the recipient correspond to those of the messenger or source?</p>	<p>The messenger, Charles de Raedt, is a chartered electrical engineer specialised in nuclear technology. The recipient, Patrick Van den Nieuwenhof, is a historian-archivist. Thus in principle two different worlds.</p>
<p>2) Does the recipient have sufficient absorption capacity (experience, technical knowledge and common language) to adopt what the messenger has developed?</p>	<p>The recipient does not have a command of the technical-scientific terms and knowledge, but from a literature study and with the clear communication of the messenger, the absorption capacity is sufficiently high.</p>
<p>3) How often does this task occur?</p>	<p>The archives relate to the core work of the messenger, i.e., power calculations.</p>
<p>4) Is it routine or non-routine work? Are there clear, definite steps, or is each step variable?</p>	<p>The implementation of the projects exhibits a certain degree of routine, although they involve fundamental findings.</p>
<p>5) Is the knowledge of the messenger mainly implicit or explicit ?</p>	<p>The knowledge is to a large extent implicit, because the experience of the scientist in question always plays a part.</p>
<p>6) How many functional areas of the organisations are affected by the knowledge to be transferred?</p>	<p>The computation department uses nuclear data and codes that also apply to the department that tests materials. Constants are thus detected that can also be used in other projects.</p>

¹⁹ The theoretical framework was tested in February 2003, Charles de Raedt was willing to help.

Elements in a knowledge transfer story

A knowledge transfer story ideally always contains four elements:

Problem	A situation in which a certain question has to be solved in order to guarantee the functioning of an organisation.	The cataloguing of a scientist's archives and making them understandable.
Starting condition	A clearly defined state of affairs at the moment that the problem arises.	We have the unclassified archives, the career and metadata can be generated from annual and other reports. The scientist in question is still alive and is prepared to provide further information on his archives.
Solution	The answer to the question	The catalogue
Explanation	An explanation shows how the problem, the starting condition, and the solution can be linked together, so that similar problems in the future can lead to a similar solution.	The projects to be catalogued are mainly power calculation projects. As the department that tests materials, for example, also uses the same codes, the result can be extrapolated to other similar projects in order to arrive at standard catalogues.

Methodology

How or by what method(s) does knowledge transfer actually take place? The commonest methods in a KM environment are:

- 1) Discussion/interviews
- 2) Participating observation

Discussion: scientists can informally give information on their work and archives. The archives of Charles de Raedt were used as a basis for detecting the knowledge that is mainly tacit, but extra dimensions were also added to the archives.

In practice, it resulted in the following three reports:

- 1) General report on the position of Charles de Raedt in the SCK and the Reactor Studies Department. In addition to a general explanation of the

principles of nuclear energy, the activities of his department were further described.

- 2) Report on the implementation of projects that Charles de Raedt has done, mainly involving calculations.
- 3) Separate reports per project.

Participating observation: as an archivist you are not outside the organisation, but you initially form part of the entire group. The method requires an active participating attitude on the part of the archivist. As the archives relate to a specialised branch of physics, some empathy is of crucial importance here. Without imposing himself on others, the archivist can choose to operate in a research group. In this way the archivist does not just passively sit on the sidelines, but shows interest and commitment.

Conclusion

Apparently dead material is brought back to life again in this “post-modern” approach. By getting scientists to talk about their archives, the archivist (re)vitalises archives that have become static. Preparatory research documents, graphs, tables, simulations are continually updated and given new meanings. Archives are not an end product, but a process in scientific research. The role of the archivist is now perhaps less one of archiving documents, but one of archivalising these documents.