

TWENTY SEVENTH EUROPEAN ROTORCRAFT FORUM 2001 MAY 11-14, MOSCOW, RUSSIA

TITLE: EUROCOPTER EC225 / 725: AN EXAMPLE OF RISKS MANAGEMENT

PAPER #21
SESSION: AIRCRAFT DESIGN

AUTHOR: Guillaume FAURY - EUROCOPTER

ABSTRACT

The EC225/725 is the latest medium lift helicopter developed by Eurocopter. Based on a Super Puma MK2 airframe, this new version embodies state of the art components and systems, allowing a large increase of the maximum take off weight and resulting in outstanding flight and mission performances. The main innovations include a new 5-blade main rotor head, new main rotor blades with high efficiency airfoils, powerful turbo-engines, a reinforced main gearbox, new main servo-actuators, an integrated de-icing system, and a modern glass cockpit instruments panel.

The full-scale development of this version as been launched in the frame of a contract with a demanding first customer, putting high-pressure on the delivery schedule. Eurocopter has therefore selected innovative methods and solutions to manage the technical and calendar risks associated to this new helicopter development.

The use of these methods and solutions has been made available thanks to the large experience gained in the past 10 years by Eurocopter in numerous civil and military developments: Super Puma / Cougar MK2, Ecureuil B3 and Dauphin N3, EC120, EC130, EC135, EC145, EC155, Tiger and NH90.

INTRODUCTION

Facing the threat of new comers in the market of the medium lift helicopters (8 to 12 tons), EUROCOPTER began in 1999 to imagine solutions in order to increase the missions performances compared to its proven and reliable Super Puma / Cougar MK2, while mastering the costs of acquisition and operation for the customers.

To compete efficiently with this new comers, EUROCOPTER built up a very demanding technical specification resulting in an 11 tons class helicopter. For commercial purposes, the technical teams were tasked to be able to civil certify this new helicopter by the end of 2002, resulting in a very challenging schedule.

Therefore, innovative solutions and methods have been used to design an aircraft capable of conciliating the constraints of a demanding technical specification with those of a short development phase.

One major key point to succeed in this approach was the management of the technical and calendar risks linked to the solutions to be selected.

That's why the teams have been tasked to compare various solutions used previously on other recent EUROCOPTER developments regarding to risks, and imagine ground tests to validate these solutions far before the flight phase.

Figure 1: EC 225 B / EC 725 first prototype



The purpose of this paper is firstly to describe what is the EC225, and secondly to describe the methods and solution that have been used to reduce the level of risk for EUROCOPTER and their customers.

WHAT IS AN EC225

The civil EC225B and the military EC725 are the latest evolutions of the famous Super Puma / Cougar helicopters family. If the relationship between the EC225 and its father helicopter - the AS332 L2 Super Puma – is obvious due to their common aspects, the newborn EC225 is a concentrate of the most recent technologies available in Eurocopter, embodied in state of the art new designed components and equipment.

This components and equipment are mainly:

- A large 5-bladed Sphériflex[®] main rotor hub,
- New high performances main rotor blades,
- An upgraded Main Gear Box with increased power ratings and dry run capabilities
- State of the art Makila 1A4 turbo-engines with Dual channel FADEC,
- A new cockpit avionics suite,
- The auto-pilot of the EC135 / EC145 / EC155 helicopters family,

The EC225 main rotor hub is a Sphériflex[®]. This type of rotor head is of a particularly light and economical design. In the mid eighties, the Sphériflex[®] rotor hub concept was initially developed by Eurocopter for the Super-Puma Mk2 main rotor as well as for the tail rotor. Now, Sphériflex[®] rotor heads are also used on EC120, EC155, Tiger and NH90.

As the one of the EC155, the main rotor hub of the EC225 is a 5-recesses hub.

All the metal parts of this hub are of new design. The sleeves and the mast are made of stainless steel. The swashplates, the scissors, and the droop restrainer are in aluminum alloy, and the lift casing is made of titanium.

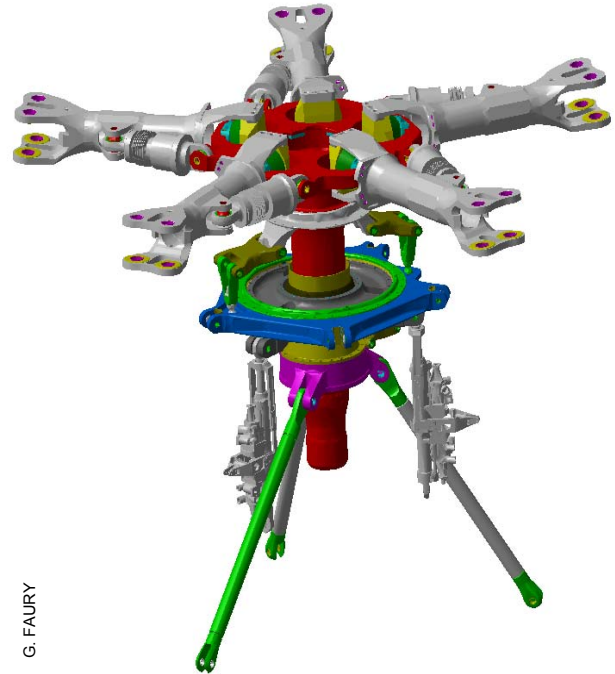
The elastomeric spherical bearing and the blade dampers are retained from the Super-Puma MK2.

Figure 2: EC 225 B Sphériflex[®] main rotor hub



G. FAURY

Figure 3: EC 225 B main rotor head



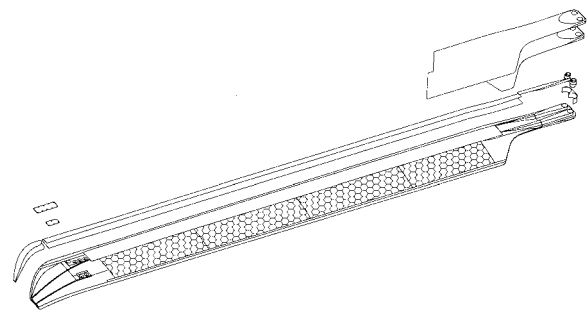
G. FAURY

The above EC225 new rotor has been designed to provide enough lift and inertia for a 12 tons helicopter, with a growth potential up to approximately 13 tons.

It includes 3 new 40% more powerful main rotor servo actuators fed by two 175 bars hydraulic generations.

This main rotor hub is fitted with 5 new blades. The chord of these blades is reduced to 550 mm compared to 600 for the Super Puma, but the rotor diameter remains 16.2 meters.

Figure 4: EC225 main rotor blade



G. FAURY

Each blade embodies a 3 boxes structure, a composite spar, an integrated tip with parabolic shape, and a stainless steel leading edge capping against erosion. Each blade tip is protected against lightning strikes with a metallic mesh.

These blades are designed with an integrated de-icing system capability. It means that the blade deicer is replaced on a non de-iced blade by an elastomeric cap with the same mechanical characteristics than a deicer.

Figure 5: EC225 main rotor blade



G. FAURY

Very efficient non symmetrical airfoils of the ONERA – AEROSPATIALE family are used on these blades to optimize the range and lift capabilities of the aircraft regarding to the power available.

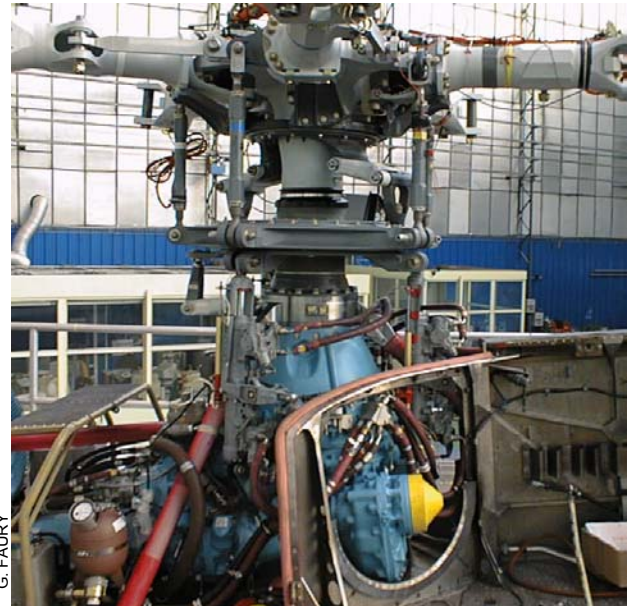
The EC225 Main Gear Box is an upgrade of the reliable and proven AS332 L2 MGB.

This upgrade is mainly based of the following modifications:

- The bevel gear drive of the L2 MGB is replaced by a new designed bevel gear drive with deep nitrogen hardening to transmit more power,
- The coupling wheel is reinforced through the enlargement of the teeth,
- The titanium top cover is replaced by a bevel casing to deal with higher rotor loads,
- The main casing is reinforced to face the maximum torque increase,
- The main servo actuators fittings are new due to the new design of these actuators,
- New bearings are installed, especially for the 8000 rpm wheel,

- And a stand-by spray system is designed and integrated to ensure the MGB resistance for 30 minutes after in flight oil loss, as required by the JAR29 regulation.

Figure 6: EC225 main rotor assembly



G. FAURY

These modifications allow an increase of 8% of the Take Off Power rating and an increase of 13% of the Maximum Continuous Power rating. Moreover, other light modifications are implemented on the magnetic plugs and on the oil filter to comply fully with the new requirements of the JAR29.

The EC225 is power by two Turbomeca Makila 1A4 gas turbine engines.

Figure 7: Turbomeca Makila 1A4



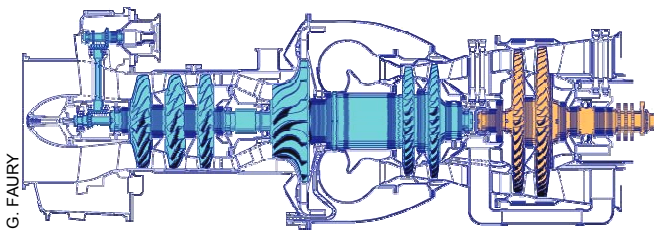
G. FAURY

The Makila 1A4 is the latest evolution of the Makila Family, that includes the Makila 1A, Makila 1A1 and the Makila 1A2 of the Super Puma / Cougar MK2. Designed to deliver more power to the helicopter, the Makila 1A4 embodies also all the latest technological improvements available in Turbomeca:

- A dual channel Full Authority Digital Engine Control with advanced back-up modes (the manual back-up mode is no more required),
- A fuel system of self-aspirating type,
- An additional overspeed protection system of “blade shedding” type, resulting in a contained separation of the free turbine stage blades in case of output shaft overspeed,
- The use of the latest materials available.

The architecture of the Makila 1A4 remains the same as of the previous Makila:

Figure 8: Makila 1A4 architecture



The Makila 1A4 are connected to a Vehicle Management System (see hereunder) that allows an in-flight automatic power check of each engine, and easy after flight maintenance access.

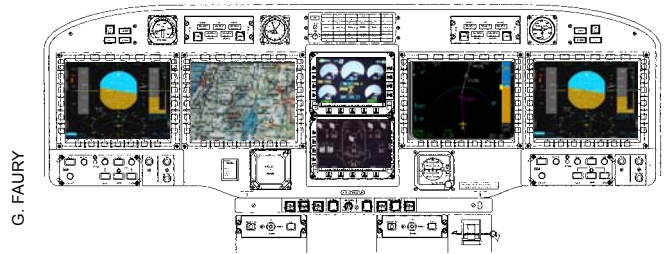
The result is a modern engine that delivers an average 14% more power than the previous Makila 1A2, with enhanced functions and maintenance improvements.

The EC225 is fitted with a new avionics suite named AHCAS for Advanced Helicopter Cockpit and Avionics System. It is based on 3 new main subsystems:

- a Flight Display System (FDS) composed of four 6x8 inches AMLCD color multi function displays,
- a Vehicle Management System (VMS) composed of two Electronic Instrument Displays (EID) and one duplex Aircraft Management Computer (AMC). The EID has a 4x5 inches AMLCD color screen
- a duplex digital auto-pilot of the “avionique nouvelle” family.

These components selected for the EC225 result in a very versatile and powerful cockpit panel:

Figure 9: EC225 cockpit panel



The AHCAS is connected with the FADEC computers in a very efficient but open avionics architecture.

The Man Machine Interface and the symbology are derived from those of the famous Integrated Flight and Display System of the Super Puma MK2.

A STRATEGY FOR RISKS MANAGEMENT

The mitigation of development risks has been used as a strategy from the birth of the EC 225. This strategy relies on 4 main rules:

- 1] Built up a new helicopter based mainly on existing components, developed and validated previously on other Eurocopter modern helicopters such as 332 L2, EC155, Tiger or NH90. This is the “puzzle game approach”.

Figure 10: 332 L2, EC155, Tiger and NH90



- 2] Never re-design from scratch a component similar to an existing one. Adapt your design to what already exists. Reduce as much as possible the number of new parts, and prefer solutions that imply the development of low risk components.
- 3] Validate the choices far before the flight test phase or the certification through laboratory or ground tests, or through the use of advanced computer tools.
- 4] The schedule must not be impacted by the delay of any new component or equipment. Therefore, prepare efficient back-up scenarios in case of problem or delay on each component.

This strategy has been successfully used on the EC225. This result is only due to the very large panel of modern rotors, MGB, blades, avionics and electrical equipment components available today in Eurocopter thanks to an impressive number of new helicopters developed by Eurocopter in the past 10 years: the single engine helicopters EC120 and EC130, and the twin engines helicopters Super Puma 332 Mk2 (first helicopter with Spheriflex rotors), EC135, EC145, EC155, Tiger and NH90.

A puzzle game is possible only if you have the pieces in your hands !

The rule 1] led Eurocopter to select the airframe of the appreciated and proven stretched Super Puma / Cougar MK2. This airframe has now a large in-service experience, and is very well proven based also on the past experience of the similar Super Puma MK1. In terms of architecture, the Super Puma and EC225 airframe is precisely what Eurocopter would design today, and is indeed what Eurocopter designed recently for the NH90. Even if the airframe has a limited impact on the performances and costs of a helicopter, this commonality with the Super Puma is enough to give a strong family likeness.

We will see hereafter that the EC225 inherits for instance the NH90 at least as much as the 332 MK2. But in terms of aspect the EC225 is difficult to identify from the 332 MK2. This is the difference between the genetic father and the spiritual father... Nevertheless, this choice has a strong positive effect regarding to the second rule: most of the optional equipment of the Super Puma MK2 can be retained on the EC225 due to this airframe commonality (hoists, floatation gear, multi-purpose air intakes, bubble windows, metro doors, infra-red suppressors, etc...)

This first rule has also led to other major choices concerning the main rotor architecture and technologies. As for the MK2, EC120, and NH90, the main rotor hub is of Spheriflex technology. Moreover, the EC225 main rotor is the third in a row

five recesses Spheriflex main rotor hub designed in Eurocopter, after the recent EC155. This main rotor has a new mast, new sleeves, new swash plates, new scissors, and other new metal parts. New materials have been used but no risk has been taken. For instance, the stainless steel used for the EC225 mast and sleeves has been used extensively before on EC120 and EC155. The EC155 main rotor hub is therefore very similar to the one of the EC155, even if the size is different.

Another illustration of this approach is given by the example of the sleeves. For reasons explained hereafter, the EC225 sleeve is somewhere in-between the MK2 sleeve and the NH90 sleeve. The sleeve root is the one of the MK2 where the head is of NH90 design. The blade interface is the same as the one of the NH90 as the blade roots of NH90 and EC225 blades are identical.

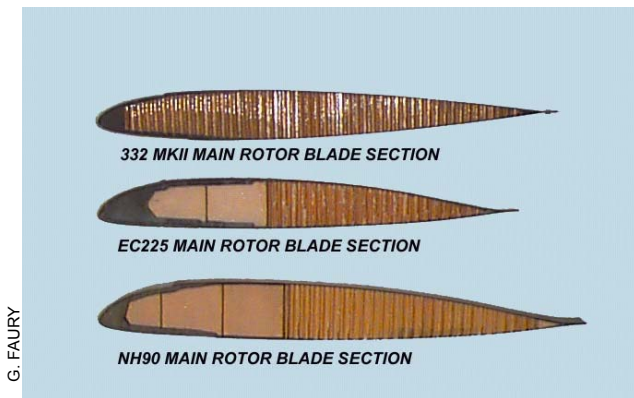
Figure 11: NH90, EC225, and 332 L2 sleeves



The new main rotor blades give a third example. These blades are of new design. The EC225 main rotor has the same diameter as the Super Puma MK2, but the EC225 blades have a 550 mm cord where the cord of the MK2 blades was 600.

Even if the EC225 blades have similar sizes compared to the MK2 blades, they are designed with the latest technologies used in Eurocopter, and therefore very similar to the NH90 blades. The airfoils are state of the art high efficiency non-symmetrical Onera-Aérospatiale airfoils, as on NH90. On the contrary, symmetrical NACA profiles were used on the Super Puma MK2 blades. The EC225 blade architecture and materials are identical to the NH90 blades. Furthermore, the blade root is of exactly the same size and design on both NH90 and EC225 main rotor blades, in spite of the difference in chord (550 mm compared to 650 mm for the NH90).

Figure 12: 332 L2, EC225, and NH90 main rotor blade sections



As a conclusion, the EC225 main rotor looks similar to the Super Puma MK2 main rotor, but belongs in fact to the family of recent Eurocopter Spheriflex main rotors, as the NH90 or the EC155.

However, a Spheriflex rotor embodies elastomeric and hydraulic parts that have usually longer and more risky developments than the metal parts. There are two of them: the blade damper and the spherical thrust bearing.

To be consistent with the rule 2] (avoid risky components developments), solutions based on existing dampers and spherical thrust bearings have been evaluated. Finally, the Super Puma MK2 provided these two components, well adapted to an eleven tons five-bladed main rotor helicopter. Each sleeve / blade / damper assembly is similar in size and characteristics compared to the MK2, but they are five on the EC225 instead of four on the MK2. This choice is of major importance with regard to the risks mitigation success on the EC225.

During the design phase of the aircraft, the validation of the chosen solutions has been achieved through innovative methods (rule 3]). Two examples are described hereafter:

- A shake test has been carried out very early in the development with a whole EC225 airframe to give guidelines for the new main rotor design. This full-scale shake test has been used also to optimize far before the flights the vibration level, and to test and validate anti-vibrations tools for the flights.
- The reinforced MGB has been fully digitized and optimized with the latest tools, as if it were a new MGB.

The main purpose of the shake test performed in 1999 on an EC225 airframe was to simulate the in-flight behavior of the EC225 with its new five blades

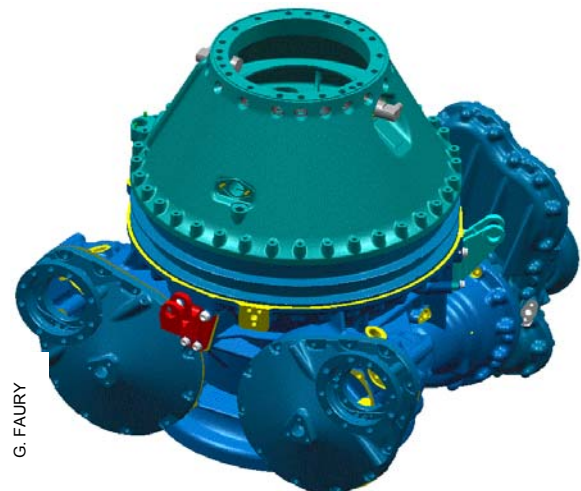
rotor, to optimize the characteristics of this new rotor before its final design is frozen. Several major modifications have been introduced in the definition due to these results. Besides, this shake test aimed to test and select specific anti-vibrations devices for the EC225. Therefore, these devices have been designed and manufactured early, and were available for the maiden flight of the first prototype. They enabled an impressively short in-flight vibration development phase.

Figure 12: full scale shake test



The MGB gives a second example of the risks mitigation approach used for the EC225. The MGB selected for the EC225 is based on the 332 MK2 MGB, with a need for 8 to 13% more power. In order to succeed in this development, it has been decided to first digitize the MK2 MGB and to validate the model based on the tests results obtained during the Super Puma MK2 certification.

Figure 13: EC225 MGB CATIA model



The EC225 reinforcements have been then introduced and tested theoretically through the modern simulation computer tools used for the EC120 and Tiger Main Gear Boxes. They have been then successfully validated months after on full-scale tests on a real EC225 MGB.

The rule 4] says: “prepare back-up scenarios...”. This kind of precautionary measures is of major importance to be able to face the hazards of such a helicopter development without suffering delays. On the EC225, this approach has been widely used. For each risky new component, an alternate solution has been designed early, and made available at the right time in the schedule.

Let’s take the example of the main rotor servo-actuators. On the EC225, there was a need for a 40% more powerful actuator compared to the 332 L2. To face this increase, the solution selected on the EC225 embodies the hydraulic generations of the 332 L2 and a new main rotor servo-actuator. Even if this new actuator is developed by a mature company through the use of proven technologies, the level of risk has been considered relatively high. Therefore the design of a back up solution based on 332 L2 actuators has been achieved through a specific kit. Finally, this back-up solution has been used for the first prototype maiden flight due to delays on the new equipment, and has been removed only after months of flights.

Other alternate options have been used to stick to the initial schedule. Among them, the use of the Makila 1A2X prototype engines has proven to be a real foundation stone. It made possible the flight at power ratings similar to the Makila 1A4 very early in the development and for two prototypes. The first flight with Makila 1A4 is now awaited for late 2001 on the second EC225 / EC725 pre-serial helicopter. This aircraft will be dedicated to engines and power plant flights.

CONCLUSION

The strategy of development risks mitigation applied on the EC225 has already proven its efficiency. The freeze of the aerodynamic and vibration configuration of the EC225 has been reached after only 7 months of flights on the first prototype.

Figure 14: EC225 maiden flight



This strategy has been made realistic only thanks to the impressive amount of solutions available within Eurocopter due to 10 years of new helicopters developments such as EC120, EC130, EC135, EC145, EC155, AS332 L2, Tiger and NH90.

Abbreviations

AMC:	Aircraft Management Computer
EID:	Electronic Instrument Display
FADEC:	Full Authority Digital Engine Control
FDS:	Flight Display System
MGB:	Main Gear Box
VMS:	Vehicle Management System

References

[1] A NEW MAIN ROTOR HUB FOR THE AS 332 SUPER PUMA by R. MOUILLE and C. BIETENHADER

[2] SPHERIFLEX ROTOR HUB: 15 YEARS OF CONTINUOUS IMPROVEMENT by Philippe LEGENDRE, AHS 57th ANNUAL FORUM TECHNOLOGIE DISPLAY