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TITLE : HORIZON HELICOPTER

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The Horizon system has been the subject of numerous presentations at international conferences and at air shows. The characteristics of the system have appeared in many publications. This presentation provides:

in the first instance, a brief description of the missions, the overall design and the performance of the system.

Secondly, it focuses on :

- **the industrial experience acquired by EUROCOPTER whilst executing the programme,**
- **the likely enhancement of the system as a result of the advances in digital data processing means and the impact of these on military systems as a whole.**

1. THE HORIZON SYSTEM

1.1 The mission

Horizon is an intelligence gathering system which is intended to establish the situation of moving vehicles on the ground and of helicopters flying at low altitude, over a broad area, from a safe distance, and within a very short time lag.

It is usable in situations of crisis prevention, during crises as such or during conflicts.

Horizon provides :

- maps of the ground tactical situation in real time both onboard the helicopter and in the ground station,
- alert messages from the helicopter, by voice,
- guidance information for helicopters or aircraft, by voice.

Figure 1 shows moving targets , result of the MTI (Moving Target Indicator) radar returns superimposed on a digitized raster map.

Figure 2 shows moving target groups tracking, using digitized vectorized road network, overlaid on raster map.

The Horizon system is very flexible: it can be used in a large variety of scenarios, depending on employment concept and threat.

Figure 3 shows a typical flight pattern related to conflict situations : It features low altitude transit, and pop-up observation phases.

A HORIZON "system" typically consists of helicopters and ground stations, communicating together via a high rate data link.

Initially the nominal configuration was consisting of 2 helicopters and one ground station; stand alone helicopters and "one helicopter and one ground station" configurations also being possible. The perimeter of the system has since been extended so as to include 2 helicopters and 2 ground stations operating in an open network and linked to other systems for experimentation purposes. This will shortly be extended further to other systems such as the French Army SIR RENS (integrated intelligence system).

Figure 4 shows the initial configurations

1.2 Physical description

(see external view of the helicopter with radar antenna in flight position in figure 5 and internal mission equipment layout in figure 6).

Each fully-equipped helicopter consists of :

- a COUGAR Mk 1 carrier aircraft, including flexibility and survivability equipment.
- an MTI (Moving Target Identification) Doppler radar, which enables moving targets (helicopters, tracked vehicles, other vehicles) to be detected, measured (speed), localized and classified, in a severe electromagnetic environment.
- a tactical console in the cabin, (OBOS: On Board Operator Station) intended for mission planning, radar data acquisition and data transmission to the ground conducting as well as data processing. The console includes COTS (Commercial Off The Shelf) computer and CRT display unit.

The hardware architecture of the console is shown in figure 7.

- a navigation system consisting of a GPS receiver (Precise Positioning Service), an inertial unit used as a sensor and for hybrid position determination, and a navigation computer which provides the navigation data and displays as well as inputs to the mission system.
- a two-way point to point data link terminal for transmission of raw data (target files) to the ground station, and to receive messages from the latter. The transmission is hardened against jamming.
- adaptations for carrying the mission system including in particular a device for maneuvering and jettisoning (emergency device) the radar antenna.

The ground station consists of :

- a carrier vehicle with an equipped shelter,
- a data link terminal for reception of raw data and transmission of messages and change requests to the helicopters
- 2 consoles (GWS : Ground Work Station) identical to those on-board the helicopter and providing planning, monitoring and data processing functions. The choice of identical consoles between the helicopter and ground stations, both from an equipment and a software point of view, was taken in order to minimise the development and integration costs.

(See external view of the ground station in figure 8 and internal layout in figure 9).

1.3 Functional description

1.3.1 Data acquisition and processing chain

(see data processing block diagram in figure 10).

The radar signal is processed by the radar itself, which elaborates "raw data". The positions of moving targets are calculated in relation to the geographic landmark using the data computed by the navigation system.

These data are then stored in digital high capacity plugable hard disks inside the tactical console. From this stage there are several possibilities, which are either manual or automatic, sequential or simultaneous, as selected by the operator.These are:

- Display of the radar data on the CRT screen superimposed on a geographic map or satellite image background over several scales.
- Analysis by the operator : picture by picture display, renewed, accumulated, movie effect, change of background map, zoom, magnification...
- Data queuing for access to the data link terminal, and data transmission to the ground station, when the link is established.
- Exploitation : this function is described hereinafter,
- Mission conducting : monitors the correct running of the mission system, detects any discrepancy between the current situation and the planned situation, provides reversion to manual control, elaboration of mission progress messages.

On the ground, after data transmission, either continuously, or by packets, depending on the mission scenario and any losses in visibility, the operators can :

- analyse the pictures,
- exploit the data,
- monitor the progress of the mission and request any helicopter mission changes.

1.3.2 Exploitation chain

The exploitation consists in using the files of dots each corresponding to moving targets, to reconstitute the groups of mobiles by calculations based on compensation of localization errors and analysis of the consistency of the speeds and positions of the various mobiles.

This processing is performed in real time at each radar picture acquisition. Then the exploitation of successive pictures makes it possible to track a group, to predict the position of the group at a given date or the time of arrival at a designated point and to calculate flows on given road segments.

The exploitation principle is as follows :

- Calculation of the projection of dots onto the digital road network (VMAP), in accordance with adjustable parameters that are consistent with the localization error model.
- Calculation of true speeds (by projection of Doppler speeds onto road sections).
- Calculation of distance difference and speed difference between mobiles.
- Groups forming and calculation of characteristics: position, overall speed, number of vehicles.

This operation can be performed as many times as required using different settings. In particular, exploitation in the ground station may be performed simultaneously by several operators using different settings, thus allowing for enhancement of exploitation performance.

This method may seem rather theoretical; however, it has been assessed that groups are easy to track and that non-co-ordinated traffic is filtered out by this function.

The result of exploitation process is shown in figures 2 and 11.

1.3.3 Mission planning

In view of the large number of parameters which can affect the mission succeed probability or effectiveness (that are intervisibility between the helicopter and the ground station, visibility at the zone to be observed, optimisation of observation points locations and radar and data link settings, flight path), computer assisted mission planning provides a tremendous aid to the crew.

This process takes into account the meteorological and tactical situation data and the air traffic constraints. It makes use of NATO standard compliant cartographic data bases (raster maps, satellite photographs, altimetric data base) using CD ROM media. Paper map scanning is also possible, as backup function.

Mission planning is performed on the ground either from the ground station or the helicopter. Each entity is tuned on the other's mission by transfer of data via exchange of removable hard disks, or digital tape.

The result of mission planning operation is shown in figure 12.

1.4 Performance

The main system performance is given in figure 13.

2. THE PROGRAMME

2.1 Organization

The 3 main manufacturers of the Horizon system, namely Thomson CSF / Division Radars et Contre-Mesures, DASSAULT ELECTRONIQUE and EUROCOPTER have co-operated in the context of a DGA (French MOD) contract under a co-production scheme.

The organization chart is shown in figure 14

The DGA awarded EUROCOPTER the tasks of :

- industrial architect,
- integrator of the equipped helicopter
- supplier of some sub-assemblies, which include the basic helicopter and the operator consoles both for the helicopter and the ground station.
- Overall system performance responsibility

The industrial architect task covers :

- Co-ordination of the industrial activities, in particular the elaboration and management of the development plan,
- System engineering : functional analyses, consistency of the specifications and functional chains, technical co-ordination, management of technical events, non-compliance and concessions.
- Configuration control,
- Planning and execution of the system testing (equipped helicopter with ground station).

THOMSON /RCM (previously TCAR until December 97), is the contractor responsible for the TARGET radar and the "radar function" module of the OBOS/GWS software. This software module ensures the radar controls and the elaboration of the data files which are subsequently displayed, processed and transmitted to the ground stations.

DASSAULT ELECTRONIQUE is the contractor responsible for the ground stations, the AGATHA data link terminals, and the "data transmission" module of the OBOS/GWS software. This module ensures the data transmission control.

EUROCOPTER is responsible for cartographic, mission planning, mission control and exploitation software. MATRA Systèmes & Information is subcontractor for this software and overall operator console software integration.

The radar and data link equipment is specific, and is taken from the "Orchidée" programme which was shelved in 1990.

The Horizon programme therefore consisted in integrating equipment and software specific to the HORIZON mission requirement with off-the shelf equipment, such as the basic helicopter (required) and the consoles (selected for the purpose). Although predominant in terms of production cost and systems integration task, the basic COUGAR was considered in this programme as a simple component of the system, appearing at the 3rd level of equipment breakdown.

This approach was needed in order to ensure the continuity and the consistency of the processing chain , from the radar radiofrequency return, aboard each helicopter to the ground situation maps available at the ground station output.

2.2 Schedule

(see development and production programme in figure 15)

The development programme was spread over a period of around 3 years, and consisted mainly in developing the software for the consoles, the integration of the civil computer within a military environment and the integration of the radar, the console and data link together onto helicopter.

The integration programme was based upon :

- a helicopter to check correct operation of the radar and the data link,
- a mobile integration rig for the development and tuning of the acquisition and exploitation chains,
- a helicopter and a ground station for the respective integration of the equipped helicopter and the system.

The recurrent production work was performed very early on, so that the last helicopter was delivered just one year after the first one.

The system is currently undergoing its operational evaluation phase within the armed forces. It has taken part successfully in two major exercises:

- Interoperability demonstration between candidate ground surveillance systems for NATO, where the JSTARS and HORIZON airborne platforms and many ground stations were operated (june 1997).
- ODAX French Air Force exercise involving the Spanish, Italian and Portuguese air forces (june 1998).

2.3 Initial risks and events

2.3.1 Anticipated risks and difficulties encountered

The risks identified at the beginning of the development phase regarded:

- the integration within a single computer of real time software modules sourced from different suppliers,
- the behaviour of a civil computer in the military airborne platform environment
- the internal electromagnetic compatibility of the equipped helicopter.

In the event, the latter point did not cause any problems, but, some difficulties were experienced in relation to the other 2 risks :

- Problems of integration of real time software were experienced with certain functions but not with others ; these were the result not of overall design problems but the development method used by some lonely team, which were subsequently identified and resolved.
- The electronic protection of the consoles (bridging of components on boards, electrical and thermic requirements, electromagnetic protection chambers) all fulfilled their functions. Some minor integration problems were

encountered. However, these were accentuated by their unusual nature due mainly to the different industrial culture between the aircraft manufacturer and the civil equipment suppliers. With hindsight, one can question the wisdom of maintaining certain temperature and supply voltage monitoring functions, which are perhaps too "protective" and therefore have sometimes generated unnecessary computer safety shut-downs.

- The open software architecture and the great operational flexibility make it possible to run the system under extremely varied modes within and beyond the operational requirements. This sometimes leads to unexpected behaviour, which can disturb the operator, or cause computer misrunning. An improvement is being implemented.

2.3.2 Main difficulties expected

These episodes having been cleared, the current foreseeable difficulties regard the obsolescence of the components, in particular the civil components, the perenniality of system know-how within the industry in order to provide the long-term maintenance, develop upgrades and provide optimised logistic facilities. This latter must enable non-specialised military operators to undertake troubleshooting and unit exchange with high effectiveness.

These activities will be conducted using the same « system approach » as was used during the development phase.

3. ENHANCEMENT OF THE SYSTEM AND NEW VERSIONS

3.1 Potential for enhancement

There is potential for technological enhancement, due to the rapidity of progress in digital technology. This regards several areas :

- Radar : modernisation of the processor enables new modes to be considered, together with a reduction in volume and weight.
- Data link: modernisation enables reductions in cost and volume to be considered at the same time as an increase in the data rate.
- Console : the advances made with the products on the market result in a huge increase of the storage capacity and the computing power.

However, this potential is directly linked to the obsolescence of components and the changes may sometimes not be limited to the simple plug to plug replacement of certain components or modules.

3.2 C^{3}I integration

The Horizon system already includes means which provide interoperability between the French and NATO systems : encrypted and protected voice communications are provided with ground assets , with AWACS or with other combat aircraft , either fixed or rotary wing (via PR4G and SATURN).

Transmission of data using these means can be envisaged in the short term. The relevant system engineering activity is in progress, and the system development potential makes it already possible.

In the longer term, (the studies will be starting shortly), data communication using even higher performance means such as MIDS LINK 16 and satellite links will provide more efficient interoperability, in terms of distance and connected assets, thus providing mutual operational benefits.

The ground stations will be integrated into command and intelligence networks via wire, optic fiber (Local Area Networks) or radio frequency links (Wide Area Networks).

As an example, the interoperability concept proposed to NATO in 1997 for their specific AGS (Alliance Ground Surveillance) core fleet is shown in figure 16.

C^{3}I integration equally involves upgrading of the operational functions which will principally mean upgrading of the software for the consoles. These upgrades regard the data formats, the types of exploitation results, the ability to automatically perform unscheduled observation requests, a broader range of helicopter / ground-station operating combinations, broadcast data transmission, fusion of data from other sensors (either included in the system or borne by other assets) etc...

3.3 Other sensors and processing means

This system, whose major components are a sensor, a helicopter, a tactical console a data transmission system and a ground station, fulfils a crucial operational mission for a military commander. Providing that this combination works well and that new military requirements are expressed, it is reasonable to envisage integration of additional sensors, associated with monitoring, processing, and data fusion means. For instance :

- Sensors : radar additional modes : sea mode, already in progress, SAR (Synthetic Aperture) mode, IFF interrogation of aircraft, electronic intelligence.

- Conducting and processing : additional consoles in the helicopter cabin, a smart terminal in the cockpit, data fusion, on-board "command and control" targeting functions.

Many combinations are theoretically feasible. The number of combinations to be offered will depend on the operational requirements, the compatibility between sensors and other means and the helicopter carrying capability.

3.4 Export derivatives

In the context of export, depending on the customers concerned, different requirements may have to be satisfied : more complex requirements and at the opposite costs minimization. Anticipations are being made with our industrial partners to build a range of systems based on the same core, including capabilities for complying with various customized requirements. The most advanced and ambitious version in that range is probably the one which has been proposed to NATO in the frame of the AGS (Alliance Ground Surveillance) Request For Information issued in 1997.

The architecture of the airborne mission system proposed to NATO is shown in figure 17.

MTI superimposed on raster map

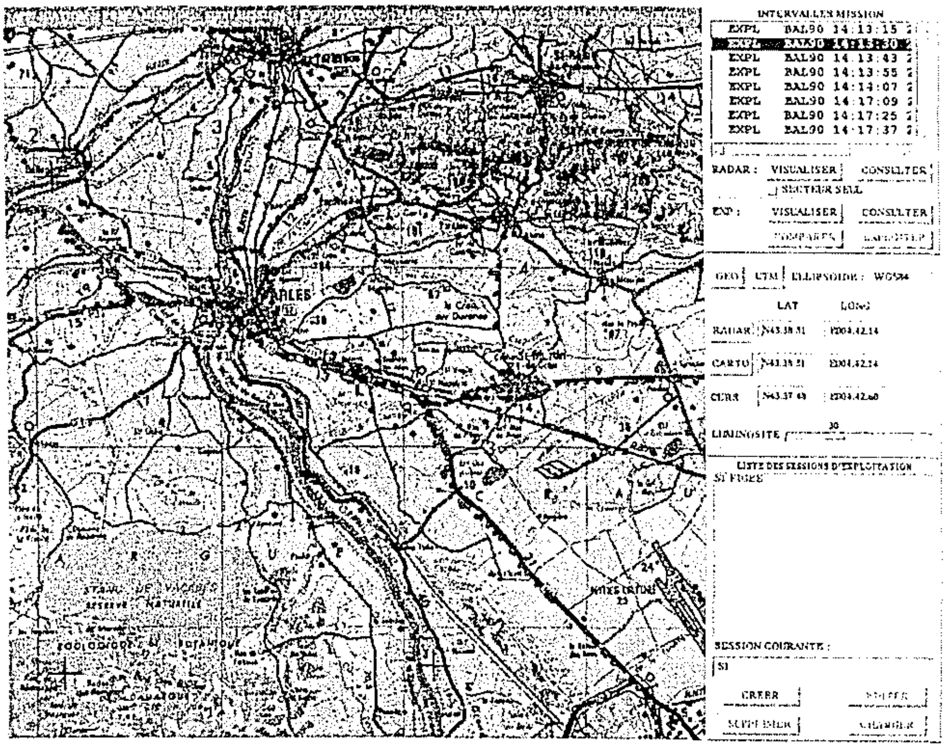


Figure 1

Groups tracking

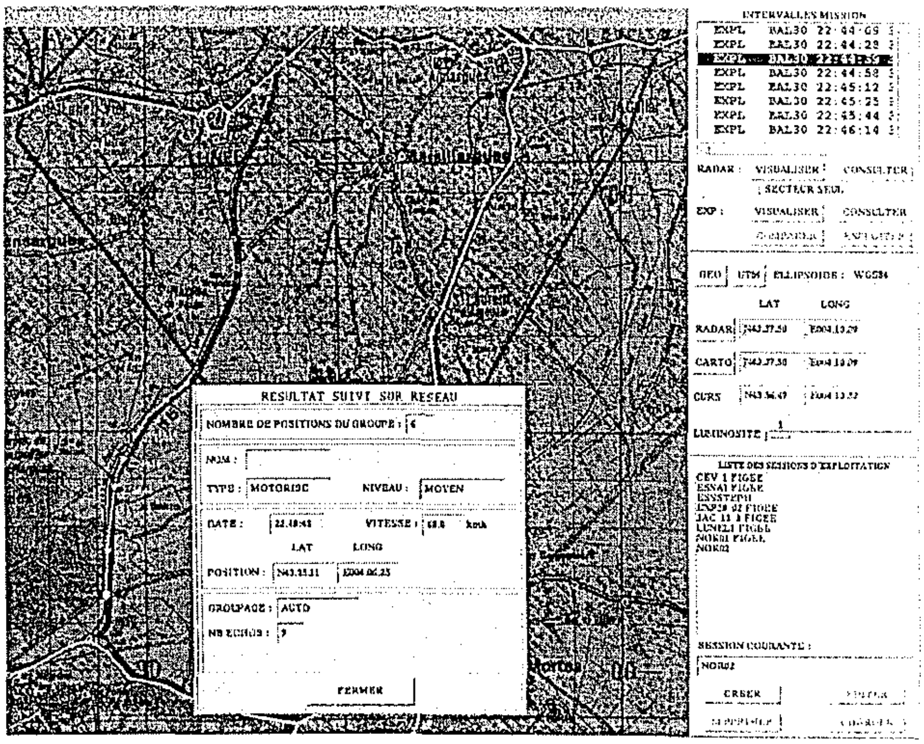


Figure 2

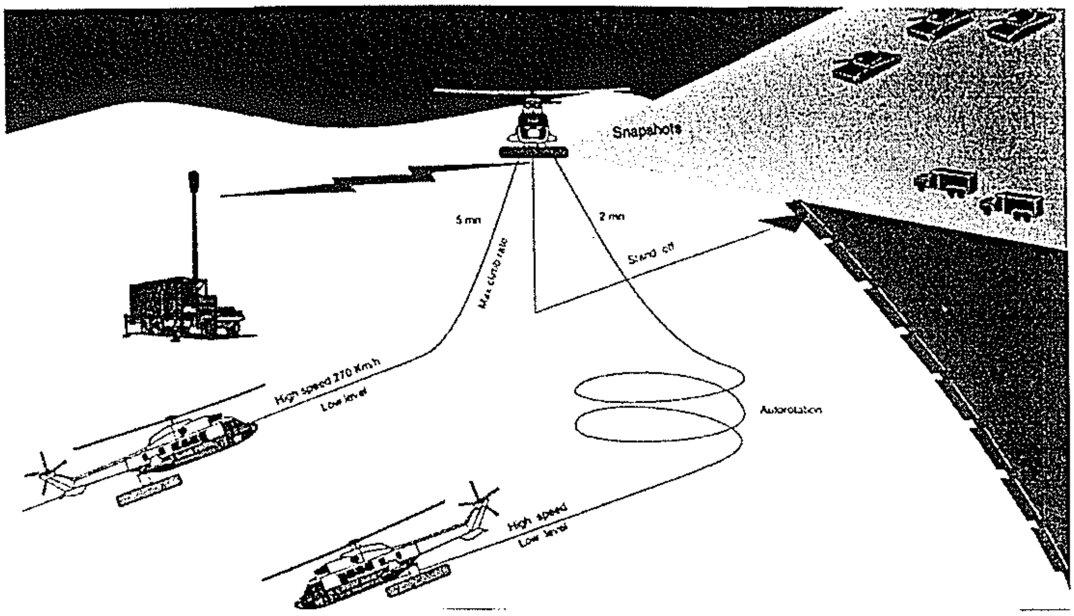


Figure 3

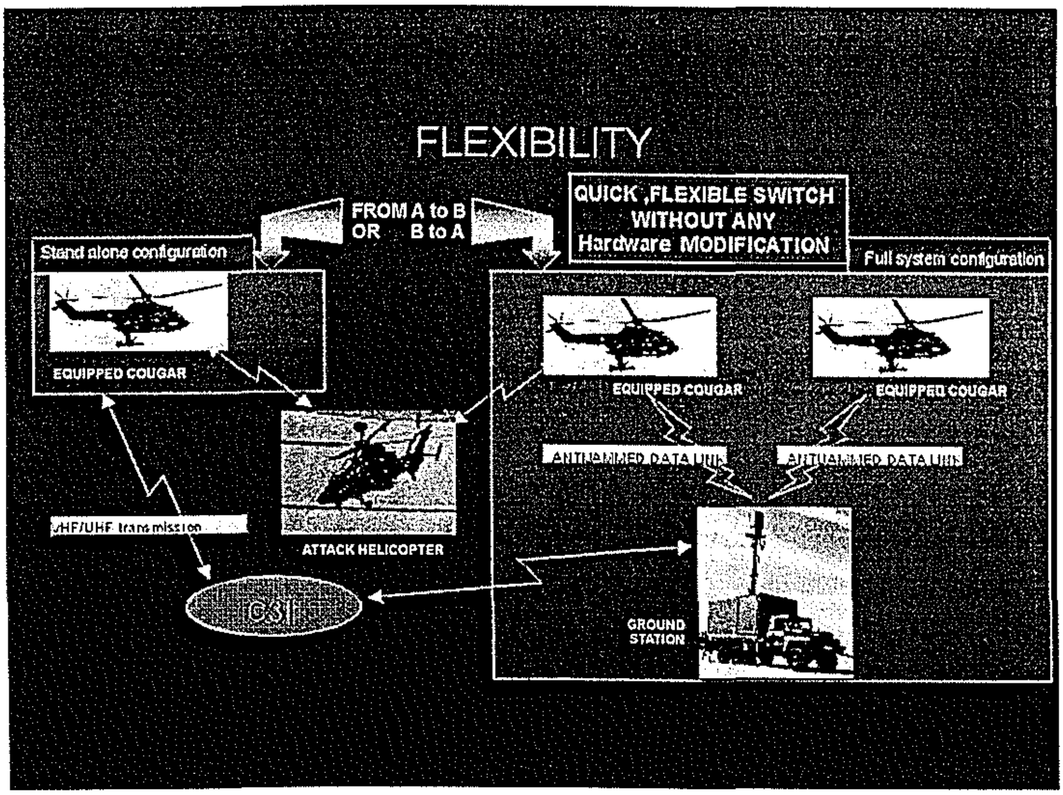


Figure 4

Figure 5

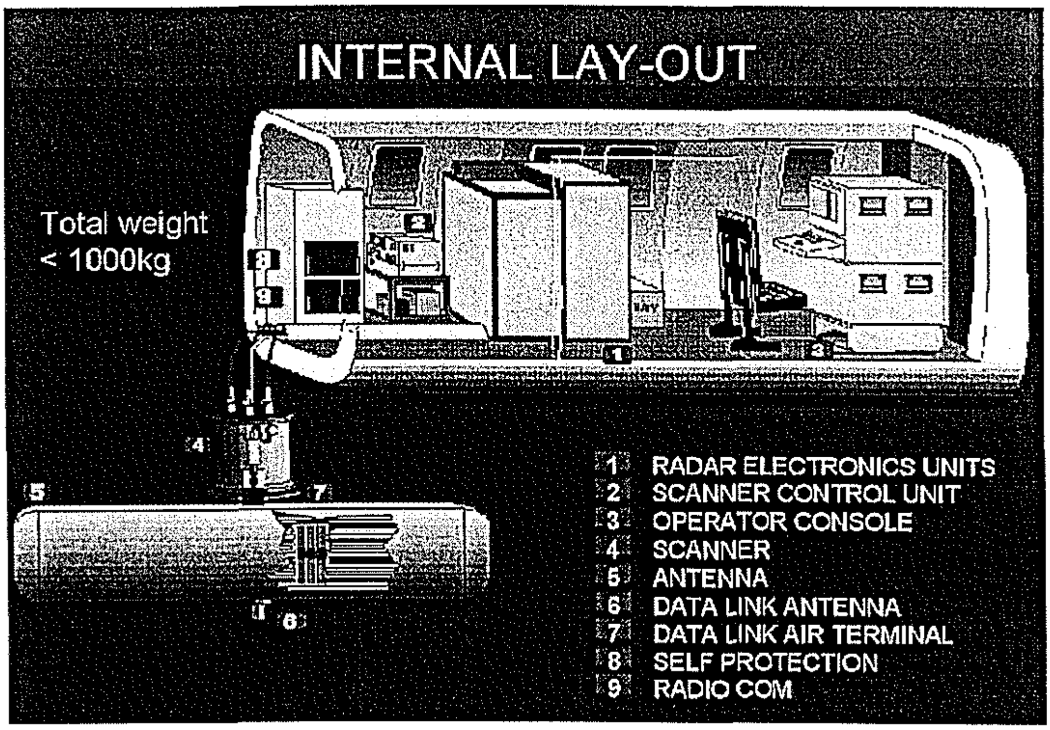


Figure 6

Observation and exploitation Airborne Workstations: AOW

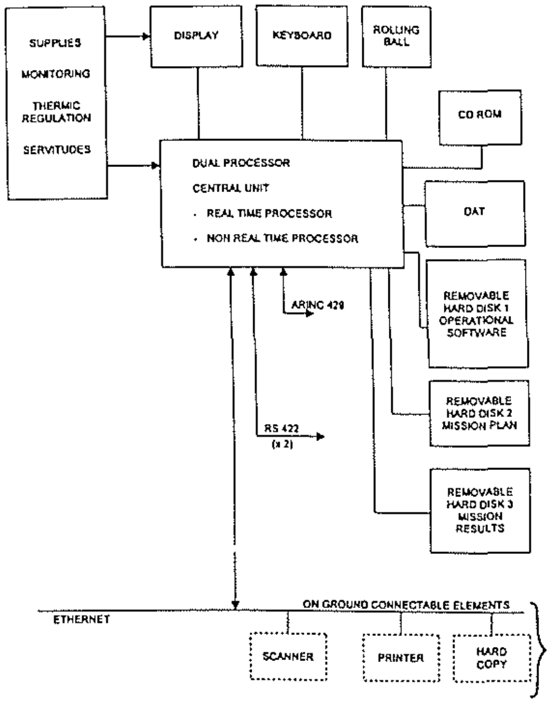


Figure 7

DATA PROCESSING BLOCK DIAGRAM

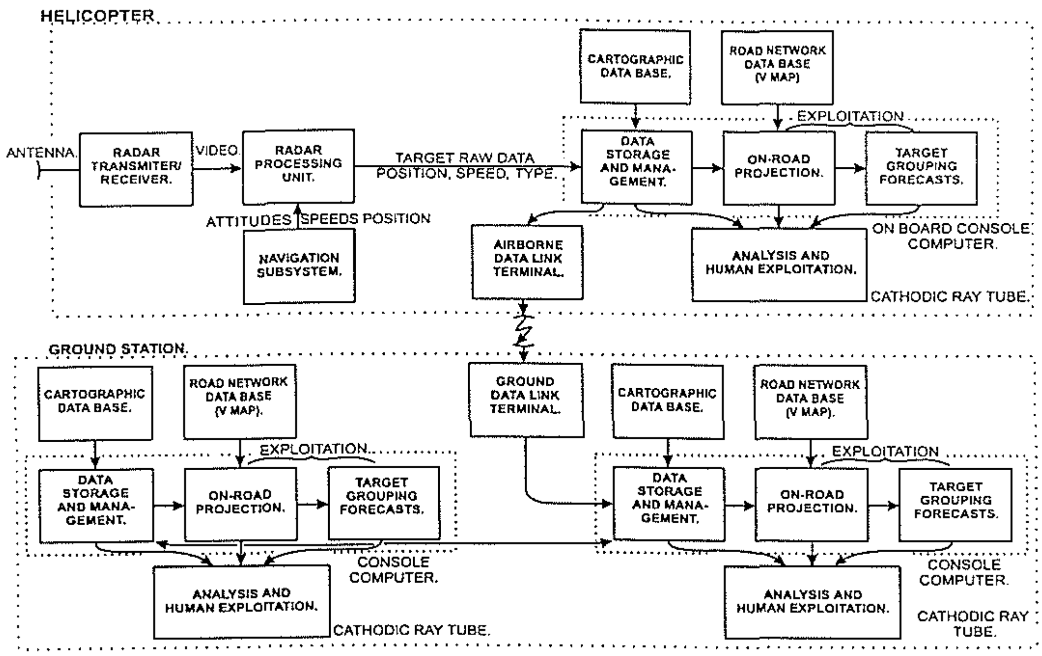


Figure 10

Figure 8

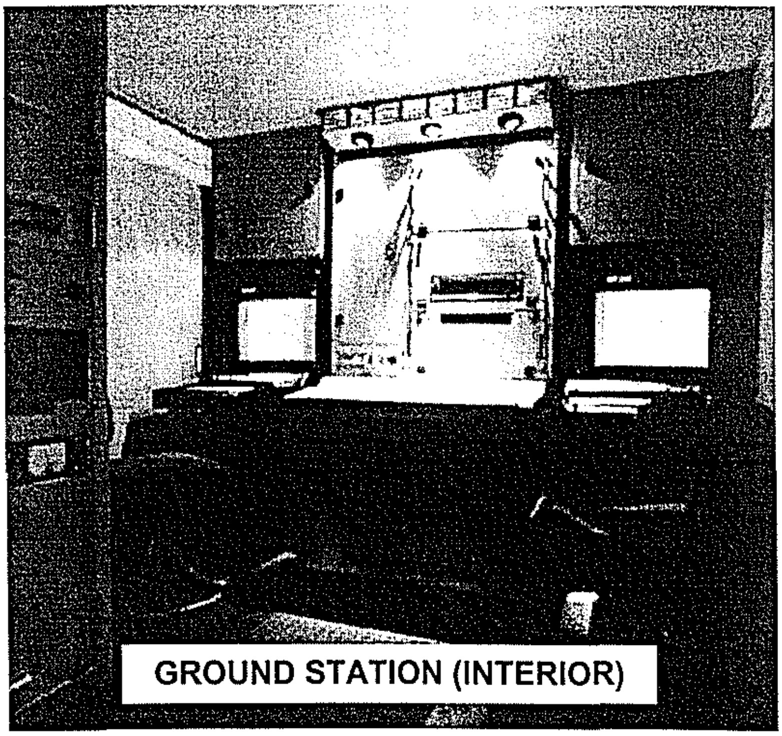


Figure 9

Data exploitation

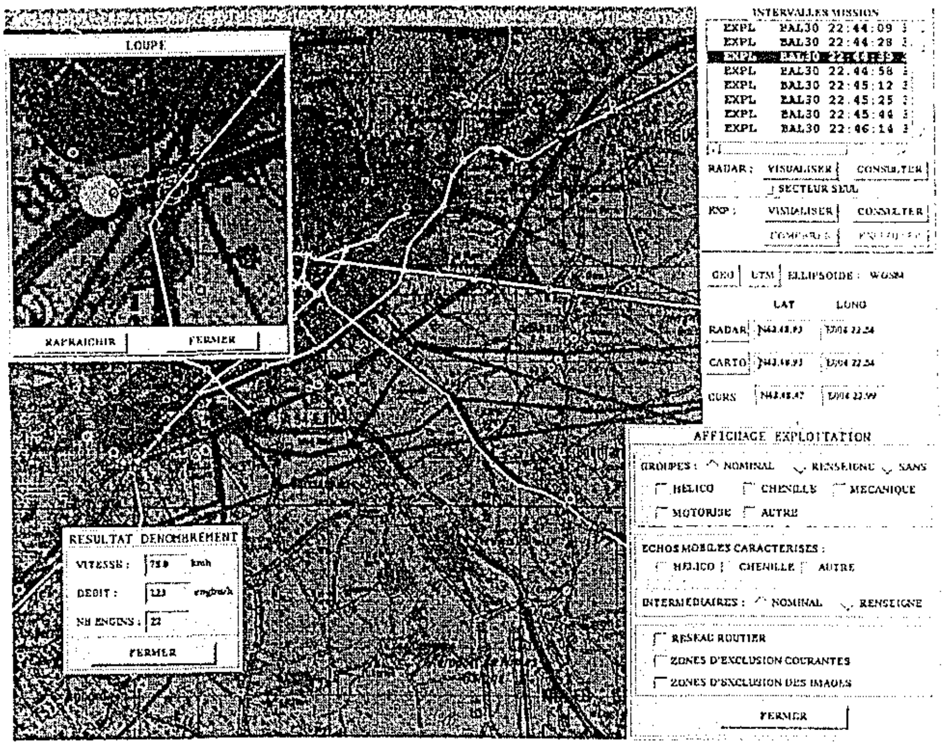


Figure 11

Mission planning with terrain profile

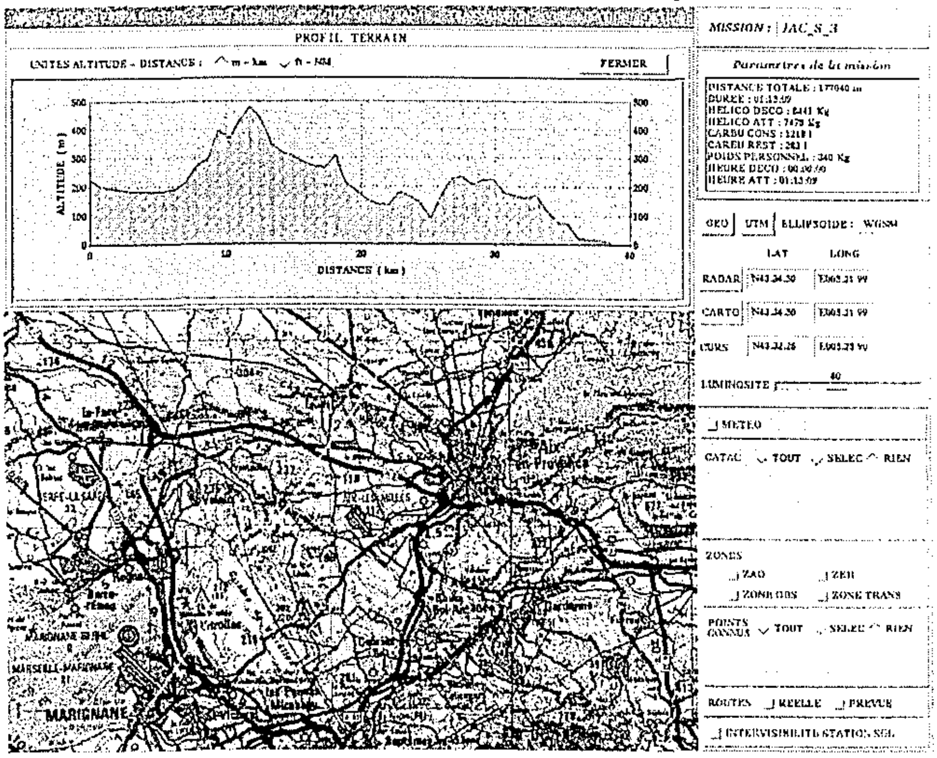


Figure 12

PERFORMANCE

Characteristics

COUGAR helicopter

- Twin engine
- Max take-off weight
  - int. load 9,000 kg – 21,494 lb

• Airspeed *	
- cruise	270 km/hr
- during observation period	180 km/hr
• Vertical speed * (climb)	10 m/s
• Altitude *	4 000 m
• Mission time *	4 hrs
• Ferry flight range *	1 000 km

* in HORIZON configuration

TARGET Radar

- All digital MTI Doppler radar
- X band, Frequency agility
- Broad band transmitter
- Ultra low side-lobe flat antenna
- Mechanical and electronic scanning
- High protection against ECM and ARM
- Terrain coverage

• Range	- (clear weather)	200 km
	- (rain and clouds)	150 km
• Resolution	- range	40 m
	- velocity	2 m/s
• Scanning	- sector width	Up to 360°
	- sector axis	Any
	- rate	2 - 4 or 8°/s
		20 000 km² in 25s

AGATHA Data link

- All digital equipment
- Ku band
- High protection against ECM

• Frequency hopping	
• Data rate	Up to 0,5 Mb/s
• Range	Up to 150 km

Ground station

- 6-wheel, 5-ton truck
- 15 kVA power generator
- 10-ft shelter in 15-ft frame
- Air conditioning
- 2 ruggedized workstations with :
  - 19" colour display
  - 3 removable hard disks
  - ETHERNET interfaces
- Peripherals :
  - B&W laser printer
  - Colour hard copier

Operator console

- Real time data acquisition, mission conduct and exploitation
- Data storage capacity : more than a complete mission at maximum sector aperture

Figure 13

INDUSTRIAL ORGANIZATION

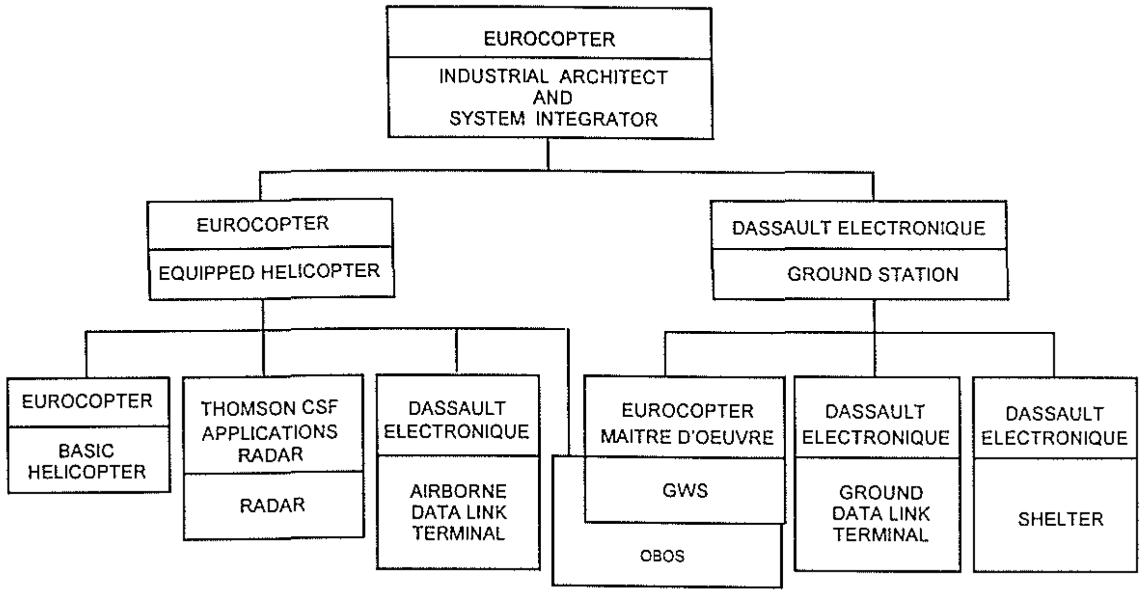
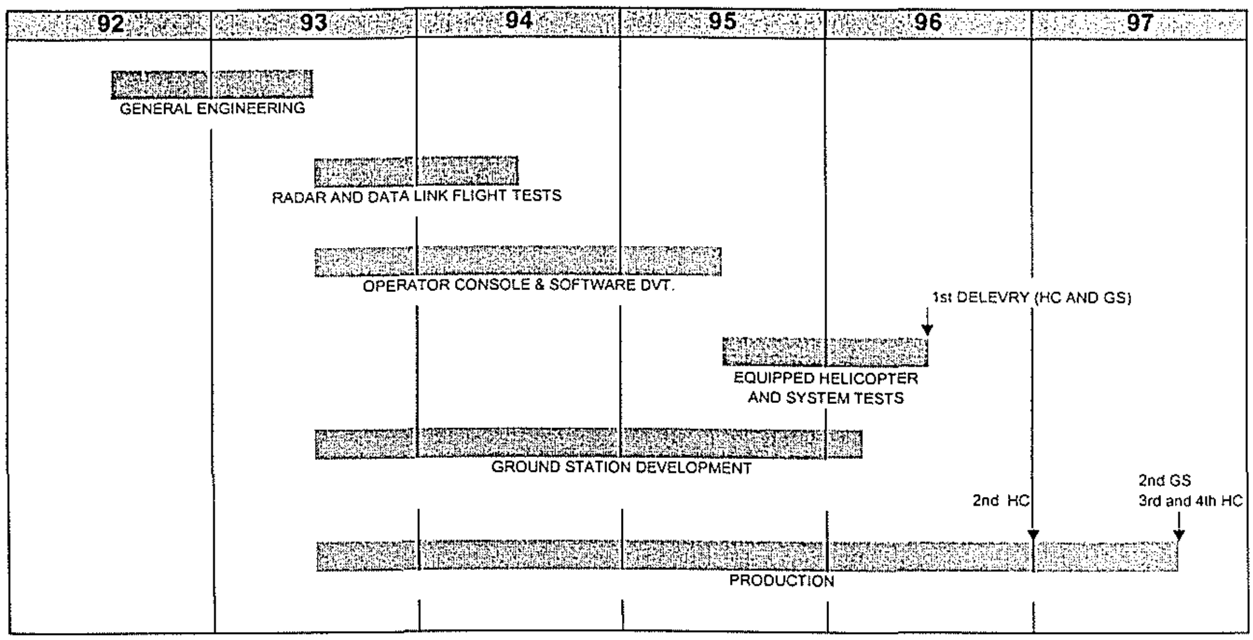


Figure 14



DEVELOPMENT AND PRODUCTION PLAN

Figure 15

HORIZON FOR NATO AGS

HORIZON INTEROPERABILITY WITHIN A.G.S.

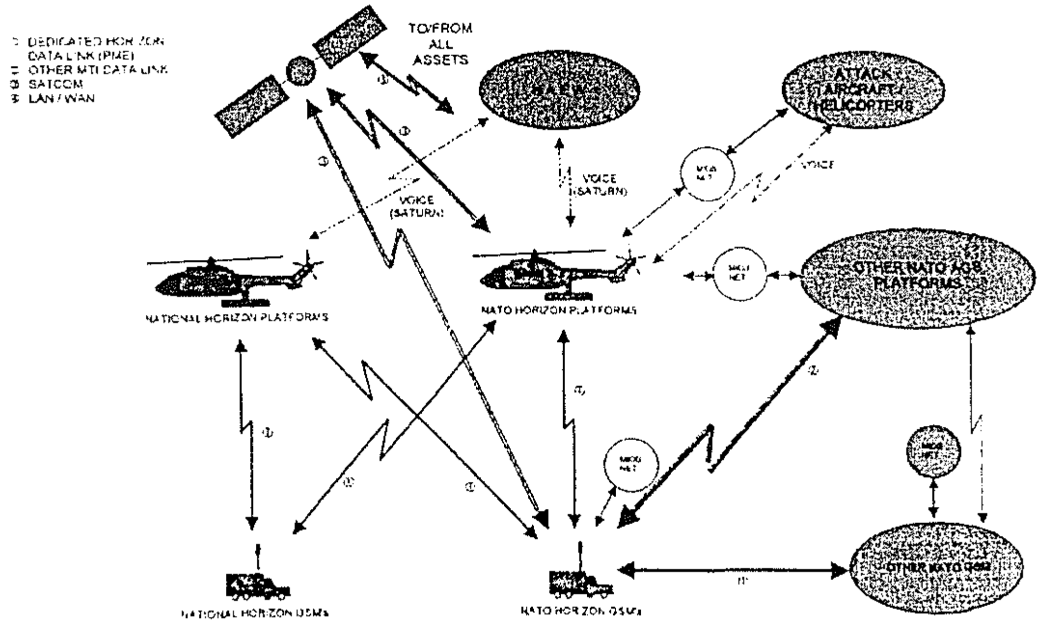


Figure 16

HORIZON AGS - AIRBORNE MISSION SYSTEM

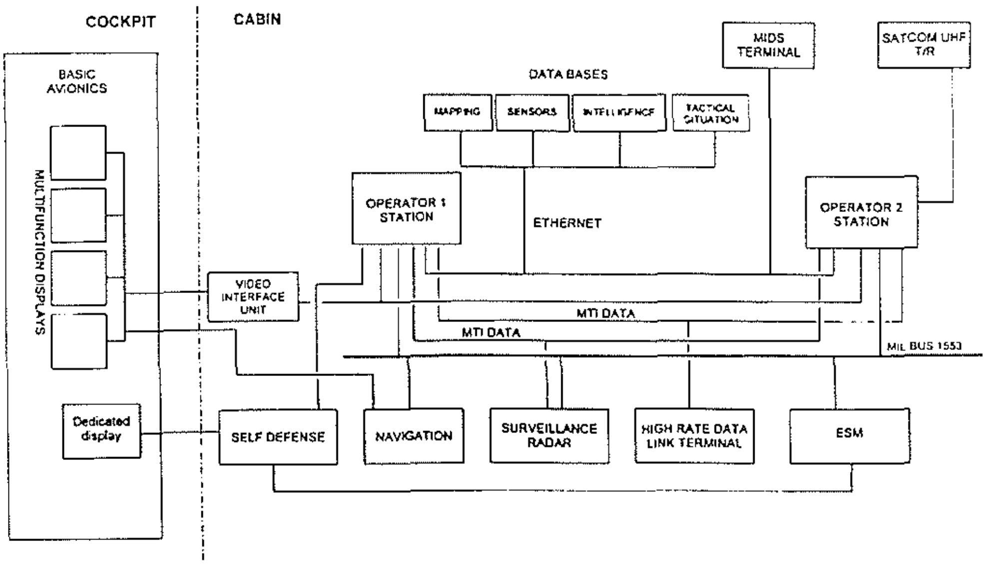


Figure 17