NINTH EUROPEAN ROTORCRAFT AND POWERED LIFT AIRCRAFT FORUM

Paper No 102

THE DEVELOPMENT OF THE NAVY VARIANT OF THE DAUPHIN II HELICOPTER

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September 13 - 14 - 15, 1983

Stresa, Italy

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ABSTRACT

AEROSPATIALE'S SA 365 DAUPHIN is a new generation 4-tons helicopter. It has been designed to meet civil and military operator's requirements in various configurations.

The civil version, SA 365 N, has been in service since 1981 ; it is particularly well suited for passengers' transport or offshore missions.

This multipurpose helicopter is easily adapted to military roles. The naval version, SA 365 F, was developed in 1981 and is being delivered now.

SA 365 F is available in several configurations for Search and Rescue (SAR), Anti Surface Vessel Warfare (ASV) and Anti Submarine Warfare (ASW) missions.

The purpose of this exposé is to review the main characteristics of these various configurations and to discuss the development of this helicopter.

1 – MAIN CHARACTERISTICS OF THE BASIC SA 365F HELICOPTER

SA 365 F retains most of the AS 365 N's mechanical components and airframe ; it also includes the latest technological advances existing on this helicopter and, in particular :

– Main rotor aerodynamics :

OA2 profile blades of relative thickness evolving from 12 % at root to 7 % at tip, sweptback blade tip.

– Extensive use of composite material on main rotor (blades, STARFLEX main rotor hub) and fuselage accounting for as much as 25 % of the helicopter's empty weight.

Composite materials certainly reduce empty weight, simplify maintenance and improve corrosion resistance.

Limited modifications were however necessary to adapt the DAUPHIN to navy missions and permit operations from low tonnage ships.

The main modifications summed up on Figure 1 can be divided into 4 headings.

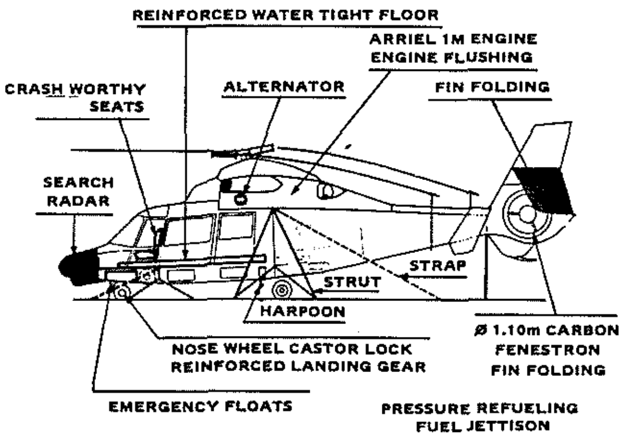

Fig. 1 SA 365 F MAIN FEATURES

1.1 – Improvement in performance

Installed power was increased and the fenestron tail rotor was redimensioned to improve performance.

ARRIEL 1M engine :

This engine replaces ARRIEL 1C and its rating is perfectly adapted to navy operation.

- Take-off power (5 min.) : 522 kW (instead of 492 kW). This power increase allows taking off at 4 tons all-up weight up to ISA + 25^{o} C.

- Max. continuous power : 486 kW (instead of 437 kW) is especially useful for extended hovers (Sonar dunking, sea rescue missions). Should an engine fail, the pilot can furthermore use the 580 kW OEI rating for one minute. This gives him time to release the stores and jettison fuel immediately after engine failure so as to lighten the aircraft and return to ship.

Fenestron tail rotor : (see Fig. 2)

The helicopter takes off from the ship's deck in heavy and turbulent winds making directional control very difficult.

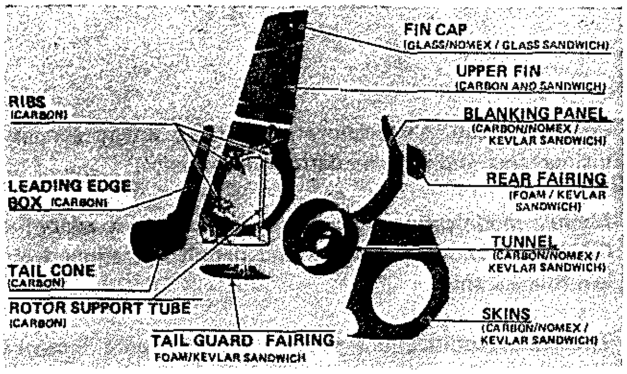

Fig. 2 SA 365 F CARBON FENESTRON ASSEMBLY

That is why AS 365 F has been fitted with an enlarged 1.10 m Dia fenestron tail rotor (Fenestron tail rotor diameter is 0.90 m on AS 365 N).

Carbon / epoxy resin were used to enlarge the fenestron without weight penalty. Since aerodynamics were, as a consequence, improved, this new fenestron increased the useful load by 100 kg while retaining the same installed power level.

1.2 — Improvement in deck landing performance

The DAUPHIN is equipped with a tricycle landing gear (see Fig. 3) ; the wheels are retracted in wells partially closed to reduce drag in cruise flight.

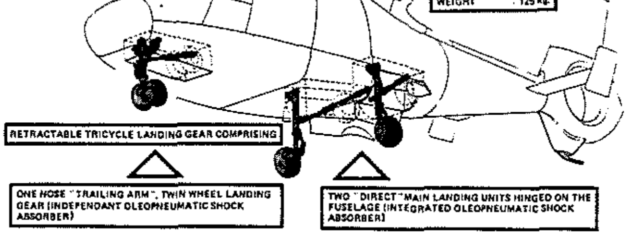

Fig. 3 SA 365 F LANDING GEAR

This landing gear has proved well adapted to operation from ships when some local reinforcements necessary to withstand higher impact speeds upon deck landing (Compliance with standard AR 56) were embodied.

A hydraulic harpoon (See Fig. 4) has been installed between the main landing gear's wheels to increase aircraft stability immediately after deck landing and before take-off. This harpoon is secured, upon pilot's order, to a grid integral with the ship's deck and applies a 1500 daN force to pull the helicopter against deck.

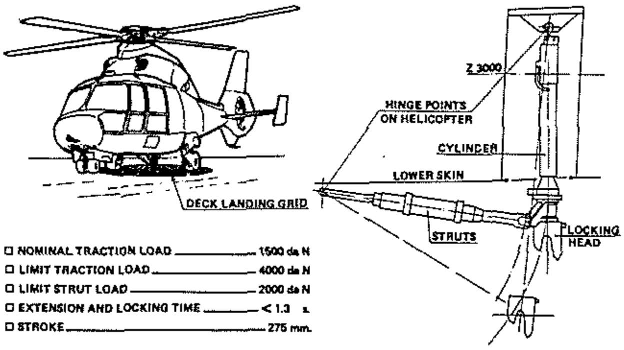

Fig. 4 SA 365 F QUICK MOORING HARPOON

This harpoon already developed on ALOUETTE and LYNX has successfully been experimented with DAUPHIN during recent deck landing trials on a French Navy ship (See Fig. 5).

Fig. 5 SA 365 F LANDING TEST ON A FRENCH NAVY SHIP

112 deck landings were attempted with 11^{o} roll and 2^{o} pitch movements of the landing pad and relative winds up to 50 knots. As the harpoon is positioned between the main landing gear's wheels, the helicopter could be rotated with the tail rotor.

1.3 — Crashworthiness

The landing gear is depressed to absorb energy up to 3.05 m/s vertical impact speed upon hard landing ; crashworthy tanks resistant to 14 m/s vertical speeds impacts have also been installed to improve deck landing safety.

Crew seats and their attachments to cabin floors have also been reinforced.

1.4 — Ditching safety

The helicopter can be fitted with an emergency floatation gear built into the fuselage to avoid aerodynamic drag.

As compared to the civil version AS 365 N, two rear floats were removed and the tail boom was sealed to save weight. (See Fig. 6).

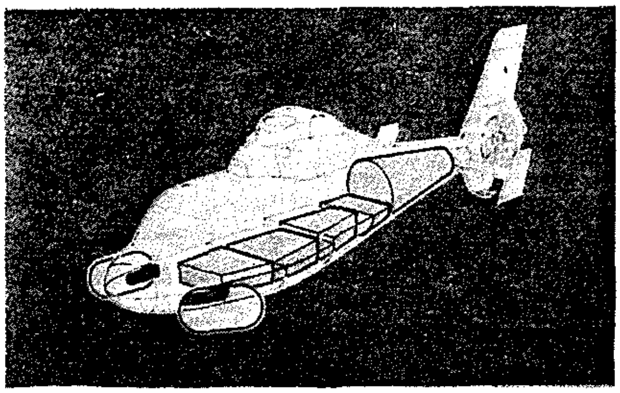

Fig. 6 SA 365 F EMERGENCY FLOATATION GEAR

2— SAR VERSION

Apart from conventional equipment such as : hoist, search light, radio navigation and radio communication, the SAR version has been fitted with :

- A self contained navigation subsystem operating from the CROUZET Nadir computer
- The SAR A.P. coupler connected to the autopilot SFIM 155
- The search radar.

Development of the above listed equipment has just been completed on AS 365 F ; the main characteristics of this equipment are detailed hereunder.

2.1 — Self-contained navigation subsystem

The self-contained navigation subsystem operates from the NADIR computer which is, in turn, connecting to the following sensors :

- A doppler radar ESD CINA B calculating ground speed.
- An air data base CROUZET BCP 44 calculating true airspeed.
- A gyromagnetic compass SFIM CG 130.

This subsystem was accurate within 2 % during flight tests.

Apart from the Doppler mode, **three additional navigation modes** are also available on the Nadir computer :

- OMEGA radio navigation
- VOR/DME radio navigation
- Dead reckoning, in standby mode, using heading and true airspeed data.

Conventional navigation parameters are maintained in the above modes and can be called up by the crew.

These parameters include :
Present position, ground speed and track, wind direction and speed, distance and way point bearing, heading, desired track, drift angle, etc ..

The computer can store 140 waypoints in protected memories. 10 routes including 10 waypoints each can be defined with these memories.

Flight management includes the following functions :

- Check list
- Fuel management : fuel consumption per kilometer, flying time and range, remaining fuel contents, fuel quantity necessary to fly to selected waypoint, etc ...
- Performance calculation with one and two engine operating.
- Helicopter monitoring.

Calculation of air data parameters

- Altitude
- True airspeed
- Static and total temperature.

Connections with the system

- Autopilot guidance along a selected route or a predetermined path.
- Search radar
- Flight director
- Navigation indicator
- Map display indicator
- etc ...

Most navigation functions as well as connection with autopilot were validated in flight on AS 365 F during the first quarter of 1983.

2.2 — A.P. coupler SFIM CDV 155

The coupler SFIM CDV 155 is a fully digital 4-axis coupler of dual lane architecture on the collective pitch channel ; this coupler was developed in cooperation between SFIM and AEROSPATIALE.

The following operating modes have been provided on this 4-axis coupler.

- «Civil» modes :

HDG	Selected heading acquisition and data hold
NAV	Route capture and tracking, data being supplied by NADIR or OMEGA VOR navigation computer
BAR-ALT	Hold of a present baro altitude
A/S	Airspeed Hold - The pilot can modify the data with the beep-trim
ILS	LOC - ILS Localizer capture and tracking B/C Back Course - ILS Localizer capture and tracking GLIDE - ILS - Glide Slope capture and tracking
VOR - A	Capture and tracking of an approach route

- «Offshore» modes :

T - DWN	Automatic transition down from cruise to a hover at a selected radio height
T-DWN NAV	Automatic transition down with data provided by the navigation system - Distance to the target and route
HOV-HT	Acquisition and hold of a selected radio height (40 to 300 ft)
HOV OR GSPD	Acquisition and hold of the Doppler hover. The crew can modify the VX and VY data with the beep trim or the winchman's joystick
CR-HT	Acquisition and hold of a selected radio height (12 to 5000 ft)
T-UP	Automatic transition up from hover to cruise
GO AROUND	Automatic acquisition of a preset airspeed and a climb speed
FL UP	«FLY UP» mode engaging automatic climb when radio altitude drops beyond safety threshold.

The T:DWN NAV mode permits hovering above a point which coordinates have been stored in the navigation computer.

This mode can be used to save rescuees as shown on Fig. 7 and 8.

In this case, the navigation computer gives steering orders to coupler CDV 155 to approach the wreck against the wind. The computer determines the point where automatic transition to hover is to be initiated and gives corresponding orders to the coupler.

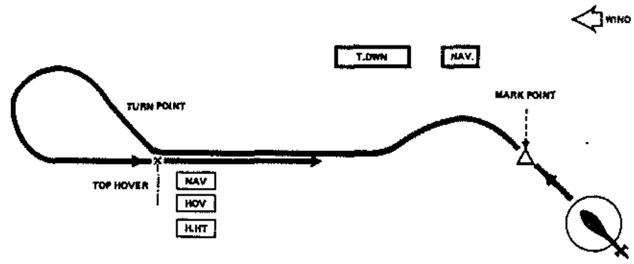

Fig. 7 APPROACH OF A MARKED POINT

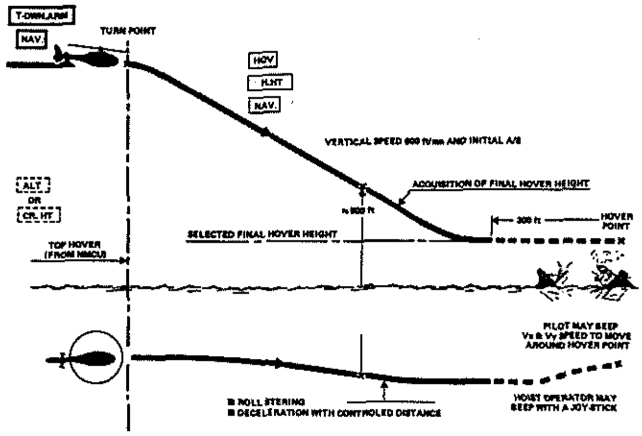

Fig. 8 AUTO T D WITH NAVIGATION

These various modes have now been validated in flight, the «civil» modes are those of coupler CDV 85 previously developed on AS 365 N, the «offshore» modes were developed and validated on AS 365 F.

2.3 – Radar

Two search radars are offered on SA 365 F.

RADAR ORB 32 OMERA with the following functions :

- Maritime surveillance
- Search and rescue at sea
- Navigation
- Weather

The radar equipment installed on helicopter includes mainly

- An antenna in the helicopter's nose (scan angle : 240°) with a stabilized line of sight (stabilization amplitude : ± 20°)
- An electronic bay installed behind copilot's seat in the cabin.

A 9" across TV display installed on instrument panel and capable of the following modes and functions :

- Radar image stabilization in azimuth and elevation, image stabilization with respect to ground (fixed image)

- Ranges covering 3 to 200 Nm
- 2 designation markers that can be moved with a joystick.

ORB 32 is a military type search radar (it is used in the EXOCET system) capable of detecting small targets from great distances.

Radar BENDIX RDR 1500

The antenna (Antenna scan angle : 60° or 120°) and electronic units are installed in the helicopter's nose. The colour indicator is located on the instrument panel between pilot and copilot.

Radar functions are :

- Search and rescue
- Precision ground mapping
- Beacon navigation
- Weather avoidance.

The radar colour indicator is a T.V. screen 7" across. The range selected varies between 26 Nm and 160 Nm.

The radar operator (copilot) moves a marker with a joystick to designate the target ; target data can be directly transmitted to the navigation computer.

2.4 – Instrument panel

Two versions of the SAR system are offered of SA 365 F :

- Conventional electromechanical instruments are used on the first version
- The second version operates with polychromic multimode CRTs.

2.4.1 – Conventional instrument panel

This SAR system's wiring is also conventional and the interconnection diagram is presented on Fig. 9.

The instrument panel's architecture is presented on Fig. 10 and it can be seen that the radar operator's role of the copilot has been emphasized.

Should the pilot be incapacitated, the copilot retains every piloting and navigation data necessary to ensure flight safety.

This instrument panel is installed on the first helicopters being delivered now.

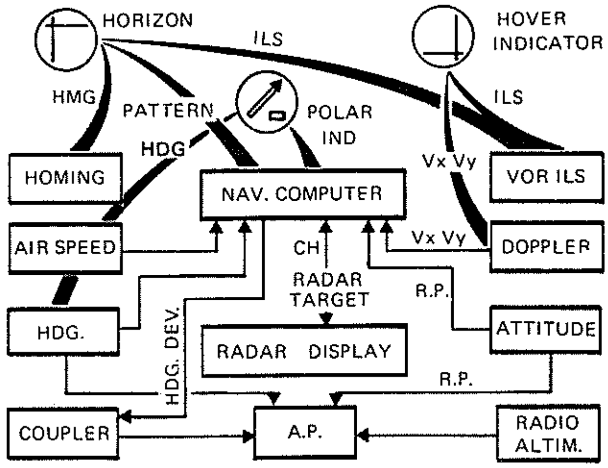

Fig. 9 SA 365 F SAR SYSTEM– INTERCONNECTION– CONVENTIONAL WIRING

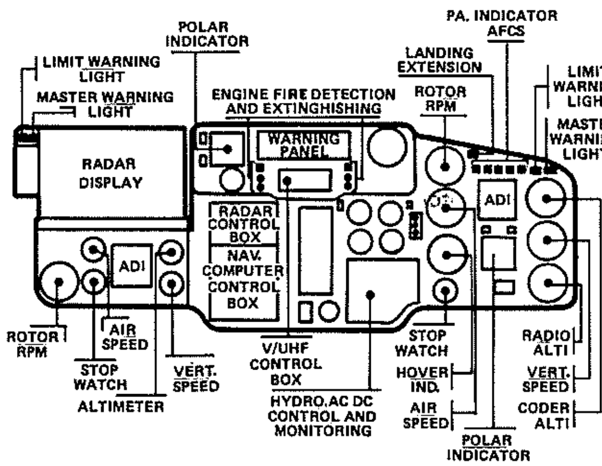

Fig. 10 SA 365 F INSTRUMENT PANEL ELECTRO–MECHANICAL FLIGHT INSTRUMENTS

2.4.2 – Polychromic CRT instrument panel

This instrument panel is under development.

Data is displayed symmetrically to pilot and copilot on two 5" x 5" CRTs (one EADI and EHSI) (See Fig. 11).

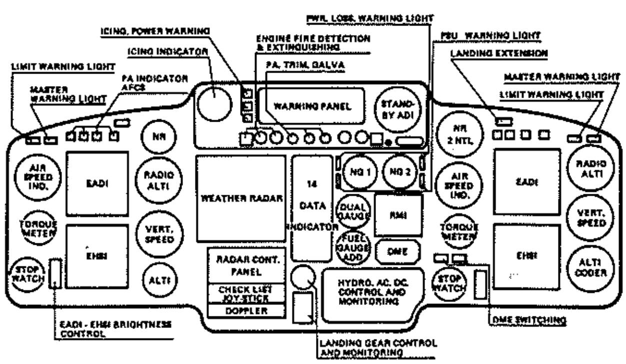

Fig. 11 SA 365 F INSTRUMENT PANEL MULTIFUNCTION DISPLAY CONFIGURATION

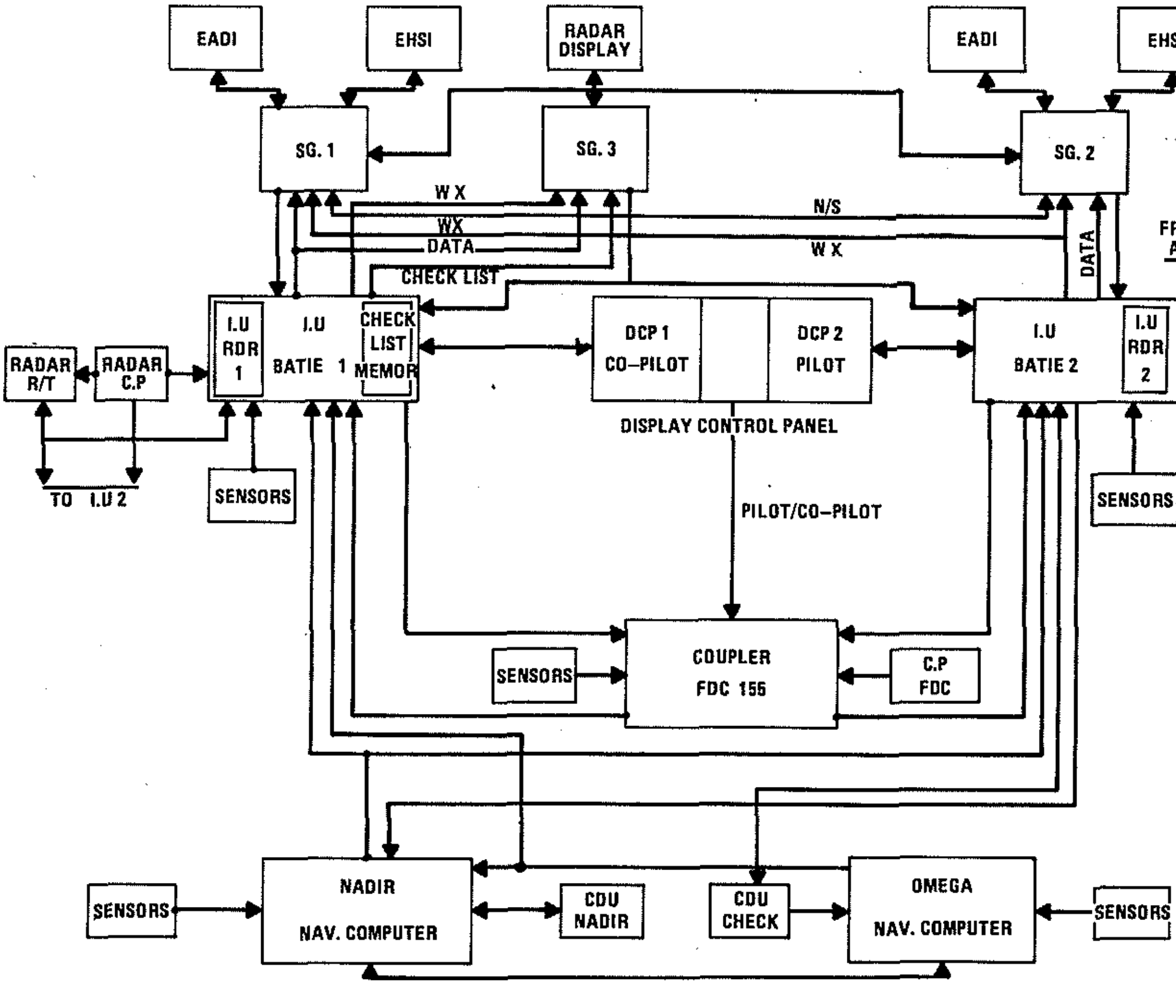

Fig. 12 SA 365 F SAR SYSTEM INTERCONNECTION MULTIFUNCTION DISPLAY CONFIGURATION

The helicopter's monitoring parameters are displayed on conventional indicators. A horizon, an electro-mechanical standby RMI and a DME indicator have also been provided.

A radar screen and control unit have been installed in the center section of the copilot's instrument panel.

Data is fed to the EADI and EHSI assemblies by two separate subsystems as shown on Fig. 12, these subsystems include :

- An interface unit formating data from the sensors, managing interfaces with navigation computers, coupler CDV 155 and radar, assessing and formating data to be displayed ; this data is transmitted to
- A generator processing the symbols used.

The radar screen is equipped with its own symbol generator.

Display modes are managed and selected separately on pilot/copilot screen and on radar screen with a dual control unit installed in console and accessible to pilot and copilot.

Should one of the subsystems fail, the data processed by the operating subsystem can be transmitted to the pilot's and copilot's screen.

Connections between the various elements of the subsystem proceed through ARINC bus bars.

The display modes available are :

EADI :

ADI mode only (See Fig. 13) presenting the following additional information : Recall of the coupler CDV 155's modes engaged or set, radio altitudes, collective pitch channel, fuel warnings, LOC, ILS and flight director data.

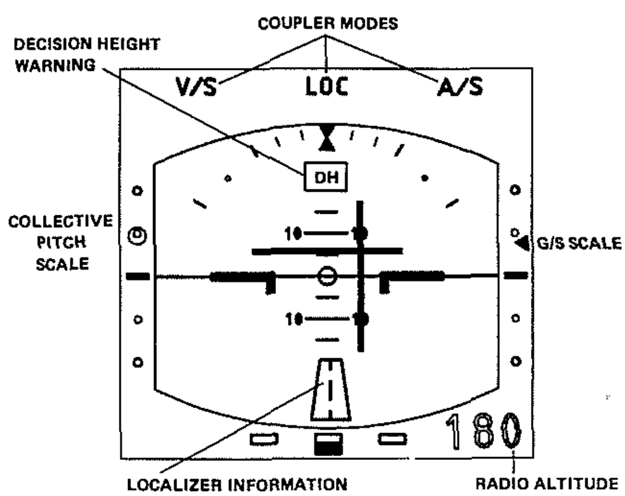

Fig. 13 E A D I SYMBOLOGY

EHSI :

The crew can select the following modes :

– HSI mode (See Fig. 14) presenting mainly a heading nose and HSI type display ; a GLIDE/SLOPE scale as well as the MARKER data can also be displayed.

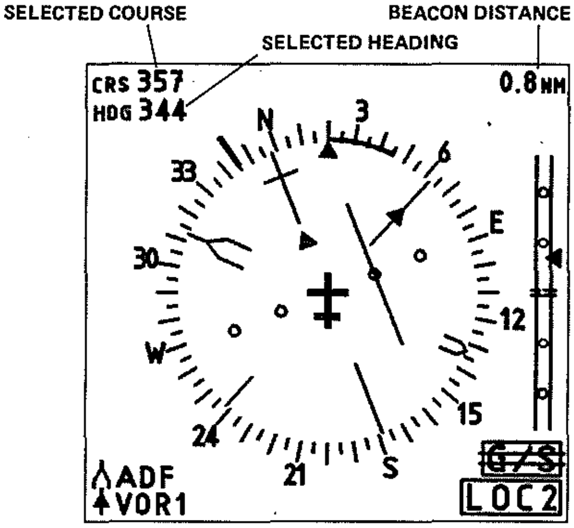

Fig. 14 E H S I SYMBOLOGY H S I MODE

– «Sector mode» (See Fig. 15) displaying a 120° sector of the heading rose, the route to be followed, the helicopter's position with respect to this route and, if necessary the radar image.

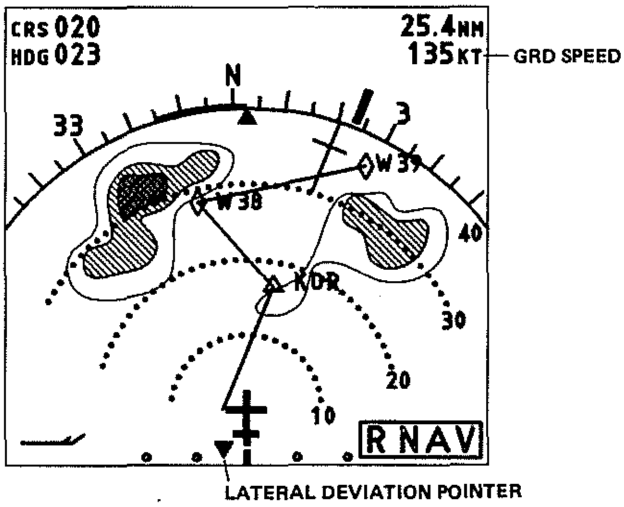

Fig. 15 E H S I SYMBOLOGY SECTOR MODE

– Pattern mode (See Fig. 16) locating the helicopter with respect to the pattern selected (There are 4 possible patterns).

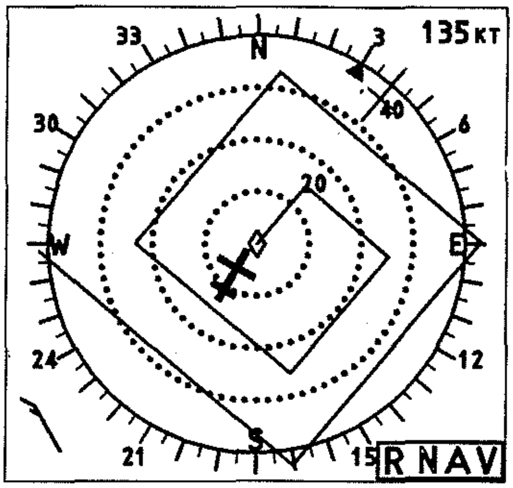

Fig. 16 E H S I SYMBOLOGY PATTERN MODE

– Hover mode (See Fig. 17) monitoring end of automatic transition to hover above a marked target ; this mode also displays target position, Vx and Vy ground speed, selected ground speed and radio altitude.

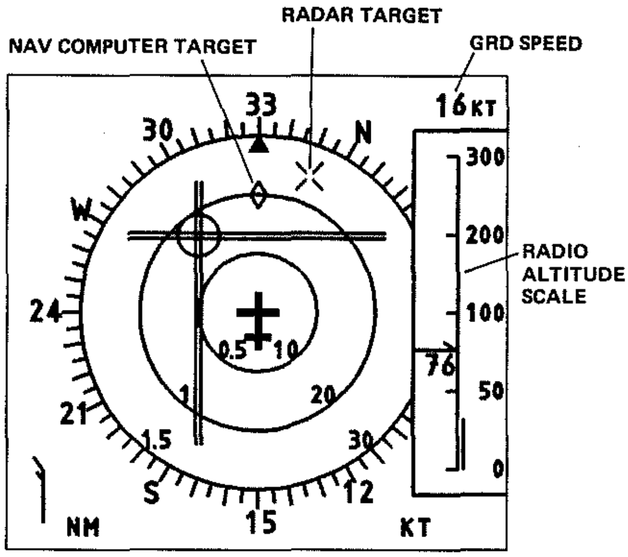

Fig. 17 E H S I SYMBOLOGY HOVER MODE

RADAR SCREEN

Apart from the conventional display modes (Search and rescue, weather), pre and post flight check list can be displayed on the radar screen.

2.4.3 – As compared to conventional instruments, operation of the CRT based system being developed for AS 365F is far more flexible. New data is presented in such a way as to reduce crew's workload and concentrate information usually displayed on several conventional instruments.

This system is being validated in the laboratory. Initial flights will take place at the beginning of 1984 and the first aircraft will be delivered in December 1984.

3– MILITARY VERSIONS

The military versions being developed are :

- The anti surface vessel warfare version equipped with the AEROSPATIALE's AS15 TT weapon system capable of firing four AS 15 TT missiles to 15 km.
- The anti submarine warfare versions capable of firing two Mk 46 torpedoes. The first version uses a magnetic anomaly detector (MAD) and the second version uses a sonar to detect submarines.

It is important to note that change from ASW to ASV configuration takes only a few hours and does not require any specific tooling.

3.1 – Anti surface vessel version (See Fig. 18)

AS 15 TT is a light all weather weapon system seeking and attacking navy targets, in severe weather conditions.

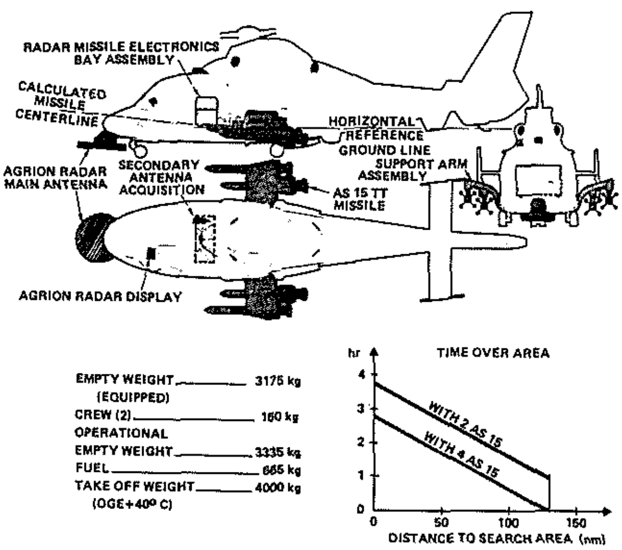

Fig. 18 AS 15 TT CONFIGURATION

This weapon system has been designed to undertake the following missions :

- Definition of a surface situation from a great distance ; this situation can be communicated to a naval force.
- Over-the-horizon target designation for long range sea-sea missiles.
- Firing of air-sea AS 15 TT missiles.

The AS 15 TT weapon system mainly includes :

- The firing equipment comprising an AGRION 15 radar. The main radar antenna is installed under the helicopter's nose. This position gives a 360° detection field and permits firing with elusive turn. The secondary antenna is used to guide the missile over the first part of its path ; this antenna is located on the cabin's roof. The firing equipment's electronics are in a bay behind pilot's/co-pilot's seat. This bay also includes the firing computer and the data transmitter's modulator.
- Four AS 15 TT missiles installed on two support arm on either side of the helicopter.
- A control and implementation unit including radar display and control box, the AS 15 TT control box.

AGRION radar

AGRION radar functions are : surface monitoring, target tracking, missile location and remote control.

This radar is also used to locate the mother ship and guide the helicopter on to the deck's helipad.

Radar characteristics :

- Long distance surveillance with appropriate frequency
- High discretion thanks to pulse compression
- High resistance to conter-measures
- 360° panoramic scan
- Track while scan
- Capability to detect small targets (periscopes, dinghies).

AS 15 TT MISSILE (See Fig. 19)

The missile weighs 98 kg and carries a 30 kg warhead. It is propelled for 45 seconds thus covering a range exceeding 15 km.

Missile trajectory is roll stabilized and controlled by :

- A vertical gyro
- A radio altimeter
- An active transponder
- A receiver of radar transmitted guiding signals.

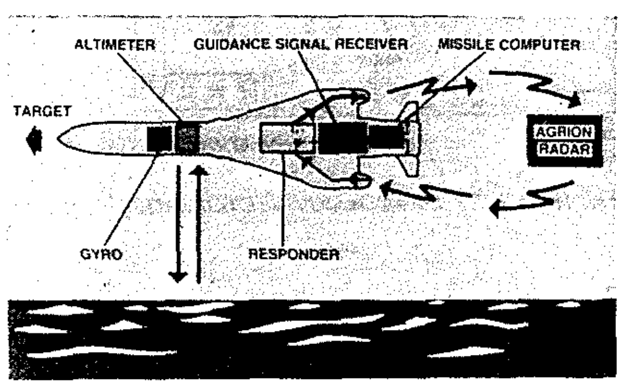

Fig. 19 AS 15 TT MISSILE GUIDANCE AND CONTROL

In the horizontal plane : (see Fig. 21)

- The initial trajectory is programmed to ensure helicopter safety
- Initial homing proceeds with a large lobe auxiliary antenna. (see Fig. 20)

In cruise flight, the radar tracks the missile in direction and distance through the transponder installed in the missile.

The firing installation generates guiding instructions determined from angular deflections measured by the radar. These guiding instructions are sent to the missile by radar signals.

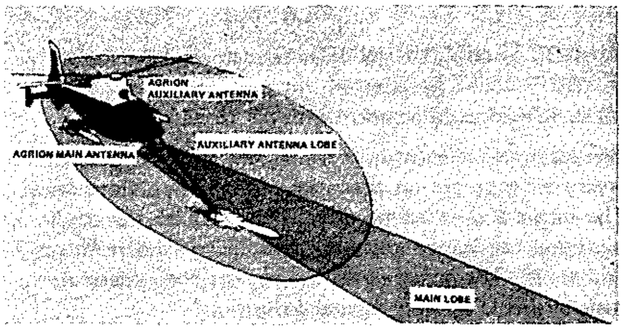

Fig. 20 MISSILE ACQUISITION

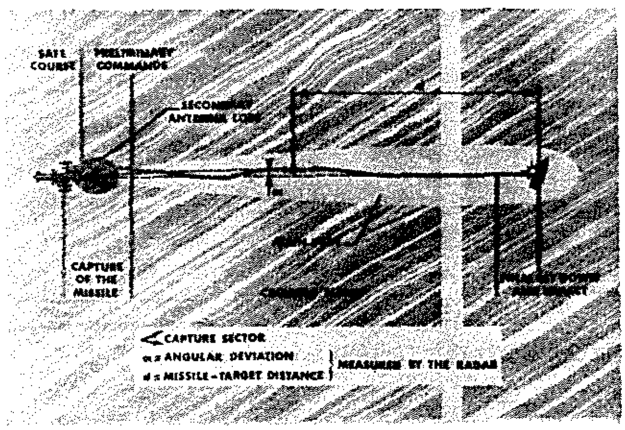

Fig. 21 AS 15 TT HORIZONTAL GUIDANCE

In the vertical plane : (see Fig. 22)

Once homed, the missile starts to descend (Descent is programmed) and stabilizes in sea skimming flight a few meters above the surface ; as it is getting nearer the target, the missile dives and strikes efficiently whatever the target's vertical size.

The above parameters will moreover allow an elusive manoeuver in the horizontal plane immediately after missile firing.

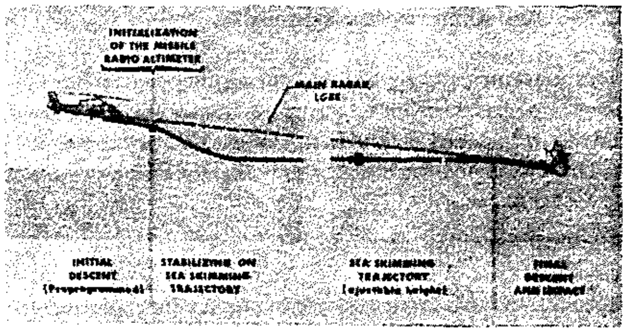

Fig. 22 AS 15 TT VERTICAL GUIDANCE

Control and operating unit

This unit includes :

- A radar screen installed on instrument panel at copilot's station
- A radar joystick allowing the operator to move the markers and designate the target
- An AS 15 control panel located on instrument panel between pilot and copilot
- A firing switch on the cyclic pitch stick
- Indication of target misalignment with respect to the helicopter's lubber line on the pilot's horizon.

Present development status

Ground tests of AS 15 system have been completed.

Flying qualities of the AS 365 F have been proven with the AS 15 system on board.

A study has also been completed on missile / helicopter separation immediately after firing and release. The pictures presented on Fig. 23 were taken during these trials.

The first successful guided missile firing from the DAUPHIN took place in June 1983. Numerous validation firings shall take place until first deliveries in July 1984.

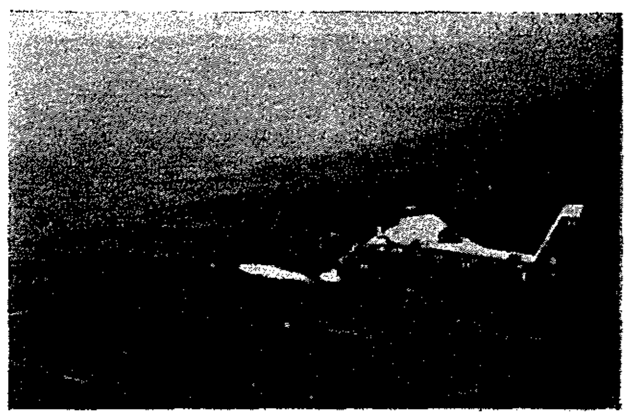

Fig. 23 AS 15 TT FIRING TESTS

3.2 – Anti-submarine warfare versions

Two versions carrying two Mk 46 torpedoes each are presently being developed. A magnetic anomaly detector (MAD) is installed on the first version and a sonar is installed on the second version for submarine detection.

MAD configuration (see Fig. 24)

Specific ASW equipment is easy to remove for rapid transfer from ASW to ASV configuration.

This equipment includes :

- MAD and hoist attached to an arm at beginning of tail boom on the left hand side of the aircraft.
- A MAD control assembly at copilot's disposal ; this includes the hoist control box, a graphic recorder on the copilot's instrument panel and a computer installed on the console ; this assembly has been designed to permit implementation of the ASW system by the copilot so that the mission can be carried out with 2 crewmembers.
- Torpedoes (one on either side of the helicopter) and the torpedo control box installed in the console.

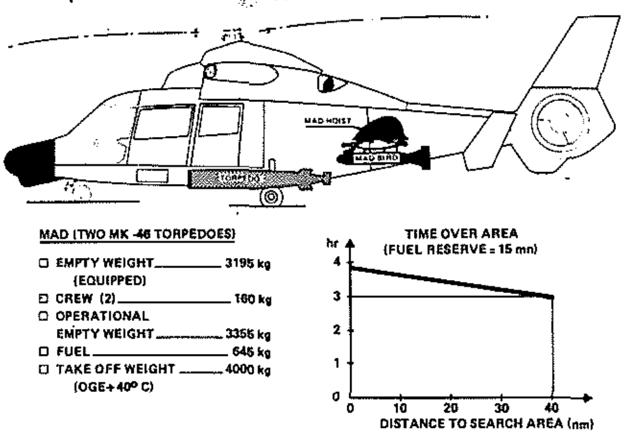

Fig. 24 M A D – TORPEDOES INSTALLATION

Development of this version is now completed.

Figure No. 25 taken during tests presents torpedo / helicopter separation.

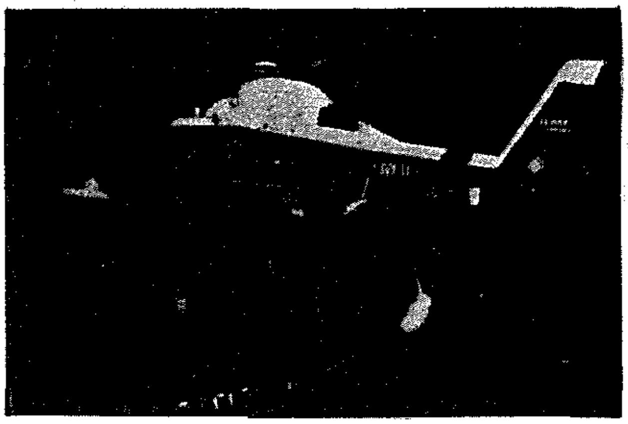

Fig. 25 TORPEDO LAUNCHING TESTS

It has been planned to complete the detection equipment with an acoustic sonobuoy system connected to a data link in order to process echoes on the mother ship.

SONAR configuration

Development of this version has just begun and should be completed by the beginning of 1985.

Sonar is installed in such a way as to authorize mission with 2 or 3 crewmembers (See Fig. 26).

As shown on the figure, the sonar has been installed rearwards of the cabin and a hole has been drilled in the bottom structure to fit a funnel. The sonar operator's console is located behind the pilot's seat. Should the mission be carried out with two crewmembers, the pilot's seat is fitted on rails, it can be pushed back and pivoted to face the console.

An ORB 32 or AGRION 15 radar can be installed. Should the AGRION 15 be selected, the aircraft can very easily be set up in ASV configuration with AS 15 missiles.

Present improvements in sonar signals' processing methods shall very soon permit processing echoes on a video image. The image shall then be directly sent on to the copilot's multipurpose screen capable of receiving data from radar and sonar. The sonar operating copilot shall therefore remain available for piloting and navigation.

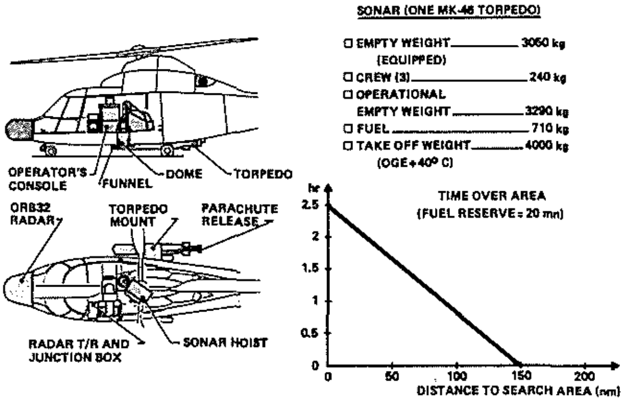

Fig. 26 SONAR – TORPEDO

4– CONCLUSION

Development of the DAUPHIN II's basic naval version is being completed.

The first SAR helicopters fitted with conventional piloting instruments are being delivered now as planned. The first SAR DAUPHIN equipped with electronic flight instruments shall be available at the beginning of 1985.

As concerns military versions, the successful firing of an 155 TT missile from a helicopter in June 1983 allows thinking that the first versions could be delivered by mid 1984.

Test trials carried out on a French Navy ship confirmed the capability of the DAUPHIN fitted with an hydraulic harpoon to operate from low tonnage ships.