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AVIONICS SYSTEMS : DEVELOPMENT METHODOLOGY AND DATA PROCESSING TOOLS

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The current avionics systems have reached a high degree of complexity. In order to meet mission requirements, they must perform a large number of functions and make wide use of the most recent technology.

This results in considerable interdependence of operational functions and multiplexing of the necessary resources. These systems are also likely to undergo significant developments to improve mission performance, accommodate new operational requirements, and integrate new equipment technologies.

The high degree of digitization of avionics systems involves the use, in particular, of digital buses, specific processors in the equipment, and an increasing volume of aircraft software.

The following points are developed below :

1) Objectives of a strict methodology applied to avionics system development.

2) System development cycle.

3) Relationship between avionics program participants.

4) Nature of modifications.

5) Avionics system development means at the Aérospatiale Helicopter Division.

1 – OBJECTIVES OF A STRICT METHODOLOGY APPLIED TO AVIONICS SYSTEM DEVELOPMENT

The major problems raised by development and implementation of complex avionics systems may be described as follows :

– It must be possible to **fully control their definition** during the design and development phases, and also during their entire life in the course of which their definition will undergo significant changes.

– **The relationship between the various partners** involved in a program which must be organized efficiently.

– Cost and deadline control must be à constant preoccupation.

The main objectives of a strict methodology applied for system development relate to :

– Specification quality.

– Relations between partners involved in a given program.

– Control of modifications.

1.1 – SPECIFICATION QUALITY

Integration of a large number of subsystems and equipment is necessary if all the functions needed to meet the operational requirements of a system are to be provided.

The full specification of the system and its components is established using a descending design process and becomes more complete at each stage. It takes the form of a large volume of documents which must evolve as the system is developed.

Specification quality therefore depends on :

Completeness

Completeness must be evaluated at each definition level in order to establish, in stages, overall cohesion of the system specification.

All efforts made in this respect are likely to reduce design errors and therefore shorten the testing phases, particularly on the integration rigs.

Structure

If the structure is correctly established during the development phase to facilitate the specification enrichment process, subsequent modifications will be easier to handle.

An advantage of using a strict methodology, which also improves the quality of work, is the possibility of capitalizing on experience by enabling recuperability from one program to another.

1.2 – RELATIONS BETWEEN PARTNERS INVOLVED IN A GIVEN AVIONICS PROGRAM

Customers, partners and suppliers all work together with us on an avionics program.

Within our industrial structure of aircraft manufacturer and prime contractor, all departments concerned take part in the program : Design, Ground and Flight Tests, Purchasing Program Management, Quality, etc ..

The nature of communication between the main partners will be examined later, but it should be stated here that another aim of a strict methodology is to formalize and facilitate relations between all parties.

In this respect, the methodology itself and its method of implementation must permit standardization of working methods in the various teams and between industrial partners in particular, and other parties involved.

1.3 – CONTROL OF MODIFICATIONS

As mentioned earlier, modifications must be controlled continuously from the start of the development phase and throughout the entire life period of the system.

For greater flexibility, modification rules must be followed throughout development of a system. A strict methodology is particularly suited to this requirement. Furthermore, the structure of specification documents, designed for ease of incorporation of modifications throughout the life of the system, lends itself to correct management of system confifurations.

2 – SYSTEM DEVELOPMENT CYCLE

The main development phases of an avionics system are described below, with specific reference to the activities involved and the ensuing results.

2.1 – MAIN PHASES OF SYSTEM LIFE CYCLE

Figure 1 shows the main phases of a system life cycle and the development methodology used.

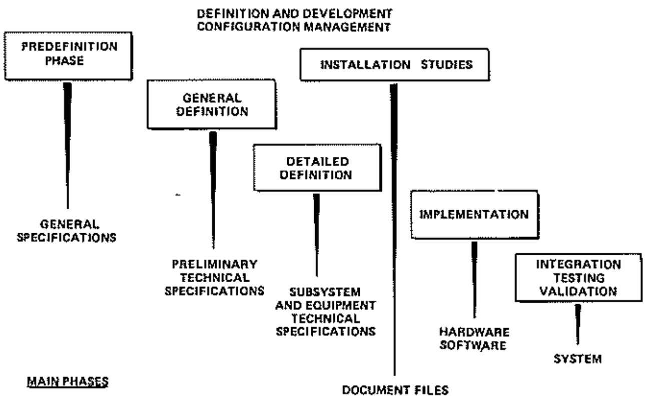

Fig. 1 : SYSTEM DEFINITION METHODOLOGY

It includes :

- Predevelopment
- Predefinition
- Definition, broken down into :
  - General definition
  - Detailed definition.
- Installation studies
- Implementation
- Integration, testing and validation.

Configuration management activities cover all development phases and continue throughout the operating life of the system.

2.2 – PREDEVELOPMENT

Activities covering general studies and operational research, conducted independently of the programs and aimed at preparing these programs, result in experimental models being produced and simulations being carried out, and also enable new concepts to be evaluated and knowledge to be acquired for implementing new technologies.

2.3 – PREDEFINITION

This phase involves establishing general system specifications on the basis of the concept chosen to meet the operational requirement expressed.

In other words, on the basis of a mission analysis, all operational functions required for mission execution are determined and the means to be used are ascertained.

Constraints relating to definition of the crew/system interface must be taken into consideration at a very early stage. The modes and commands project is therefore an important task in the predefinition phase. It results in :

A functional organization project for the cockpit with, in particular, task allocation between the crew members and a description of equipment needed for execution of these tasks.

A project describing the operating modes required for mission sensors, display systems (associated controls and logic).

On completion, the predefinition phase gives the outline of work to be performed and a preliminary description of the operational functions, the cockpit, sensors, and hardware architecture of the system.

2.4 – DEFINITION

The system definition phase leads to the technical specification being drawn up for the system, subsystems and associated equipment.

It comprises two stages :

General Definition during which the preliminary technical specification is established.

Detailed Definition during which the technical specification is made more complete, the level of detail being brought up to that required for equipment manufacturing purposes.

2.4.1 – General Definition

In the development process, the general definition covers the following three main activities :

2.4.1.1 – Definition of Functional Architecture of the System

Using a descending structured analysis method, the system is broken down into functional «modules» on the basis of a very general description, and the interfaces between the various items in this breakdown are established.

Processing operations contained in final level functional modules will be specified at a later stage in the detailed definition.

Functional chains of the system are defined through knowledge of the functional dependencies existing between information constituting the interfaces between the functional modules.

2.4.1.2 – Hardware Architecture Definition

Knowledge of the system in the form of a set of functional modules and their interfaces having been acquired on completion of the previous stage, these functional modules are now assigned to the various subsystems and equipment.

«System» functions involve several items of equipment, federated into subsystems in a hierarchical structure coming under central computers. These computers allocate the tasks to the various subsystems, thus creating a complex functional chain. This is a resource management function in terms of on-board equipment for a given mission.

The basic tasks need not be identical for an item of equipment when the configuration of a given system changes. This compares with a simple set of juxtaposed equipment.

At this stage, the nature of exchanges is identified and global exchange traffic on the bus is evaluated.

2.4.1.3 – System Characterization

A study predicting system characteristics defines :

- Performance
- Mission reliability
- Availability
- Safety
- Maintainability
- Etc ...

2.4.2 – Detailed Definition

This stage is aimed at bringing the technical specifications up to an adequate level of detail for equipment manufacturing purposes. Activities relate specifically to :

- Detailed specification of processing operations.
- Specification of equipment hardware interfaces.
- Full specification of exchanges in the system and, for bus links, specification of protocols and the exchange frame.
- Specification of interfaces with the crew including detailed specification of symbologies for display systems.

2.5 – INSTALLATION STUDIES

Tasks relating to installation of all system components on the integration rigs and on the aircraft are carried out in parallel with the detailed definition work. All electrical file drawings are prepared.

2.6 – PRODUCTION

The technical specification as a whole constitutes the entry point into the equipment production phase, for both hardware and software.

The development phases are also implemented in preparing aircraft software. Global design and then detailed design activities based on the software specification lead to the coding phase and the software integration phases by defining tests to be performed.

When the hardware and software aspects of an item of equipment are entrusted to an outside supplier, monitoring is carried out by AS/DH for Quality Assurance purposes. Details are given in the paper by A. Reboul «Quality Control of Software in Avionics Systems».

When the development of «system» type software or software affecting «sensitive» functions directly involves helicopter manufacturer knowledge, AS/DH will arrange for System Studies of the software concerned to be carried out in a specialized section.

2.7 – INTEGRATION, TESTING AND VALIDATION

After the equipment has been produced and undergone acceptance at Marignane, integration and debugging work is carried out on the system integration rigs. Flight tests constitute the final validation phase for an avionics system.

3 – RELATIONS BETWEEN PARTICIPANTS IN AN AVIONICS PROGRAM

3.1 – AVIONICS PROGRAM PARTICIPANTS

3.1.1 – In the Study Process

Figure 2 shows the relations between the system prime contractor AS/DH, and the subsystem and equipment manufacturers in the system study process.

Contracting authority involvement is also shown.

The following points should be emphasized :

- From the predefinition phase, work is conducted with cooperation between the system prime contractor and the subsystem and equipment manufacturers.
- The system prime contractor asks the subsystems and equipment manufacturers for a final technical and commercial offer as soon as the preliminary technical specification covering the system, subsystems and equipment constituting the requirement has been issued.

The detailed definition phase is conducted in association with the suppliers selected, who now commence their development studies.

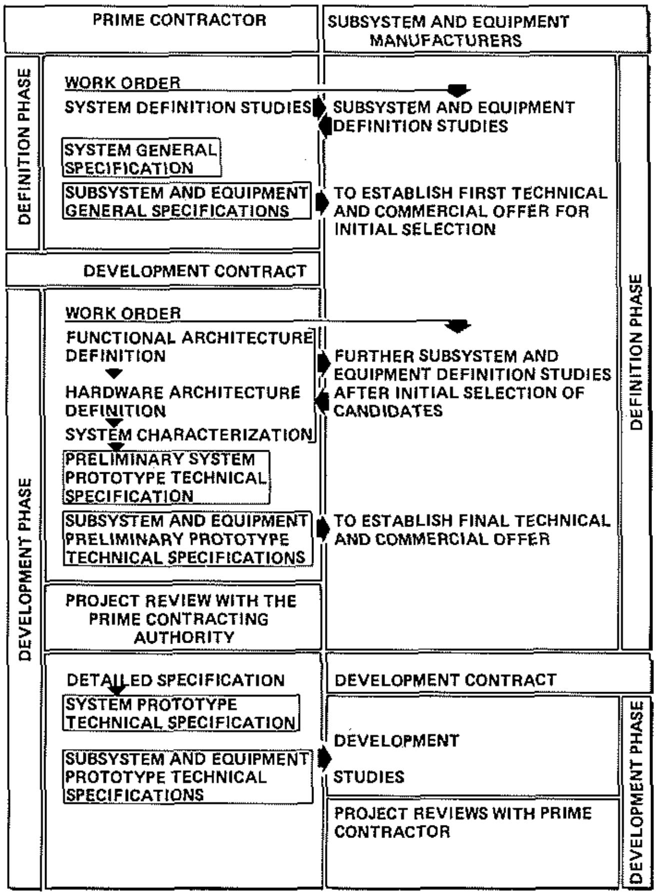

Fig. 2 : DIAGRAM OF RELATIONS BETWEEN PRIME CONTRACTOR AND SUBSYSTEM/EQUIPMENT MANUFACTURERS IN THE DESIGN PROCESS

3.1.2 – In the Integration and Testing Process

The system is perfected on integration rigs set up by Ground Tests and operated on the basis of series of tests defined during the detailed definition phase. Great care is taken with respect to management of the configuration of the system under test (equipment supplies) and that of the test facilities.

3.1.3 – In the Program Management Process

These aspects, and particularly the aspects relating to Quality Assurance activities, are described in the paper by A. Reboul «Quality Control of Software in Avionics Systems».

3.2 – COOPERATION

In the above processes, there is no objection to the system prime contractor being composed of several companies with industrial agreements governing problems of decision making.

4 – MODIFICATIONS ASPECT

There are two types of modification request :

Modifications resulting from the ground and flight testing and validation phases.

Modifications corresponding to integration of additional customer operational requirements.

In all cases, the objectives of effective configuration control are :

Keeping all specification documents up to date.

Enabling equipment deliveries and complete system deliveries to be defined.

Identifying at the most general level of the system the effect of a modification request at the level of each component.

Handling acceptance procedures for modification requests and updating applicabilities to define system «standards» in development and in production.

Enabling project heads to consult the various development states of all entities involved in the definition of the system with which they are concerned.

For this purpose, monitoring of modification requests is based on the following principles :

A «system» card is drawn up to describe the modification at general system level. It is broken down into equipment cards for the equipment affected by the change, processed to determine its effect on the various products of the system life cycle with a view to preparing its presentation at technical conferences and then its incorporation on the basis of the results of these conferences.

5 – AVIONICS SYSTEM DEVELOPMENT MEANS IN THE AEROSPATIALE HELICOPTER DIVISION

To fully master development of aircraft avionics systems, the aircraft manufacturer must :

Establish the general and detailed system definitions.

Control software development.

Carry out system integration tests and validation.

The complexity of integrated digital systems necessitates the use of suitable means (computer tools in particular) for accomplishing these tasks.

5.1 – These are primarily computer aided means for design work and for the general and detailed system specifications. They serve to :

Produce a system complying with customer operational specifications.

Provide detailed equipment specifications (hardware and software) permitting their development.

This set of means is designated by the Aérospatiale Helicopter Division as the «**System Design Shop**».

The nature of the tasks to be performed has resulted in a distinction being made within the System Design Shop between the following four components **(see Figure 3)** :

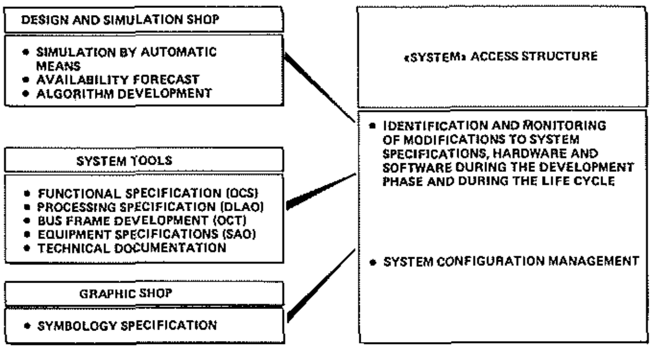

Fig. 3 : SYSTEM DESIGN SHOP

a) Design and Simulation Shop

It handles all types of tasks as follows :

Conceptual studies prior to specification tasks, detailed specification of algorithms using fine models, and system characterization..

b) System Tools

These are mainly tools used to establish the following :

Functional Specification

The tool used at present is SPECIFX which will be replaced by OCS (System Design Tool) as soon as it is available.

Processing Specification

The DLAO (ESD) tool (Computer Aided Software Definition tool) is installed.

Bus Frame Development

The OCT tool (Bus Frame Development tool) is now defined and partly modelled. It will be integrated in the Shop.

Equipment Specification

The SAO tool (Computer Aided Specification tool) based on an interactive graphic language is used for current projects.

c) Graphics Shop

Currently being set up, it is to provide support for the detailed specification (graphic and logic) of symbologies.

d) System Access Structure

Being developed at AS/DH, it constitutes the basic structure of the System Design Shop through which users access dedicated tools, and it provides coherent management within the shop, in particular with respect to :

Data transfer between tools.

Developed system modification monitoring.

5.2 – There are also the aircraft software development means, designated as the «**Software Shop**»

Certain software at «system» level is considered as a DH development task. This «system» layer corresponds to high level functions involving several items of equipment federated into subsystems in a hierarchical structure under central computers. It is also a point of strategy for the aircraft manufacturer to develop software which will increasingly undergo customization work, this work often being carried out in the past at installation level.

Figure 4 shows the four components of the Software Shop enabling a strict development methodology to be implemented.

a) Software tools.

b) Programming Shop.

c) Software Integration Station.

d) Software Access Structure, its main role being to provide configuration management during software development. Like the System Access Structure, it is the basic structure of the shop and effectively manages all information present.

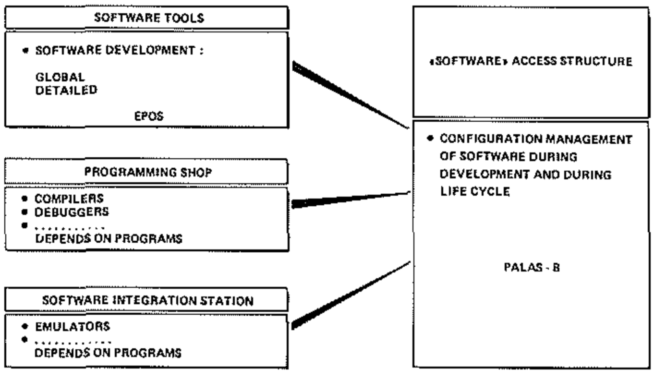

Fig. 4 : DH SOFTWARE SHOP

5.3 – There are also the means for preparing and structuring the **electrical file.**

5.4 – TEST MEANS also exist :

«Real time» integration means for testing and functional validation of the system. These are the «**System Rigs**».

Mechanical test and integration means (mainly the means for adjusting helicopter-mounted sensors).

Electromagnetic compatibility and hardening test means to prove system behaviour in its own environment and in the external environment stipulated in the Technical Requirements.

CONCLUSIONS

A certain number of computer tools are already used in the development of our current avionics programs. Their use has already produced certain beneficial results, in particular :

- Improved communication between partners
- Higher quality of specifications
- Improved system definition monitoring.

Forthcoming programs should provide complete validation in full-scale utilization.

This methodological process, resulting in the utilization of computer tools, concords with that conducted by the French avionics community under the auspices of the Ministry of Defence in the context of the ITI Studies.