Annotation as a base to improve in-service feedback exchange during life cycle of complex systems

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Abstract
Operation, maintenance and decommissioning are important functions of the product life cycle. Information content of the product’s documents must be updated and adapted to the various needs of use of this information. This paper will focus on the issues concerning the formalization and normalization of the digital document exchange between engineering/constructor and owner/operator of an industrial product or process facility. Many authors point out the under instrumentation of the reading and interaction means with digital documents although information feedback of in-service use is critical for the updating of information and its use for design improvements. This paper will expose the results of studies on the use of digital repositories in product and process industries in order to identify improvements we consider as essential. It proposes a typology of annotations, first step of a more formal approach for the standardization of generic structures to support digital reading activities.

Keywords
Product life cycle, document structures, interactive technical publications

1 INTRODUCTION
Operation, maintenance and decommissioning are important functions of the product life cycle. These functions are supported by the documentation available for the product.

Each step of the life cycle and each function require a particular point of view on this documentation.

Moreover this documentation has to be updated and enriched by the knowledge collected by various specialists.

Information is more and more edited through the help of software tools and the challenge is to make information flows as streamlined as possible avoiding re-editing.

Aerospace and defence industries have carried out significant efforts to formalize and normalize information exchange between constructors and operators by editing and implementing international specifications like S1000D [1] for the production of technical publications.

Feedback on the use of the documentation produced in such a way allows us to draw preliminary lessons and to determine tracks for improvements and future evolutions.

On the theoretical point of view, the digital mutation has led to a new interest of the researchers for the concept of document. A document is usually considered as a support of information characterized by its persistence. It is supposed to have structures to be abstracted for operationalization by computers. What is a structure? How to determine it? Which structures should be developed to improve and enable the information exchange between the various users during the product life cycle?

We will focus here on interaction structures that is to say structures supporting a better appropriation and feedback from maintenance workers.

A first typology of annotation needs will be given. It is a first step of a modelling work for a general application to the use processes of technical documents.

Our paper is divided in 3 parts:
• Part 1 recalls theoretical elements on the general concept of document,
• Part 2 focuses on the example of structured technical documentation and we identify users needs to be satisfied,
• Finally part 3 points out the interaction needs and considers the concept of structure in order to build a more solid ground for the design of digital document systems.

2 THEORETICAL FRAMEWORK
2.1 A functional approach
In the mid-seventies, Robert Escarpit [2] was one of the rare researchers in France to have a general thought on the concept of document. Without giving an explicit definition of “document”, he considered the quality of persistence as essential; the document was for him an anti-event, kept stable in the flow of time. The reader was seen as completely free in the case of a written paper document. On the contrary Escarpit considered audio or videotapes as “half-documents” because the reader was constrained by the flow of sounds or images. Surprisingly, Escarpit didn’t speak of digital documents.

In a well-known article [3], M. Buckland tells the question: “What is a digital document?” From the works of Paul Otlet and S. Briet, the Belgian document researchers, M. Buckland uses a functional definition of a document as a material object giving access to evidence of a fact. This functional definition is independent of the support; nevertheless, it points out the material aspect of a document and the notion of evidence. Inherited from document researchers it recalls that a document must belong to an organized set and that indexing precisely gives a document its place in that set.

2.2 Digital mutation and document structures
The difficulty to find a scientific definition of document has been underlined in the collective report of R. T. Pédauque [4]. The authors of that report, using analogy with the linguistic distinction between syntax, semantics and pragmatics, propose to distinguish three aspects of the document: the document as form, the document as sign and the document as medium.
In a more recent report [5], the authors have carried out a work on the recent choices of document engineering. They have noticed 3 successive layers of grammatization with respectively SGML DTD, XML schemas and RDF/OWL ontologies. They have pointed out that the third level is radically different from the two first ones and have warned against a too simplified approach of the concept of signification.

Concerning the two first levels, they have outlined an essential fact about digital documents: only the perceptible form of a document, offered to the reading of the user, really exists; content is an abstraction, an invariant from which multiple possible presentations are produced. Separation of the concrete and perceptible form from the abstract content is actually the most essential difference between digital and printed documents. The authors considered the perceptible document as a result of a calculation, as a reiterated event. In relation with the position of R. Escarpit, we may question if a reiterated event is still an event. We think it can be a document provided that the transformations involved give the same result by design. That means that the structures of the document are formalized.

B. Bachimont and S. Crozat [6], questioning the separation form/content have proposed to abstract the document structures. These structures are often implicit and should be explicit for an operationalization. They have distinguished three levels of structures as shown on figure 1 with the corresponding formats involved.

Observation of the technical object is an immediate perception; reading of a document is a mediated perception; a human being uses its observation and reading skills altogether and with the help of a network of competencies, generally in collective activities to face a situation and determine what is to be done.

Direct observation of the technical product in its life cycle is an infinite source of knowledge either tacit or explicit. Explicit knowledge may be integrated to the documentation after a complete edition and publication process for extended sharing.

Aerospace and defence industries have implemented the SGML technological standard to formally describe the structures of documentation and have normalized them through a specification.

The roots of SGML with separation of form and content are solidly planted in the industrial sector. Goldfarb [7] has distinguished in fact 4 phases of a document:

- Phase H like Human thoughts,
- Phase A like Abstraction,
- Phase R like Rendition,
- Phase P like Presentation.

He has proposed the HARP method to determine the structures of a document according to the needs of a publication process.

For Goldfarb, phase A is the closest counterpart of phase H and phase R is the closest counterpart of phase P. Only P is a perceptible form of a document. Analysis and reengineering of a publication process aim at determining a final state of a document in a A phase that is to say a formal description of the logical structure of a document. Rendition is actually a program that produces automatically the same presentation. Conversion from one rendition to another rendition is however generally sources of problems and needs manual clean up. Transformation of an abstraction to a rendition is on the contrary precise by design and eliminates the manual clean up.

Actually this abstraction called by Goldfarb a control document controls from the beginning the writing process. With a unique abstraction form of a document it is possible to obtain many renditions and thus many presentations of the same content. Thus it allows a publication process to be more efficient. SGML is a mean to control the creation of that abstraction which is a structured document.

In short the idea is that data come before the processes and that their structures make possible automatic future data processing. SGML is basically a separation of data and process, data being structured in such a way that makes the results of their transformation precise by design.

It’s worth noticing that the abstract structure is obtained through the analysis of a process with identification of the tasks to be automated according to recurrent needs of the process. It consists in identifying invariants in different changing situations in order to build a generic form, a new final state of a document in a publication process.

International specification S1000D has been set up and is revised according to the same principles.

There is a parallel to be made between the needs of a documentary process and abstract structures able to support more efficiently the concerned process.
Nevertheless publication of digital documents creates new needs in the processes of using this documentation, for example in reading, updating or reediting processes.

The analysis of these processes is the best way to the specification of new tools provided that invariants and corresponding structures are formalized and normalized. If not we can observe disorientation of the reader and difficulties in the updating and the appropriation of digital documentation. We have been able to verify these hypotheses through studies in the field of the use of electronic documentation in industrial environments.

3 FEEDBACK FROM USE OF DIGITAL TECHNICAL PUBLICATION

3.1 General framework of technical documentation in industry

The life cycle of an industrial product includes several steps where various technical specialists are involved. Information is more and more edited thanks to the help of software tools with their own data structures and their own encoding formats.

Usually data and documents are organized to fulfill the needs of one step and according to rules specified by a prime contractor; the needs of the following steps are often insufficiently taken into account for various reasons and we can always observe difficulties in conveying information for instance from a constructor to an operator and more generally at each change of the main actor in the product life cycle. Feedback from downstream steps to upstream steps is even more difficult. Practically we assist to massive reediting of data and the integration possibilities of digital technology are far from being used.

3.2 Digital technical publications in aerospace and defence industries

To face these problems, European and American aerospace and defence industries have joined their efforts to define in the S1000D specification the rules to be applied to produce technical publications. The specification has been implemented now on many programs. For instance the French Ministry of Defence had expressed the need to have a full electronic documentation available for the Rafale aircraft and had decided with concerned industries to apply that specification.

The production of the publication is split up in structured modules collected in a common source database. Sets of modules or part of modules are extracted from this base to build publications diffused in the forces. These publications are consulted thanks to an Electronic Consulting System (ECS).

The international S1000D specification can be used for air, sea or land systems and has been recently adopted by civil air industry.

We have carried out studies in the French Navy and in the French Air forces to collect information about the use of the system. 17 users of the French Navy have been interviewed near the electronic consultation system and 10 users of the air forces have been interviewed and observed using the electronic consultation system during real maintenance tasks.

We have detailed the results of one of these studies in a former paper [8].

We recall here the two main types of lessons of these studies, which partly confirm our hypotheses of under-instrumentation of electronic document systems:

• Users find out in a publication the modules they need through various modes and they can go from one module to another through links: we have observed that there is a need for predefined ways from one module to another according to generic situations. Freedom in browsing the publication may conduct the users to lose their references or even worse to consult the modules in a wrong or incomplete order. Only a careful analysis of the needs of generic operations can point out a set of invariants to be formalized and supplied to the users as help for consulting and reading documents,

• Tools to edit personal digital annotations are not used: this fact could be considered as in contradiction with our hypotheses of under-instrumentation. We will study in more detail this apparent contradiction hereafter:

  • Needs for updating are supported with a tool “Comment” for editing on a structured form, management information, annotations on extracted parts of documentation either textual or graphical, and textual comments. These forms follow a complex workflow in the air forces until they reach the concerned industrial company. Then they are integrated or not in a new version of the publication. This process can take months and thus the comments forms are added as public annotations for rapid sharing of the information,

  • Personal annotations, which are not shared by the community, are considered among the users as a practice to be avoided. An information to be added to the documentation is to be validated and shared by the community and not be kept for its own use,

  • However we have noticed annotations on paper prints of extracted modules from the ECS; procedural documents are generally detailed because they aim at obtaining the same behaviour of the users; thus annotations for additional information would be of poor utility; annotations on such documents have been observed for instance when test environment in the documentation is different from the real one; annotations on descriptive documents are more common; descriptive documents are used to understand the equipment and its operation, to find out the reasons of a problem ; they are moreover considered as insufficient and appropriation of their content needs interaction: add names of parts, pick-up interesting information and edit an abstract, mark drawings to support a trouble shooting process for instance on wiring diagrams.

Possibilities of appropriation and interaction of digital systems for descriptive contents are for some aspects simply less efficient than the traditional paper/pencil system.

However any practice of use of ECS information to produce other documents either paper or electronic is questionable about the updating of these derived documents when changes occur in the sources of the ECS.

3.3 Types of difficulties

Our observations allow us to identify 3 types of difficulties in the use of new tools for consulting of digital documentation:
• Tools seem not simple enough to rapidly identify, in the work environment, finalized precise services they could support.
• Training to the use of the tools is incomplete; this training should not be limited to expose functionalities of the product but should include practical exercises in working conditions.
• Digital technology offers a possibility of continuity in the processes of writing – reading – rewriting; it thus creates derived needs of management of multiple writings and increases the needs for structuration, formalization and normalization.

3.4 Annotations to support a Life Cycle Management Strategy

Life cycle management implies to consider the industrial system as a continuously changing whole, including the material product, the documentation as a symbolic representation system and the human resources. The challenge is to better support coordination of operations on that system with techniques and particularly information techniques, which are based on a discrete approach.

Digital techniques have to support continuous processes of knowledge use, creation and sharing.

The digital documentation system should be provided with more efficient digital interaction tools, e.g. digital annotations to better support these processes and particularly should better support knowledge capture and management.

Contents of annotations edited on paper or on editors, which are not integrated with the reference system, cannot become validated shared knowledge and thus have an undefined status.

Operation and maintenance environments have to be rethought for a better integration of the information system considering that updating and feedback are becoming an essential part of these functions of the system life cycle.

Human resources have to be trained to face these new responsibilities in terms of information creation and management.

Digital annotations and comments are one of the means for users with new skills to better interact with the whole system, with the other maintenance teams and with experts of design and manufacturing functions of the constructors.

4 INTERACTION NEEDS AND STRUCTURES

In this last part we are going to focus on annotation needs and to propose a first typology of annotations in order to prepare a formal model.

However interaction tools and structures should not be limited to annotation tools. Other interaction forms, like blogs and users forums, integrated or coupled with the ECS could be very helpful to prepare updating and sharing of information along the life cycle.

4.1 Typology of annotations

First we think that an annotation has to be distinguished from a bookmark and from a comment. A bookmark is traditionally a mark different from the consulted object in order to easily find back a page for example in a book. A comment is also in general on another support than the original commented document; it may be found in another document, at the end of the original document or as a footnote but an immediate proximity with the original content is not required.

On the contrary annotation, as indicated by the etymology of the word, is characterized by its proximity with the annotated content. It is perceptible on the same support and its contextualization is necessary for its understanding.

Our observations and analysis of corpus of annotations either on paper or digital in various industrial sectors conduct us to the following preliminary typology:

• Annotation to control the progression of reading or of doing a task supported by this reading; it can for instance take the form of highlighting each accomplished step of a procedure being executed,
• Annotation to complete a part of content; it is for instance an explicit link to other resources inside or outside the original document,
• Annotation to correct or modify content for example to update a drawing after a modification of a facility.

4.2 What is an interaction structure?

We focused here above on annotations as examples of interaction structures. How could we define more precisely what is an interaction structure and even a structure?

J.J. Gibson in [9] writes: “The term structure is vague…essential structure consists of what is invariant despite the change” and about the concept of invariant: “But to repeat, the invariant structure separates off best when the frozen perspective structure begins to flow”.

If we follow J.J. Gibson [9], multiplication of viewpoints is not an obstacle. On the contrary it is necessary and the changes of points of view are an opportunity to observe invariants and thus the essential structure of what we are looking at.

We may see this approach as a general approach of specifying an artefact or its modification for improvement and the method proposed by Goldfarb, cited here above [7], to specify the structure of a document to support an edition process as an application of such an approach.

An interaction structure should be found in specification of a tool aiming at the satisfaction of recurrent needs in the studied processes and taking into account the substantial and surface properties of a support, in the sense given by Gibson to the concepts of substance and surface. The surface separates the substance from the environment and the surface is what is perceived by the living being according to his needs to be satisfied.

We consider that the electronic support has substantial properties not directly perceived by the user and should be provided with more developed “surface” properties directly perceived by the user as means of interaction, as “affordances” according to the sense given by J.J. Gibson [9].

For instance a set of paper wiring diagrams has up to now greater “affordances” than electronic wiring diagrams when a team of users is involved in a trouble-shooting process. And this is not only a matter of insufficient training or of habits. New digital tools have to be specified and implemented to fulfill the need for interaction with the information support in such tasks. Training should also be necessary to identify the new “affordances”.

4.3 Structure and continuity in digital environments

Digital technology has a tremendous potential of integration. It allows the integration on the same support of texts, drawings, 3D or multimedia documents and to extend the means of technical communication. It makes possible to consider a continuity of writing and reading.
activities. Some industrials think that the use of 3D documents could bring major changes in the technical documentation. For instance, today the key to access information is based on a hierarchical codification the users have to know to be efficient in the information retrieval. A 3D representation of the physical system can improve the user friendliness of a documentation system and users should not have the need to remember a complex codification.

These potentials to be effective must be transformed in concrete structures easy to identify for the users.

One of the objectives of the industrials is to produce documentation reusing as much as possible information already edited.

Tools for the manipulation of 3D representations allow moreover the direct production of illustrated parts catalogs, which were before edited on specific tools in long and costly processes. These tools will also allow the preparation of complex or dangerous tasks.

Efficiency of these technological possibilities is conditioned by the production of high-level standards.

Mark-up languages like SGML/XML should be implemented from the first steps of the product life cycle. C. Mc Mahon and D. Davies have shown in [10] the interest to make converge feature-based design and text mark-up to address the long-standing issue of multiple points of view.

5 CONCLUSION

Studies we have carried out show the interest and also the limits of digital structured documentation. They actually show that the analysis of the processes should be extended in order to develop structures and their support by tools to be integrated to the electronic consultation systems that are available today.

Particularly the mark-up technology born to make publication processes more efficient should be extended or even redefined to take into account new needs of control or interaction coming up with the digital reading.

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7 REFERENCES


