



**AS 332 MKII  
DEVELOPMENT AND CERTIFICATION**

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**ABSTRACT:**

The subject is an overview of the AS 332 MKII development and certification process, based on the main definition differences and specificities, compared with its "elder brother" AS 332 MKI (L and L1 versions).

About 80 % of the aircraft definition is new or has been modified, specially concerning the rotors and transmissions, the avionics and electrical power system.

These modifications were intended to meet the following main objectives:

- Set new standards for this helicopter category in terms of:
  - . safety,
  - . maintenance,
  - . passenger and crew comfort (vibration level, air conditioning, crew work load).
- Generally speaking, enhance the product based on MK I experience.

The total development and certification process, to meet first DGAC certification for the basic aircraft, took place within 6 years. This certification was granted on 12th June 1991, and will be followed by DGAC and CAA offshore version certification at the very beginning of 1992.

Delivery to the 1st customer is planned during the 2nd quarter of 1992.

This development has been conducted with 3 prototype helicopters, which have logged 800 flight hours since 1987, including approximately 300 hours for certification purposes within the last 12 months.

AS 332 MKII is currently the only helicopter in this category (up to 20000 Pds) certified according to FAR 29 Amendment 24 and a number of special conditions including in particular:

- EMI protection (Up to 600 V/m).
- Foreign object damage resistance.

- Single engine "super contingency" power (OEI 30').

Full demonstrations were also carried out for certification purposes, in particular for:

- Composite structure, according to the latest standards of damage tolerance justification
- Critical composite parts, following a damage tolerance approach
- Damage tolerance for each critical composite part.
- Fatigue substantiation tests for new rotor and transmission parts.
- Flight endurance trials.

The planned production rate of Super Puma MKII is 30 helicopters per year, by 1995.

**SUMMARY:**

- 1 - INTRODUCTION - 332 MKII HISTORY
- 2 - SUPER PUMA MKI/MKII MAIN DESIGN DIFFERENCES
- 3 - CHARACTERISTICS
- 4 - DEVELOPMENT
- 5 - CERTIFICATION
- 6 - PRODUCTION SCHEDULE
- 7 - CONCLUSION

## 1 332 MKII HISTORY - INTRODUCTION

The Super Puma MKII derives from the Super Puma MKI version (L, M, L1, M1), which was itself deriving from the Puma (330).

So far, 350 Super Puma have been delivered all over the world, totting up around 710.000 flight hours. The leading aircraft nearly cumulates 14.000 flight hours. Some of the helicopters are operated, at a rate exceeding 150 flight hours a month.

Super Puma MKII development was officially initiated early 1986, to prepare for an upgrade of the MKI versions. The new version is intended to complete and then replace the current MKI versions, until about 2010.

The first purpose was to improve the performance, in order to compete in this market segment over the coming 20 or 30 years. The definition of the basic aircraft progressively evolved to reach a final standard by 1989. The main evolutions were meant to set new standards:

- new regulation requirements (FAR 29 Amendment 24 + special conditions).

- modernization,
- maintenance and reliability,

and to improve MKI reconducted definition.

Some of these improvements were initiated further to discussions with our main MKI customers, in order to take into account MKI operational experience.

The Super Puma MKII has also been designed to remain a versatile A/C flyable both in the civil and military transport/armed versions.

The development priority has been given to the civil versions, specially for the offshore market aiming at a 1st aircraft delivered in the second quarter of 1992 (DGAC and CAA certified). The 1st military or VIP version delivery can take place as from 1993.

Both of them will be improved through the modifications designed for the basic version, specially the availability of an enlarged cabin, which allows more seats in military transport (up to 29) and new furnishing possibilities on VIP versions.

## 2 SUPER PUMA MKI/MKII MAIN DESIGN DIFFERENCES:

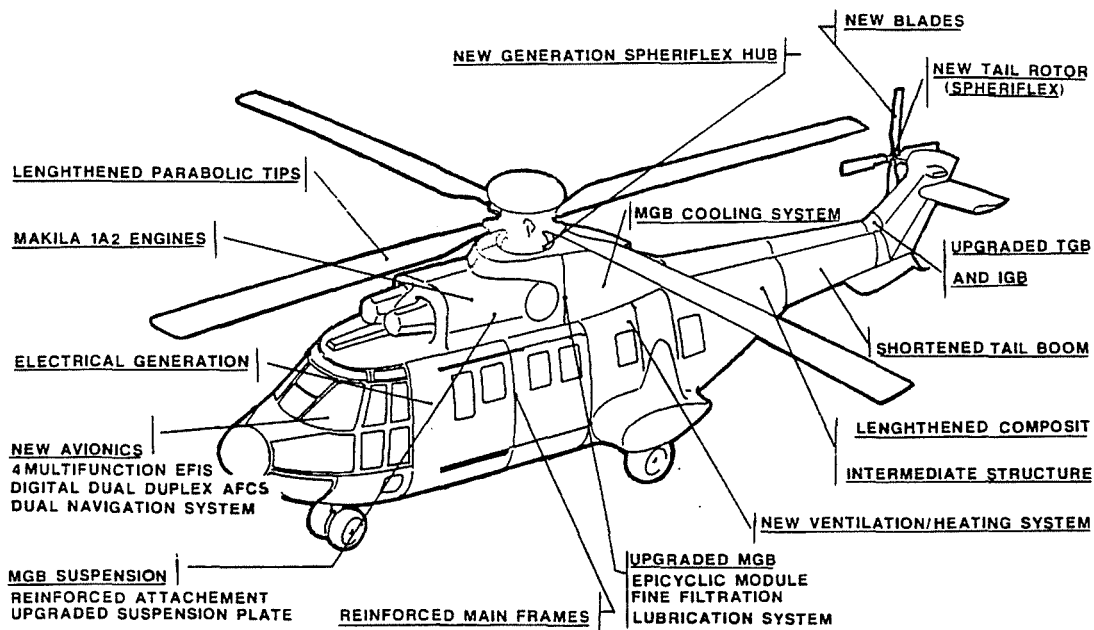


Figure 1: 332 MK II NEW EQUIPMENT ITEMS

The redesigned subsystems installed on the Super Puma MKII are:

- The Spheriflex main rotor head (hub and blades).
- The Spheriflex tail rotor head (hub and blades)

- Cabin and cockpit ECS (ventilation/heating).
- An IFDS (Integrated Flight Display System) featuring :
  - dual dual digital AFCS
  - 4 multifunction EFIS
  - AHRS

- The DECU (Digital Engine Control Unit) with 3 OEI ratings including a Super Contingency Power
- Aft Intermediate structure made of composite sandwich.

The elements derived from the Super Puma MKI are:

- Upgraded transmissions.
- Upgraded engines (MAKILA 1A2, which is a derivative of the MAKILA 1A1).
- Hydraulic systems.
- Landing gear and structure (specially doors and cowlings).

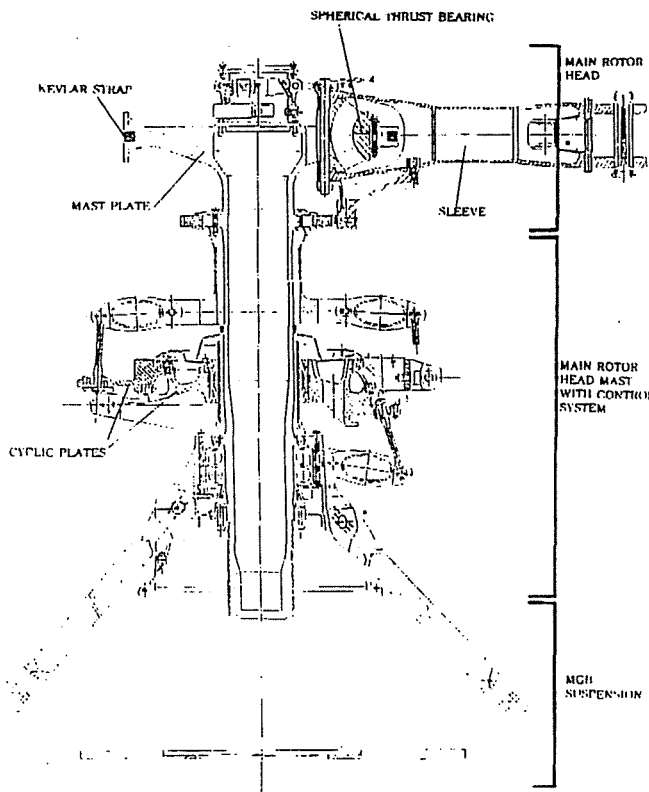


Figure 2: SPHERIFLEX MAIN ROTOR HEAD

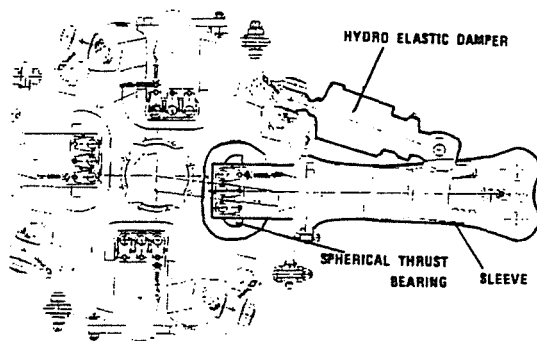


Figure 3: NEW 16.2 m DIAMETER BLADE

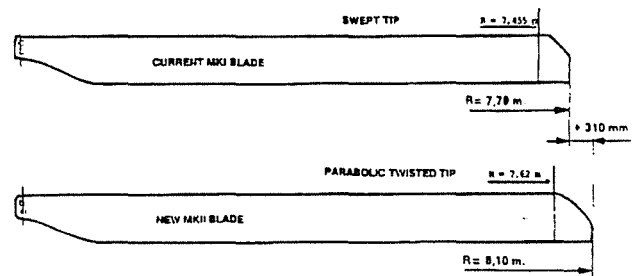
- AC AND DC Electrical power generating system.

## 2.1 New subsystems

### 2.1.1 Spheriflex main rotor hub: (Fig. 2 & 3)

The main rotor diameter has been increased from 15.58 m to 16.20 m. The rotor head is a patented spheriflex type, where blade motions are made around a spherical thrust bearing, the blade being restrained by a hydro-elastic damper..

The diameter increase comes partly from the new parabolic blade tip, designed for hover performance enhancement.



### 2.1.2 Spheriflex tail rotor hub: (Fig. 4)

The tail rotor hub is a complete new designed spheriflex rotor, with "fork type" blade attachment acting as a sleeve. The new definition was designed in order to enhance performance, reliability and maintenance of the rotor head.

2.1.3 Cabin and cockpit ventilation/heating:  
(Fig. 5 & 6).

The cockpit ventilation system includes the EFIS ventilation device. The general performance of the whole system has been enhanced to increase passenger and crew comfort. The new system performances match the whole temperature range of the aircraft, from -45°C up to +50°C, while ensuring passengers and crew comfort, as well as the satisfaction of equipment installation requirements.

The basic system includes full provisions for an air conditioning freon type system.

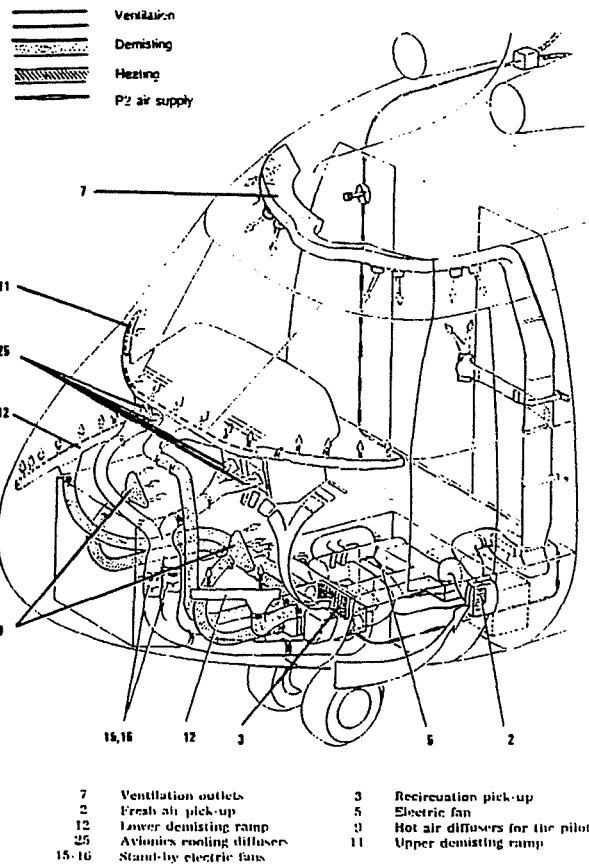


Figure 6: 332 MKII COCKPIT AIR CONDITIONING SYSTEM

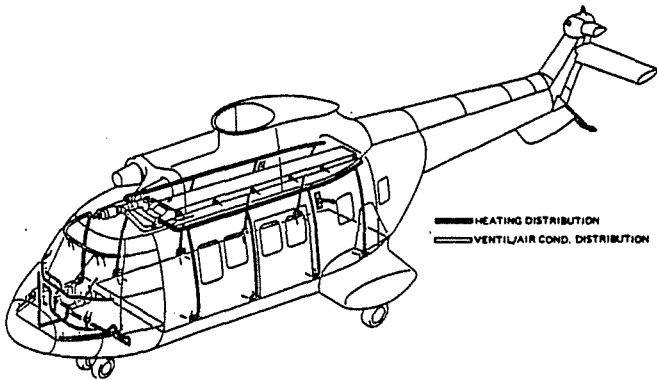


Figure 5: VENTILATION/HEATING AIR DISTRIBUTION SYSTEM

2.1.4 IFDS (Fig. 7 & 8)

The Integrated Flight Display System is a digital integrated system composed of 2 half identical systems, working independently, and which may be reconfigured in case of any failure.

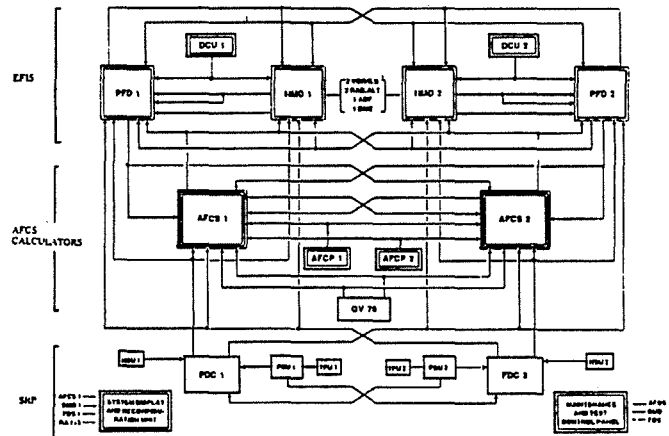


Figure 7: I.F.D.S. ARCHITECTURE

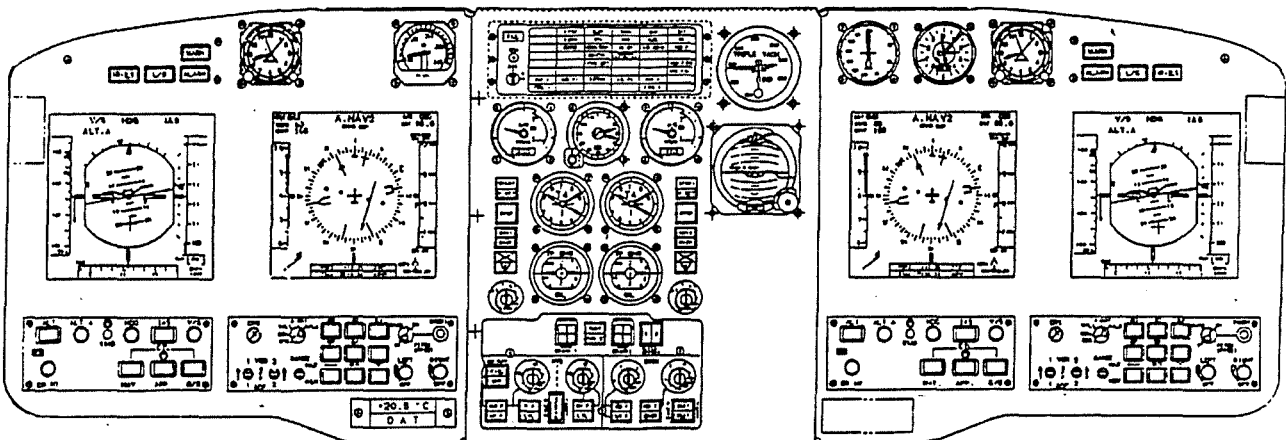


Figure 8: INSTRUMENT PANEL

Each half system is composed of:

- 1 display system (2 EFIS, one for navigation, one for primary flight data),
- 1 automatic flight control system (Incl. 1 dual computer),
- 1 primary reference system (Incl. 1 AHRS).

All these subsystems are connected by digital ARINC 429 lines.

### 2.1.5 Engine governors

The MAKILA 1A2 is driven by a DECU. The Emergency Power of the MAKILA 1A2, in case of One Engine Inoperative, is provided by 3 different ratings :

Unlimited OEI: for continuous flight on one engine :1417 KW.

OEI 2': 1464 KW.

Super Contingency power OEI 30': 1569 KW.

This 6 % power increase, compared with the MAKILA 1A1, appreciably increases cat. A performance, in particular regarding new OACI regulation.

### 2.1.6 Intermediate structure: (Fig. 10)

In order to enlarge the cabin volume, a new composite aft intermediate structure is installed, increasing the maximum number of comfort seats, from 19 to 24 for civil transport version (Fig. 9), and from 24 to 29 in military utility version. This structure is made of sandwich composite material to save weight and provide maximum inside volume.

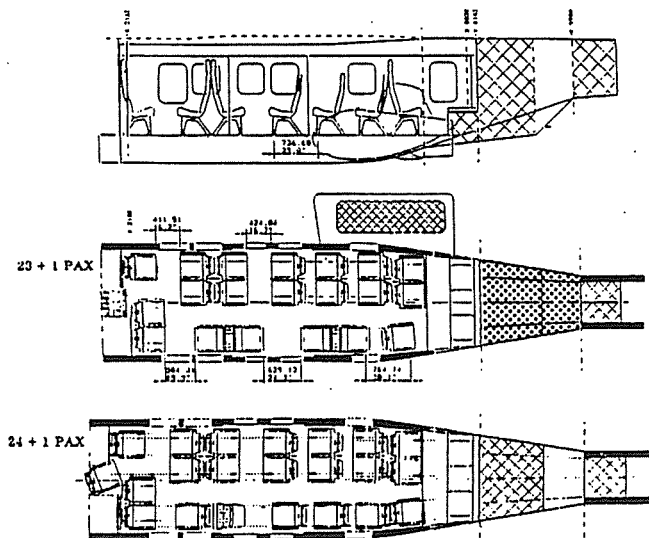


Figure 9: OFFSHORE CABIN

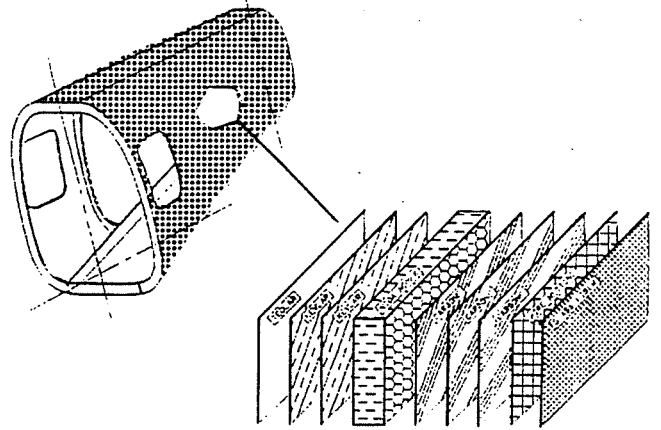


Figure 10: INTERMEDIATE ENLARGED COMPOSITE STRUCTURE

## 2.2 Modified sub systems

### 2.2.1 Transmission systems (Fig. 11, 12 & 13)

The transmission systems have been adapted to the rotor hubs, and the engine power, while enhancing reliability and life time.

The Main Gear Box is fully modular, and the epicyclic module has been redesigned and reinforced.

The intermediate and tail gear boxes are similar to the MKI's, as regards their concept.

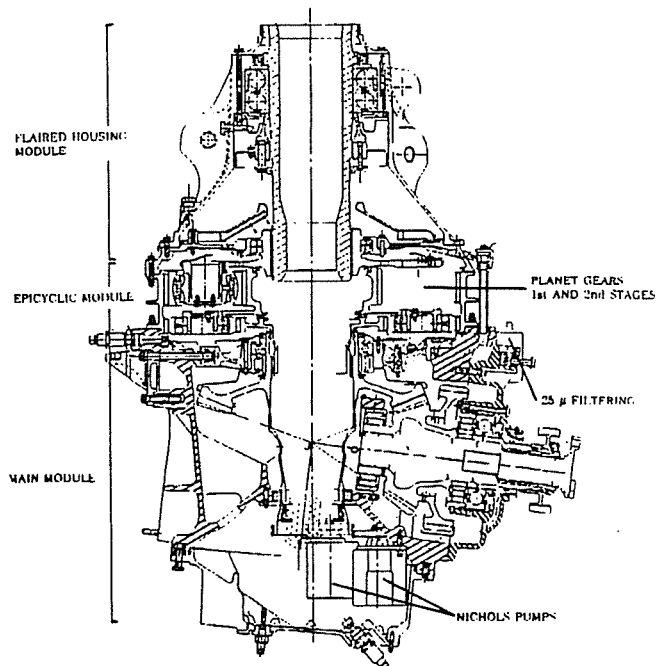


Figure 11: MAIN GEAR BOX

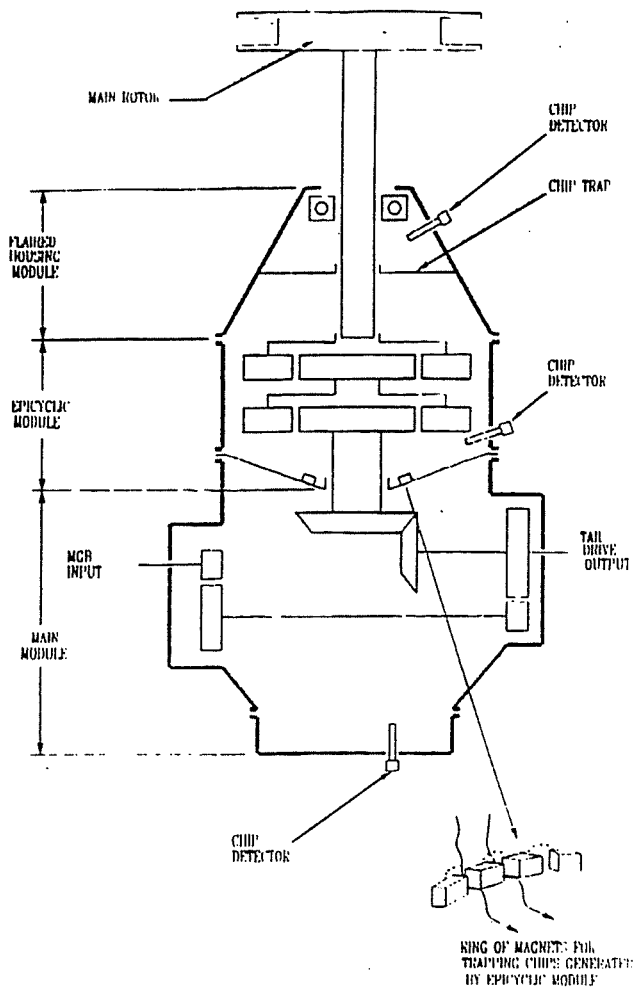


Figure 12: CHIP SEPARATION DEVICE IN MAIN GEARBOX

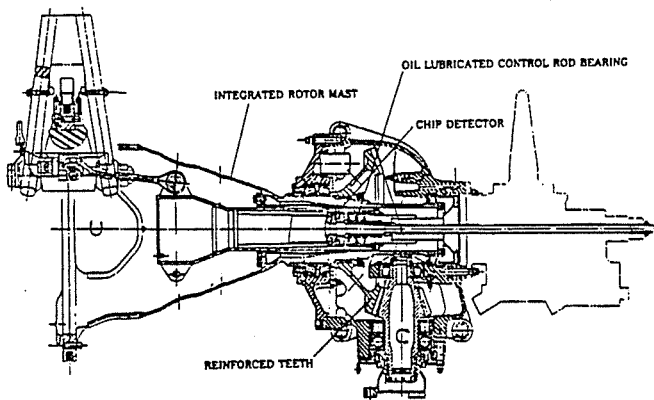


Figure 13: TAIL MECHANICAL ASSEMBLY

### 2.2.2 Structure (Fig. 14)

Except for the aft intermediate structure the MKII structure is fully derived from the MKI structure.

The modifications are related to the new helicopter equipment. The structure has locally been reinforced, including its capability for a weight growth potential up to 9500 kg for civil use.

The modified structure provides a substantial EMI attenuation (Electro Magnetic Interferency) to meet the Special Condition of EMI allowance on the helicopter up to 600 V/m.

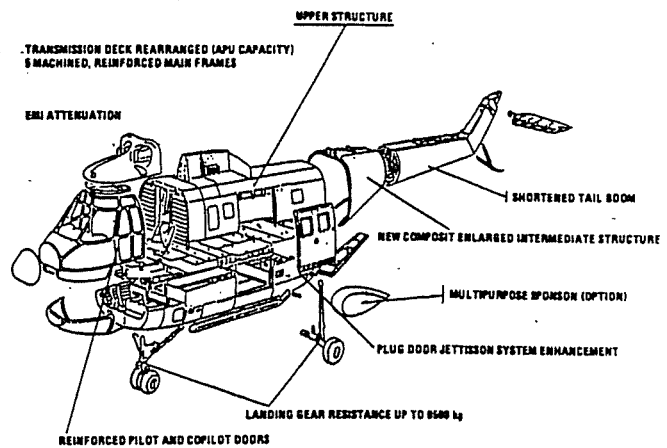


Figure 14: STRUCTURE

### 2.2.3 Electrical power generation

The MKII electrical power generation main characteristics are:

- a full Left hand and Right hand segregation,
- improved routing in which interconnections are grouped in a connectors matrix ("patchboard"),
- modular concept to allow easy reconfiguration between basic power units or optional more powerful units (20 KVA or 40 KVA AC power units),
- a customisable routing, allowing access to wiring during manufacturing or maintenance.

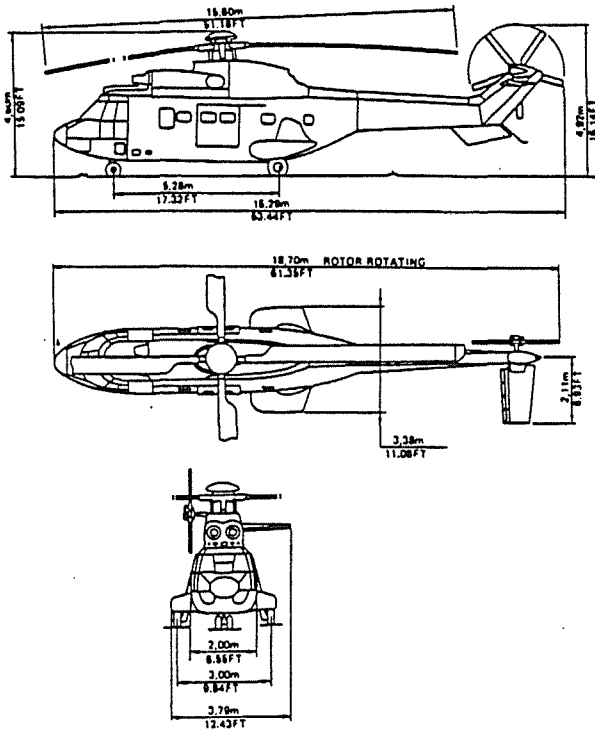
A third emergency alternator is available as an option, driven by the left hand main hydraulic circuit, for specific applications. The electrical power generation can also be driven on ground by an APU (Auxiliary Power Unit), as a third engine used before take-off, to supply power before engines start. The APU can also be used for air conditioning needs on ground for example.

The basic aircraft has a full capability for these two equipment items, in terms of connections or space reserves.



3 CHARACTERISTICS

MARK I



MARK II

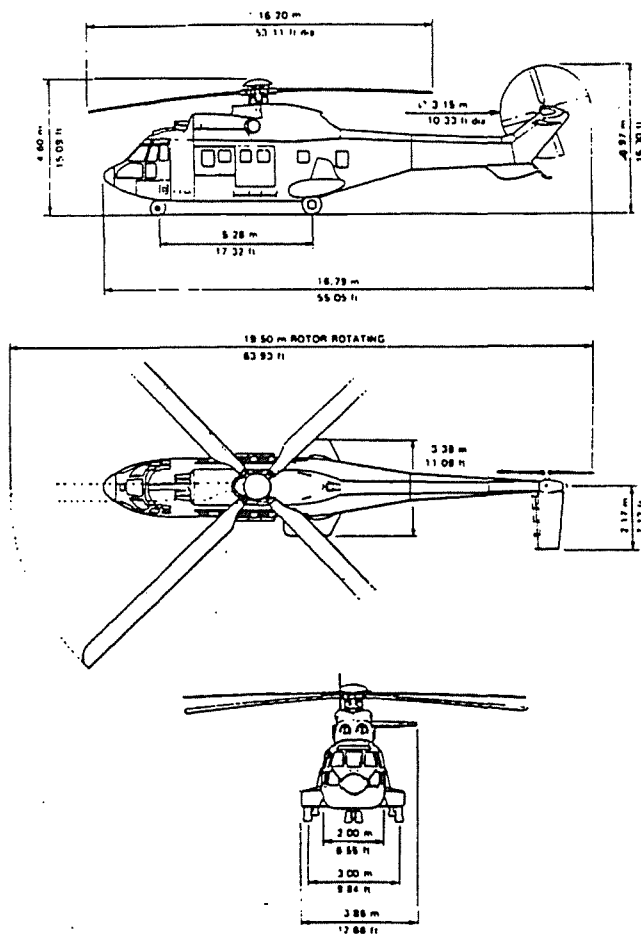


Figure 15: EXTERNAL DIMENSIONS

COMPARISON BETWEEN MAIN 332 MKI/MKII BASIC AIRCRAFT CHARACTERISTICS (CIVIL VERSION)

	MK I	MK II
Engine	2 x MAKILA 1A1	2 x MAKILA 1A2
Engine power		
Max continuous power	1185 kW	1236 kw
Max take-off power	1330 kW	1373 kw
Max contingency power	1400 kW	1569 kw
Main rotor diameter	15.58 m	16.20 m
Max. take-off weight	8600 kg	9150 kg
Payload	4140 kg	4490 kg
Passengers	19 + 2 crew members	24 + 3 c.m.
Max cruise speed	262 km/h	277 km/h
Range	824 km	857 km

- The civil version has been certified at a max. take-off weight of 9150 kg. The design weight of the aircraft is 9500 kg, which is the final weight objective during its life time (for civil use).
- The military max. take-off weight is 9500 kg.
- Max take-off weight with external load is 10000 kg.

4 DEVELOPMENT

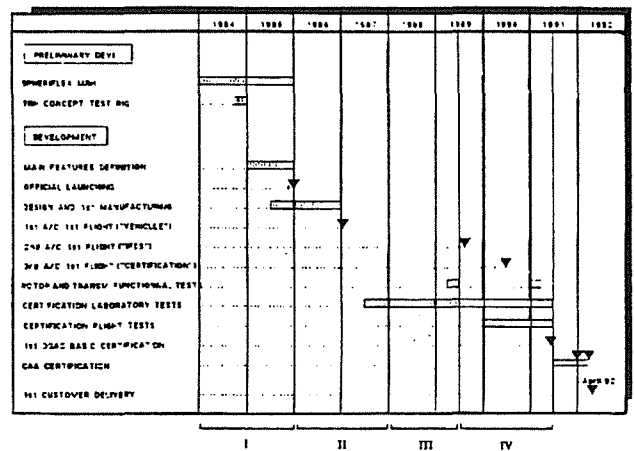


Figure 16: AS-332 MKII DEVELOPMENT PLANNING

The basic aircraft development was officially initiated early 1986. It was divided into three major phases, preceded by a preliminary period where the main and tail rotor head spheriflex concept was tested (Fig. 16).

**Phase I:** Flight tests of a spheriflex main rotor head.  
Rig tests of a spheriflex tail rotor head.

**Phase II:** Rotor heads development start.  
IFDS development start.

**Phase III:** Evolution of basic aircraft definition, to meet latest commercial and regulation requirements.  
Mid 89: Final standard definition.

**Phase IV:** Peak development activity on all subsystems.  
12th June 1991: Basic aircraft DGAC certification.

The phase IV is presently followed by the final certification step of the civil offshore 332 L2 version, for which certification is planned at the end of January 1992 for the DGAC, and during the first quarter of 1992 for the CAA, followed by the FAA certification a few months after.

**Development main features:**

3 flying prototypes have been used (Fig. 17).

AS 332 n° 2210: First flight in February 1987.

Helicopter devoted to the new rotors and transmission flight development, and to the new aft intermediate composite structure.

Mid 1991: 320 flight hours.

AS 332 n° 2167: First flight in October 1989.

Helicopter also equipped with the new rotors, but dedicated to IFDS flight development and certification tests.

Mid 1991: 250 flight hours.

AS 332 n° 2298: First flight in June 1990.

Helicopter devoted to certification flights.

Production definition for: Dynamic components.  
Hydraulic system.  
Cockpit ventilation/heating system.  
Engines (since October 1990).  
Electrical generation.  
IFDS.

Mid 1991: 200 flight hours.

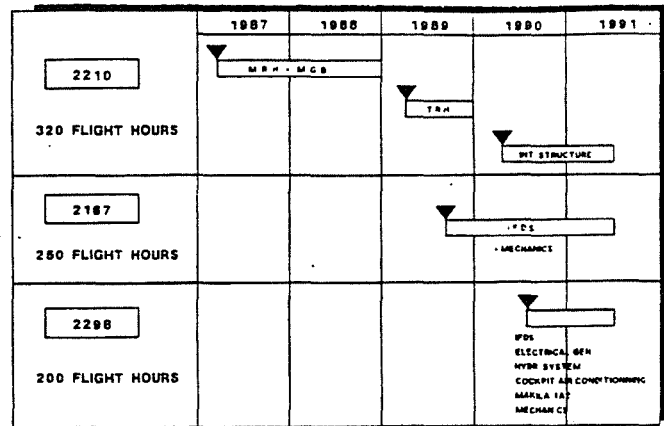


Figure 17: HELICOPTERS FOR DEVT AND CERTIFICATION

These 3 helicopters have been used for basic aircraft development during the last 5 years.

The whole catalog of MKI options is renewable on the MKII, but needs to be adapted to the new basic definition, the enhanced general performances of the aircraft and new regulations.

Some new options are now shown in the MKII catalog, such as the third emergency alternator or the APU, as described above.

**5 CERTIFICATION**

The Super Puma MKII is to be certified by DGAC, CAA and FAA.

The first basic aircraft DGAC certification was granted on 12th June 1991.

Full offshore aircraft DGAC certification is planned at the beginning of 1992, followed by CAA and then FAA certification.

**5.1 DGAC certification**

**5.1.1 Certification basis**

FAR 29 amendment 24, with Special Conditions:

- HIRF (up to 600 V/m).
- Super Contingency Power (OEI 30').
- Resistance to bird impact at  $V_H = 300$  km/h.
- Flight endurance.

This certification basis represents the world highest level for a helicopter being certified today.

### 5.1.2 Certification main features

The main certification activities took place from mid 1990 to mid 1991 and are composed of:

- 300 flight hours on the three helicopters (Included in all 800 flight hours).
- 250 run up hours on a fourth helicopter fixed on ground for dynamic component endurance testing, following 400 hours in same conditions on a rig during development process.
- About 100 laboratory tests, including in particular:
  - . Fatigue tests on sub-assemblies or components.
  - . Damage tolerance tests on composite critical items.
  - . Lightning and EMI tests on helicopter or components.
  - . Functional or endurance tests, specially on elastomer elements.
- The certification file consists of approximately 500 documents.

### 5.2 Certification process: (main items)

The high standard of new definitions and new regulations required a major effort over the last 12 months, which followed final standard definition freeze.

The prototype mainly used for certification flight tests (2298) flew 155 hours in 5 months, since the beginning of 1991: (Fig. 18).

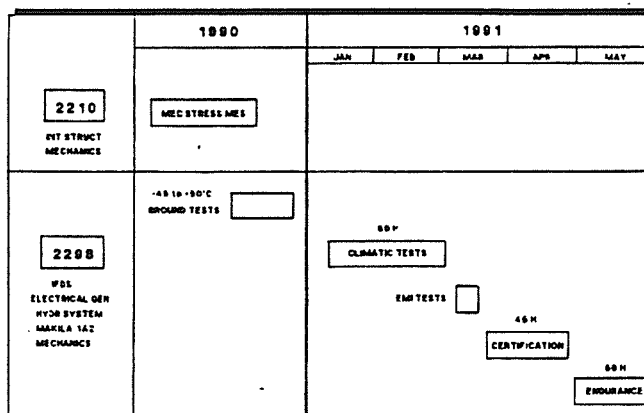


Figure 18: MAIN CERTIFICATION FLIGHTS

### 5.2.1 Climatic tests

The outside temperature envelope for 332 MKII is -45°C to ISA + 35°C, limited to +50°C.

The helicopter has been dedicated to climatic flight tests for 2 months, grouping hot weather and cold weather conditions one after the other.

60 flight hours were carried out; 45h in Australia, at an average temperature of +43°C. 15h in Canada, at an average temperature of -35°C.

Such an unusual mission operation, has been very successful.

The helicopter, in a very short time, has demonstrated its reliability and maintainability in very extreme conditions, with no extrapolation required.

The flights tests had been preceded by previous functional ground tests on the whole helicopter in a climatic chamber, at extreme temperature, which made it possible to correct the defects before final certification flight tests.

### 5.2.2 Endurance

A DGAC special condition requires an equivalence of 150 flight hours endurance demonstration on new designed systems, considering that:

5 development flight hours are necessary for 1 endurance flight hour.

2 ferry flight hours are necessary for 1 endurance flight hour.

The total 800 flight hours, ending by a 50 hour flight period devoted to endurance, met the Special Condition. In order to demonstrate, before delivery, the reliability and maintenance progress of the new subsystems:

- rotors,
- IFDS,
- engines.

Furthermore, AEROSPATIALE has decided to increase endurance demonstration with a complete 100 hours flight endurance period in operational conditions, before first delivery.

### 5.2.3 EMI tests

The DGAC special condition requires that critical and essential equipment or functions be resistant to HIRF.

The objective is reached by:

- structure attenuation. EMI shielding was necessary in 6 different zones,
- increase of equipment resistance to EMI impulse,
- wiring shielding to avoid resulting electrical power.

During the development process, a preliminary test phase was performed on a full size helicopter mock-up, in order to determine the necessity/choice for a given solution, per critical or essential function.

The certification tests consisted of:

- supplier tests on equipment completed by tests on the hole helicopter at each frequency,
- flight tests near critical frequency radar.

The Super Puma is currently certified to HIRF level requirements as follows :

Frequency	Average level V/m	Top level V/m
10 kHz - 6 MHz	100	-
6 MHz - 30 MHz	200	-
30 MHz - 200 MHz	50	-
200 MHz - 400 MHz	50	-
400 MHz - 1 GHz	400	6000
1 GHz - 3 GHz	200	6000
3 GHz - 8 GHz	400	6000
8 GHz - 20 GHz	600	6000

### 5.2.4 Resistance to bird impact

The demonstration must prove the full safety of flying after impact of a 4 Lb bird at  $V_H$  max (300 km/h).

Demonstration had been made on MKI, but:

- new rotors had to be tested,

- max speed has increased from 272 to 300 km/h.

Impact tests were done on:

- Main rotor head cover.
- Main rotor head control rod.
- Front fuselage (front panels, in particular in front of controls).
- Landing gear cowling.
- Engine air intake.
- Main blade tip.

Demonstration as been carried out for the rear blades resistance to a 100 g metal object impact.

### 5.2.5 Fatigue substantiation on rotor and transmission system

The SAFE-LIFE concept was used to demonstrate a life time on metal components.

The FAIL SAFE concept was used for elastomer components (spherical thrust bearings and dampers).

The FAIL SAFE concept for elastomer components consists in:

- Defining a visual and measurable criteria for removal of the component.
- Demonstrating non-catastrophic consequences due to a defect in flight, between two inspection intervals.

### 5.2.6 Damage tolerance on composite structure

The composite structure certification is under a damage tolerance process (cf AC 20-017). All static and fatigue tests on components and fully assembled structure take into account maintenance or manufacture damage.

A complete static and dynamic test program has been performed on a structure:

- static test to limit and ultimate load,

- dynamic testing under flying spectrum, covering 20000 flight hours,
- final static test equivalent to the previous one, up to ultimate load.

Maintenance and manufacture damage to be demonstrated were fitted in the tested structure.

### 5.2.7 Safety analyses

The Amendment 24 of FAR 29 features a requirement for quantitative safety analyses implementation.

This process was to be applied to avionics and new design involving digital techniques.

Safety objectives have been settled at a first stage (preliminary safety analysis) in agreement with certification authorities.

These objectives have then been taken into account for the system design, and their satisfaction has been finally verified through the system safety analysis.

### 5.3 CAA certification

The CAA process certification, whose basic regulations were approved early in 1991, is now applied to complete offshore version.

Basic aircraft certification is based on DGAC certification, complemented with several CAA specificities, which do not affect the basic definition.

Basic CAA aircraft will be fitted with a HUMS (Health and Usage Monitoring System), in accordance to CAA new philosophy.

This system will bring an extra advantage regarding safety of the rotors and transmission systems, but does not intervene in minimum safety requirements for critical parts.

Basic CAA aircraft is also fitted with the emergency alternator, to meet regulation requirement of half autonomy after a complete loss of electrical power generation.

CAA civil offshore certification is planned in first quarter of 1992.

## 6 PRODUCTION SCHEDULE

First customer delivery will take place in 1992.

6 aircraft are to be delivered during this year.

The MKII Production rate will progressively increase up to a stabilized average of 30 helicopters/year by 1995, while Super Puma MKI Production rate decreases to maintain an annual Super Puma rate of about 40 helicopters/year.

Super Puma MKI military naval version will still be produced at the same time as the Super Puma MKII.

### Current catalog:

- 332 L1: Super Puma MKI, civil version.
- 532 UC: Cougar MKI, military, "utility", short version.
- 532 UL: Cougar MKI, military, "utility", long version.
- 532 AC: Cougar MKI, military, "armed", short version.
- 532 AL: Cougar MKI, military, "armed", long version.
- 532 SC: Cougar MKI, naval military version.
- 332 L2: Cougar MKII, civil version.

### Future catalog:

- 332 L2
- 532 U2: Cougar MKII, military, "utility" version 1993/94
- 532 A2: Cougar MKII, military, "armed" version 1993/94
- 532 SC
- 532 UC
- 532 AC

## 7 CONCLUSION

Super Puma MKII is a Super Puma MKI derivative. However, to meet new regulation requirements as well as commercial objectives, the resulting definition of this new version sets new standards for this helicopter category.

Super Puma MKII is the outcome of 10 years experience of Super Puma in operation, with a ponderated selection of new technologies available for helicopters.

Super Puma MKII is currently certified under the most recent and complete regulation, ready to take place in the civil and military market for the next 20 years.