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ORCHIDEE
ROLE OF THE HELICOPTER WITHIN A COMPLEX SYSTEM

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ABSTRACT

This document describes the approach followed for defining the ORCHIDEE battlefield surveillance system and its air segment in particular.

It shows how the general definition of the helicopter has been established from a functional analysis of system requirements and various experimental work carried out using a «demonstrator».

This form of approach for defining a helicopter is the result of a fundamental change in the use of helicopters, particularly for military applications.

The ORCHIDEE system is an example of this change, and marks a major change in Helicopter Division activities.

1 – THE ORCHIDEE SYSTEM : MISSIONS AND GENERAL ORGANIZATION PRINCIPLES

The ORCHIDEE system is the main system to be used by the French Army in the 1990's, to provide battlefield surveillance for preparing engagement of its ground forces.

It will provide a global, real-time picture of the deployment and movement of enemy units over the full depth of their lines.

This system is made up of three segments (see Figure 1) :

An air segment, consisting of helicopters equipped with an observation radar transmitting radar images to the ground for processing and synthesis.

A ground segment, consisting of ground stations managing overall mission and receiving radar images. These stations process these images to produce the desired information which is transmitted to the Army Corps Command Post.

A second ground segment, consisting of helicopter pads from which the helicopters are operated.

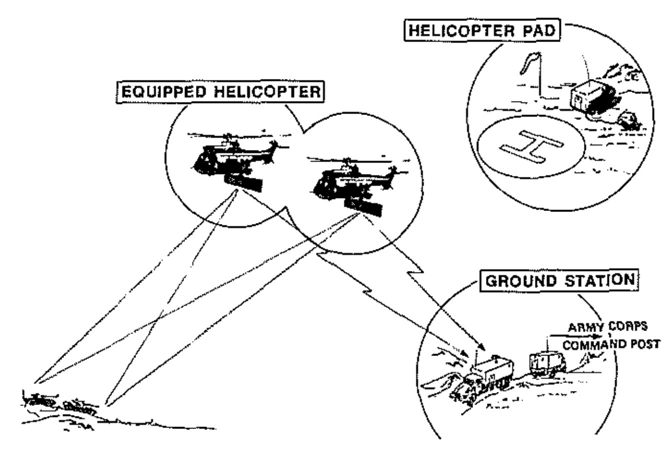

Fig. 1 : ORCHIDEE SYSTEM - GENERAL LAYOUT

2 – FUNCTIONAL ANALYSIS OF THE EQUIPPED HELICOPTER

2.1 – GENERAL PRINCIPLES

The previous section gave an indication of main system segments in terms of equipment : equipped helicopter, ground stations, helicopter pads. Details of the lower levels of this structure have steadily become clearer as the definition became more precise, and it has been possible to :

Establish a work breakdown structure, covering all tasks to be implemented for the programme as a whole, and determine equipment quantities required.

Present simply and comprehensively the specifications for the various equipment to be developed (software or hardware).

However, when defining and developing a complex system, this material aspect must be complemented by a functional analysis for the purpose of :

Defining system requirements on the basis of missions to be accomplished.

Defining and optimizing the part played by the various system components in meeting these requirements.

This analysis provides a functional breakdown structure of the system organized in several levels. The elementary level of this breakdown provides subfunctions, each of which may be associated with an item of equipment so as to correspond with the entities of the material arborization (see Figure 2).

Intermediate levels correspond to the various levels of partial integration of the system.

A functional breakdown of the ORCHIDEE system reveals four main functions structured in three or four levels.

A surveillance function, covering all battlefield information acquisition and processing tasks for obtaining the information required by the Army Corps Command Post.

A survivability function, covering all tasks for reducing system vulnerability to possible forms of military attack.

An operability function, covering all tasks ensuring correct utilization and implementation of the system in its general environment (climatic and geographic environment, military support environment, etc ...).

An interoperability function, covering all tasks assuring the exchange of information between the ORCHIDEE system and the future surveillance systems JSTARS (US) and ASTOR (UK).

2.2 – RESULTS OF FUNCTIONAL ANALYSIS

By analyzing these functions, all tasks which the equipped helicopter must perform can be identified and defined.

In many cases, this functional analysis results in unusual requirements for a helicopter.

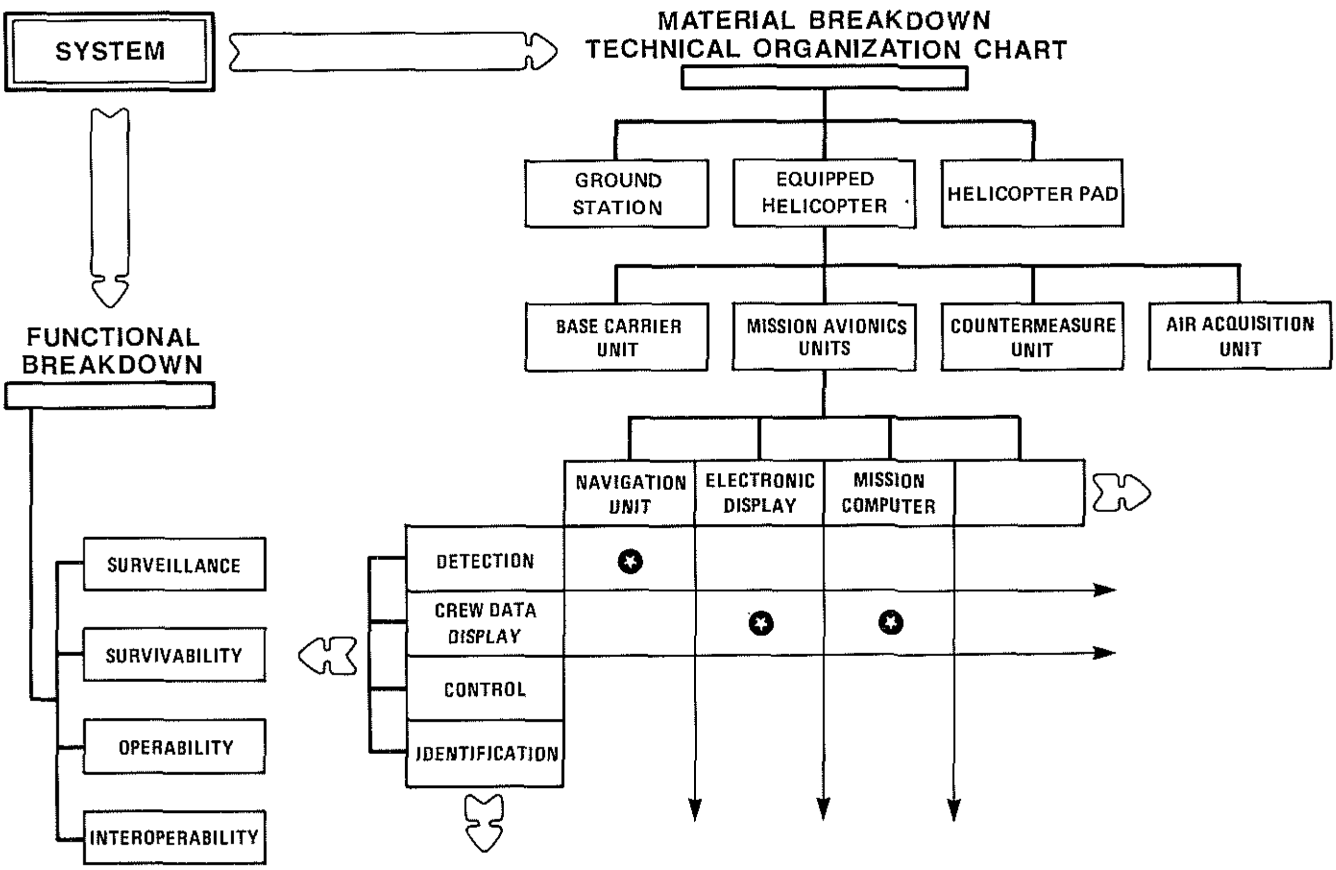

Fig. 2 : FUNCTIONAL AND MATERIAL BREAKDOWN QUALITY

SURVEILLANCE FUNCTION

In fulfilling this function, the equipped helicopter must be capable of collecting radar information.

This function involves principally the following two tasks :

Radar carrying : The surveillance radar installation and large antenna produce mechanical loads for which the structure was not initially developed.

Helicopter stabilization during radar observation phases involves more than conventional attitude stabilization. The stabilization required for radar operation also necessitates :

- Stabilization of rate of yaw compatible with antenna scanning regulation.
- Maximum vibration levels at the rear of the cabin in order not to reduce the radar fixed echo elimination rate.
- Limited heading error variation during the target illumination time for accurate prelocation by the radar.
- Adequately low harmonization errors between the radar antenna and navigation unit for this same prelocation function.
- A constant, adequately low mean heading error on an antenna scanning to enable convoys to be located by the ground station.
- Knowledge of the helicopter's position at the time of radar observations with an accuracy greater than that for normal navigation requirements.

VULNERABILITY FUNCTION

This function involves maintaining below a given threshold, for each equipped helicopter in flight, the probability of its destruction by military attack, taking into account participation of the friendly military deployment within which it must operate.

The most characteristic tasks to be performed to fulfill this function are :

Following flight paths behind the line of contact with enemy forces and within an airspace protected by friendly ground and air units, hence creating unusual navigational constraints.

Not exceeding minimum flight heights giving adequate visibility for radar observations.

Implementing various technical solutions for reducing the infrared and electromagnetic signatures of the helicopter facing threats which are not the same as those encountered in helicopter nap-of-the-earth flight.

Operating various countermeasure equipment on board the helicopter for jamming and decoying these threats.

Operating the systems permitting helicopter identification by friendly units.

OPERABILITY FUNCTION

The most characteristic tasks of this function are :

– Ground Station Mission Management :

  The entire system is controlled by the active ground station both before and during missions. Flight of the helicopter is therefore controlled in real time by the ground station. The helicopter must go to the observation or data transmission positions specified by ground station operators.

  These positions are of the rendezvous type involving both a position requirement and a time requirement, without which it is not possible to achieve correct sequencing of the tasks performed by the ground station and by the helicopters.

  The helicopter must also be capable of responding periodically to updated flight plans as required by a ground station.

– Equipped Helicopter Mission Management :

  Additional management is provided at helicopter level to handle events not foreseen by the ground station (weather conditions, threats, etc ...).

  The basic avionics provide the necessary information to the crew, ground station operators being informed by means of data transmission. This duality is necessary for in-flight validation of ground station requests. It also provides for beneficial interaction between the equipped helicopters and the ground stations.

– The position accuracy required during radar observation phases necessitates regular resetting of the inertial navigation unit on the basis of telemetric information provided by data transmission and the surveillance radar.

To summarize, the functional analysis allows identifying and analyzing close links between the helicopter in flight and various ground entities : system ground stations, ground protection units, navigation unit resetting systems.

Furthermore, the functional analysis gives rise to a series of complex technical requirements for the helicopter, requiring the helicopter to be considered from a new angle. In this respect, available design data and past experience at commencement of the project were inadequate.

In view of this situation, an equipped helicopter «demonstrator» was developed.

3 – ORCHIDEE DEMONSTRATION

The equipped helicopter demonstrator was developed from an ALAT PUMA fitted with antenna operating device, LCTAR radar of the ORPHEE family, SAGEM inertial navigation unit type ULISS 45, and a radar operator station (see Figure 3).

Fig. 3

This equipment was adopted for its good technical representativity of desired production solutions.

This demonstrator has taken part in various industrial and Government test campaigns, the main campaigns being conducted at Marignane for industrial tests and at Bretigny and Phalsbourg for Government tests.

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This demonstrator has taken part in various industrial and Government test campaigns, the main campaigns being conducted at Marignane for industrial tests and at Bretigny and Phalsbourg for Government tests.

The experience gained with this demonstrator is now in excess of 200 hours flying time and has made it possible to :

- Establish an improved definition of the technical characteristics and requirements for the equipped helicopter :
  - Radar cross-section of equipped helicopter.
  - Vibration levels at radar/helicopter interfaces.
  - Harmonization error levels between antenna and navigation unit.
  - Functional characteristics of radar/navigation unit interface.
- Evaluate and confirm technical solutions :
  - Antenna mounting and associated operating system.
  - Autopilot precontrol for helicopter stabilization during radar observations.
  - Radar systems for helicopter speed compensation and fixed echo elimination.
  - Inertial navigation means and envisaged position update means.

This equipped helicopter demonstrator has now been complemented by a ground station enabling an initial positive approach to be made to mission management requirements (see Figure 4).

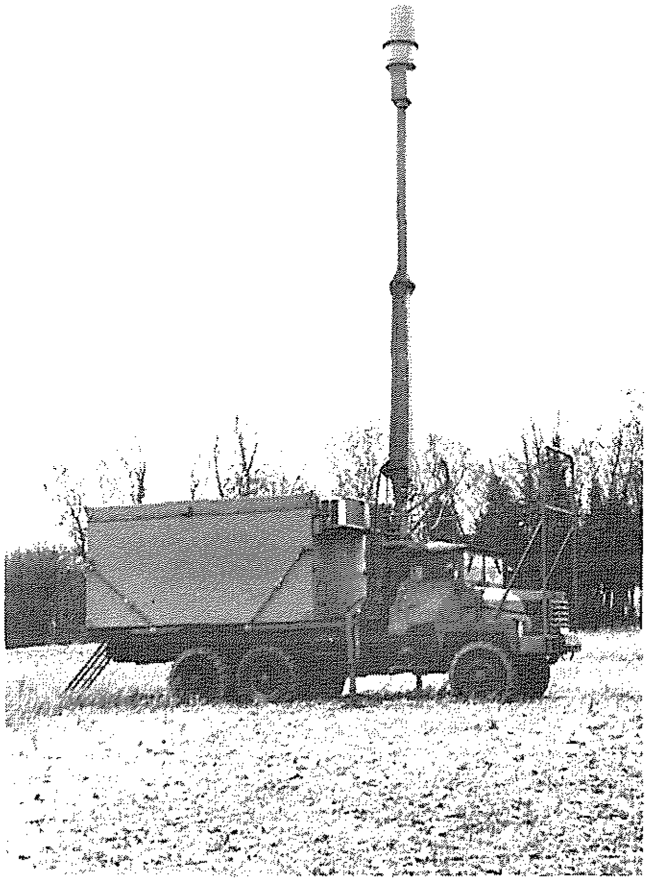

Fig. 4 : PRE-ORCHIDEE GROUND STATION SHELTER

4 – TECHNICAL ORGANIZATIONAL AND ARCHITECTURAL CHARACTERISTICS OF THE EQUIPPED HELICOPTER

4.1 – MISSION EQUIPMENT

The production version of the equipped helicopter will be based on an AS 332 MK2.

On-board integration of mission equipment (mission avionics countermeasures, radar) has led to a modular type structure being adopted, with standard links being used for inter-equipment communication (see Figure 5).

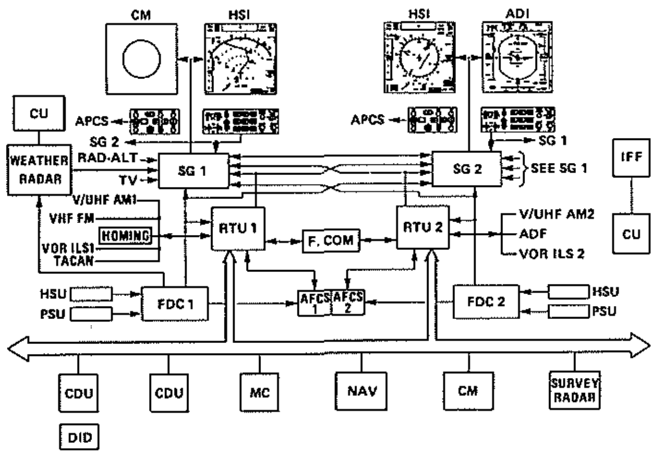

Fig. 5 : ORGANIZATION AND ARCHITECTURE OF AIRBORNE EQUIPMENT

This type of organization allows providing an «integrated» structure intended for uniformity and best overall effectiveness of the equipped helicopter, while retaining a «side-by-side» structure ensuring that modifications to equipment as a result of ORCHIDEE installation are kept to a minimum.

This structure facilitates setting-up of on-board equipment by enabling preliminary adjustment to be made at sub-assembly and assembly levels, and at the same time provides adequate development capability for future upgrading of the system.

A multiplexed serial bus link forms the backbone of the communication network between mission equipment on the one hand and between mission equipment and basic avionics on the other.

The main mission equipment connected to the bus link is as follows :

Control display units controlling navigation, countermeasures and radio equipment.

A mission computer managing bus exchanges and performing various mission calculations.

An inertial navigation unit.

Countermeasure equipment.

A data transmission and surveillance radar exchange and management unit.

Remote terminal units providing an interface with the basic avionics.

4.2 – BASIC AVIONICS

The organization and architecture of the basic avionics, and of the associated instrument panel, are not modified by integration of the ORCHIDEE system.

Integration of this system is obtained by :

– Additional software at autopilot level (specific higher order modes) and symbol generators (specific navigation and technical situation symbologies).

– Reprogramming of symbologies displayed on the four instrument panel CRT screens for the various phases of a mission (see Figures 6 and 7).

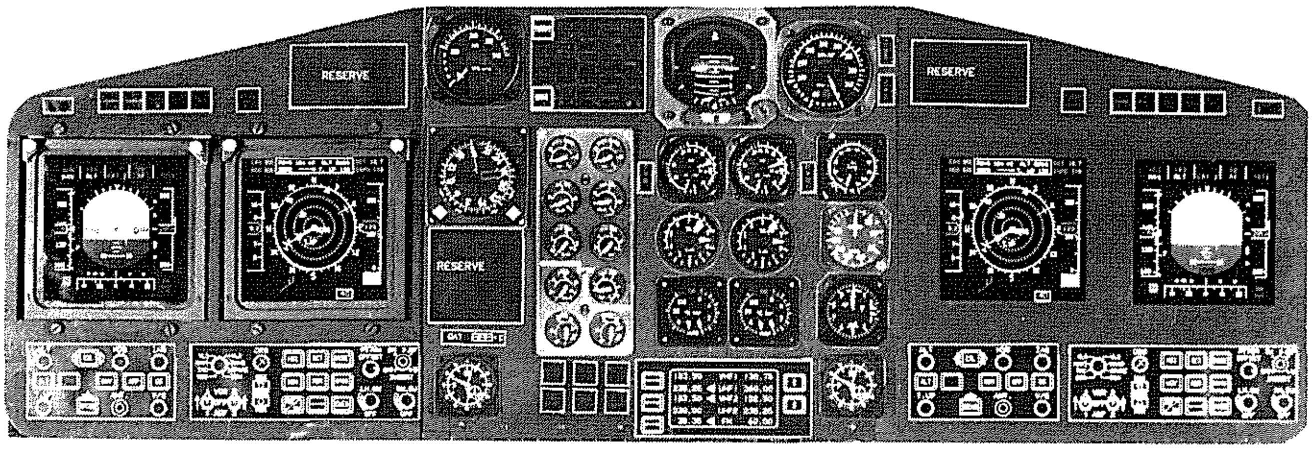

Fig. 6 : INSTRUMENT PANEL LAYOUT

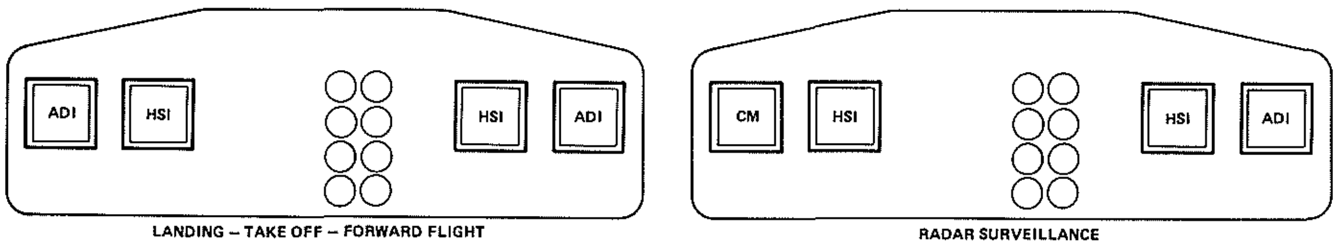

Fig. 7 : UTILIZATION OF INSTRUMENT PANEL C.R.T. SCREENS

During the phases of landing, take-off and low level flight to the observation zone, the instrument panel configuration is conventional and provides an ADI type symbology symmetrically to pilot and copilot, and an HSI or RMI type navigation symbology.

During the observation phases, the ADI type symbology presented to the copilot is replaced by a tactical situation symbology and the navigation symbologies are adapted to provide 40 navigation information.

4.3 – ANTENNA MOUNTING (see Figures 8 and 9)

The antenna mounting and operating system developed requires only local reinforcement of the basic structure. A hydraulic cylinder moves the antenna from its landing/take-off position (antenna up, positioned horizontally and transversally below the tail boom) and its cruising or observation position (antenna down, positioned horizontally below the fuselage).

In the «down» position, electric actuators operate the antenna in elevation and azimuth.

A pyrotechnic device is included in this installation for jetissoning the antenna from any position if so required for reasons of flight safety.

This installation has been designed not to modify the basic aircraft landing gear.

The main landing and crash protection characteristics are retained : maximum nose-up position, landing capability with one or two tyres deflated, maximum crash load factors.

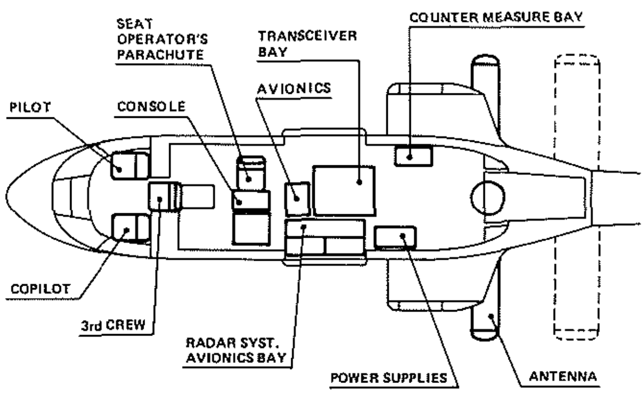

Fig. 8 : SUPER PUMA M2 LAYOUT

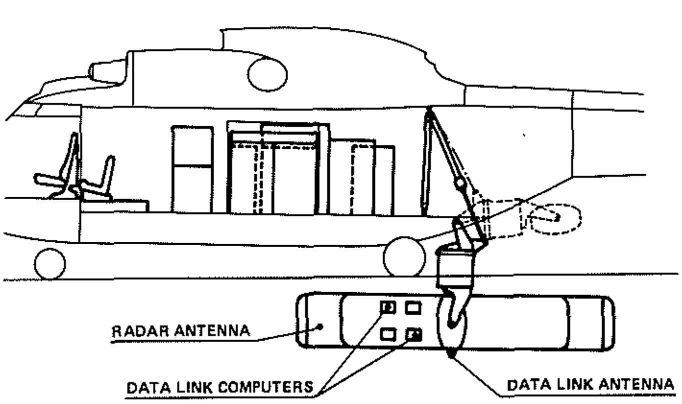

Fig. 9 : SUPER PUMA M2 LAYOUT

5 – THE ORCHIDEE SYSTEM : PROSPECTS AND CHANGES FOR THE AEROSPATIALE HELICOPTER DIVISION

The ORCHIDEE system marks a major change in Helicopter Division activities. This is due partly to the role of Aérospatiale as Industrial Architect for all development work on the system, and also to the technical complexity of the equipped helicopter in terms of its definition, design and integration.

This change in activity is accompanied by the opening of new fields of application for the SUPER PUMA.

The ORCHIDEE programme demonstrates the suitability of this aircraft for carrying airborne, long-range, ground- or low-altitude surveillance radar. Its carrying capacity, particularly carrying antennae of up to 5 metres span, and its ability to provide a stabilized reference platform moving at low speed are its main advantages.

In addition to the above capabilities, the helicopter-mounted radar configuration often provides increased operational autonomy compared with an aircraft-mounted radar configuration for the Armies.