Contextualised Operational Documentation: an Application Study in Aviation

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Abstract. This paper describes the development of a new generation of electronic operational documentation in the aviation domain. This electronic documentation provides the user with contextual information that is valid in a specific situation and for a specific task. In order to author such manuals, the information is contained in documentary units, tagged with meta-data describing the context. Contextualised documentation becomes a support facility addressing the actual or the expected situation of the user, both in operation and in training. Next to the development of contextualised documentation description, an analogy is made with instrumentation. This analogy enables us to make a parallel between instrumentation conception and the contextual documentation conception.

1 Introduction

In the aeronautical domain, operational manuals are the means to support the storage and use of useful information, as well as technical facts describing or limiting operations. The development of operational documentation is a continuous process integrating lessons learned from on line operations or training practices and is the technical reference for system behaviour descriptions. Lessons learned are related to the iteration of best practices and manufacturers and airline training organisations widely communicate them.

Despite significant advances in aircraft design, the present operational manuals format and medium have remained basically unchanged. These manuals remain “classic” paper documents, and are organised accordingly. However, progress has been made in systems to store documentation electronically. Electronic documentation introduces the concept of structured modular documentation. The emerging computer standards such as the eXtensible Mark-up Language (XML) will permit industrial application of object-oriented databases. In the near future, operational documentation will migrate from static paper output to dynamic electronic format.

Operational documentation has always been used as a reference publication and this will always be maintained. New information technologies will permit the continuous consultation of operational documentation enhancing its impact on the user learning process. The availability of multiple devices and networking capabilities will enable large amounts of information to be taken into account, as well as the integration within the working environment of electronic operational documentation as a performance support tool [3].

The migration of operational documentation from the status of reference to the status of an integrated performance support tool will not be trivial. The operational environment in aviation, especially in the aircraft cockpit, is already sustained by information. The role of a new performance support tool will have to be identified with respect to the existing environment. Its conception will go beyond the content of the documentation; properties for the right exploitation of the content will have to be specified. The changes will impact both end-user's daily operations and training, as well as organisation operational documentation production and culture.

In this paper, first we describe the present aviation documentation scope, then we introduce what is the challenge of documentation contextualisation by using the analogy of instrumentation. Next we will propose a conception methodology in order to implement the required documentation properties. We will introduce articulation concepts for the exploitation of electronic operational documentation in the aeronautical domain and finally, we will discuss some issues related to training and knowledge management aspects.

2 Operational Documentation in Aviation

Today, operational documentation deliverables are organised into products, each of which is adequate to respond to a particular need. For example, the Flight Crew Operational Manual (FCOM) is commonly used by aircrews, airline operations management and planning staff as an aid to daily aircraft operation and planning. The FCOM is used both in flight and on the ground. The Aircraft Flight Manual (AFM) is a document that summarises the necessary information to safely operate the related aircraft for certification purposes. The AFM information is a subgroup of the FCOM information. The Minimum Equipment List (MEL) and the Configuration Dispatch List (CDL) are both dispatch condition products that summarise possible aircraft problems and their consequences. FCOM and AFM relate to MEL and CDL, and vice versa, each time the information is complementary. MEL and CDL are at the frontier between operation and maintenance worlds [9]. Next to the use of operational manuals in an operational environment for support with technical documentation, they play a role in aircrew training, and serve as a reference for the development of training material. Computer Based Training (CBT) introduces aircrews to aircraft system operations. It adapts operational information to the benefit of ab-initio trainees. Even if the form of each product is different, content always consists in providing information for operational work.

The transition from paper to electronic format will enable the integration of documentation into one single database, eliminating today's documentation segmentation. It will be up to the documentation interface to filter the relevant content with respect to its particular use. An analogy can be made with flight instruments. In the past, instrument information was given on separate displays. It was up to the pilot to integrate the information. Today, the information is presented in a way that enables the pilot to see needed information at once. The transfer to electronic displays has provided the flexibility for presenting information in an integrated manner, although this information still comes from different sources [7]. The same kind of flexibility should be possible for electronic operational documentation.

Assuming that operational documentation will migrate into a performance support tool, we will use the instrumentation analogy on an example to identify the new performance support tool specifications.

3 Anemometer Instrument: an Analogy Example

Once the aeronautical domain had identified that "speed" information is necessary information for flight management, engineers developed the anemometer to provide aircrew with the aircraft's speed. In order to design such an instrument, engineers had to consider several questions. First, what information to provide? Second, which physical environment parameters are representative of the aircraft's state in terms of speed measuring? Third, understand the laws that guide the evolution of the physical environment parameters, and fourth, to correlate those parameters to the indicator so that the information is valid in a given "context". The first question relates to the information need, while the second, third and fourth questions relate to the need of each instrument: a calibration process.

In the case of the anemometer, several theories have driven its development. Bernouilli's law introduced the relation between energy and aerodynamics making possible the measurement of a given speed in respect to static and dynamic pressure (physical environment parameters); Saint-Venant's law generalised the theory for the subsonic scope and Lord Rayleigh's law extended the theory for the supersonic scope. Anemometers are specified accordingly. Figure 1 summarises the calibration inputs and the information output:

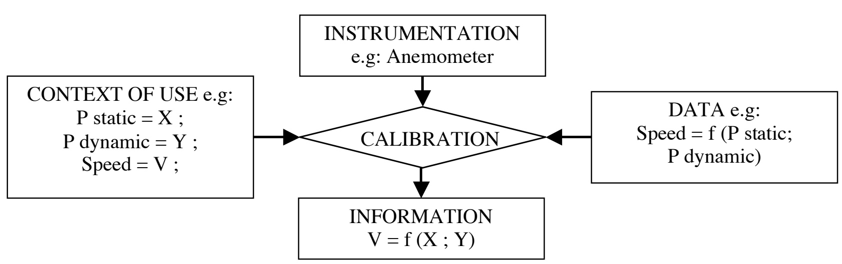

Fig. 1. Calibration process input and output

Once operational documentation is available as an electronic tool, the physical difference between instrumentation and documentation will tend to disappear. Both concepts (instrumentation & documentation) will be able to provide digital dynamic information. It will be necessary to differentiate instrumentation and documentation in another way. As documentation information is the sum of available information, we will make here the assumption that a documentation performance support tool is the sum of instrumentation tools, and that the calibration of documentation is called contextualisation. Figure 2 takes up the process of Figure 1 and generalises the input and output in the case of a performance support tool:

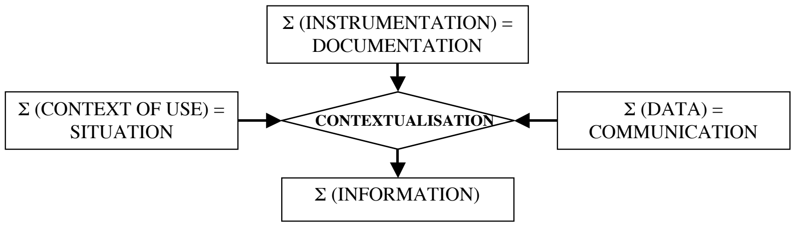

Fig. 2. Contextualisation process input and output

The questions that have been answered in the case of the anemometer have now to be studied for the documentation, Table 1 gives the anemometer and documentation analogy in terms of conception:

Table 1. Anemometer and Electronic Operational Documentation analogy

	Anemometer	Electronic Operational Documentation
1)	Speed is a needed information	What is the information need for an operator in the aeronautical domain (aircrew)?
2)	Static and dynamic pressure have to be measured	Which descriptors are relevant in terms of context of use in order to make possible domain situations explicit?
3)	Saint-Venant's and Lord Rayleigh's law correlate speed, static and dynamic pressure	How to correlate communication to the situation in order to produce information?
4)	For dynamic pressure equal zero, the anemometer indicator communicates zero	What are the possible patterns of meaning that link together communication and situation in order to deliver information?

4 Electronic Operational Documentation Conception

What is the information need for an operator in the aeronautical domain (aircrew)? The aviation community already has extensive operational documentation content. We will consider that the present operational documentation traces all needed information and we will concentrate on the calibration of operational documentation: a contextualisation process.

Which descriptors are relevant in terms of context of use in order to make possible domain situations explicit? Each object of an electronic database will be made up of data and meta-data. Data is the content of the documentation and meta-data is a means to describe and exploit database properties with appropriate tools.

The concept of Documentary Unit (DU) is at the heart of the segmentation of operational electronic documentation into defined entities and is the documentation data. A DU is meant to be a granule of the structured object-oriented database and can contain descriptions, schematics, animations, performance data etc.

Meta-data will be assigned to each DU in the form of descriptors. A descriptor is meant to qualify the content of a DU [5]. The attribution of DU descriptors is a process that will have to take place in parallel to DU authoring. We call documentation contextualisation the process of assigning a set of Context Descriptors (CD) to each DU in order to frame the DU applicability.

In order to describe the content of a DU, we have identified independent families of CD in the flight operational domain. Each family is split into categories [11]:

- Artefact family (for technical content description), split into:
  - System category (functional referential, for example “hydraulic”);
  - Interface category (physical referential, for example “overhead-panel”);
- Task family (for work description), split into:
  - Phases of flight category (linear work segmentation, for example “cruise”; Phases of flight definitions have been standardised in 2002) [12];
  - Operation category (parallel work segmentation, for example “descent preparation”).
- Environment family (for conditional relevance), split into:
  - External environment category (aircraft independent condition, for example “low visibility”);
  - Internal environment category (aircraft dependent condition, for example “hydraulic pump failure”);

Each CD will translate concepts related to the operational documentation domain. Logical relation links may be implemented between different concepts. The CD structure will take the form of an ontology network.

In order to build the CD ontology with the defined families of CD, we define the concept of ontology dimension. An ontology dimension will take the form of a logical tree, with one root, multiple nodes hierarchically organised through multiple branches as shown in Figure 3. Root and nodes are CD:

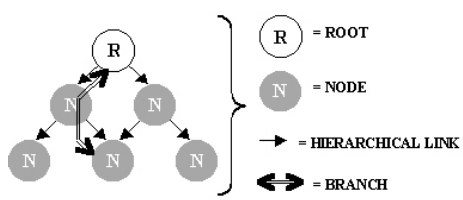

Fig. 3. Ontology dimension properties

For the Artefact family, ontology dimensions can be built with respect to System and Interface category properties:

- System category: The Air Transport Association (ATA) chapters are a standardised cutting out of aircraft mechanical parts [1]. There are logical hierarchical links between CD of one (ATA) chapter ontology. For example, in the ATA70 Power Plant chapter, “engine” is composed of: “compressor”, “turbine”, etc. The System category will have many ontology dimensions. For example, each ATA chapter described in the documentation may be a System category ontology dimension. One descriptor of one ATA chapter ontology may be linked to another ATA chapter ontology. For example, “fuel pump” may be part of the ATA28 Fuel chapter ontology and also be part of the ATA49 Auxiliary Power Unit chapter ontology;

- Interface category is a particular ontology that is, for instance, a decomposition of all aircraft parts that may be used or controlled by an end-user. As for the System category ontology, there are hierarchical links between descriptors, and one CD of one System category ontology may be linked to the Interface category ontology. For example, “thrust lever” may be part of the Interface category ontology and also be part of the ATA70 Power Plant chapter ontology.

Figure 4 shows how the Artefact family is articulated in order to build System and Interface category ontology dimensions:

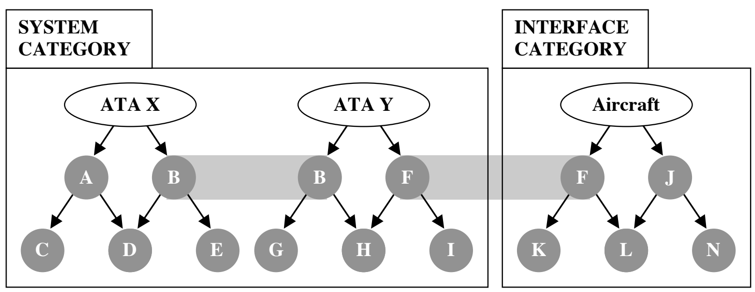

Fig. 4. Artefact family ontology architecture

Task and Environment families are inter-related. Environment family descriptors are conditions that will have an impact on Task family relations. For example, “landing” (Phase of flight category) with “low visibility” (External environment category) will have an impact on the “precision approach” (Operation category).

- Each Internal & External environment category descriptor will be the root for constructing an ontology dimension (the “standard” root may be considered as a particular Environment descriptor). They are directly linked to Phases of flight category each time the Environment family descriptors imply an impact for a particular phase of flight. There is an impact on the Task family descriptor if the Environment family descriptor triggers or changes one Action linked to an Operation category descriptor;
- Phases of flight and Operation categories are a segmentation of the work to accomplish and summarize all possible planned situations. It is a compilation of situations in a mutual inclusive system. Each Operation category descriptor is linked to Actions in order to finalize a task analysis architecture. The first ontology dimension that may be built will be with a particular root called “standard”. This ontology will represent the standard practices.

Figure 5 represents the architecture obtained by building each ontology dimension out of Task and Environment families:

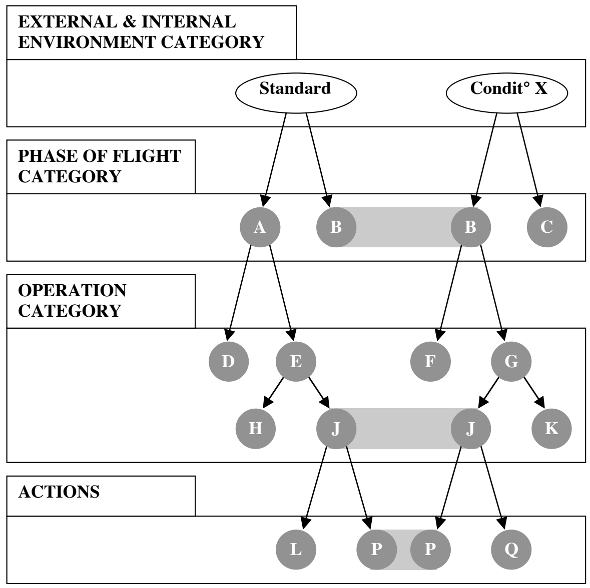

Fig. 5. Task & Environment family ontology architecture

How to correlate communication to the situation in order to produce information? One major concern in defining DUs is the wish to be self-contained in order to be unambiguously understood by a documentation end-user. The self-contained characteristic is relative and we use the notion of context to frame the self-contained property. We introduce the Documentary Group (DG) concept as being a group of contextualised DU related to the same context. This implies that the amount of information contained in one DG is a function of the DG context. In this paper, we will make the hypothesis that a DG is self-contained only if we can define its content via the context in order to frame its applicability. Documentation contextualisation is a means to permit the segmentation of the information flow.

In order to better understand this approach, we will use the metaphor of a database taken as a library. In a library, the granule of self-contained information may be the book. In the section about aeronautics, we find the so-called operating manual. If the operating manual is a self-contained manual (corresponding to the DG definition), then what is its definition (context)? The International Civil Aeronautic Organisation (ICAO) states in its 6th annex of the operational procedures that the definition of an operating manual is [4]:

> "Manual where are indicated all procedures, instructions and indications for the operating personnel in the execution of their tasks."

Thus, the operating manual DG is the sum of all DU attributed with Task family CD.

As operating manuals in the aeronautical field are the major application of the study, we will stick to this definition to elaborate a methodology for the correlation of operational documentation (DU) to its context of use (CD families). Consequently, we will use a task-oriented approach, together with the pre-defined ontology architectures, to elaborate an operational documentation contextualisation process. Figure 6 illustrates the process:

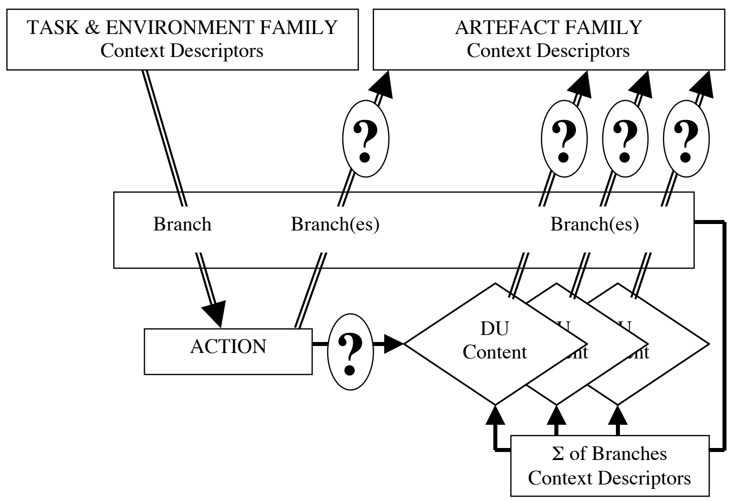

Fig. 6. Task-oriented documentation contextualisation process

Each top-down branch of the multiple Task & Environment ontology will lead to Actions. Each Action will trigger documentation needs in order to understand or apply the related Action taken in its Task & Environment branch context. The DUs that properly respond to the related Task & Environment branch context will be attributed with the respective CD. The content of each Action and corresponding DUs will be compared to the multiple Artefact ontology nodes of the CD structure. If an Artefact ontology node is recognised as relevant in the Action or DU content, the relevant bottom-up branch(es) of the Artefact ontology will be attributed as CD.

What are the possible patterns of meaning that link together communication and situation in order to deliver information? The contextualisation process will make it possible to extract the documentation meta-data from the documentation data, and to homogeneously link data and meta-data together. Building contextualised documentation will build a complex network linking together DU and CD. If we study the case of the anemometer again, we can imagine what pattern of information could emerge from a documentation contextualisation process. Figure 7 gives a snapshot of a possible network around the information needed: aircraft speed; and Figure 8 summarises the pattern in the form introduced during the anemometer case study.

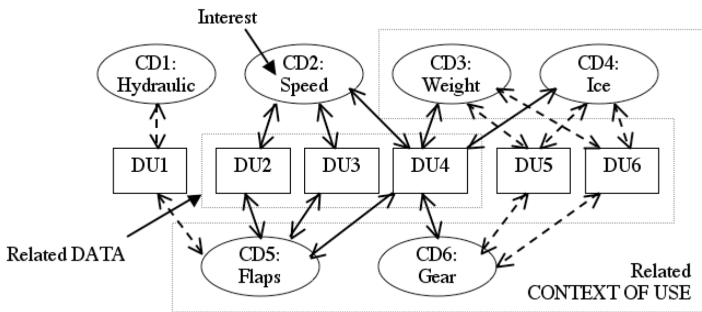

Fig. 7. Network relating data (Documentary Units) to meta-data (Context Descriptors)

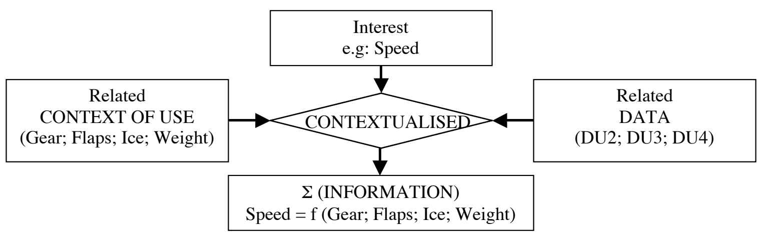

Fig. 8. Contextualised documentation pattern generation

This way of enriching information is similar to the current upgrade of glass cockpit information driven by the shift to instrumentation digitalisation. Within a Primary Flight Display of a modern commercial aircraft, the speed information is contextualised in the sense that for relevant speeds, symbology will inform the aircraft limits, for example, the maximum speed with gear and/or flaps extracted will be indicated.

5 How to Use the Contextualised Documentation?

Next to traditional search methods such as word search and indexes, users can now search by context. For contextual search, users have to input CD in order to filter relevant information. Three axes may be combined to orient the input. These three axes can be related to three direct questions the user may ask him/herself from an operational point of view:

- What do I use?: need for knowledge on systems and interfaces that have to be used in a given context. For example: “I want to retract my landing gear”;
- What will I do?: need for anticipation of the tasks to perform in a specific phase of flight or during a specific operation. For example: “I want to perform a go-around”;

- What if I have?: need for analysis of what will happen if the task is influenced by external and/or internal conditions. For example "I have an hydraulic fault and low visibility at my arrival airport".

Within the framework of defined context ontology dimensions, it is possible to initiate a dialogue between an end-user and the documentation as illustrated in the Figure 9. In this illustration, the knowledge-level (Interest Process) allows users to take advantage of the multiple ontology dimensions in order to refine the scope of targeted information. For example, request for information regarding the "landing" phase (Task family CD) especially with respect to "auto-land" system (Artefact family CD). Another possibility is to gather user interest during documentation use. For example, request for information regarding the "engine start" phase (Operation family CD), availability of information with respect to engine start in "volcanic ashes" condition (Environment family CD).

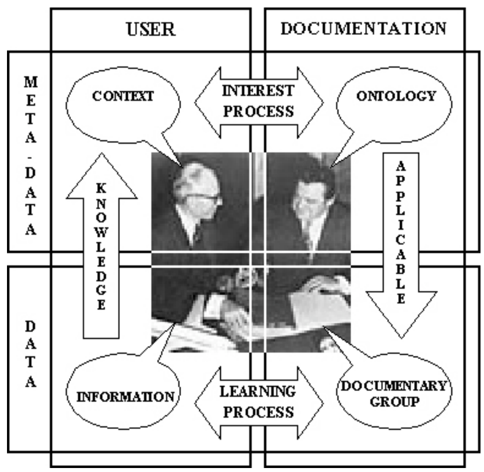

Fig. 9. User-Documentation communication model

In order to guide the User-Documentation communication model, context descriptors properties may be used. The hierarchical structure of the ontology dimensions may be used in order to filter the interest process. For example, using the top levels of ontology dimensions for interest gathering, and then refining the search within one ontology dimension.

Other context descriptor properties may also guide the User-Documentation communication model, such as the dynamical link that timely relates Task family CD together [6]. These kinds of properties will facilitate the production of scenarios that are extensively used for training purposes. Figure 10 shows the possible dynamics of the Task family. The {G; H; J} CD are from the Phase of Flight category and the numbered CD are from the Operation category.

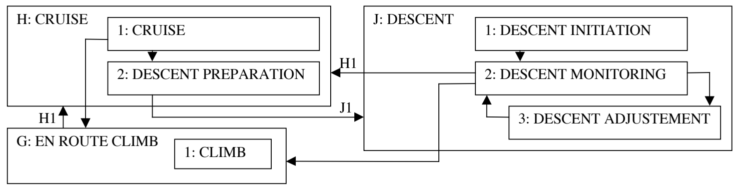

Fig. 10. Phase of Flight & Operation categories dynamic links example

6 Discussion

This paper offers a method enabling a systematic definition of electronic operational documentation properties in the aviation domain. Within this scope, exploitation of these properties will offer interesting facilities in the enhancement of operational documentation usability. However, the impact on the operator's management of information of the integration of an operational documentation tool in an operational safety critical environment has to be studied.

The contextualisation of documentation based on a task-oriented analysis enables the use of documentation in a scenario-based manner [10]. The correlation of operational documentation with the possible domain situations will facilitate the use of documentation as a training support. The contextual access to operational documentation may enhance experience when documentation usage is the same in training as in operations. In that case, training and operations share a common strategy, supporting ongoing learning by making use of the contextualised documentation [2] as illustrated in Figure 11:

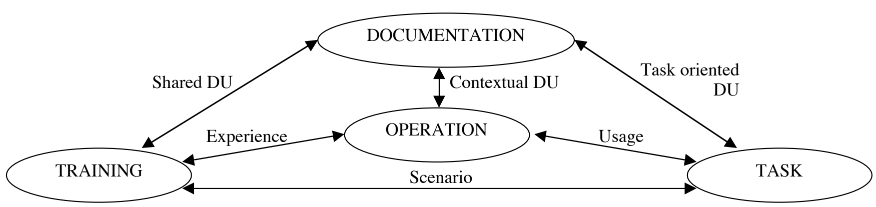

Fig. 11. Integrated view of Documentation, Operation, Training and Task

We see an operational documentation tool as being not only an individual task performance and learning aide, but also an integrated communication system that is connected to the knowledge management processes of the organisation. Defining a set of context descriptors involved in the authoring process and in the end-use of documentation will construct a common referential between authors and end-users [8] and will facilitate the organisational learning capabilities. This common referential aims at defining the documentation to be issued in respect to operational requirements. The iteration of this common referential, together with its associated documentation, may be an answer to the first question of our conception framework: What is the information need?

Acknowledgment

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