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A STUDY OF THE INFORMATION CONTENT OF THE ENGINEER'S LOGBOOK

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Abstract

The practice of maintaining a logbook is undertaken by the majority of engineers. These logbooks represent a significant amount of design information and knowledge, a large proportion of which is not formerly recorded and managed. Arguably this information could be of considerable benefit for supporting both current and future design activities. Hence there is a need to develop improved methods for managing this important and frequently neglected information resource. Prior to developing such methods, it is firstly necessary to understand the information content of the engineer's logbook. This understanding is a prerequisite for the development of strategies for effectively managing the content and also provides important information handling requirements for the creation of an electronic engineers' logbook. This paper presents the results of a detailed study of the information content of a variety of engineers' logbooks. The study highlights the key classes of information associated with logbooks and examines the distribution of these classes of information with respect to various engineering roles.

Keywords: Design knowledge, information management, communication

1. Introduction

The management of information and knowledge are important activities for any organisation. This is particularly the case in the engineering domain, where considerable amounts of information are required not only for the business processes but also for undertaking the activities of design, manufacture and product life-cycle support [1-4]. For these reasons it is widely accepted that improved information and knowledge management can lead to improved product quality and performance, and assist in reducing time to market [5]. The importance of enhancing information management within engineering organisations is highlighted in a recent survey of over 300 organisations [6], where it is shown that engineers spend between 20 to 30 percent of their time acquiring, using and communicating information. Arguably, considerable benefits can be achieved through improvements in information management which reduce the proportion of the engineer's time consumed by these information based activities.

In the field of engineering design, significant work has been undertaken that deals with the management of product data for design and manufacture [7-9], the management of design data and engineering documents [10, 11], and the effective use of trade journals and suppliers' literature [12 -14]. However, the engineer's logbook is an area of work that has been largely overlooked, effectively resulting in a significant gap in the scope of information managed during the design process. One of the key reasons for this is that the majority of engineers' logbooks are paper based and generally considered to be either informal or personal. With the advent of electronic notebooks [15] there is a real potential to incorporate this valuable information and knowledge resource into the overall information management strategy and hence better support the engineer, the design and manufacturing processes, and ultimately the organisation. However, prior to achieving this it is necessary to understand the information content of the traditional engineering logbook. This understanding is critical for establishing the requirements for managing the information and eventually creating an electronic logbook which offers improved functionality to the engineer and the organisation.

This paper summarizes the results of a detailed investigation of engineering logbooks from a variety of practicing engineers. The initial sections discuss the engineers' logbook and describe the research method. Following this, the results of the study are presented and a framework for characterising the various classes of information contained in the engineer's logbook is presented. This framework is then used to assess the overall information content of the logbooks and explore the relationship between information content and the differing roles of the authors.

2. The engineer's logbook

During the undertaking of the design process engineers produce a variety of important information that is formally managed by the organisation. This includes design reports, CAD files and supporting documentation. In addition to this, a wealth of potentially valuable design information is also created and recorded by means of a variety of what can be thought of as personal records. These include logbooks, diaries and memorandums, and are listed in an order corresponding to their relative utilisation as identified by Court [16]. Court's study also revealed that the logbook is the most widely used physical means for recording design information and may therefore be considered to be an important information resource. Although the process of maintaining a logbook is not always part of any formal training programme their use has been common practice for engineers and designers since the fifteenth century. In fact, much of what is known about engineers and inventors of the past has been obtained from their historic working papers and notes [17]. This alone demonstrates the amount and potential importance of the information contained in these resources.

In the main, logbooks provide a record of background information, decision options and constraints, design ideas, calculations, meetings, potential issues and the outcome of discussions. Naturally, a proportion of this information will eventually be embodied in formal reports and design documentation. However, a large amount of potentially important information will remain unreported by virtue of the lack of any formal means to capture and organise it. As a result it will remain inaccessible to the majority of individuals within the organisation. Furthermore, upon completion of a logbook, or at the end of a project or a period of employment, logbooks are either consigned to a storage facility with little or no indexing, or taken by the engineer as a personal record of work done. In both cases there is a significant loss of potentially valuable information for the project team, department and the organisation.

This lost or inaccessible information may represent what can be thought of as design knowledge, which if used with the formal design documentation and engineering reports, could provide a complete record of the design evolution, decisions taken, design constraints and pitfalls encountered by the design team. Access to this information and the understanding embodied within it, is not only desirable during active projects but is also essential for effective design reuse. For example, the information contained within logbooks can provide:

- Fundamental design information and understanding to support decision making

- Information for design audit purposes and even a legal document for accountability and intellectual property issues
- The results of analyses
- Informal information on suppliers and customers
- The outcome of discussions with experts

In general, logbooks take the form of a hardback book, held by an individual or a project team [18]. Consequently, the layout, content and structure of logbooks vary widely and may follow a format that is author specific. This personal or individual nature of the content makes particular elements of information hard to identify, interpret and reuse. Various studies have demonstrated that 'social values' such as personality, qualifications, education, experience, culture, language, communication, time, learning and information literacy all contribute to how the individual uses information [19]. The potential complexity of managing the information content of logbooks is further compounded by the absence of standardised procedures for their organisation and use. Other factors such as the individual's position in the organisation or the stage in the design process may also affect the use of logbooks. Because of this variety and diversity of information content, entries within a logbook may involve many different information types and be composed of structured and unstructured information elements or a combination of both [20]. Understanding this information content and establishing the various classes of information are essential for the development of more effective information management strategies and ultimately the creation of an electronic logbook.

3. Research method

In order to understand the information content of the engineer's logbook a detailed investigation of sixteen logbooks comprising over 3000 pages of design information has been undertaken. These logbooks were supplied by engineers working in large multinationals and medium-sized enterprises operating in the processing, packaging, pharmaceutical, aerospace and defence industries. The analysis considers the underlying form of each 'entry' and in particular, its structure and format. Here, the term structure relates to the flow or order of the information elements and the term format relates to the form of the representation of the information element.

For the purpose of this study an 'entry' in a logbook can be composed of a number of information elements and is generally defined by two dates or a date and a terminator. A terminator could be a ruled line or an empty portion of page. Within each entry there maybe various information elements occurring a number of times, such as notes and sketches.

The investigation attempts to establish and characterise the range of information typically entered into logbooks. In addition to this, the presence of individual identifiers is also considered. These identifiers include for example dates, names and file locations and can be associated with certain information classes. To further inform the relative composition of the engineer's logbook the various classes of information are analysed by amount and by number of occurrences. These results are then contrasted against the role of the authoring engineer within their organisation. These roles included senior managers, project managers, CAD operators, designers, research engineers and service engineers.

4. Investigating the information content

The first part of the study sought to establish the generic classes of information held within a typical logbook. Using this classification the information content of a proportion of the sample logbooks was analysed by *amount* (i.e. number of pages of each information class) and by *occurrence* (number of individual occurrences of each class). These two metrics were considered in order to determine the most suitable basis for evaluating the overall composition of each logbook. Figure 1 shows the average percentage occurrence and amount for the least and most commonly occurring classes of information over the sample population. This preliminary analysis shows that in general the most frequently occurring information classes also represent the greatest proportion of the total amount of information. Although for some classes of information there was not such a direct correlation, the relationship was not worse than 2:1 (for example, 32% of occurrences and only 17% of amount). It is arguable that both metrics provide a representative measure of information content. However, it was felt that the *occurrence* was the most suitable measure as it is largely independent of the size of individual entries or the logbook and as such removes any bias.

	% occurrence	**% amount**
Most common class	47.0	45.2
Two most common classes	74.2	72.4
Two least common classes	5.6	3.8

Figure 1 Comparison of criteria used to present results

4.1 Identifying and characterising information classes

In order to identify the key classes of information a preliminary assessment of the logbooks was undertaken. As previously stated this analysis considered the structure and format of entries. It also considered the underlying form of the information representation and its intended purpose. This preliminary analysis revealed twenty-eight information types which can be grouped into thirteen fundamental classes. These classes are described in figure 2 and also categorised according to three basic information types, namely textual, graphical and a combination of both. In total there were six classes of textual information, three classes of purely graphical information and four classes of a combinatorial format.

Of particular interest was the inclusion of external documents within a large number of the logbooks. These include sections from technical reports, CAD drawings and photos. In addition to an information class representing these external documents, CAD drawings have also been identified as a separate class. This is due to their widespread use and particular importance in the context of engineering design. Annotated documents were also defined separately as it was felt that these annotations were likely to relate to or highlight potentially important elements of information.

In addition to identifying the key information classes a variety of individual identifiers were also assessed for each entry. The range of identifiers typically associated with each class of information is depicted on the right hand-side of figure 2. These identifiers include items such as dates, names and file locations. The inclusion of such identifiers is important for not only identifying and searching individual entries but is also potentially important for cross-referencing, auditing and verifying entries.

	Class	Description	Sub-Types	Identifiers
Textual	Written Notes	Personal notes made by the engineer in an individual or collaborative work session.	*Writing* *Computer Code*	*-Date* *-Subject* *-Project* *-Source*
	Meeting Notes	Notes taken as a result of a meeting	*Meeting Notes*	*-Date* *-Location* *-Subject* *-Project* *-People present* *-Organisation*
	Contact Details	Names, phone numbers and email addressees etc	*Contact Details*	*-Name* *-Organisation* *-Position* *-Phone number/Email address* *-Project*
	Calculations	Hand calculations, from simple to complex	*Simple Numerical* *Matrices*	*-Date* *-Subject* *-Project* *-Source*
	Tables of Figures	Hand drawn	*Tables of Figures*	*-Date* *-Subject* *-Project* *-Description*
	Completed Forms	Usually completed by service engineer on-site	*Completed Forms*	*-Date* *-Subject* *-Organisation* *-Project* *-Author*
Graphical	Sketches	Hand drawn, from pencil scribbles to 3D representations with colour	*Simple line (2D)* *3 Dimensional* *(above) + Colour*	*-Date* *-Subject* *-Project* *-Description*
	Graphs/Charts	Hand drawn	*Line Graphs* *Scatter Graphs* *Pie Chart* *Gantt Chart*	*-Date* *-Subject*
	CAD Drawings	Printed and pasted into the logbook	*CAD Drawings*	*-Date* *-Author* *-Subject* *-Project* *-Source* *-Description* *-Organisation* *-Revision/Version Number*
Text & Graphical	External Documents	Sections from reports, product info, photos etc, pasted into the logbook	*Product Brochure* *Printed Tables of Figures* *Graphs/Charts* *Data Sheets* *Photographs* *Drawings* *Sections of Formal Reports*	*-Date* *-Author* *-Subject* *-Project* *-Source* *-Description*
	Annotated External Documents	As above, but altered or marked up by hand	*As External Documents*	*As External Documents + Date and author of Annotations*
	Annotated CAD Drawings	As CAD Drawings, but altered or marked up by hand	*Annotated CAD Drawings*	*As Annotated CAD + Date and author of Annotations*
	Memorandums	Added information in the form of 'post-its', 'sticky notes' or symbols in order to highlight important information or elements to keep in memory.	*Memorandums*	*-Date* *-Author*

Figure 2 Fundamental classes of information contained in engineers' logbooks

In total fourteen identifiers were determined. These are presented in figure 3, which also shows the percentage occurrence of each identifier for the various classes of information. Not every information element in each logbook will contain all the identifiers listed for that class. For example, a list of the individuals attending a meeting may not be included for all the occurrences of the 'meeting minutes' class of information.

	Identifier													
Information Class	Date	Title/Subject	Description	People Present	Location	Page Number	Revision or Version	Source	Author	Author of Annotations	Name of Contact	Phone Number	Email Address	Organisation
Written Notes	100	100				13.3		6.6	13.3					
Meeting Notes	100	80		90	10									50
Contact Details											100	100	37.5	75
Calculations	90	70				10		20						
Tables of Figures	90	90												
Completed Forms	100	100			100				100					100
Sketches	85.7	71.4							7.1					
Graphs Charts	80	80												
CAD Drawings	100	100					100	100	100					100
External Documents	88.9	100	44.4			33.3		55.6	33.3					
Annotated External Documents	100	100	25			25								
Annotated CAD Drawings	100	100					100	100	100					100
Memorandums														

Figure 3 Occurrence of identifying elements with respect to classes of information

The study shows that the most common identifying element in all classes of information is a date. Since the entries in logbooks are generally arranged in chronological order, this is not surprising. Titles and subjects are also common, although they are rarely particularly descriptive or detailed. The incompleteness of the identifier information reflects the informal nature of logbooks and their use for quick recording of notes and ideas. Whilst this means that information that would otherwise be lost is recorded, the relative lack of identifying elements and structure has important implications for searching and communicating this information. For example, the trustworthiness of external documents or calculations may have been verified by the author at the time, but if the information is to be reused in the future, this implicit information may take time to verify. The same is true of individuals identified only by initials or forenames, and for dates without years. In general where descriptive identifiers are considered (title, description, location, source, and organisation) the detail varies significantly from full sentences to only acronyms or even partial data. Furthermore, project titles were often abbreviated, and where external documents were consulted they were rarely referenced.

4.2 Characterising overall information content

The second stage of the study attempts to characterise the overall information content of the engineer's logbook. To achieve this, the compositions of individual logbooks were assessed with respect to the previously developed classification. During the assessment it is important to be able to clearly identify the occurrence of a particular information class. At the highest level an occurrence may represent an individual entry i.e. between two dates or a date and a terminator, such as a line or a blank portion of a page. However, many individual entries comprise a number of information types. For example, one single entry comprised of a 'note' followed by a 'graph' then another 'note' on an unrelated topic. This was characterised as two separate occurrences of 'note', even though they may be contained in the same entry. Therefore each entry has to be assessed in some detail. The results are summarised in figure 4, which shows the relative occurrence of the different information classes for each logbook.

Although there appears to be a large variation in the information content of logbooks, further analysis of the data reveals a number of similarities. None of the logbooks contained more than eight classes of information (from the 13 classes previously defined), with the average being just six information classes per logbook. For the sixteen logbooks considered the greatest proportion of information content is represented by *diary notes*, *meeting notes*, and *sketches*, followed by *calculations*, *contact details* and then *external documents*. The two most common occurring classes of information across all the logbooks are *diary notes* and *sketches* which occur in 93% and 100% of the logbooks respectively.

4.3 Influence of the engineer's role on information content

The final part of the study examined the relationship between the engineer's role and the distribution of the various information classes within the logbooks. For the purposes of this work, four organisational roles were used as the basis for analysis: Management (M), Design activities (D), Research activities (R) and Service engineer (S). The logbooks associated to individuals in a management role showed strong similarities, with the majority of the content being *diary notes*, *meeting notes* and *contact details*. The latter two of which are relatively uncommon in the logbooks associated with other roles. Although the sample size is limited (<30) and conclusions need to be qualified, it is not counter-intuitive to suppose that managers spend a greater proportion of their time in meetings and making notes about the various projects.

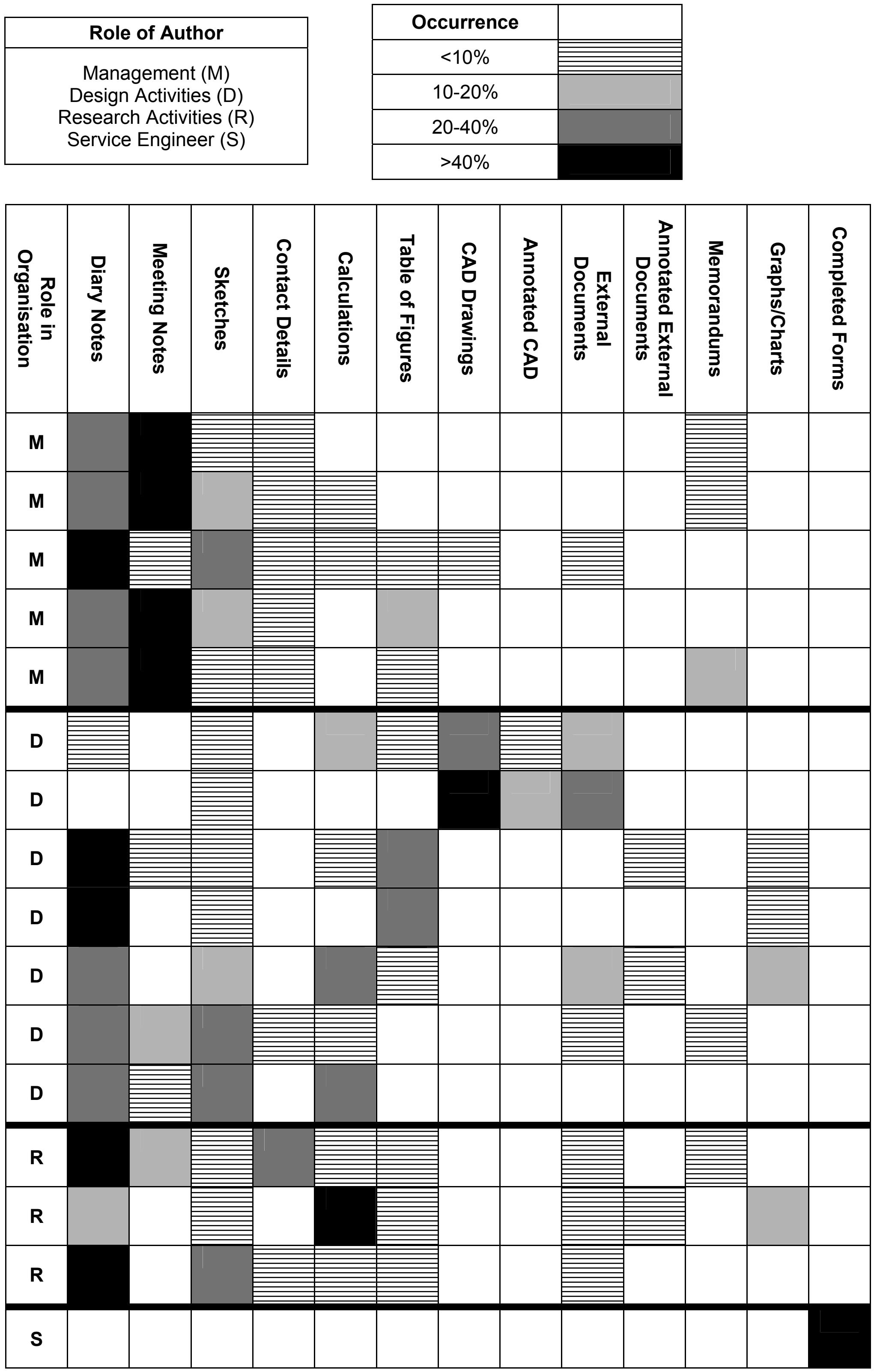

Figure 4 Relative occurrence of each class of information

In contrast to the logbooks of those in a management role the logbooks belonging to those in design or research roles represent a greater variety of information classes. Given the large range of activities and projects that these roles may encompass this wide variety is perhaps to be expected. In particular, these logbooks comprised a greater proportion of *calculations*, *tables of figures* and *external documents*, although *diary notes* and *sketches* were still two of the most prevalent classes.

The results of the study demonstrate that the information content of a logbook are largely dependent on the nature of the work being undertaken and on the role of the engineer. The design of an engineering component will obviously involve CAD drawings, just as research into mathematical modelling techniques will produce a large number of calculations. For example, sketches play a fundamental role in creative design and the communication of ideas, and contact details are vital when managing relationships with customers and suppliers.

Although a number of differences and overall trends have been observed between the information content of the logbooks and the four roles considered, it is not possible to draw a clear distinction between the information classes and particular roles. This is partly due to the individual preferences of the authors to use various information classes to represent particular information. For example, a sketch, a calculation or a diary note could be used to represent the same information. In addition to this, engineers are frequently involved in a number of projects and may be part of various multi-disciplinary teams. Within such teams the design, research and management activities are often highly distributed and engineers may undertake a variety of roles. As a consequence of this, all of the various classes of information could potentially form part of any logbook.

4.4 General remarks

During the undertaking of this study a number of general observations were made. The first of these relates to information access and structure. The majority of entries in the logbooks were arranged chronologically, although two logbooks were organised into projects or topics (themselves arranged chronologically) by virtue of ‘post-it’ notes. A large number of logbooks contain information which has to be referred to quickly and frequently, such as contact details, project plans and standard engineering data. To support this information is often contained in a separate portion of the logbook; either at the front or at the back. In addition, some sections were linked to others by virtue of ‘PTOs’ (Please Turn Over) and ‘post-it’ notes. For example, a series of meetings with a supplier or a certain group of people may contain common topics or discussions, but be physically dispersed throughout the logbook.

The second of the general observations relates to the identification of the author and co-authors. In particular, there were a large number of anonymous annotations in the logbooks noticeable by the different handwriting styles. These annotations were particularly common where CAD drawings and external document had been inserted. In general, the flexible and ubiquitous nature of paper means that any number of individuals can, for example, annotate a CAD drawing or contribute to a sketch, provided they are in the same physical location. Whilst this freedom may help encourage creativity and the exchange of ideas, the potential downside lies with the lack of provision for elements that identify the author and the author’s intention, or even the date on which the annotations took place. Although implicit identifiers (e.g. handwriting) could be used, as the number of individuals collaborating increases, so does the difficulty in identifying each one of them. It was also observed that few logbooks contain sufficient information to identify the author. For example, less than a quarter of logbooks were titled and only half included the authors name or some form of contact details.

Finally, it was observed that many logbooks contain a large number of blank pages. Because of this, blank pages were also considered in the analysis of information content, as they often constituted a significant proportion of the logbook (up to nearly 50%, with an average of 23.2%). In fact, in six of the sixteen logbooks analysed, blank pages occupied more space than the most common class of information. One of the likely reasons for the inclusion of blank pages is the anticipated need to continue or expand a previous entry. A feature which is common place in any electronic word processing environment.

5. Conclusions

The paper presents the results of a unique investigation into the information content of sixteen logbooks obtained from engineers working in various roles in large companies and small medium-sized enterprises. The investigation reveals that the information content of the engineers' logbook can be classified into thirteen fundamental classes: *written notes*, *meeting notes, contact details, calculations, tables of figures, completed forms, sketches, graphs charts, CAD drawings, external documents, annotated external, documents, annotated CAD drawings and memorandums*. The assessment of information classes also highlights fourteen identifiers associated with individual entries and the various classes of information.

This classification of information is used as the basis for investigating the information composition of the logbooks. Although there is a large variation in the composition of each logbook, further analysis of the data reveals a number of similarities. Firstly, when considering all the logbooks, none contain more than eight classes of information with the average being just six. Overall, the most common classes of information are *diary notes*, *meeting notes* and *sketches*. Surprisingly, the number of blank pages often constitutes a significant proportion of the logbook (approaching 50% in some cases, with an average 23.2%). The assessment of the information content of the logbooks with respect to organisational role reveals that those involved in predominantly management activities tend to use *diary notes*, *meeting notes*, *sketches* and *contact details*. In contrast to this, those involved in design and research activities use *diary notes*, *sketches*, *calculations*, *tables of figures* and *external documents*. Whilst some overall differences in the information content where identified between the roles it is not possible to exclusively associate particular classes of information with specific roles.

The results of this study provide an important insight into the engineer's logbook. Establishing the information content of current logbooks is essential for the development of tools and strategies for improving the management of this important information resource. The findings of the study provide the basic information handling requirements and issues that would need to be met and addressed in the creation of an electronic logbook for engineers. Furthermore, the ability to determine information classes and the identifiers could be used as the basis for organising and searching the information content of past and active logbooks.

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