

AN ENGINEERING DATABASE MANAGEMENT SYSTEM FOR SPACECRAFT OPERATIONS

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ABSTRACT

Studies at ESOC have demonstrated the feasibility of a flexible and powerful Engineering Database Management System in support for spacecraft operations documentation.

The objectives set out were three-fold: first an analysis of the problems encountered by the Operations team in obtaining and managing operations documents; secondly, the definition of a concept for operations documentation and the implementation of prototype to prove the feasibility of the concept; and thirdly, definition of standards and protocols required for the exchange of data between the top-level partners in a satellite project.

The EDMS prototype was populated with ERS-1 satellite design data and has been used by the operations team at ESOC to gather operational experience.

An operational EDMS would be implemented at the satellite prime contractor's site as a common database for all technical information surrounding a project and would be accessible by the co-contractor's and ESA teams.

Keywords: operations, documentation, spacecraft, database

1. BACKGROUND

During the design of a satellite and after its manufacturing, a large amount of information has to be transferred from the prime contractor to the European Space Agency (ESA). The most important document is the Flight Operations Manual (FOM).

Also, to respond to the needs of Operations and Assembly, Integration and Validation (AIV), ad-hoc documentation has to be produced.

All this documentation is delivered in a paper-based form. Thus, once this documentation is received by the operations teams, the information contained therein needs to be retyped to produce e.g. the Flight Operations Plan (FOP) - the document which contains all the nominal and contingency flight procedures for a space mission.

This effort requires enormous manpower from the operations teams. Also, production of operations documentation by spacecraft contractors historically receives a lower priority.

2. PROBLEM

The first consequence of this situation is that FOM's - these are produced by spacecraft sub-system - arrive late e.g. after the launch of the spacecraft.

Furthermore, due to the intrinsic complexity of current generation spacecraft systems, problems arise in the overall management of the documentation. Thus, the spacecraft documentation will contain incoherent information. Also, the lack of management in spacecraft design changes has impacts on mission control.

The nature of the documentation delivery - paper - generates huge distribution costs e.g. copying, mailing.

Finally, because the documentation is not stored in a single repository, there is no complete access to information.

3. ANALYSIS

One can identify a potential risk of mission failure (or at least a risk of reduced mission capability) from the above problems. Hence, the requirement to analyse the operations documentation production and review cycle within a spacecraft mission.

Analysis of the ERS-1 mission (as a case study of a typical current generation mission) has revealed several shortcomings in all of the aspects of operations related documentation: generation, distribution, maintenance, review and archiving. The analysis included the working procedures of prime and co-contractors as well as the operations and spacecraft check-out teams.

The main shortcoming identified was the lack of a single (and complete) repository for all operations documentation for a space mission. A concept for an Engineering Database Management System (EDMS) for spacecraft operations was thus developed.

4. DEFINITION OF EDMS CONCEPT

A set of constraints - technical and operational - dictated the main aspects of the EDMS concept.

4.1.1. Distributed architecture

Due to the distributed nature of spacecraft and mission development it is essential that each partner (prime, co-contractor, operations, etc..) in a spacecraft project can work independently on their own documentation and yet still have access to a common repository of information. A network of UNIX workstations and servers would satisfy this constraint.

4.1.2. Open systems

Because of the large number of partners involved, one must build an EDMS on open systems. This includes both hardware and software solutions. Software solutions must place the emphasis on neutral formats and standards for data exchange (e.g. SGML for text) and less on selection of specific software packages.

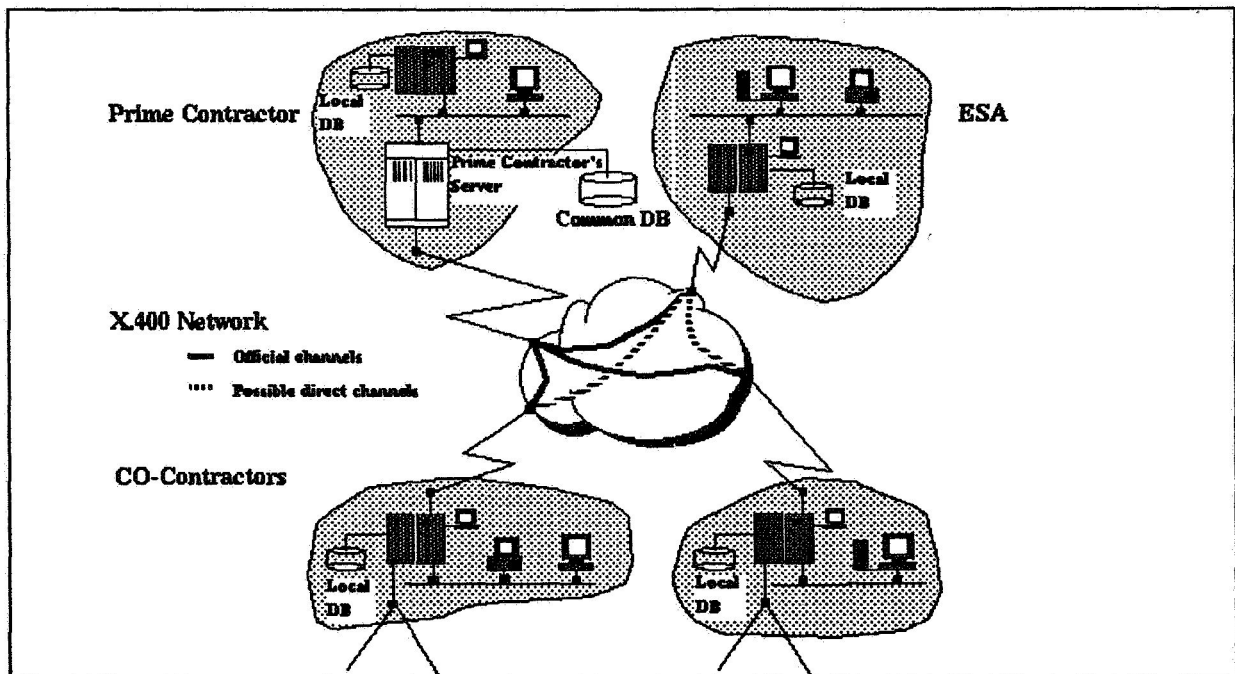


Fig. 1: Proposed network architecture for an operational EDMS

4.1. Constraints

4.1.3. Wide area networking

Since a spacecraft project involves a large number of partners, typically spread-out over several countries, an efficient means of distributing large volumes of documentation is needed. A Wide Area Network (WAN) based on standard communications protocol would meet this requirement.

4.1.4. Operations-friendly environment

Use of an EDMS and production of operations documentation must follow closely procedures used in current paper-based space missions e.g. document review cycles, production of Review Item Discrepancies (RID's), Non-Compliance Reports (NCR's), etc..

Furthermore, the types of current documentation must be maintained e.g. User Requirements Documents (URD's), System Requirements Documents (SRD's), Interface Control Documents (ICD's), FOM's, etc..

4.2. Functionality

Functional requirements for the EDMS generated from the above problem analysis and constraints.

4.2.1. Desktop publishing

Requirements here call for non-destructive editing (annotations), multi-author access, hyper-media functions, version and configuration control.

4.2.2. Communications

Identified requirements include E-mail, dissemination of documentation, delivery acknowledgement, access and security.

4.2.3. Data archiving and retrieval

Main requirements defined include adoption of unified data model and neutral data format for information storage and exchange, document browsing and navigation, text and concept retrieval.

4.3. Responsibilities

The mission prime contractor is seen as the key role player in any implementation of an EDMS. The prime contractor will be responsible for the gathering, maintenance and distribution of documentation from a Central Database (CDB).

Co-contractors, ESA Project Offices, mission operations and check-out teams would maintain their own Local Database (LDB) which could contain an up-to-date version of the CDB as well as their own 'working' copy.

4.4. Usage Scenarios

Usage scenarios would map the procedures from conventional project review cycles e.g. Baseline Design Reviews (BDR's), System Requirement Reviews (SRR's), FOM reviews, etc.. Additionally, the format and structure of project documents would be maintained in support of these formal reviews.

5. IMPACT ON OPERATIONS

The foreseen implementation of an operational EDMS will have several positive impacts on spacecraft missions:

- Increased productivity - within ESA as well as the contractors
- Improved communication of information
- Reuse of information
- Reliability and manageability of information

In addition to the improved productivity within the operations teams in preparing documentation, it is anticipated that there will be a minimisation of response time in the case of a spacecraft anomaly.

6. PROTOTYPE IMPLEMENTATION

A prototype was implemented, containing the main functions of an operational EDMS, in order to demonstrate the feasibility of the concept described above.

The main elements of the prototype included:

- ◆ Sun workstations
- ◆ Commercial-Off-The-Shelf (COTS) S/W packages:
 - DTP tool, *Framemaker*
 - RDMS tool, *Oracle*
 - Information retrieval tool, *Topic*
 - DB front-end/MMI tool, *CIM-Linc ID*

- X. 400 messaging system, *BIM-Mail*

They must also be able to accommodate the various constraints pertaining to specific aerospace domain

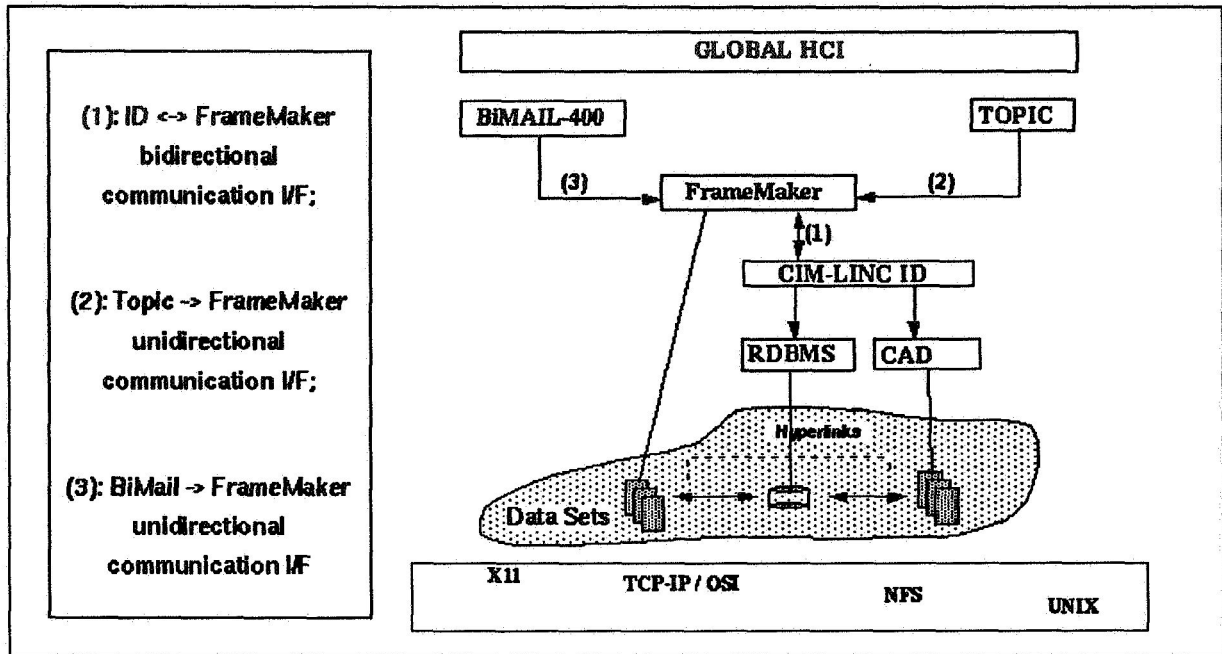


Fig. 2: Software architecture of EDMS prototype

The prototype was populated with data from ERS-1 platform and the IDHT instrument. A review scenario was developed for the IDHT FOM life-cycle.

7. PROTOTYPE DEMONSTRATION

The prototype was demonstrated at ESOC in February 1992. The demonstration consisted of two workstations at ESOC, Germany - acting as the operations team - linked to one workstation based at Everberg, Belgium - acting as the prime contractor. The link was provided by ESA's X. 25 network, *ESANET*.

The prototype has since then been delivered to ESOC where it has been evaluated by the operations team.

8. STANDARDS

The adoption and use of neutral standards for the representation and the exchange of design knowledge is a key factor for the successful deployment of EDMS in real space projects. These standards have to rely on existing international recommendations when available and applicable.

in terms of accuracy, flexibility and confidentiality.

Current study effort has already identified Standard General Mark-up Language (SGML) as a potential standard for text exchange. Above and beyond this, the adequate definition of related Document Type Definitions (DTD's) is required - to ensure information completeness - for all documentation generated during a space mission life-cycle.

9. CONCLUSIONS

The feasibility of an operational EDMS has been proven through the implementation and demonstration of the prototype.

The prototype demonstration received a positive response from major potential users of an EDMS: prime contractor, operations and check-out teams.

There is a strong interest from spacecraft prime contractors to get involved in a pilot implementation of an EDMS within in a real space project.