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Digitization and performance monitoring of PT6C-67C engines power chart: AW139 Helicopter case study

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ABSTRACT

The focus of this research mainly aims to upgrade and raise the level of safety of helicopters, especially those that carry out search and rescue missions, through which the helicopter in general and the engine in particular may be exposed to some challenges and natural obstacles mainly.

In order to ensure the readiness and effectiveness of the helicopter engines, the task of following up the performances of the engines was assigned to the flight operations department and through it to the maintenance department.

This work aims to provide a more effective tool for the flight operations department to follow up the performance of the engines of each helicopter and to anticipate malfunctions.

ملخص

إن محور هذا البحث يهدف أساسا إلى ترقية والرفع من مستوى سلامة الطائرات العمودية خاصة تلك التي تقوم بمهمات البحث والإنقاذ والتي من خلالها قد تتعرض الطائرة بصفة عامة والمحرك بصفة خاصة إلى بعض التحديات والمعيقات الطبيعية أساسا

ولضمان جاهزية وفعالية محركات الطائرة العمودية تم إسناد مهمة متابعة خصائص المحركات إلى غرفة العمليات الجوية ومن خلالها إلى ورشة الصيانة

يهدف هذا العمل إلى توفير وسيلة أنجع لغرفة العمليات للمجموعة الجوية للحماية المدنية من أجل متابعة أداء المحركات الخاصة بكل طائرة عمودية واستباق الأعطال وهذا بهدف إبلاغ مسؤولو الصيانة للقيام بالفحوصات اللازمة للمحركات بهدف تجنب بقاء الطائرة في الأرض وضمان جاهزية الطائرات العمودية في كل وقت من أجل التدخل السريع والفعال

Résumé

L'objectif de cette recherche vise principalement à mettre à niveau et à élever le niveau de sécurité de l’hélicoptère, en particulier ceux qui effectuent des missions de recherche et de sauvetage, à travers lesquelles l’hélicoptère en général et le moteur en particulier peuvent être exposés à certains défis et obstacles naturels principalement.

Afin de s'assurer de la disponibilité et de l'efficacité des moteurs d'hélicoptères, la tâche de suivi des performances des moteurs a été confiée au service des opérations aériennes et à travers ce service à l'atelier de maintenance.

Ce travail vise à fournir un moyen plus efficace pour le service des opérations afin de suivre les performances des moteurs de chaque hélicoptère et d'anticiper les dysfonctionnements.

Nous insistons d'emblée, à préciser que ce travail est le fruit d'une contribution Soutenue et guidée par un personnel actif et dynamique à qui nous exprimons une grande et profonde gratitude.

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Nous remercions **Dieu** le tout-puissant, de nous avoir inspiré et accordé la santé et la clairvoyance pour accomplir cette modeste contribution.

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Ammar BOUKROR

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Mes amis et frères '**Jmaat El Khir**' : les années passées à l'université ont été marquées par des moments inoubliables, et vous avez joué un rôle essentiel dans cette expérience enrichissante. À travers nos rencontres, nos discussions passionnantes et nos aventures communes, vous avez fait de ces années une période exceptionnelle.

To all of You Reading this work, come close and focus – People don't have to like you –People don't have to love you –They don't even have to respect you – But when you look in the mirror – you better love what you see

-YOU BETTER LOVE WHAT YOU SEE -

Boussaïd Abderraouf

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A

- **AEO** All Engine Operative
- **ADF** Automatic Direction Finding
- **ASCB** Avionics Standard Communications Bus
- **AC** Alternating current
- **AGB** Accessory Gear Box

C

- **CENAC** The National Coordination Center
- **CSN** Cycle Since New
- **CPAG** Civil Protection Air Group

D

- **DC** Direct current
- **DME** Distance Measuring Equipment

E

- **EEC** Electronic Engine Control
- **EAPS** Engine Air Particle Separator
- **ENG** Engine

F

- **FCU** Fuel Computer Unit

H

- **HP** Horsepower
- **HD** Hight Decetion
- **HOGI** Hovring out ground effect
- **HIGE** Hovring in ground effect

I

- **IGB** Intermediate Gear Box
- **ILS** Instrument Landing System
- **IGE** In ground effect

- **ITT** Inter Turbine Temperature
- **IAS** Indicated Air Speed

M

- **MANEX** Operations Manual
- **MTOW** Maximum Takeoff Weight
- **M/R** Main Rotor
- **MGB** Main Gear Box
- **MFD** Multi-function Display
- **MSN** Manufactory Serial Number
- **MPOG** Minimum Pitch On Ground

N

- **NG** Gas Generator speed
- **NF** Power turbine speed
- **NR** Rotor speed

O

- **OEI** One Engine Inoperative
- **OGE** Out Ground Effect
- **OAT** Outside Air Temperature

P

- **PAM** Power Assurance Margin
- **PFD** Primary Flight Display

R

- **RH** Right Hand

S

- **SMS** Safety Management System
- **SHP** Shaft Horsepower

T

- **TR** Tail Rotor

- **TGB** Tail Gear Box
- **TSN** Time Since New
- **TAS** True Air Speed
- **Transponder (XPDR)** Short for transmitter-responder
- **TQ** Engine torque
- **TSO** Time Since Overhaul

V

- **VHF-COMM** Very High Frequency Communication
- **VOR** Very Hight Frequency Omni Range
- **VNE** Velocity Never Exceed
- **Vy** Rate of climb
- **Vx** Angle of climb

Units used:

- **A** Ampere
- **Bar** a metric unit of pressure
- **°C** Degree Celsius
- **Ft** Feet
- **KTS** Knots
- **Mb** Millibar
- **Kg** Kilogram
- **Psi** Pound per square inch
- **V** Volt

1

INTRODUCTION

A helicopter is an aircraft that is lifted and propelled by one or more horizontal rotors. Each rotor consisting of two or more rotor blades.

Today, helicopters are used for transportation, construction, firefighting, search and rescue, and a variety of other jobs that require its special capabilities.

The operator ability to predict the performance of a helicopter is extremely important. It helps to determine how much weight the helicopter can carry before takeoff, if the helicopter can safely hover at a specific altitude and temperature, the distance required to climb above obstacles, and what the maximum climb rate will be.

This manuscript is intended to address a problem of helicopter engine performances degradation and how to avoid the grounded helicopter situation that will affect the search and rescue mission of the group and this by preventing and scheduling maintenance actions in order to maintain the helicopter in service.

For this reason, our aim is to provide an efficient tool that will help flight operations department of Civil Protection Air Group to avoid such situation and alert the maintenance department for actions.

In order to clarify and give a resolution for this technical problem, we will structure our manuscript as follows:

In the first chapter, we will discuss about the host organization, which is the Civil Protection Air Group, then we will give an overview about the Italian helicopter Augusta Westland AW139.

In the second chapter, we will give a general description of Pratt & Whitney Canada PT6C-67C engine which is considered as one of the most reliable turbo shaft engine ever built, and this by giving their main components and functions, then we will mention the helicopters performances, taking in consideration all the parameters affecting them.

In the third chapter, we will focus mainly on the Power Assurance Check and their importance as a tool for preventing engine malfunction.

In the fourth and final chapters, we will present the fruit of our work, the application that is named **HELIOS** that will help the operators to make a long term follow up in order to prevent the helicopters grounding and reducing maintenance costs. In addition, we will give all the steps that flight operation officers and users should follow to reach the correct values from maximum allowable ITT and NG using this application.

We will close our work by a general conclusion then giving some application limitations and future enhancement for future development.

2

CIVIL PROTECTION AIR GROUP PRESENTATION AND AGUSTA WESTLAND AW139 HELICOPTER OVERVIEW

Our end-of-cycle project was realized at the Civil Protection Air Group. For that, this chapter focuses on the presentation of the Civil Protection Air Group unit and the AGUSTA WESTLAND AW139 helicopter used in our work.

Contents

2.1 Introduction

The Algerian Civil Protection, resulting from decree n° 64-129 of 1964, is a service responsible for the protection of people, property and the environment in Algeria. It is responsible for the protection and the fight against fires, accidents, natural disasters. It is also responsible for the assessment and prevention of natural and technological risks and other various interventions (rescue of animals, gas leaks, etc.).

To accomplish its missions, the headquarter of Civil Protection is developing more and more by relying on new technologies and by training its staff. And to reduce the intervention delay and extend the range of action, the Algerian Civil Protection has been reinforced by an air fleet managed by one of its units, which is the Civil Protection Air Group. The latter is specialized in reconnaissance, rescue, emergency evacuation and the fight against forest fires.

In this chapter, we will present the missions, the structure and the responsibilities of the different departments of Civil Protection Air Group. Then, we will talk about the fleet of the Civil Protection Air Group including the AGUSTA WESTLAND AW139 helicopter. The main systems constituting AGUSTA WESTLAND AW139 are presented after as well as its operational performance and mass limits.

2.2 Civil Protection Air Group Presentation

2.2.1 Creation and headquarter of the Civil Protection Air Group

The Civil Protection Air Group CPAG was created by Executive Decree No.12-70 of 12th of February 2012. Its infrastructure is set at the airport of Algiers Houari Boumediene in Dar El-Beida. Several other advanced bases and unities are also considered at Medea, Tikjda, Bejaia, .etc.

Figure 2.1: The Civil Protection Air Group hangar

2.2.2 The missions of the Civil Protection Air Group

The Civil Protection Air Group CPAG carries out prevention and aerial intervention missions for the protection of the population, property, and the environment, under the rules and procedures in effect. It is responsible to:

- ensure the rescue in perilous and difficult access areas;

Figure 2.2: Rescuing in dangerous and difficult access areas

- conduct a recce of disaster areas to assess the damage, and to engage the appropriate means of intervention;
- ensure the supply of the populations enclaved in the disaster areas;
- transport rescue teams and specific Civil Protection equipment to disaster areas;
- participate in the surveillance of forest massifs and firefighting actions;
- provide emergency medical service for primary air evacuations from the scene of a disaster to appropriate medical facilities;
- Firefighting.

Figure 2.3: Rescue service for primary evacuation

Figure 2.4: Firefighting Operations

2.2.3 Internal organization of the Civil Protection Air Group

The Air Group has a main unit CPAG and regional units. Each unit contains centers and departments of structures indicated by the figures below.

2.2.3.1 General organization chart of the Civil Protection Air Group

Figure 2.5 shows the general structure of the Civil Protection Air Group unit.

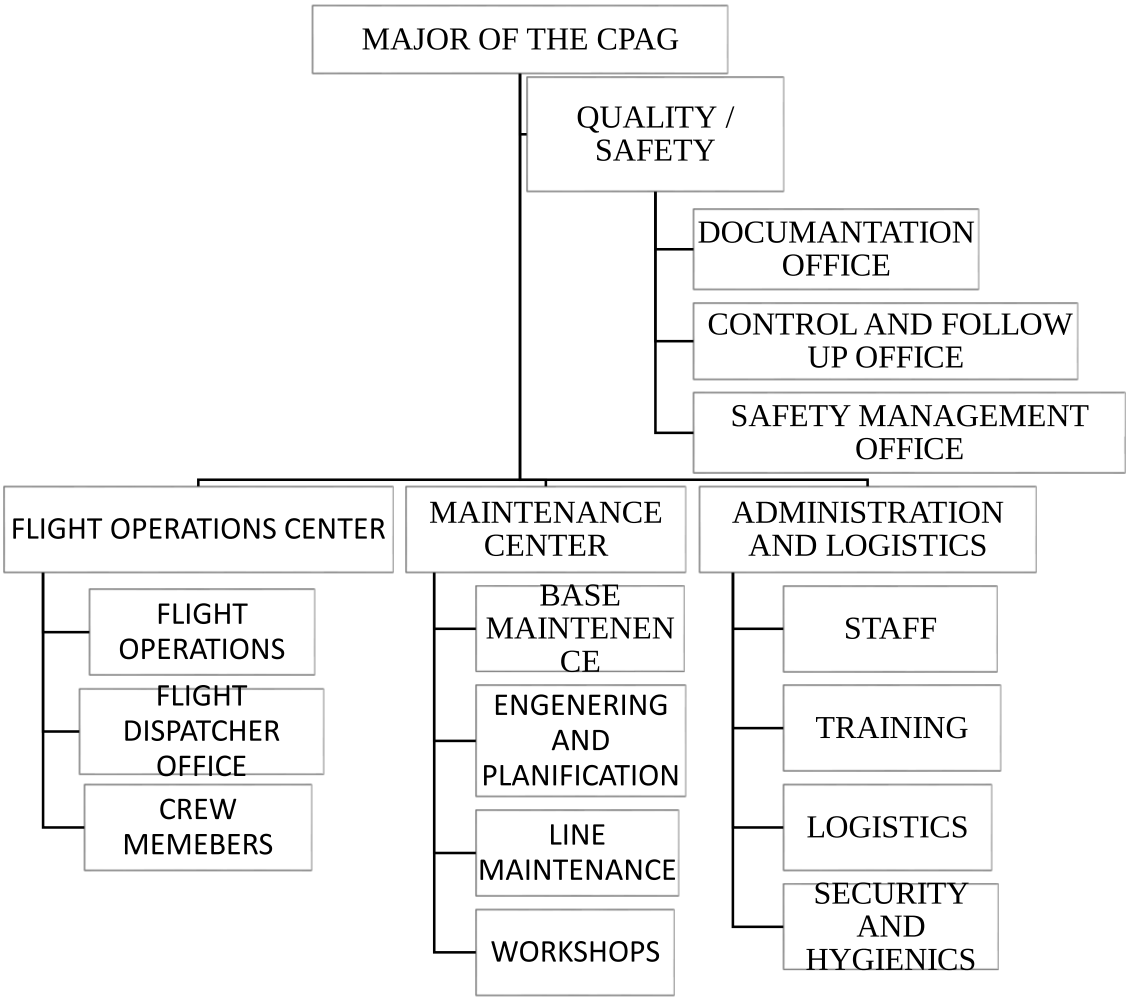

Figure 2.5: Organization chart of CPAG

2.2.3.2 General organization chart of regional units

The CPAG has regional air rescue units in Saïda, Oum El Bouaghi, Boughezoul and Ouargla of the structure given by Figure 2.6 below.

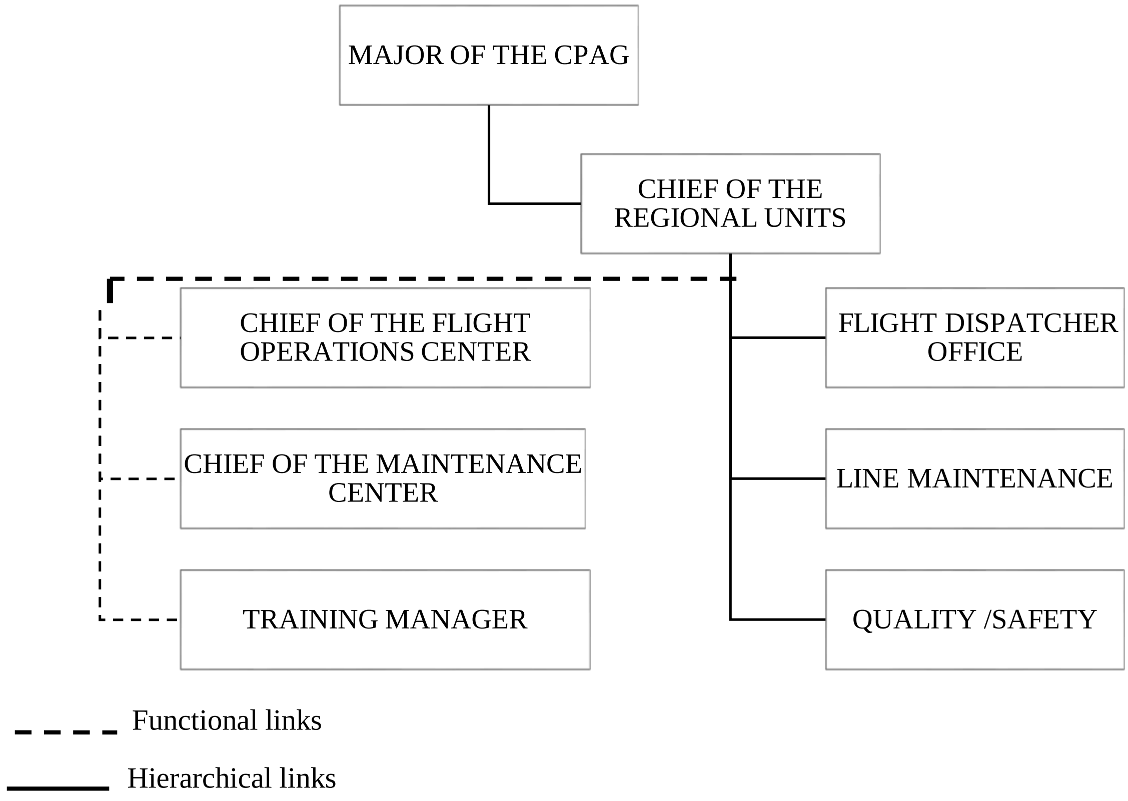

Figure 2.6: Organization chart of CPAG regional units

2.2.3.3 General organization chart of the flight operations centre

The flight operations center's primary mission is to coordinate and manage flight operations. It is structured as shown in Figure 2.7.

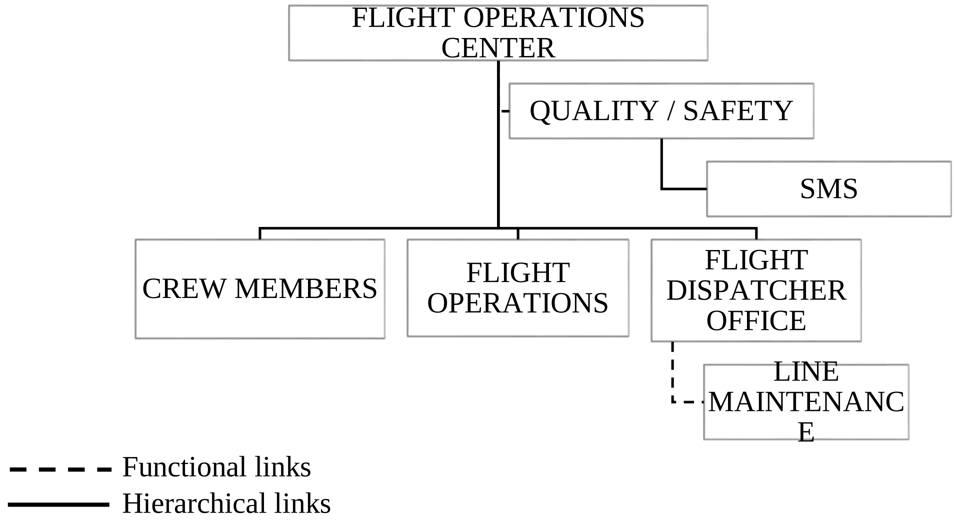

Figure 2.7: Organization chart of the flight operations centre

2.2.4 Responsibilities of the departments of the Civil Protection Air Group

Actually, the Air Group consists of 22 helicopter pilots (05 under training), 4 airplane pilots (01 under training), 06 rear crew members, 57 engineers, and technicians (32 are qualified on the type) 04 flight operations engineers, and a support staff. These workforces are distributed in the different centers and departments with responsibilities mentioned below.

2.2.4.1 Responsibilities of the quality and flight safety services

The services of the quality and flight safety have the following responsibilities

- ❖ Ensure the application of civil aviation standards and rules;
- ❖ Evaluate risks and analyse procedures specific to major events and reinforce the air safety of the Air Group;
- ❖ Develop and update the Air Group's Quality System Manual and Safety Management Manual;
- ❖ Implement and include an audit and control program that allows a regular review of all the structures and services of the Air Group;
- ❖ Ensure the issuance and renewal of aviation personnel licenses by the competent authorities.

The department comprises three (3) offices:

- ✓ Documentation office;
- ✓ Control and follow up office;
- ✓ Safety management office.

2.2.4.2 Responsibilities of the flight operations centre

The flight operations center ensure the following responsibilities:

- ❖ Prepare the files and technical documents needed for the realization of the missions for each flight;
- ❖ Manage and coordinate flight operations with the authorities and concerned services.
- ❖ Coordinate with the national coordination centre CENAC;
- ❖ Ensure compliance with operating standards and practices and ensure their conformity with the regulations governing civil aviation;
- ❖ Coordinate with the maintenance service regarding the airworthiness of aircraft;
- ❖ Elaborate and update the MANEX and the flight manual and validate them by the Civil Aviation Authority under the legislative and regulatory provisions;
- ❖ Validate the designation's program of the crew;

This department includes three offices:

- ✓ Flight Operations;
- ✓ Flight dispatch Office;

- ✓ Flight Crews.

2.2.4.3 Responsibilities of the maintenance centre

The maintenance center ensure the following responsibilities:

- ❖ Control and ensure that the maintenance system is carried out according to the procedures approved by the civil aviation authority;
- ❖ Plan and schedule the maintenance and control of aircraft under approved standards;
- ❖ Ensure the airworthiness of aircraft;
- ❖ Ensure the repair and overhaul of unserviceable aircraft, equipment or parts;
- ❖ Develop and update the maintenance guide and manuals according to the standards of the manufacturer and the civil aviation authority;
- ❖ Ensure the management of maintenance schedules and directives imposed by the civil aviation authority or the manufacturer.

It includes four offices:

- ✓ Base Maintenance
- ✓ Engineering and Planning;
- ✓ Line Maintenance ;
- ✓ Workshops.

2.2.4.4 Responsibilities of the Administration and Logistics Services

The responsibilities of the Administration and Logistics Services are mentioned as below:

- ❖ Monitor the management and distribution of human and material resources of the services and structures belonging to the air group;
- ❖ Prepare and execute the specialized training program for the air group personnel;
- ❖ Ensure the supply and acquisition of the means, equipment, and materials necessary for the operation of the air group;
- ❖ Ensure the maintenance and protection of the air group's infrastructures;
- ❖ Participate in the preparation of the contracts of the air grouping and ensure the follow-up of their execution.

The services include four offices:

- ✓ Staff ;
- ✓ Training ;
- ✓ Logistics ;
- ✓ Security and hygiene.

2.2.5 The fleet of the Civil Protection Air Group

The current fleet of the Air Group is composed of:

- four (4) Zlin Saphir Z-43S aircraft
- six (6) AGUSTA WESTLAND AW-139 helicopters, which are used for several missions.

2.2.5.1 Zlin Saphir-43 Z43S aircraft

The Zlin Safir-43 is a light four-seater aircraft of the Algerian manufacturer ECA. It is equipped with a six-cylinder piston engine LOM M337AK with a power of 210 hp, maximum cruising speed of 290 km/h, the autonomy of 5 hours, and its maximum flight level is FL 105.

Figure 2.8: Zlin Saphir Z43-S (7T-VQR)

The Air Group has four Zlin Saphir Z-43S. It is derived under license from the Czechoslovakian Zlín Z-43 aircraft. Table 2.1 shows the Maximum Take-Off Weight MTOW value and engine type of the four Zlin Saphir Z43 immatriculations available to CPAG.

Table 2.1 : Zlin Saphir-Z43 immatriculations and their MTOW and engine type

Immatriculations	MTOW (Kg)	ENGINE
7T-VQR	1350	LOM M337AK
7T-VFZ	1350	LOM M337AK
7T-VQP	1350	LOM M337AK
7T-VWQ	1350	LOM M337AK

2.2.5.2 AGUSTA WESTLAND AW139 helicopter

The AGUSTA WESTLAND helicopter, currently known by LEONARDO, was originally designed jointly by the Italian helicopter manufacturer AGUSTA and the American company Bell Helicopters.

Figure 2.9: AW139 Enhanced version (7T-VWI)

Having performed its first flight on 3 February 2001, the AW139 entered revenue service during 2003 and quickly proved itself to be a commercial success.

The AW139 is a multi-role aircraft equipped with two Pratt & Whitney PT6C-67C turbine engines. Over 1,100 rotorcraft had been sold by January 2021.

This helicopter is offered in four different versions, each version comes with its own set of features and configurations.

The different versions are:

- ✓ Short nose;
- ✓ Long nose;
- ✓ Enhanced;
- ✓ Plus.

2.3 AGUSTA-WESTLAND AW139 Helicopter Overview

2.3.1 Presentation of the AGUSTA-WESTLAND AW139 Helicopter

The AW139 is a helicopter from European manufacturer AGUSTA WESTLAND. It has two engines, a medium size, and it can transport up to 16 people. It is a comfortable helicopter and is suitable for many professional and personal uses.

The Civil Protection Air Group CPAG owns six AW139 helicopters of the Enhanced version, which is an advanced Long Nose version with low density cabin configuration and has another six helicopters in production that will be delivered soon.

Figure 2.10: The Six AW139 helicopters of the Air Group

The Italian machine is equipped with two Pratt & Whitney PT6C-67C turbine engines that generate 1531-unit horsepower.

Table 2.2 : AW139 immatriculations and their MTOW and engine type

Immatriculations	MTOW (Kg)	ENGINE
7T-VWD	6400	PT6C-67C
7T-VWE	6400	PT6C-67C
7T-VWF	6400	PT6C-67C
7T-VWG	6400	PT6C-67C
7T-VWH	6400	PT6C-67C
7T-VWI	6400	PT6C-67C

2.3.2 The major components of AW139

2.3.2.1 Main dimensions of AW139 Helicopter

Figures 2.11 and 2.12 show the principal dimensions of AW139 enhanced version and the dimensions of its cabin and baggage compartment respectively.

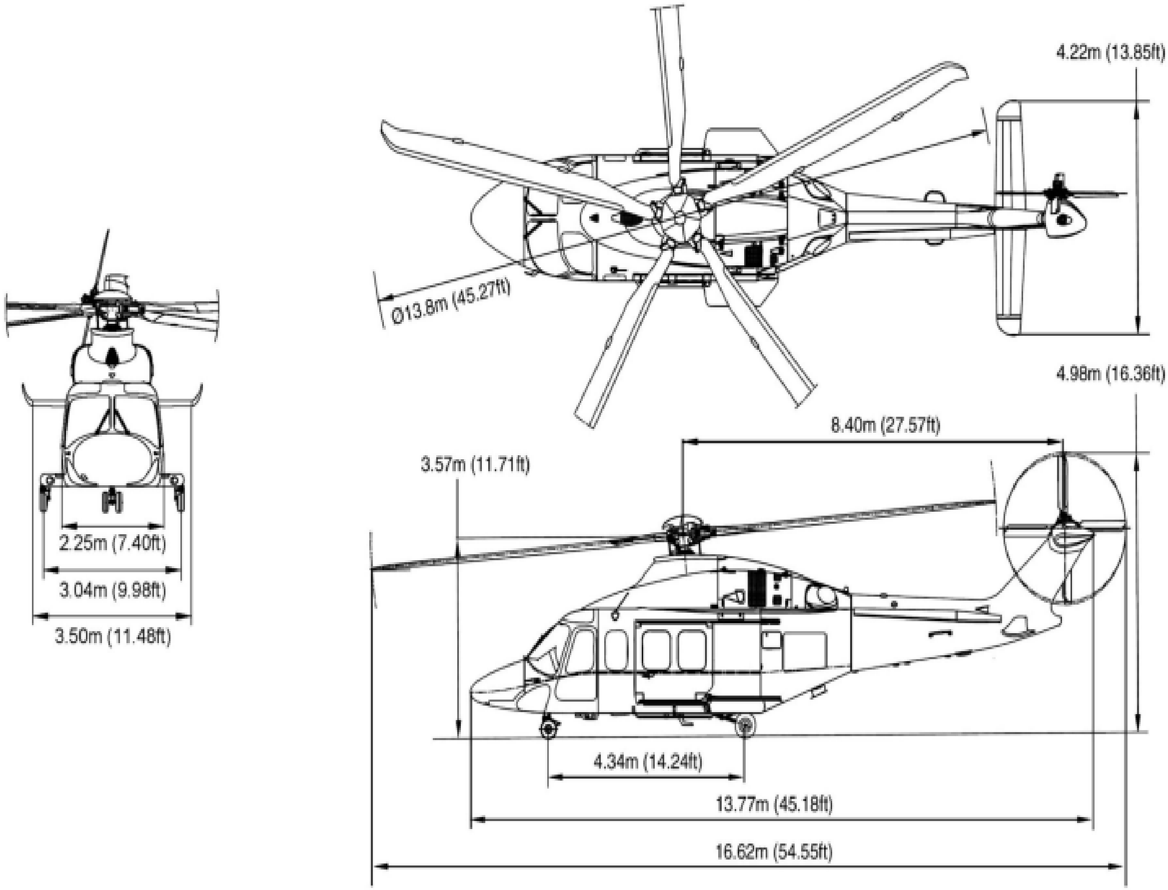

Figure 2.11: Principal dimensions (Enhanced version)

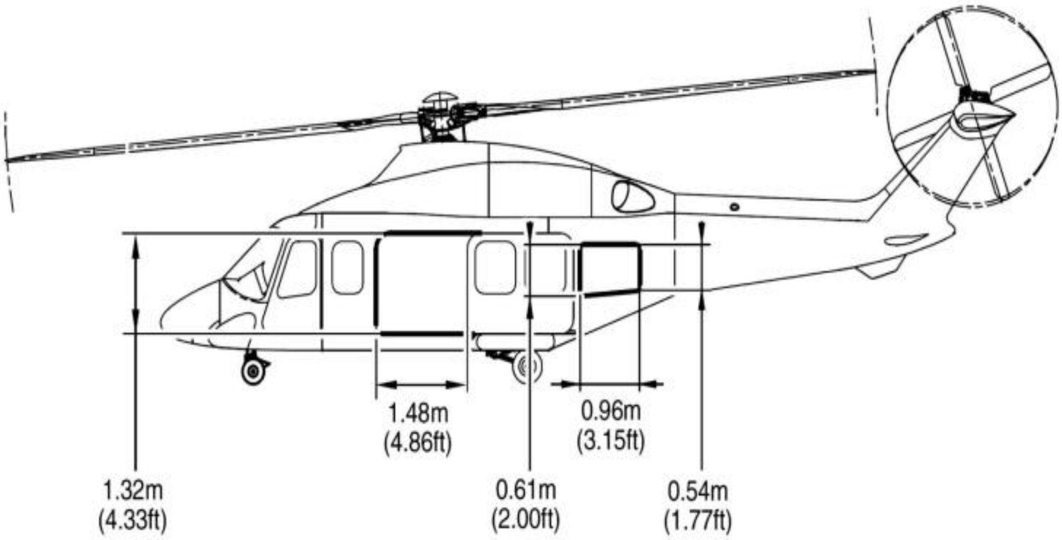

Figure 2.12: Cabin and bagage compartment dimensions

2.3.2.2 Major zones of AW139

Figure 2.13 shows the major components of AW139 such as the fuselage and the tail.

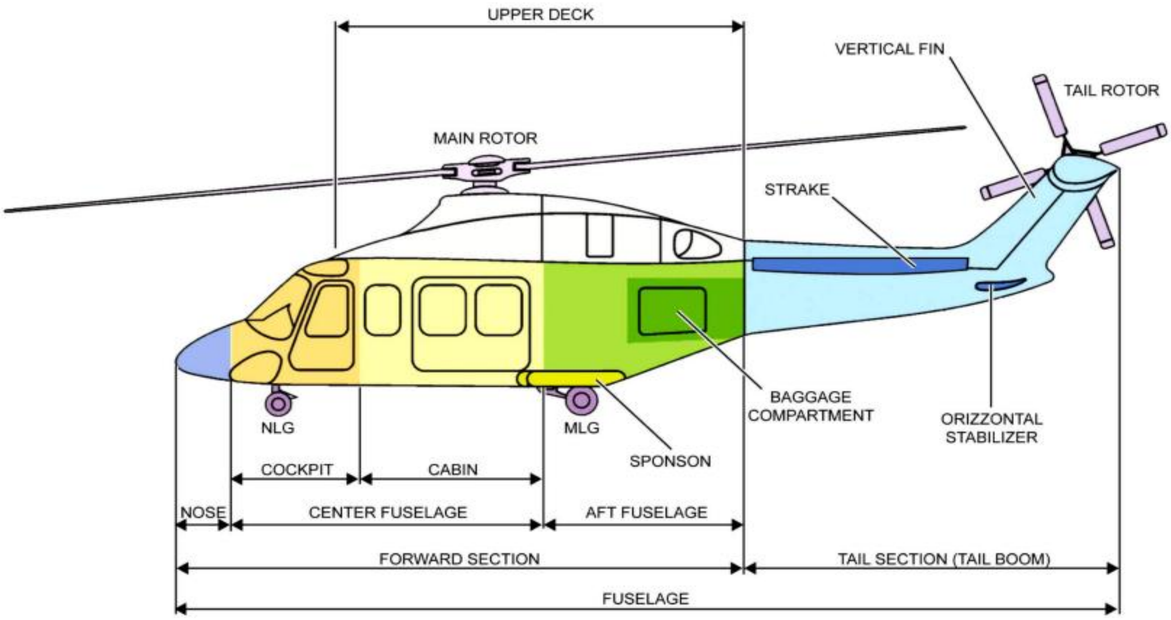

Figure 2.13: AW139 major zones

The **Fuselage** is the helicopter's main body section. It is designed to provide the required safety conditions such as control deformation when having crash load, sustaing lighting effects and fireproof in fire critical areas. It holds and support the following:

- the passenger cabin
- fuel tanks
- hydraulics
- dynamics components
- landing gear and flight controls
- the engine installation

The **Forward fuselage** is a Metallic construction made with: - Longerons, frames and sandwich panels. They provide pilot cabine floor and an interface with the cockpit, also a nose landing gear (mainly) housing and support the canopy assembly.

The **Rear fuselage** is constructed with Metallic semi-monocoque made with: Sheet beams, frames, and sandwich panels. They provide baggage compartments, avionics installation and Engine installation.

The **Tail** is a Metallic semi-monocoque construction made with: Sheet, Beams, frames and sandwich panels attached to the rear section with 6 bolts.

The top side of the center fuselage is completed with the upper deck/engine fairings and cowlings. The upper deck fairings are manufactured in composite materials.

2.3.2.3 Major Components-Fuselage materials

The AGUSTA WESTLAND AW139 is composed of several materials. Each material has its own purpose for placement in defined locations in the fuselage, and this composition includes:

- **Titanium :** It the most heat resistant, has extraordinary resistance to corrosion and an ability to withstand extreme temperatures of 600°C.

- **Carbon fiber :** It is a very strong material that also very lightweight. Carbon fiber is five-times stronger than steel and twice as stiff.
- **Kevlar (Para-aramid) :** It is a strong synthetic fiber, and heat resistant. It is used in many of the most critical parts of the helicopter because of its impact-resistant which is greater.
- **Glass fiber :** It is a material consisting of numerous extremely fine fiber glass. Although not as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites, with better damage tolerance for impact loading and specific strength and stiffness**.**

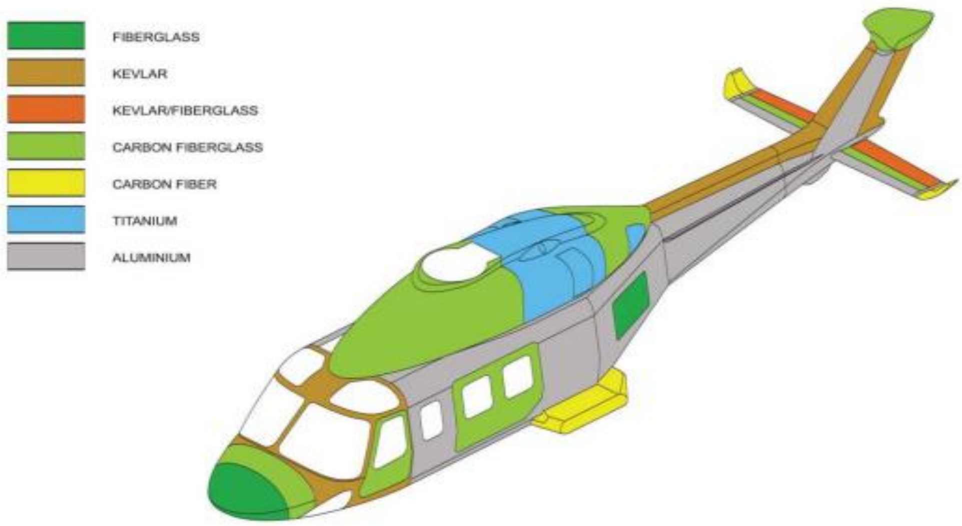

Figure 2.14: Major Components-Fuselage materials

2.3.3 AW139 Systems overview

2.3.3.1 Power plant

The Power Plant shall comprise engines and related installation, fire detection, and extinguishing system.

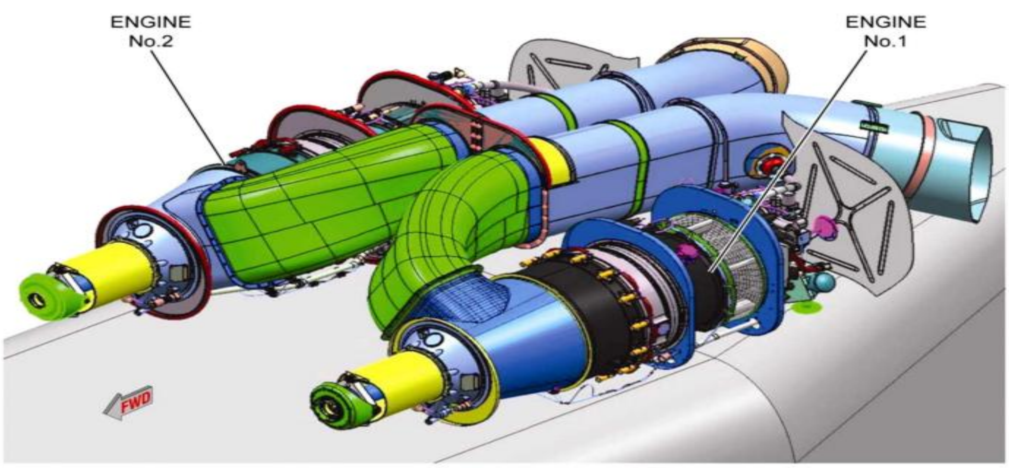

Figure 2.15: Power plant

Engines

AW139 helicopter is powered by two PT6C-67C turboshaft engines. Each engine is installed in a separate fireproof area above the cabin roof and supplies power to the drive system utilizing a rotating shaft. The engines are connected to the airframe employing two attachment points on the engine body and to the main gearbox using a tube and a gimbal joint. Air is supplied to the engine via individual, side-facing air inlets. The engines are started by a DC starter-generator. Engine control is achieved via a control panel located in the cockpit and manual backup of the engine control via push pull cables. The engines are provided with torque sensing and matching.

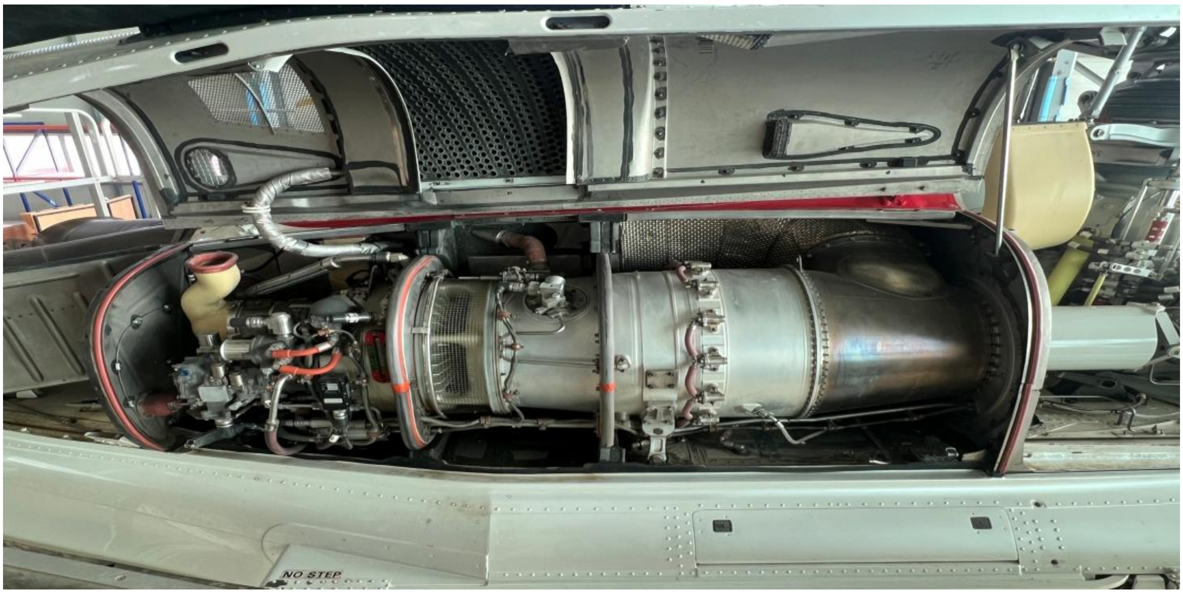

Figure 2.16: External view of PT6C-67C Engine

2.3.3.2 Rotors

The Rotor System consists of a main rotor (MR) and a tail rotor (TR). The main rotor is five blades, fully articulated rotor. The tail rotor is four blades and a fully articulated rotor.

Figure 2.17: The main rotor and the tail rotor of AW139

2.3.3.3 Drive System

The Drive System consists of the Main Rotor Drive System and the Tail Rotor Drive System.

The **Main Rotor Drive System** mainly consists of the Main Gearbox (MGB) that is mounted on the roof of the cabin using four struts and an anti-torque device. The MGB has three stages of reduction and includes a duplicated oil lubrication system. It provides the attachment points for the rotor brake coaxial with the Tail Rotor Drive output. The MGB drives three hydraulic pumps and other accessories.

Figure 2.18: Main Rotor Drive System

The **Tail Rotor Drive System** consists of three drive shafts driven by the MGB, the Intermediate Gearbox IGB, and the Tail Gearbox TGB oil splash lubricated. The Main Rotor is five blades, fully articulated rotor. The Tail Rotor is four blades and a fully articulated rotor.

Figure 2.19: Tail Rotor Drive System

2.3.3.4 Hydraulic Power System

The Hydraulic Power System consists of two independent circuits that supply hydraulic fluid at a nominal working pressure of 3000 psi (207 bar). Both Hydraulic Power System circuits supply the hydraulic power necessary to operate the flight control servo-actuators and the landing gear.

For ground test and malfunction conditions, a shut-off valve allows to shut-off of the flight control circuits. For safety reasons, another shut-off valve allows to shut the landing gear circuits

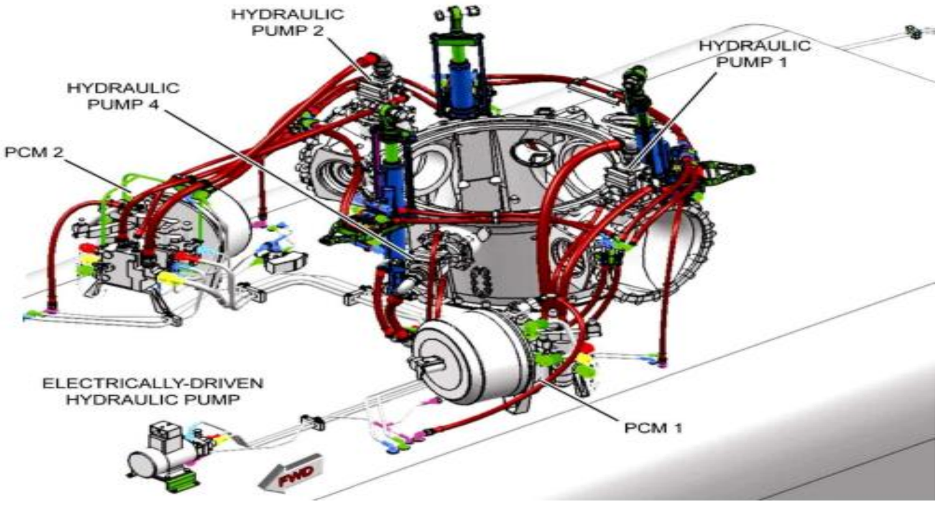

Figure 2.20: Hydraulic Power System

off, increasing the survivability of the flight control functions. Hydraulic power to the landing gear actuators is used to extend and retract the main and the nose landing gears. The main and nose landing gear are maintained in the UP position by the hydraulic pressure (no mechanical uplocks are provided). The extended DOWN position is maintained with a mechanical lock in the main and nose gear actuators.

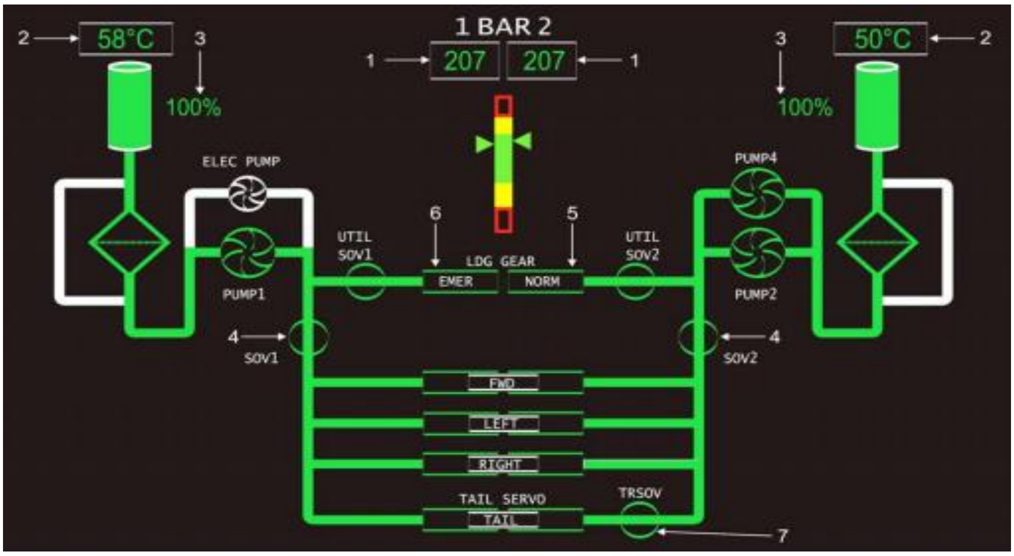

Figure 2.21: Hydraulic synoptic page

2.3.3.5 Fuel System

The Fuel System includes crash-worthy fuel tanks located in the rear area of the cabin. Each tank contains a booster pump, an engine feed line, and a fuel and water drain valve. Filling with fuel is achieved by gravity.

The fuel selector manifold allows fuel to supply each engine separately or fuel both engines in a cross-feed condition. The fuel quantity gauging system is composed of four capacity probes, a Fuel Computer Unit (FCU), and a fuel low-level sensor for each tank.

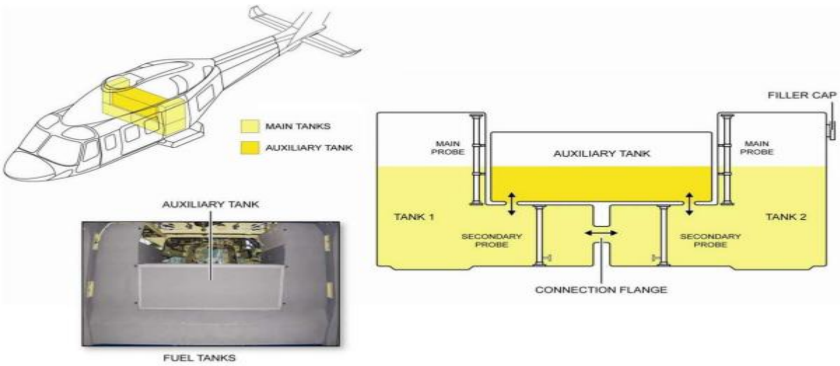

Figure 2.22: Fuel Tanks

2.3.3.6 Electrical Power System

DC power is generated by two 30V, 300A DC air-cooled generators. Two batteries provide a backup source of emergency power if both generators fail and power for autonomous ground operations and engine starting. The electrical power is delivered to aircraft systems by a dual system of distribution bus bars consisting of the Main (MAIN), Essential (ESS), and Nonessential (NON-ESS) busses. Power from a DC external power source can also be connected to the aircraft busses.

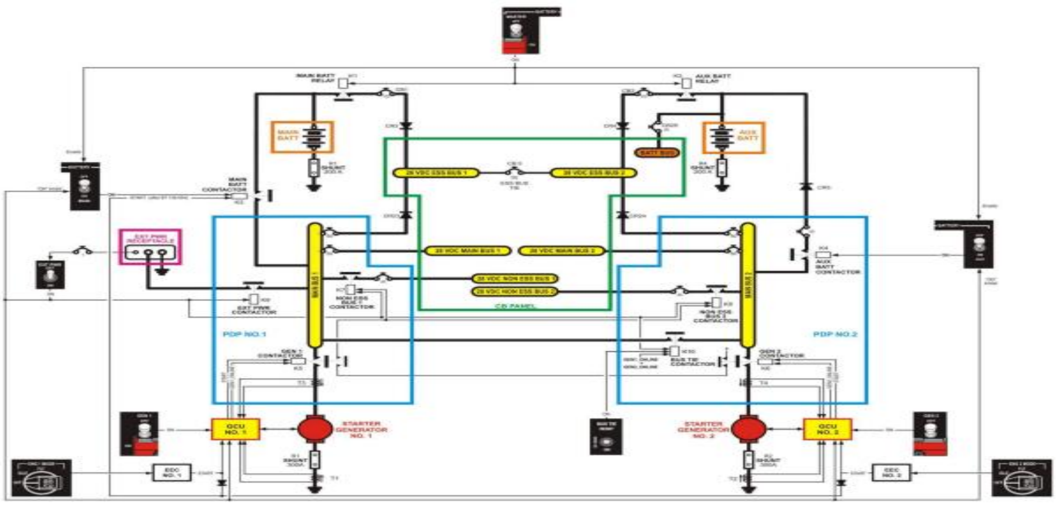

Figure 2.23: DC power general arrangement

2.3.3.7 Avionic System

The PRIMUS EPIC system is an integrated avionic system that includes the following sub-systems necessary to operate:

- Auto-Pilot
- Flight Management System
- Communication System
- Indicating and Recording Systems
- Aural Warning Generator
- Navigation System

- Crew Alerting System
- Central Maintenance Systems (CMS)

The PRIMUS EPIC system is integrated into:

- two Modular Avionic Units (MAU)
- two primary flight display PFD and two multifunction display MFD to show data in the cockpit
- two Modular Radio Cabinets (MRC) that include the following radios:
  - VHF-COMM
  - VOR/ILS
  - ADF
  - DME
  - Transponder (XPDR)

The MAUs, the DUs, and the MRCs are directly connected via a bi-directional digital data bus named Avionic Standard Communication Bus-D (ASCB-D).

A LAN digital bus also interconnects the same units for maintenance purposes. In addition to the PRIMUS EPIC integrated avionic system, the following systems are also part of the aircraft's standard avionic configuration:

- Standby Instrument
- Emergency Locator Transmitter (ELT)
- Flight Data Recorder / Cockpit Voice Recorder FDR/CVR

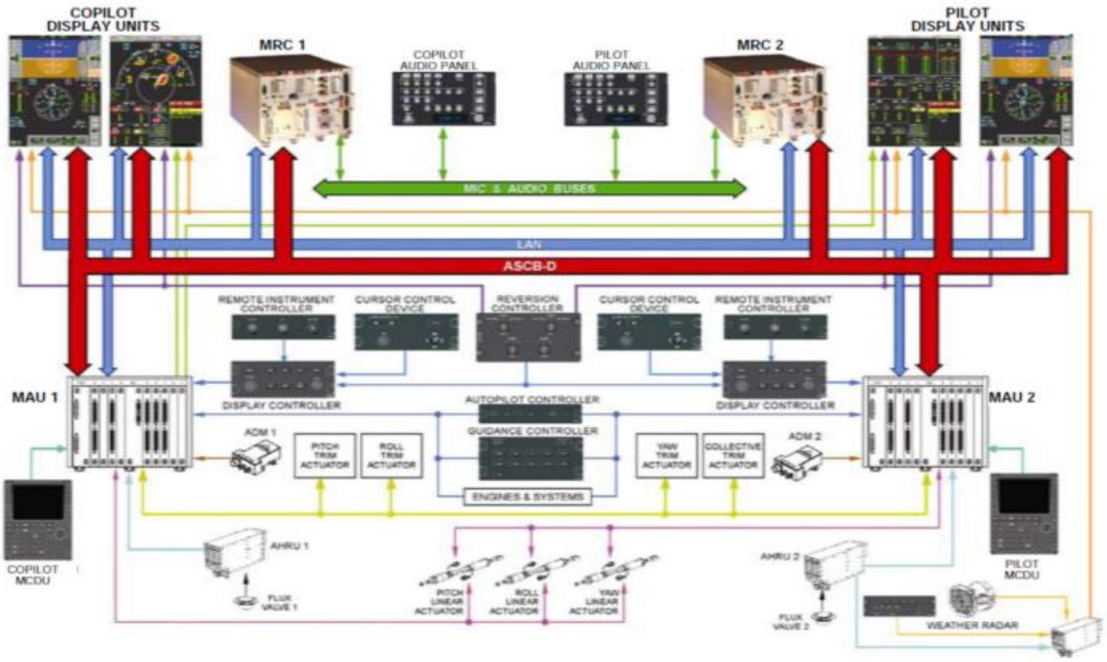

Figure 2.24: Avionic general arrangement

2.3.4 Operational Performance and Mass limits of AW139

The operational performance and mass limitations of AW139 are given as follows:

- VNE (AEO).. 167 KIAS.
- Rate of climb (AEO)... 2150 fpm.
- Service ceiling (Hp or Hd) .... 20000 ft.
- Hover Ceiling (IGE & OGE) .... 18000 ft.
- Takeoff and landing ceiling .... 14000 ft.
- Operating temperature................................. from -40°C to 50°C.
- Maximum take-off weight... 6400 Kg.
- Maximum take-off weight increased................. 6800/7000 Kg.
- Minimum weight for rotor rotation............................. 4400 Kg.

2.4 Conclusion

During this chapter, we briefly introduced the Civil Protection Air Group. We have mentioned the various missions carried out by the Air Group, its organizations and the responsibilities of its main structures. The Group's fleet, made up of Zlin Saphir Z43 aircraft and AGUSTA WESTLAND AW139 helicopter, is also presented, whose the AW139 is detailed at the end of the chapter.

3

GENERAL DESCRIPTION OF Pratt & Whitney Canada PT6C-67C ENGINE

This chapter is devoted to the study of the P&WC PT6 engine installed on AGUSTA-WESTLAND AW139 helicopter.

Contents

3.1 Introduction

On a helicopter, the main rotor or rotor system is the combination of several rotary wings (rotor blades) with a control system, which generates the aerodynamic lift force that supports the weight of the helicopter, and the thrust that counteracts aerodynamic drag in forward flight.

The Pratt & Whitney engine variants are found in helicopters, boats, and industry. According to the P&WC website, the P&WC PT6 turboprop engine has 400+ million flying hours and flies in 180 countries.

In this chapter, we will discuss about the characteristics and advantages of this engine as well as its basic components and different external parameters affecting performances.

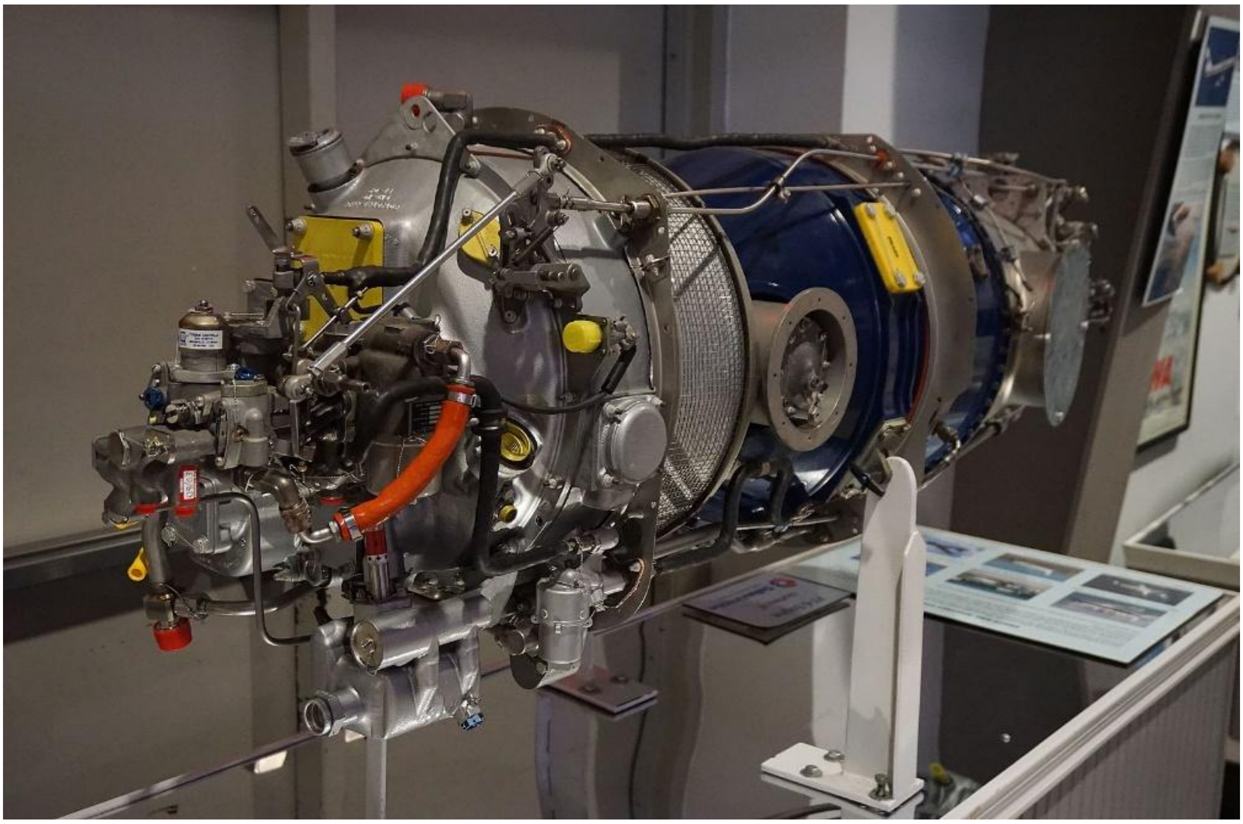

Figure 3.1: P&WC PT6 Turboprop Engine

3.2 Power plant of AW139

The AW139 is powered by two Pratt & Whitney Canada PT6C-67C turbine engines. Each engine is a free turbine turbo-shaft propulsion engine that includes a four-stage axial compressor and a one-stage centrifugal compressor. The compressors are driven by a single-stage compressor turbine. The two-stage power turbine drives the output shaft which supplies power directly to the input gears of the MGB. An Electronic Engine Control (EEC) unit, with a hydro-mechanical Fuel Management Module (FMM), ensures automatic control of the engine and fast response to changes in power demand. The Engine Control Lever (ECL) provides manual backup in case the automatic engine control system fails. The engine indicating system includes sensors and probes installed on the engine that check the status of the engine. Each engine supplies 1872 SHP in OEI condition.

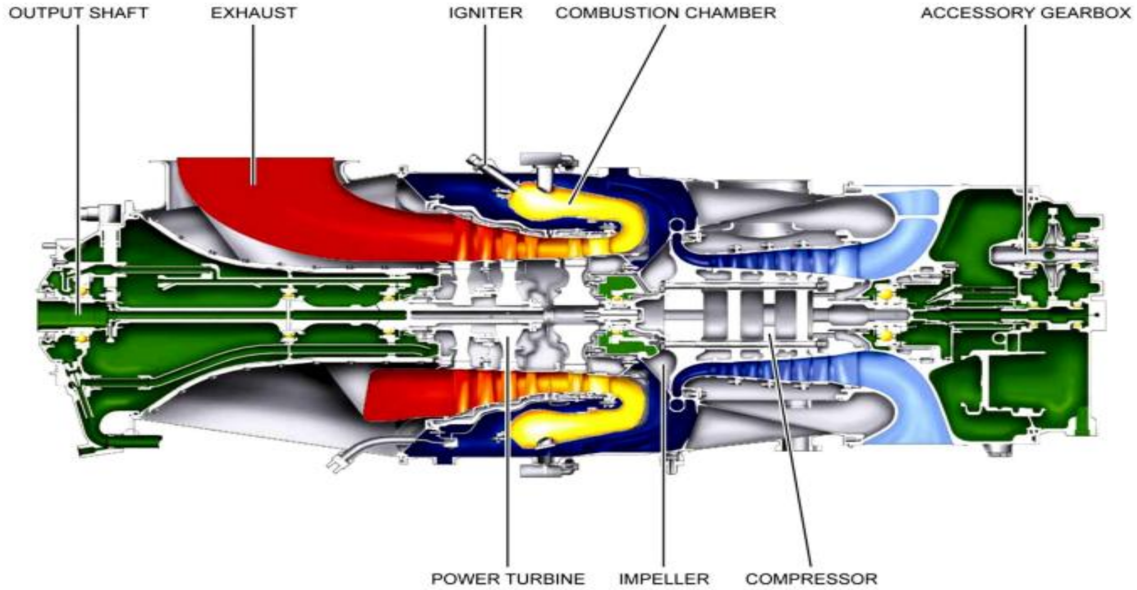

Figure 3.2: AW139 power plant Schematic

3.3 Thermodynamic cycle and engine stations

Engine stations are specific locations within the engine that are significant in terms of operating pressures and temperatures.

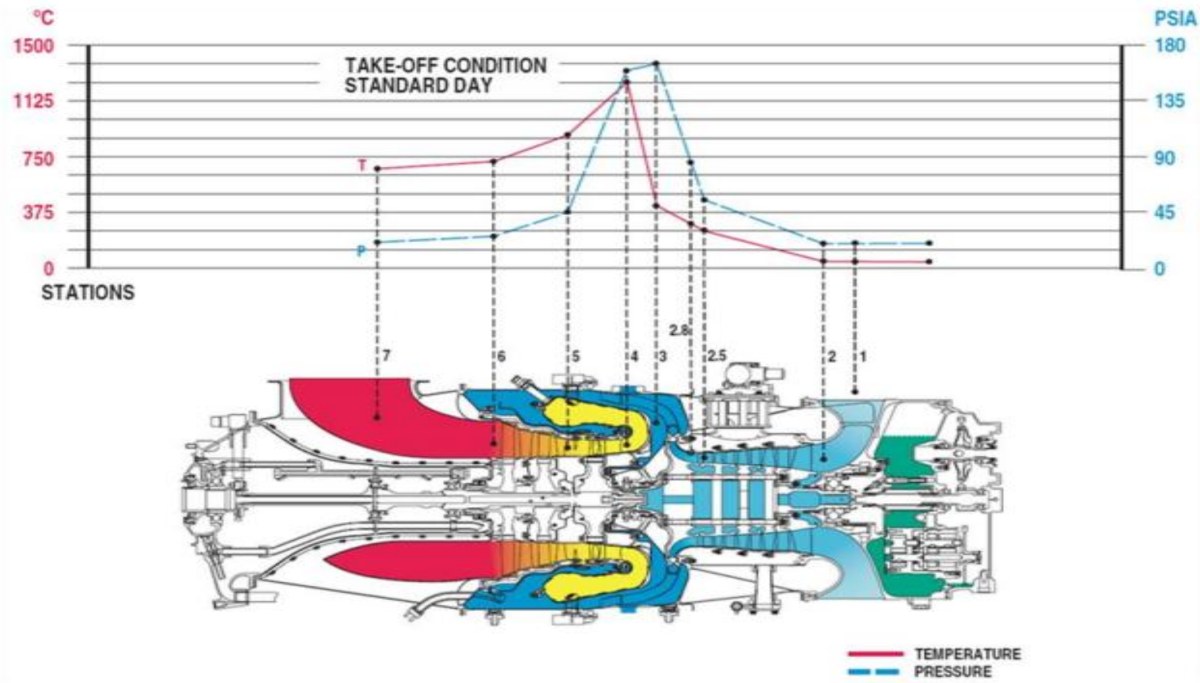

Figure 3.3: Pressure and temperature values of air station

The stations are numbered from the intake to the end of the engine as follows:

- STATION 1 – Air intake
- STATION 2 – Inlet to axial flow compressor
- STATION 2.5 – Between axial and centrifugal compressors

- STATION 2.8 – Intermediate point of centrifugal compressor
- STATION 3 – Outlet from the centrifugal compressor
- STATION 4 – Inlet to the compressor turbine guide vanes
- STATION 5 – Between the compressor turbine and power turbines
- STATION 6 – Exit from the power turbine
- STATION 7 – Engine exhaust exit

3.4 Main components of P&WC PT6 Engine

P&WC PT6 Engine consist of several components explained below.

3.4.1 Oil filler cap

It is possible to remove the oil filler cap to fill the integrated oil tank.

3.4.2 Oil sight glass (left and right)

Two oil sight glasses are installed, one on the right and one on the left side of the engine oil tank to permit checking the oil quantity.

3.4.3 Ng Sensor

The Ng Sensor is located on the top left side of the engine accessory gearbox. It is a magnetic sensor that uses the starter-generator gear shaft teeth as the speed reference.

3.4.4 Permanent Magnetic Alternator (PMA)

The PMA provides the primary power source for the EEC unit when the engine is running above 40% Ng. The PMA is an integral part of the accessory gearbox.

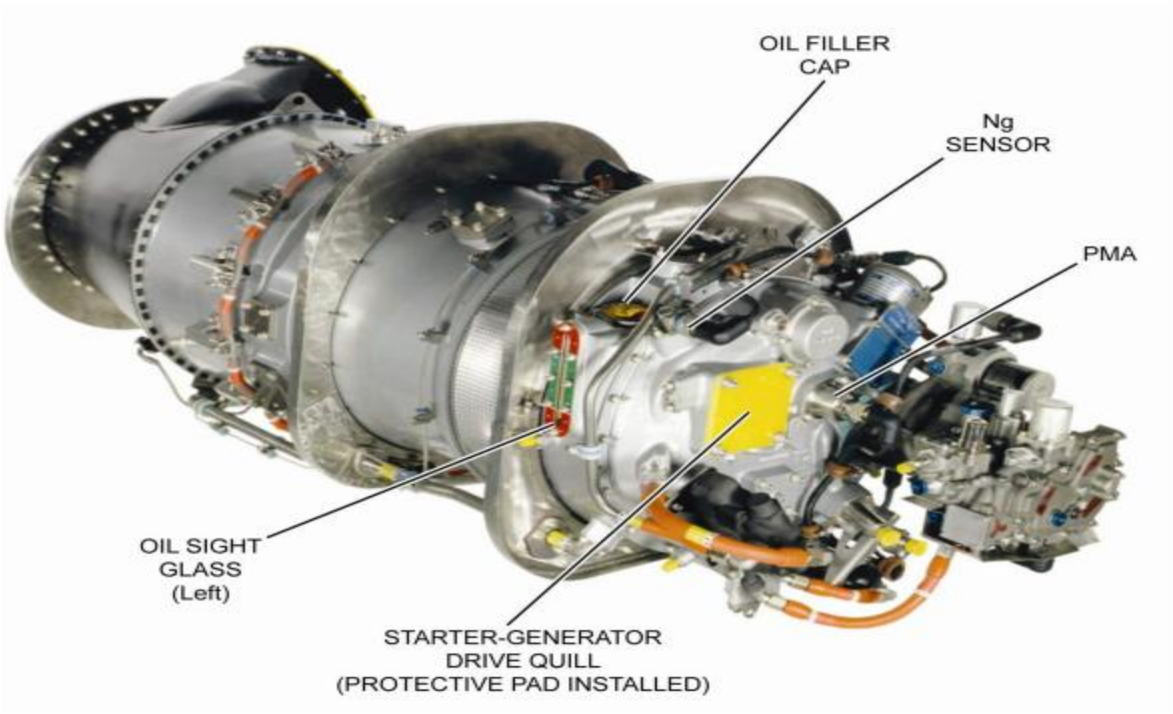

Figure 3.4: Permanent Magnetic Alternator

3.4.5 Fuel Heater

The Fuel Heater preheats the fuel to prevent a fuel filter restriction caused by any possible ice formation. It also allows engine operation at low outside air temperatures without using fuel additives.

The fuel filter traps any possible foreign particles or ice crystal present in the fuel.

3.4.6 Data Collection Unit (DCU)

The Data Collection Unit (DCU) is an electronic memory device that is installed on the engine and interfaces with the EEC via the engine's electrical harness. It stores engine trim data and records engine fatigue and exceedance data.

3.4.7 Compressor bleed valve

The compressor bleed valve prevents compressor stall or surges at low-speed Ng values.

3.4.8 Fuel nozzles

The Fuel nozzles deliver and atomize the metered fuel into the combustion chamber.

3.4.9 Engine exhaust

The engine exhaust directs the exhaust gases to the exhaust duct.

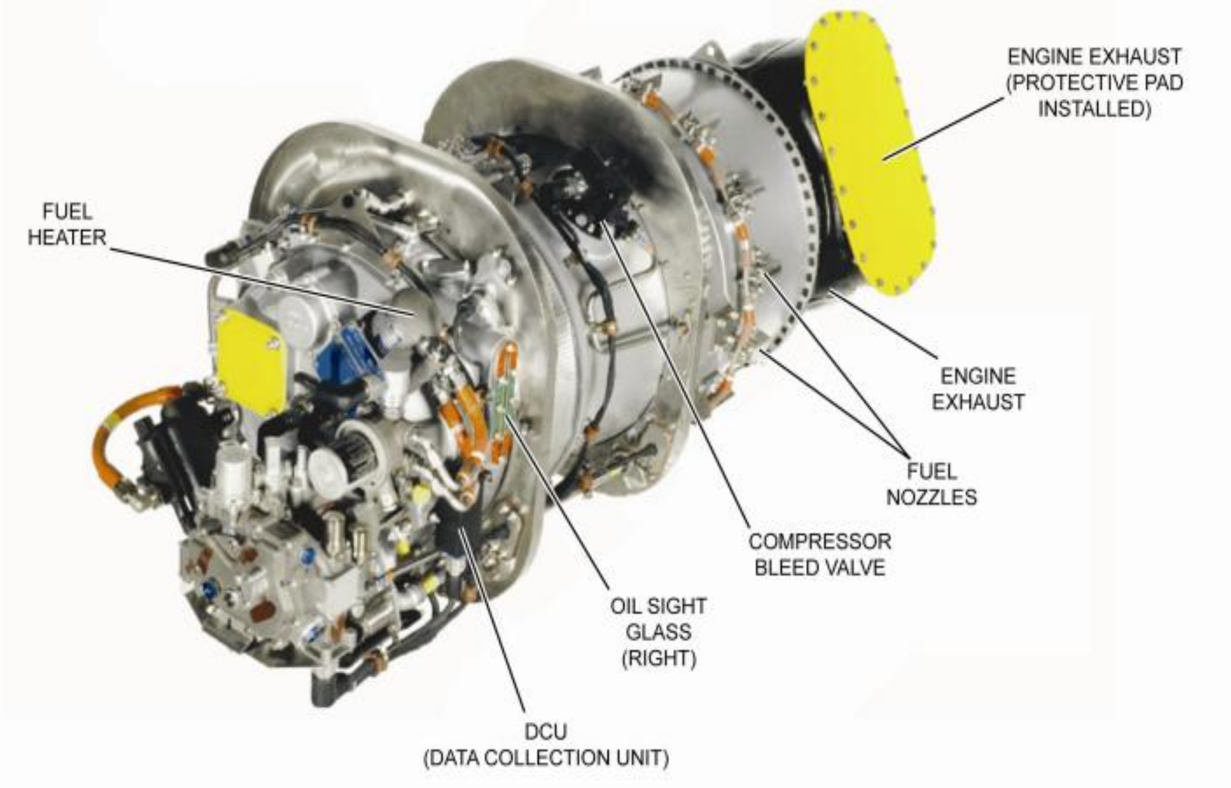

Figure 3.5: Engine exhaust

3.4.10 Oil filter (with BYPASS)

The oil filter traps foreign particles that may contaminate the oil as it lubricates the various engine components. The oil filter assembly is equipped with a bypass valve to prevent oil starvation in the event of oil filter blockage.

3.4.11 Oil chip detector

The engine oil chip detector is installed on the top RH side of the accessory gearbox. It detects the presence of metal chips in the engine oil.

3.4.12 Starter generator drive quill

The Starter Generator drive quill (Figure 3.4) provides the drive for the starter generator.

3.4.13 Fuel Management Module (FMM)

The FMM works in conjunction with the EEC to control the metered fuel flow over the entire operational range of the engine.

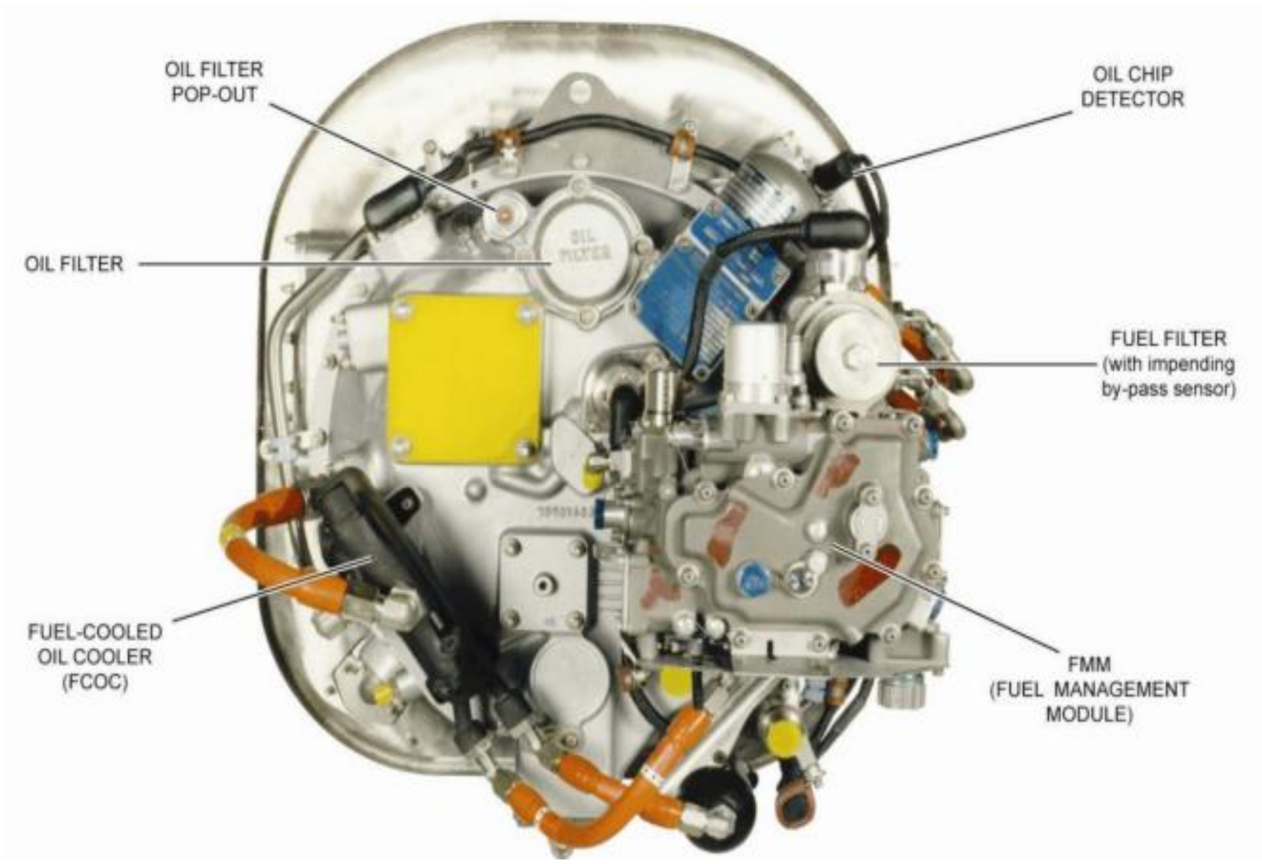

Figure 3.6: Fuel Management Module

3.4.14 NF/TQ Sensors

On the PT6C-67C engine, two independent NF/TQ Sensors are installed. Each sensor detects both NF speed and engine Torque. They are located on the bottom of the n° 5 bearing support housing (Figure 3.9). The sensors detect the passage of the torque shaft teeth and generate an AC electrical signal due to the change in the magnetic flux associated with the proximity of the gear tooth about the sensor tip.

3.5 Electronic Engine Control

The Electronic Engine Control (EEC) is an electronic package that contains all the components necessary for effective automatic control of the engine and helicopter rotor system. The EEC is installed in the aft electronic compartment.

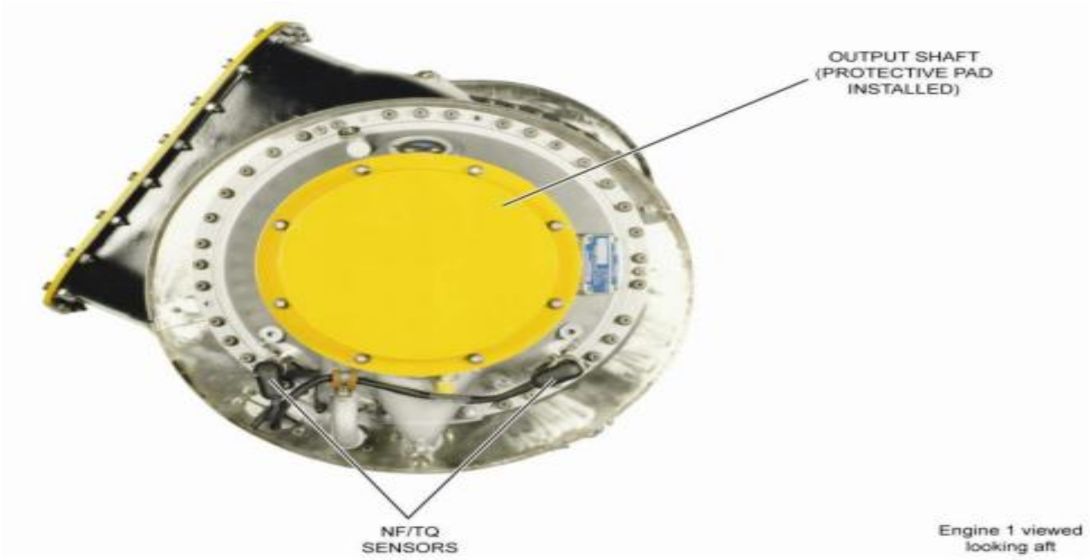

Figure 3.7: NF/TQ Sensor

3.5.1 EEC Features

The EEC is characterized by:

- Single channel control computer and Cross-talking function
- Starting and shutdown supervision
- Auto-start with ITT limiting logic
- Power management
- Independent NF overspeed protection
- Torque limiting logic
- Fault detection and display management

3.5.2 Description of EEC

The EEC consists of two following functionally independent subsystems:

- The "**control subsystem**" which provides control of the engine fuel flow.
- The "**limiter subsystem**" which provides independent hardware protection against inadvertent power turbine overspeed.

Both subsystems are isolated from each other, including power supplies, signal conditioning interface, and signal inputs.

3.5.3 Operation of EEC

The EEC monitors all engine parameters and controls the FMM providing automatic adjustment of the fuel flow delivered to the engine. The EEC controls the fuel flow from start to full power within established upper and lower limits. In case of a power turbine overspending, the limiter subsystem of the EEC automatically reduces the fuel flow, independently of the EEC fuel flow control.

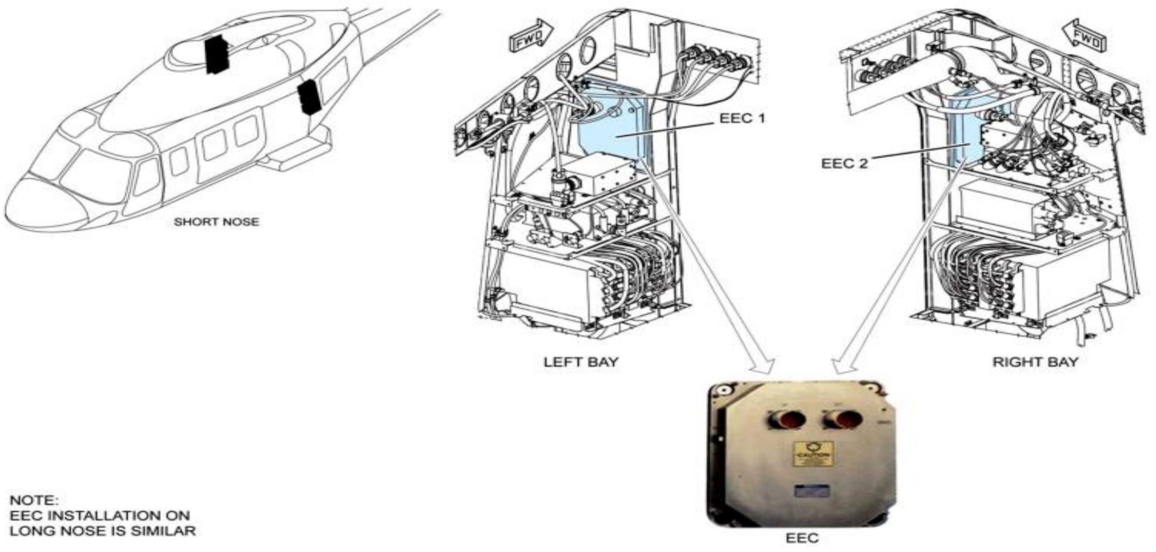

Figure 3.8: Electronic Engine Control

3.6 Engine bearings and lubrification

The main function of the bearings is to support the major rotating assemblies. There are 5 main bearings in the engine as follow:

- Ball bearings n° 1 and 5 that
  - Absorb axial and radial loads,
  - Position rotational assemblies in place
- Roller bearings n° 2, 3 and 4 that
  - Absorb radial loads only,
  - Permit axial movement caused by thermal expansion. All bearings are pressure lubricated.

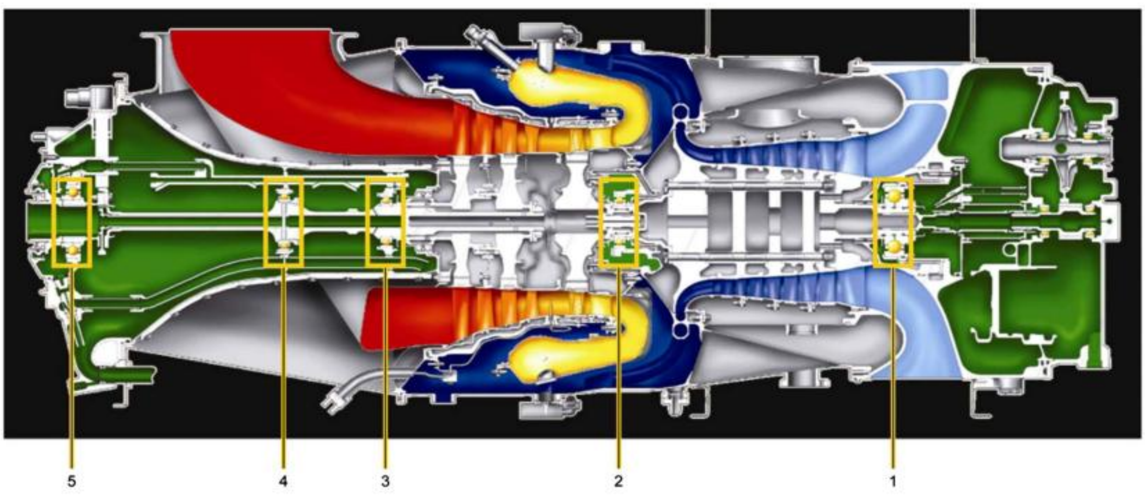

Figure 3.9: The five main engine bearings

The engine oil system supplies a flow of filtered oil to the engine to cool lubricate and clean different components. The oil system consists of:

- integral oil tank
- Pressure system
- scavenge system
- breather system.

The oil tank is integrated with the engine. It is an annular cavity created between the air inlet case and the accessory gearbox rear case. Oil level indication is achieved with two oil level sight glasses, one per each side of the AGB (Accessory Gear Box).

Oil is pressurized by a gear pump mechanically driven by the engine AGB. Leaving the filter, engine oil flows through the Fuel Heater and then it is distributed to the pressure-lubricated bearings. Oil pressure and temperature are sensed by two sensors that drive the indicators on the MFD.

The scavenging system returns the oil to the AGB by either gravity or dedicated pumps. All returned oil flows near a magnetic chip detector located at the inlet of the oil tank.

The oil breather system separates air from oil and vents it overboard through the centrifugal impeller.

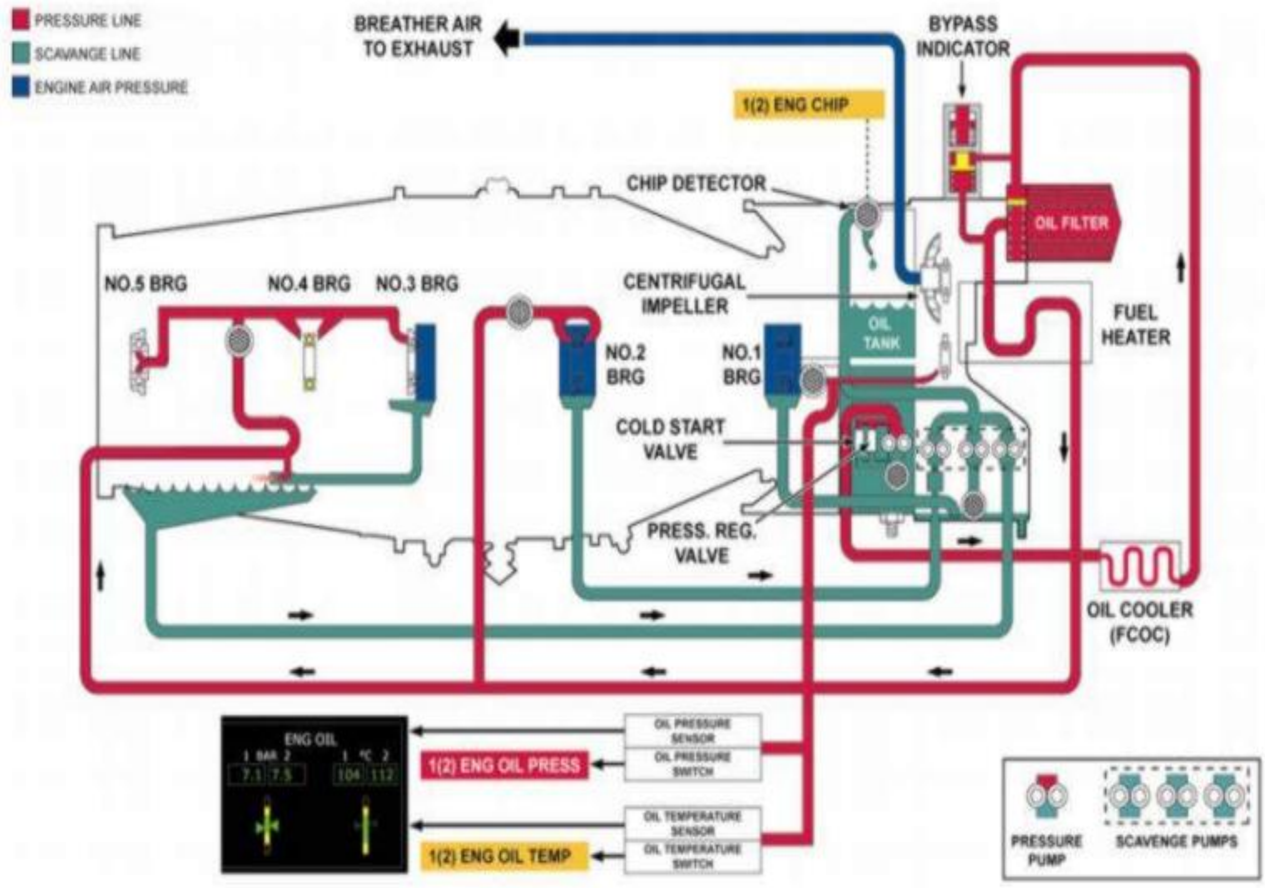

Figure 3.10: Schematic of oil system

3.7 Engine Indications

The primary and secondary engine parameter indicators and triple tachometers are displayed on the MFD (Power Plant page). Other engine parameters, Power Index, and the Triple Tachometer indicators are displayed on the PFD.

The NG, ITT, TQ, and PI indicators have one single vertical scale with one analog pointer and one digital readout per engine.

The Triple Tachometers combines NF and NR indications on a dual vertical scale with one analog pointer and one digital readout. The Triple Tachometer on the PFD does not have digital readouts for NF.

Secondary engine parameters (oil pressure and oil temperature) are displayed with a vertical scale with one analog pointer and digital readout per engine.

We specify that:

- **NG** is digital readout for engines 1 and 2 gas generator turbine speed, in percent of rpm.
- **ITT** is digital readout for engines 1 and 2 inter turbine temperature, in °C, it is a digital calculation of T5-T1 via dedicated sensors installed inside the engine.
- **TQ** is digital readout for engines 1 and 2 torque, in percentage.
- **NF** is digital readout for engines 1 and 2 free turbine rpm, in percent value.
- **NR** is digital readout and for main rotor speed, in percent of rpm.

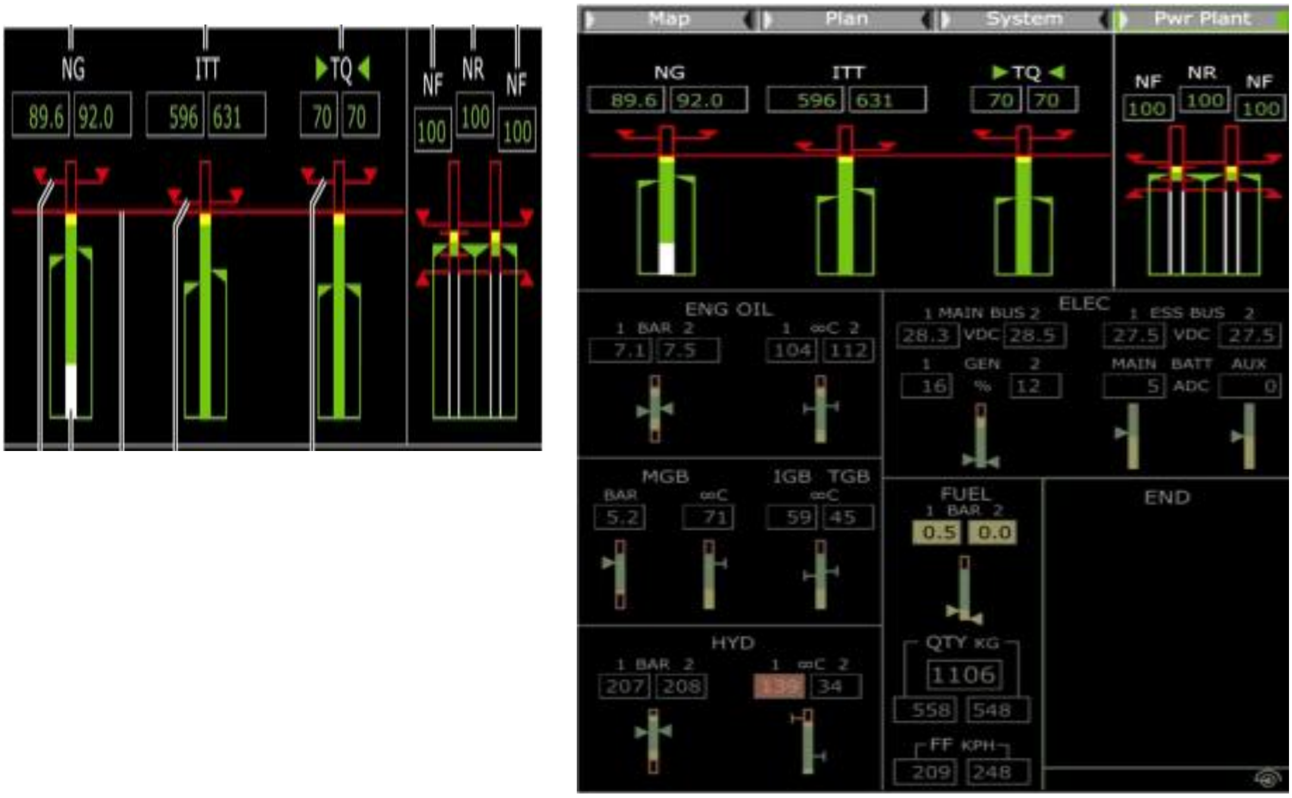

Figure 3.11: The helicopter engine indicator

3.8 Power Index Indicator

The Power Index indicator, located on PFD, is a single scale instrument that provides the pilot with an overall indication of the engine performance by displaying a composite of the three primary engine parameters (NG, ITT, TQ) over a scale that is the same as the TQ indicator in Power Plant page of the MFD. PI is an expression of "equivalent torque"; to achieve this, Ng and ITT values are re-scaled to the percent of torque. PI displays the power available at any instant and the parameter that is closest to reaching its operational limit.

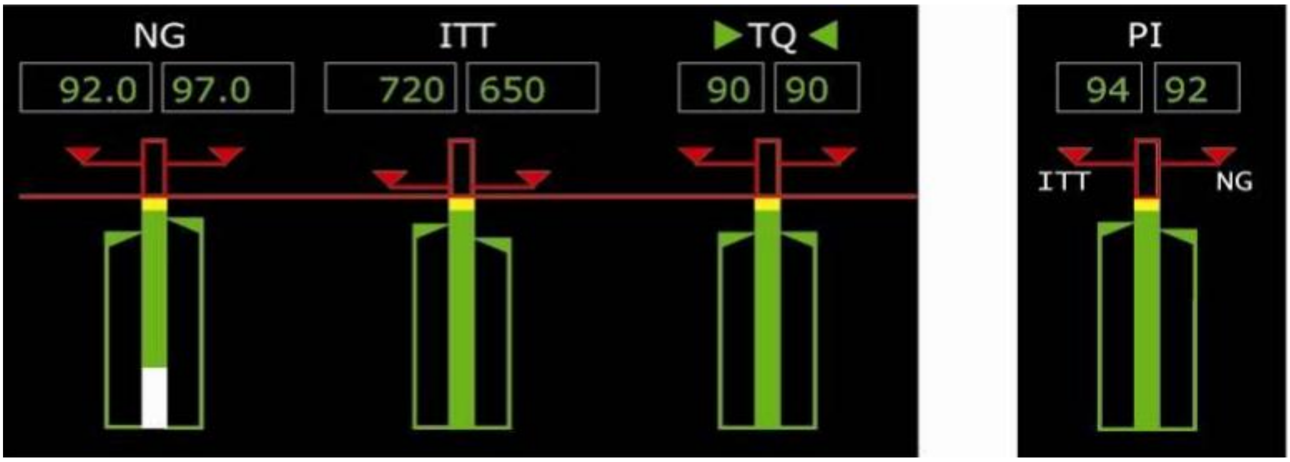

Figure 3.12: Power index indicator (MFD)

3.9 Engine Performances

Helicopter performance revolves around whether or not the helicopter can hover. More power is required during hover or take-off than in any other flight regime. So if a hover can be maintained, a take-off can be made, obstructions aside.

3.9.1 Height/Velocity Diagram

Figure 3.13 shows the flight path (red line) that permit, in case of an engine failure or not during take-off, to improve the chance of secured landing. For this purpose, we must neither operate in zone A nor zone C or B.

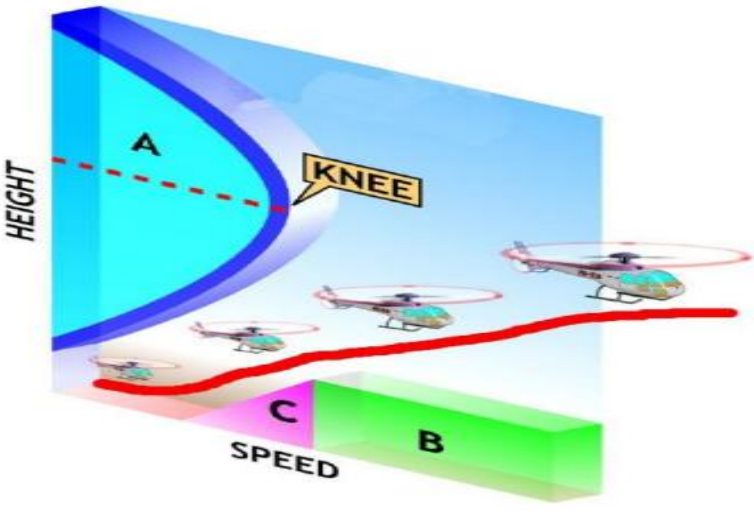

Figure 3.13: Height/Velocity Diagram

Operating at the altitudes and airspeeds shown within the crosshatched or shaded areas of the Height/Velocity diagram may result in a hard landing with heavy damage up to a fatal crash.

During hovering flight, a helicopter maintains a constant position over a selected point, usually a few feet above the ground.

For a helicopter to hover, the lift and thrust produced by the rotor system act straight up and must equal the weight and drag, which act straight down.

3.9.2 Ground effect

When hovering near the ground, a phenomenon known as ground effect takes place.

When a helicopter is flying at an altitude that is approximately at or below the same distance as helicopter's rotor diameter, there is an often noticeable ground effect.

This is caused primarily by the ground interrupting the blades tip vortices and downwash behind the blades. When a blade is flown very close to the ground, blade tip vortices are unable to form effectively due to the obstruction of the ground. The result is lower induced drag, which increases the lift of the aircraft.

In addition, we can distinguish two types of ground effects: When the helicopter gains altitude vertically, with no forward airspeed, drag increases which means a higher pitch angle, and more power is needed to move the air down through the rotor.

In this situation the hovering flight is performed Out-Ground Effect with more power required.

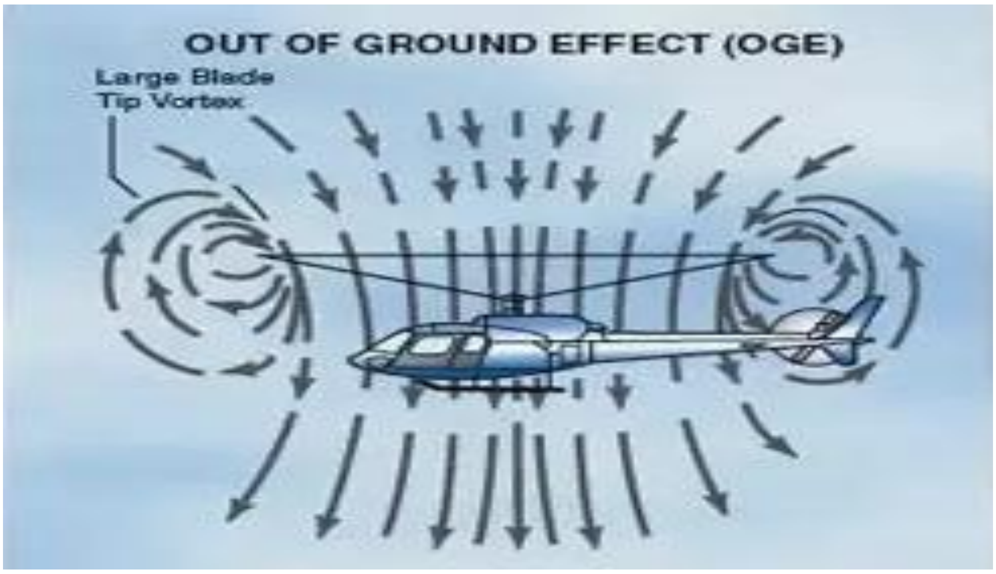

Figure 3.14: Out of ground effect

This effect usually occurs less than one rotor diameter above the surface.

As the induced airflow through the rotor disc is reduced by the surface friction, the lift vector increases.

This allows a lower rotor blade angle for the same amount of lift, which reduces induced drag.

In this case the hovering flight In-Ground Effect requires less power.

Figure 3.15: In ground effect (IGE)

3.9.3 Performance charts/Take-off performance

The graphic of Figure 3.16 illustrates the maximum available power with all engines operating and plots the amount of engine power necessary to sustain level flight at various airspeeds.

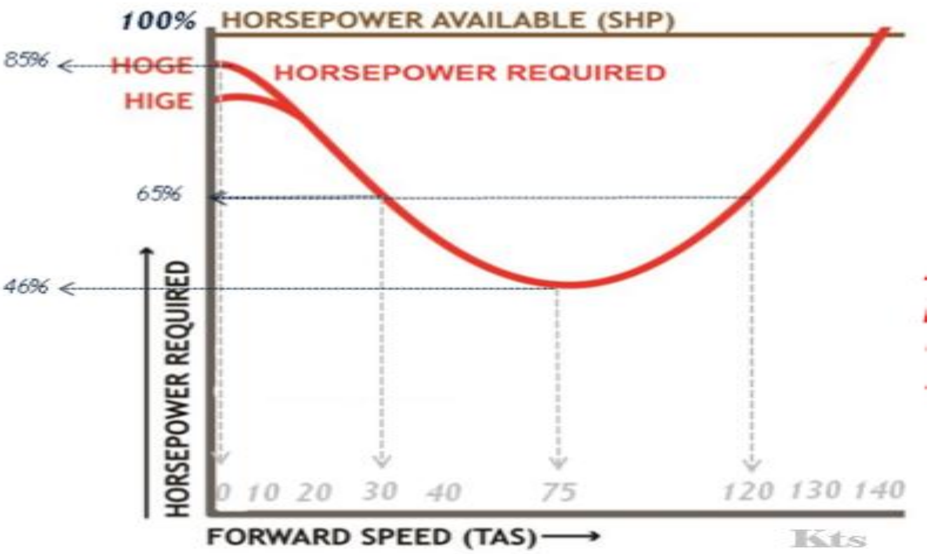

Figure 3.16: Performance charts

3.9.4 Climb performance

Most factors such as turbulent air, pilot techniques, and overall condition of the helicopter affect hover and take-off performance and also affect climb performance. So, for safety reasons, the available power is always more significant than the power necessary to take off and remains open in case of emergency.

The Climb performance is provided by the best Rate of Climb Vy, the best Angle of Climb Vx, and the maximum performance vertical take-off.

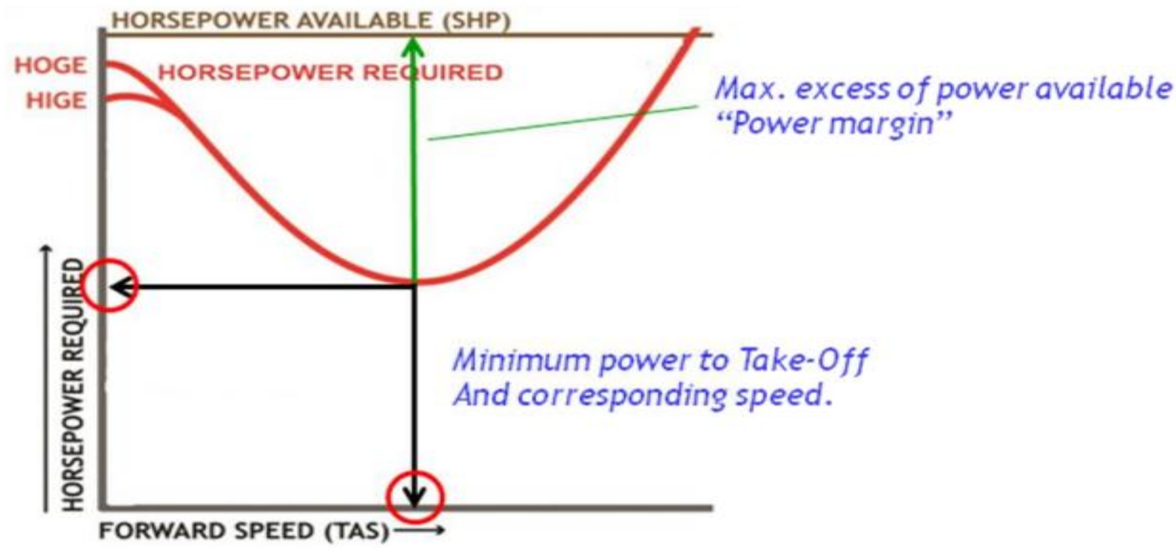

Figure 3.17: Climb Performance charts

3.9.4.1 Best Rate of climb Vy

To reduce the load on the engine, the crews realize the more often take-offs and climb at reduced power. This Take-Off profile at reduced power defines what we call the « Rate of climb Vy», which will give the helicopter the most significant gain in altitude over a given period.

This Vy speed occurs when the power curve is at its lowest point when there is the most excess power available. It represents the maximum altitude gain against time. The Rate of climb speed results in the highest climb rate, but not the steepest climb angle, and may not be sufficient to clear obstructions.

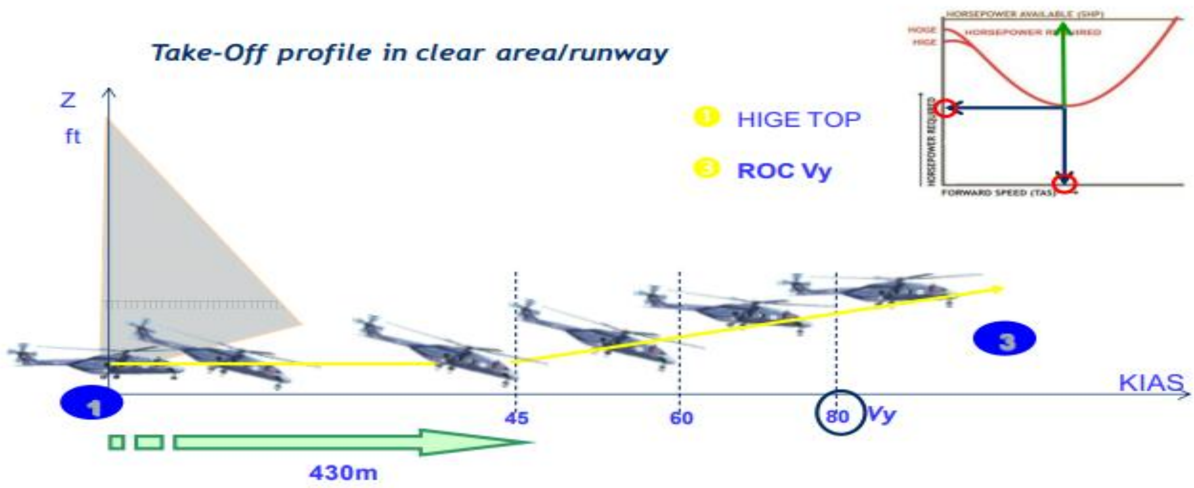

Figure 3.18: Climb performance chart (Rate of climb)

3.9.4.2 Best Angle of Climb Vx

The regulation and standards impose that the helicopter must be capable to clear an obstacle of 50ft. On the take-Off path, what we call in terms of performance the « Angle of climb Vx ».

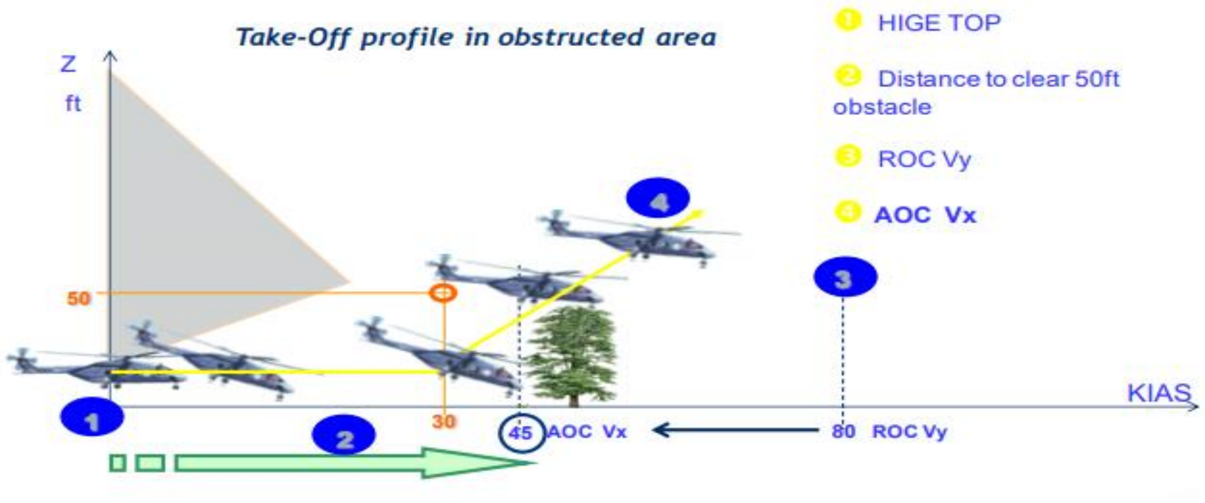

Figure 3.19: Climb performance chart (Angle of climb)

The Angle of climb Vx is a function of altitude gained over a given distance, and the speed of this angle depends upon the power available. If there is a surplus of power available, the helicopter can climb vertically, so the angle of climb speed could be zero.

3.9.4.3 Maximum performance vertical take-off

A maximum performance take-off is used to climb at a steep angle to clear barriers in the flight path. It can be used when taking off from small areas surrounded by high obstacles.

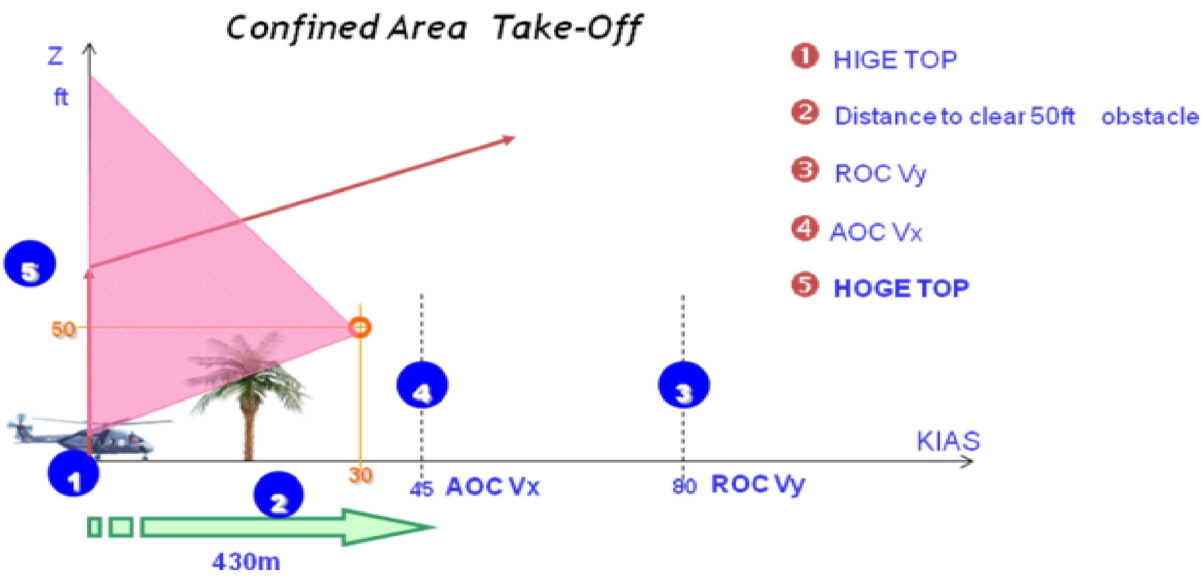

Figure 3.20: Maximum take-off performance

The pilot must imperatively ensure a safe altitude that allows him to cross the obstacle and leave zone A quickly. However, if there is an engine failure, he will lose altitude, but still, he will have a margin of error that will allow him to cross the obstacle in all safety and without having either a hard landing or a fatal crash and then gain altitude again. Therefore, the loss of altitude rate will generate a speed gain to access the safety envelope.

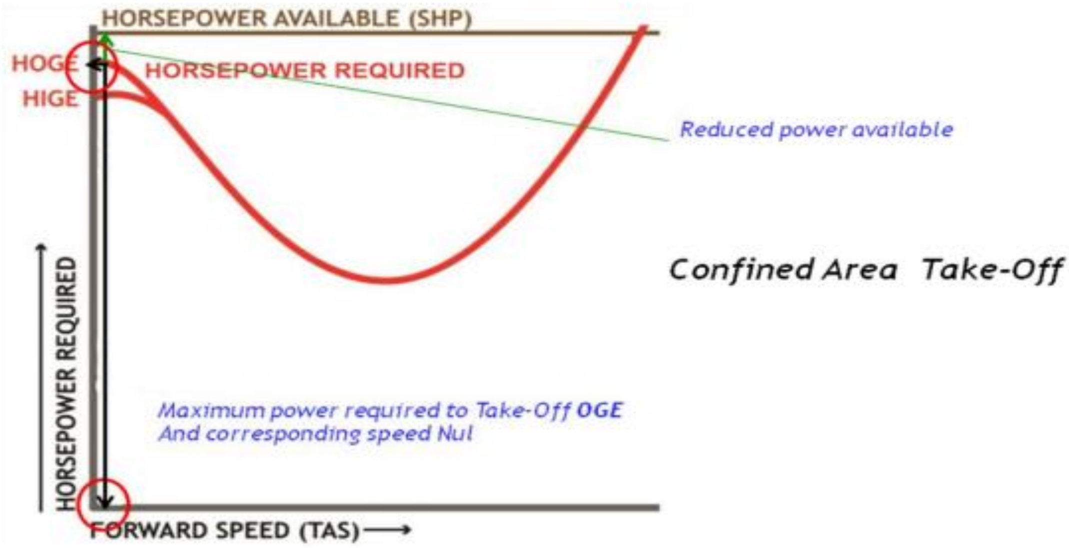

Figure 3.21: The Maximum power required and corresponding speed

3.9.5 Engine Failure Performance

Engine failure represents a major safety concern to helicopter operations, especially in the critical flight phases of takeoff and landing.
When a twin-engines helicopter, operating with All Engines Operative AEO, is suddenly forced to be operated with One Engine Inoperative OEI, the pilot is expected to know and complete the appropriate emergency procedures described in the rotorcraft flight manual to manage a critical situation.

A significant loss of power is available regarding the power required to sustain level flight.

From Figure 3.22, the horizontal dashed line labeled "Maximum OEI" indicates the maximum power available to the aircraft when one of the engines becomes inoperative.

While operating under the given conditions, the helicopter is only capable of sustaining level flight with one engine inoperative when flying in the range between 30 and 120 Kts airspeed. At speed outside of this range, this helicopter cannot sustain flight OEI. Therefore, the pilot will always ensure to stay in this comfort range without exceeding 60% of the required power of the engine.

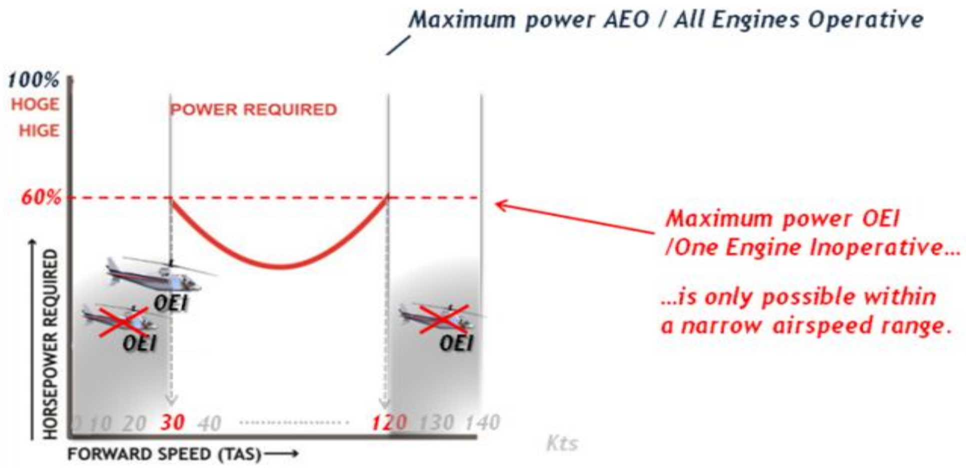

Figure 3.22: Maximum power provided with one engine inoperative

3.10 Conclusion

In today's environment, civil, military, and government helicopter operators confront performance imperatives and budget realities that have never been more demanding.

These operators have new and emerging opportunities and requirements to perform. They need and want the newest technology and the best, most reliable equipment available to perform multiple missions, including search and rescue, combat search and rescue, airborne law enforcement or cargo but can't afford to overpay for a system.

With excellent performance, reliability, and value, and by offering flexibility and capability for a variety of applications the Pratt & Whitney Canada (P&WC) PT6 turboprop aircraft engine entered service in 1964 and continues to evolve, powering mid-size aircraft across the world.

4

POWER ASSURANCE CHECK

In this chapter, we will talk about the power assurance check, which is considered as a critical and crucial procedure in order to ensure the safety and efficiency of the helicopter's engines.

Contents

4.1 Introduction

As mentioned in the previous chapter, the helicopter can be lifted by an OEI consideration within a specific performance's envelope.

The engine is able to recover some power when the other one is out of service. For this reason, all the parameters are pushed to its limits.

To ensure that, all the parameters will never exceed the maximum range of limitation. A Power Insurance Check is a mandatory procedure before every flight or maintenance action. The aim of this procedure is to simulate, on ground, an engine failure and record some parameters (NG, ITT) of the operative engine in real time. Then, using a chart, we compare the recorded parameters with the maximum allowable values deducted from the chart.

Then, we mention the different external parameters affecting the engine and rotor efficiency, which are the outside air temperature (OAT), the pressure altitude, moisture, and wind.

After that, we will give the Power Assurance Check process which is a series of steps to ensure the smooth running of the operation.

In order to clarify, we will give in this chapter a real example using hover power chart and then comparing values recorded on board the helicopter with the values found after the chart projection.

4.2 Power Assurance Check periodicity and graphs

The purpose of the Engine Power Assurance Check is to provide a mean of monitoring engine health. A Power Assurance Check procedure is provided to the operator.

The procedure should be done to check if the engine power is available before take-off, and all the parameters are within the limits mentioned in the Rotorcraft Flight Manual 'performance section'.

This procedure is a mandatory action every 25 hours maintenance time or before every flight. If some average margin of the engine parameters are close to the limit, the Power Assurance Check is required daily. In the case of AW 139 equipped with an engine PT6C-67C, these averages are:

- Average ITT Margin is less than 10 °C
- Average NG Margin is less than 0.5%.

However, for helicopters that operate in Saharans and sub-Saharans regions, it is a must for the engine to be equipped with air intake's filter to protect the engine against ingestion of sand, dust and other particles. So, the Algerian civil protection' helicopters are equipped with EAPS (Engine AIR Particle Separator) filter. The system consists of two (2) particle separators located in front of each engine air intake. Foreign particles are separated by the swirling action of the air passing through the vortex generators contained in the particle separator. The clean air enters the engine air intake, while the foreign particles are directed into a lower chamber by the scavenge flow. From this chamber, the foreign particles are discharged outboard through an ejector activated by the engine bleed-air. The particle ejector may be activated by the pilot through switches, one for each engine.

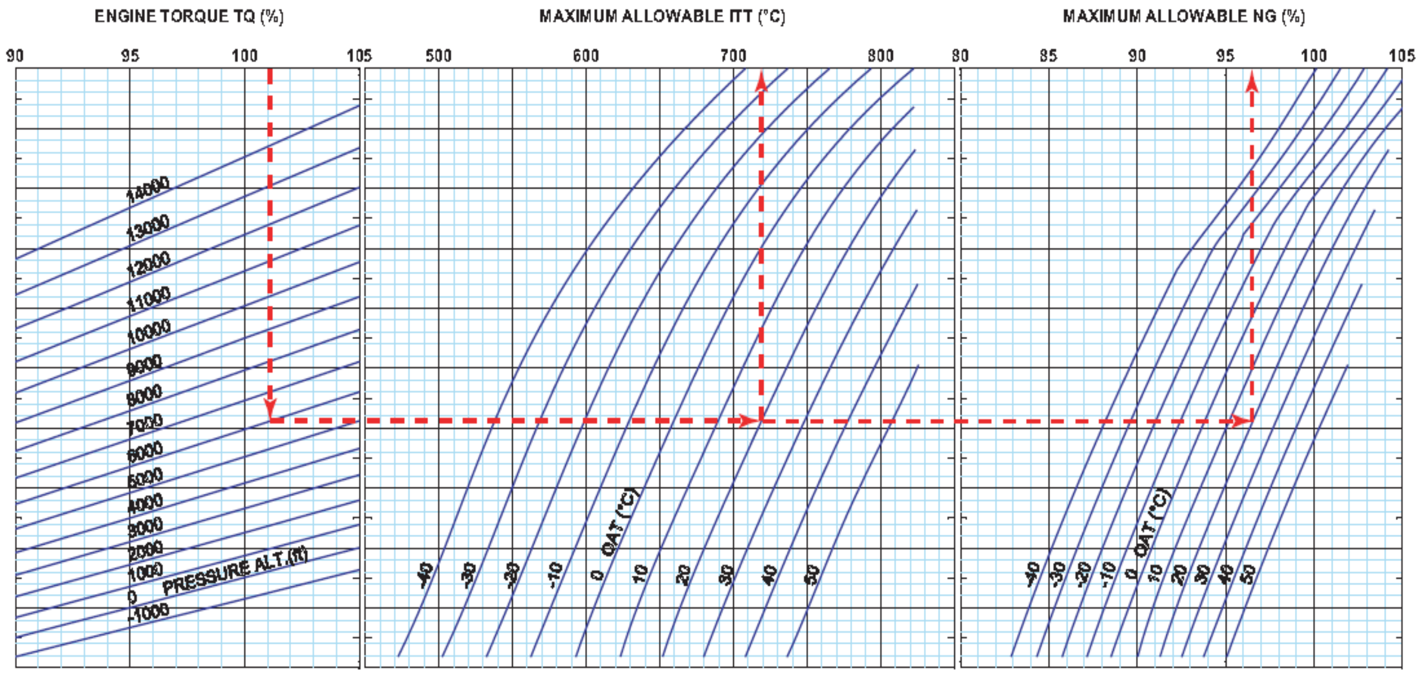

Figure 4.1: Power Assurance Check graph

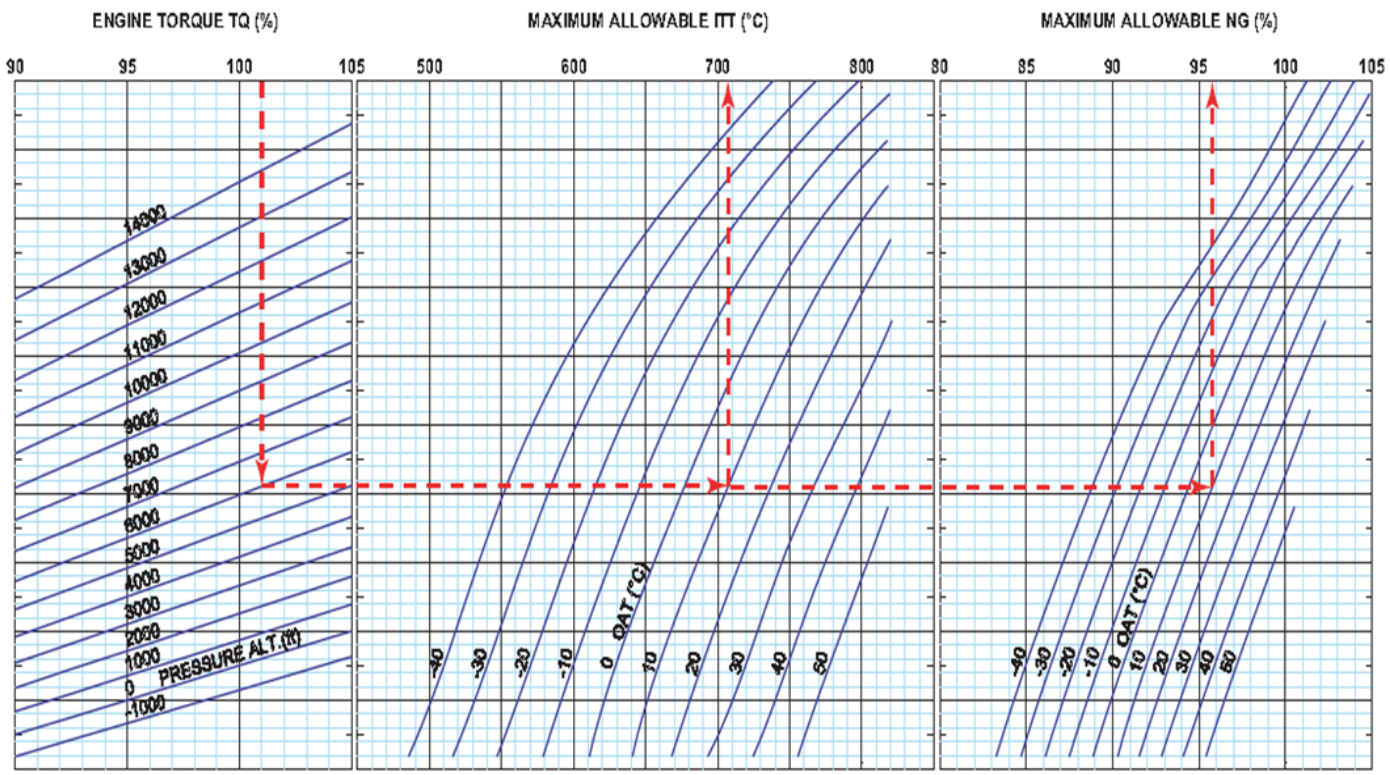

Figure 4.2: PWC PT&C-67C Hover Power Chart with EAPS ON

If the helicopter is equipped with EAPS, the pilot can control it from the following switch:

Figure 4.3: EAPS control switch

For more efficiency, the Power Assurance Check process should be done with an activated filter. Even this procedure is fair without a filter ON but with big changes of values on the graph. Therefore, two different graphs are available in the Rotorcraft Manual, one with filter activated and other without filter.

4.3 Factors affecting engine performance

A helicopter's performance is dependent on the power output of the engine and the lift produced by the rotors, whether it is the main rotor(s) or the tail rotor. Any factor that affects engine and rotor efficiency affects performance. The major factors that affect performance are Weight, Humidity, Temperature, Atmospheric pressure, wind, and Altitude.

4.3.1 Moisture (Humidity)

Humidity alone is usually not considered an important factor in calculating density altitude and helicopter performance. However, it does contribute. There are no rules of thumb used to compute the effects of humidity on density altitude,

There appears to be an approximately 3 or 4 percent reduction in performance compared to dry air at the same altitude and temperature, so expect a decrease in hovering and take-off performance in high humidity conditions. Although 3 or 4 percent seems insignificant, it can be the cause of a mishap when already operating at the limits of the helicopter.

4.3.2 Temperature

Temperature changes have a large effect on density as warm air expands. The air molecules move further apart, creating less dense air.

Since cool air contracts, the air molecules move closer together, creating denser air. High temperatures cause low density, and helicopter performance decreases.

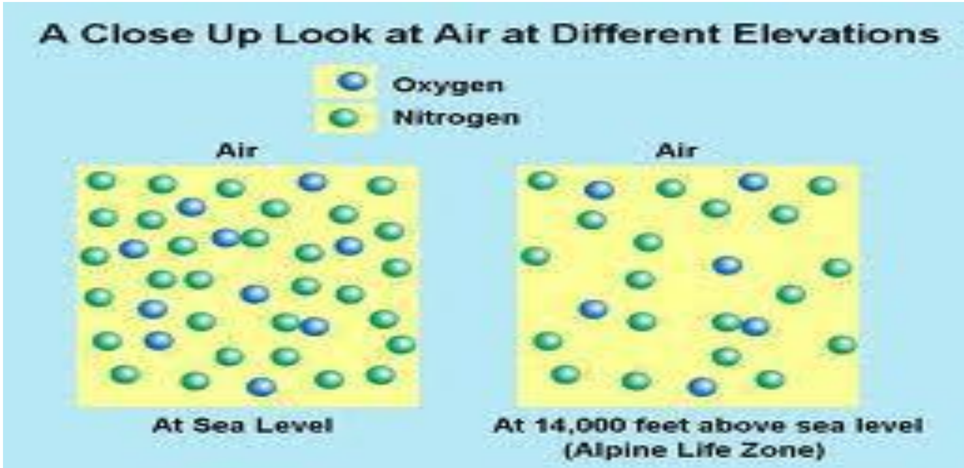

Figure 4.4: Cold and warm air Molecules

4.3.3 Atmospheric pressure

Atmospheric pressure is the force exerted at any given point on the Earth's surface by the collective weight of the air molecules.

Due to changing weather conditions, atmospheric pressure at a given location changes from day to day.

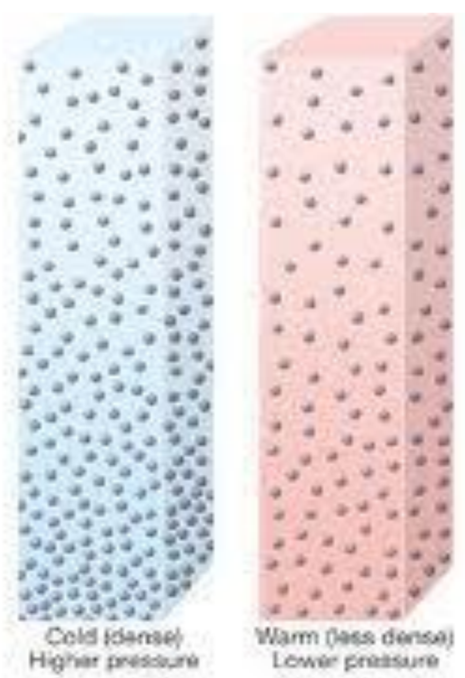

Figure 4.5: Atmospheric Pressure Molecules

If the pressure is lower, the air is less dense, and as a result helicopter performance decrease. For this reason, the helicopter cannot operate above 14,000 feet.

4.3.4 Wind

Wind direction and velocity also affect hovering, take-off, and climb performance. This occurs whether the relative airflow is caused by helicopter movement or by the wind.

Assuming a headwind, as wind speed increases, translational lift increases, resulting in less power required to hover. The wind direction is also an important consideration. Headwinds are the most desirable as they contribute to the greatest increase in performance.

Strong crosswinds and tailwinds may require the use of more tail rotor thrust to maintain directional control.

Take-off and climb performance are greatly affected by wind. When taking off into a headwind, the effective translational lift is achieved earlier, resulting more lift and a steeper climb angle. When taking off with a tailwind, more distance is required to accelerate through the translation lift.

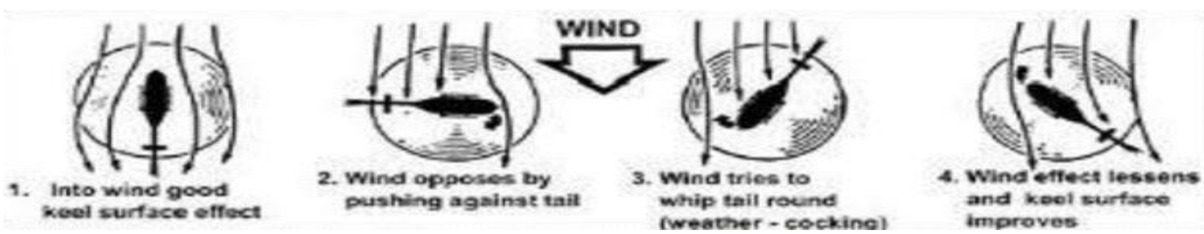

Figure 4.6: Wind Effect

4.3.5 Altitude

As the helicopter climbs in altitude, the air gets thinner or less dense, requiring the blades to work harder to generate the same amount of lift.

This is because the atmospheric pressure acting on a given volume of air is less, allowing the air molecules to move further apart. Dense air contains more air molecules spaced closely together, while thin air contains fewer air molecules because they are spaced further apart. As altitude increases, density decreases and helicopter performance decreases.

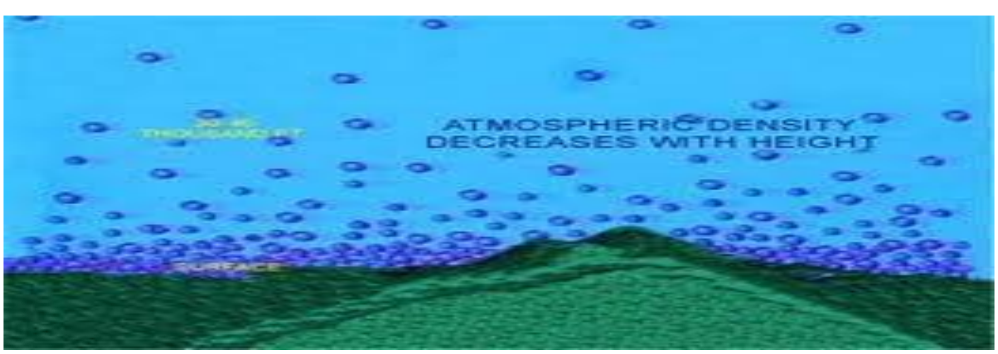

Figure 4.7: Atmospheric Density

4.4 Power Assurance Check process

Performing a Power Assurance Check is an essential procedure for helicopter pilots to ensure that the aircraft's engine and critical systems are functioning correctly before take-off. This check involves a series of verifications and procedures to confirm that the helicopter is operating safely and efficiently. It is noted that we should observe all engine and transmission max continuous limits and aircraft operating limits during this check.

The steps to follow for the safe and efficient operation of the helicopter are explain by the real example, in hover power chart, as follows:

1. Position the helicopter into the prevailing wind to minimize hot gas ingestion
2. Record the date, aircraft serial number, aircraft hours, engine serial number, and engine hours.

AW139 / PT6C-67C
POWER ASSURANCE CHECK RECORD SHEET
Relevé Point Fixe

Rev : 00, Date :02/2023
N°................

- HELICOPTER AW139-

Registration :	MSN :	TSN :	CSN :	Station :	Reason for Power Assurance Check
7T-VWI	31415	817:50	1991	ALG/DAAG	Daily Inspection

- ENGINE -

Engine 1			Engine 2		
S/N	TSN	TSO	S/N	TSN	TSO
PCE-KB0989	817:50	.........../.........	PCE-KB1096	812:50	.........../.........

- STARTING DATA -

	ITT Peak °C	Starting time	NG %	NF %(65%±1)	NR % (65%±1)	Wind (KTS)	OAT (°C)	Press ALT (ft)
ENG. 1	646	24'	60	65	65	—	30	1000
ENG. 2	660	24'	68,5	65	65			

- POWER ASSURANCE CHECK IN HOVER MODE (NR=100%) -

NOTE: THE POWER ASSURANCE CHECK IS DONE BY A PILOT, THE TECHNICIAN MAKE THE RECORDS:

- EAPS ON
- HEATER/COND OFF
- GENERATOR LOAD TO MINIMUM (BELOW 17%)
- SET NR to 100%
- TEST ENGINE MODE SWITCH: FLIGHT
- OTHER ENGINE MODE SWITCH: IDLE
- INCREASE COLLECTIVE UNTIL LIGHT ON WHEELS OR HOVERING AT 5 FEET, NOSE ON WIND.

DO NOT EXCEED 775°C ITT OR 102.4% NG OR 105% TQ

- STABILIZE POWER 1 MINUTE, THEN RECORD OAT, PRESSURE ALTITUDE, ENGINE TORQUE, ITT AND NG
- ENTER CHART AT INDICATED TQ, MOVE DOWN TO INTERSECT PRESSURE ALTITUDE, PROCEED TO THE RIGHT TO INTERSECT OAT,
- THEN MOVE UP TO READ VALUES FOR MAXIMUM ALLOWABLE ITT AND NG
- IF INDICATED ITT OR NG EXCEEDS MAXIMUM ALLOWABLE, REPEAT CHECK
- REPEAT CHECK USING OTHER ENGINE
- IF EITHER ENGINE EXCEEDS ALLOWABLE ITT OR NG, PUBLISHED PERFORMANCE MAY NOT BE ACHIEVABLE. REFER TO EMM

NOTE: SEE RFM SUPPLEMENT 5 ENGINE AIR PARTICLE SEPARATOR (EAPS)

Recorded OAT:........................°C PRESSURE ALTITUDE:......................ft

	Engine TRQ (%)	Recorded ITT (°C)	Recorded NG (%)	Max. Allowable ITT (°C)	Max. Allowable NG (%)
ENG. 1	90	570	81,4	708	93,7
ENG. 2	90	476	60,7	708	93,7
	Engine NF (%)	Fuel Flow (Kps)	Oil Press (Psi)	Oil Temp (°C)	
ENG. 1	100	257	7	120	
ENG. 2	100	252	7	118	

FINDING	PERFORMED BY	CONTROLLED BY
YES ☐ NO ☒	Nom:	Nom: ....
N°..	Date:	Date: ....
	Visa	Visa

PC/AW139/LC/03

Figure 4.8: Power Assurance Check Record Sheet

Figure 4.9: Students on-board of the AW139 taking the real values

3. Confirm that the AUTO MODE COND/HEATER switch is set to OFF and HEATING SOV switches are OFF, if fitted.

Figure 4.10: COND/HEATER Switch Panel

4. Set the barometric pressure to 1013 mb or 29.92 inches.
5. Confirm both the ENG MODE switches at FLT, set the BUS TIE switch to ON, and select the ENG MODE switch of the engine NOT being tested to IDLE.

Figure 4.11: Engines Switch Modes

6. With the rotor speed at 100%, set the collective until light on wheels or Hover at 5 feet to obtain a percent torque value within the range shown on the top graph, depending on the airfield elevation.

Figure 4.12: AW 139 Engine Collective

7. Maintain a fixed collective for one minute,
8. then record the following data from the Primary and Multifunction Display:
   - ✓ Pressure Altitude
   - ✓ OAT (OUTSIDE AIR TEMPERATURE)
   - ✓ NG
   - ✓ TQ
   - ✓ ITT

Figure 4.13: AW139 Multifunction Display

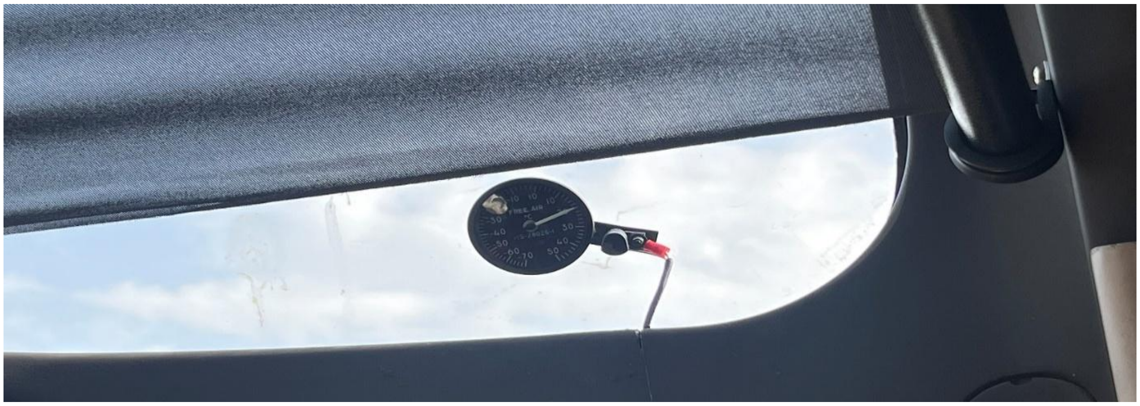

Figure 4.14: Outside Air Temperature Indicator

9. When recording is completed lower collective to MPOG (Minimum Pitch On Ground), select ENG MODE switch of the engine not being tested to flight.

10. Repeat steps (1) through (8), for the remaining engine.

11. Select BUS TIE and switch to AUTO.

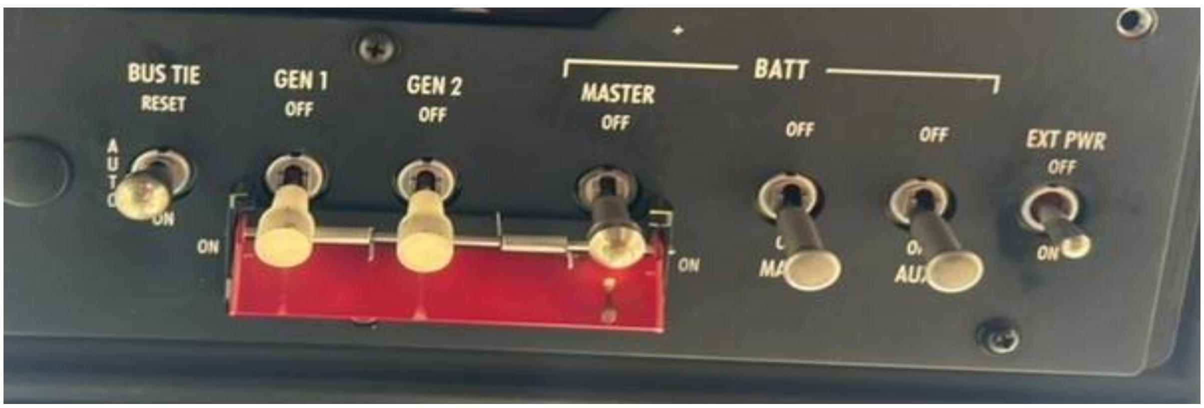

Figure 4.15: Electrical panel

Figure 4.16: BUS TIE

12. On the appropriate figure, plot the readings for each engine as follows:

a. Enter the left graph, as appropriate, with the recorded torque value. Drop vertically until intercepting the recorded pressure altitude value (interpolate between the curves, as necessary). Move horizontally to intercept the recorded OAT value for ITT and NG. From these points move up to read the maximum allowable ITT/NG values for the test condition.

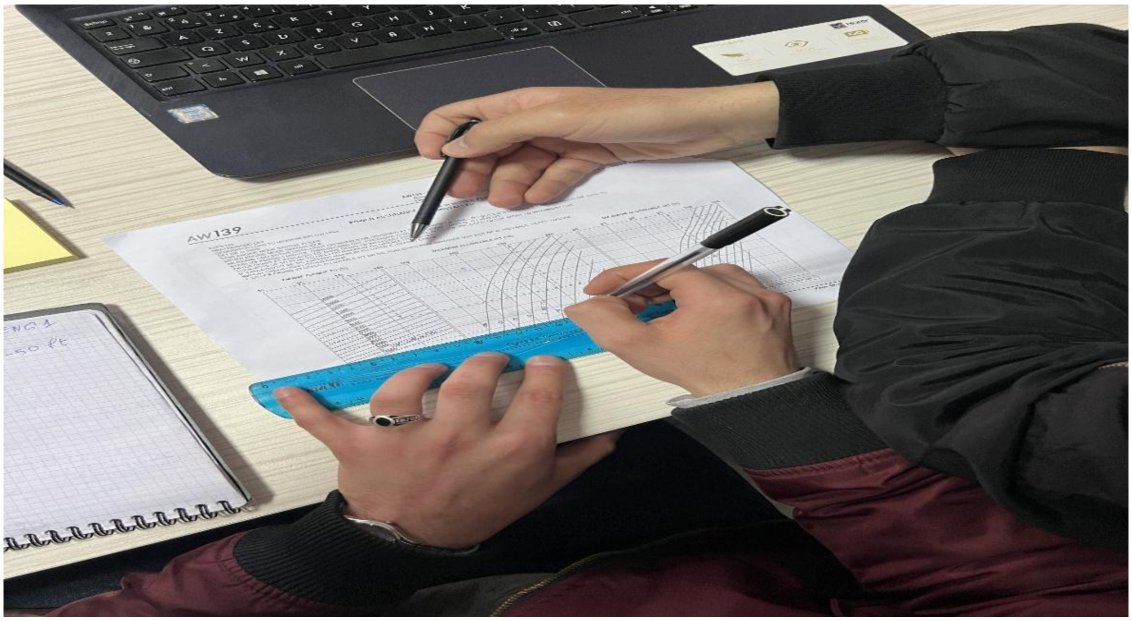

Figure 4.17: Students making projection on the charts

b. Compare the maximum allowable ITT and NG values to the recorded ITT and NG values.

Figure 4.18: Students in flight operations department

c. If the recorded ITT or NG values are less than the maximum allowable ITT or NG value, engine condition is acceptable for flight.

The difference between the maximum allowable ITT/NG and recorded ITT/NG is called the Power Assurance Margin (PAM).

4.5 Power Assurance Check of the 7T-VWI

We will make a Power Assurance Check of a real case for the helicopter under the registration 7T-VWI for the two engines bearing the serial number PCE-KB0989 for engine number N 01, and PCE-KB1096 for engine N 02, which have a total flight hour of 817 hours, and a total flight cycle of 1991 hours.

The pilot will first select the ideal torque to use. In this case, he has used Torque 90. Then, he will drop down the torque on the pressure altitude of the day on the graph, which was that day (-50 ft).

(-50 ft) is a very small value compared to the other values, so we took it as (0 ft) in the graph.

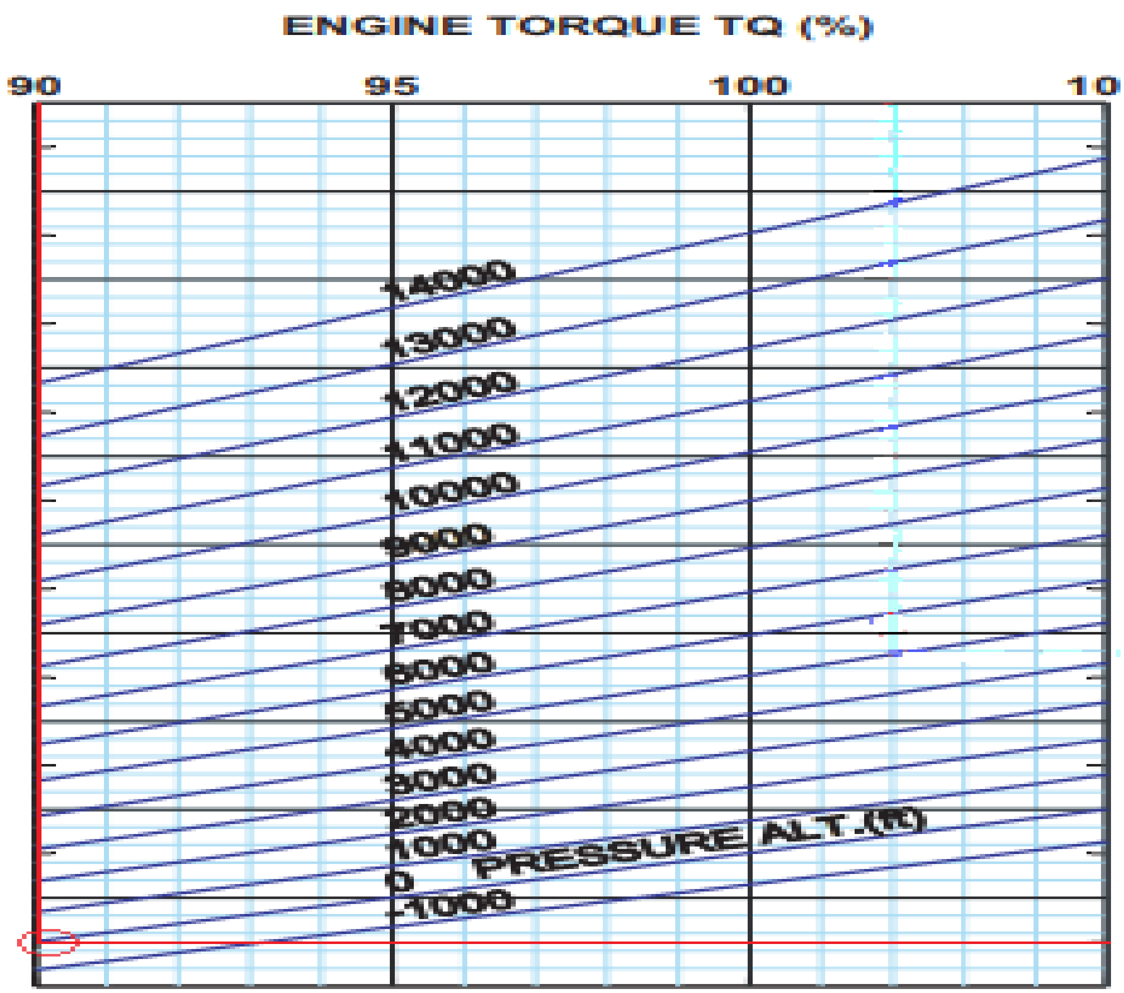

Figure 4.19: Projection of Engine Torque TQ on Pressure Altitude

When he projects on the OAT, which was taken from the OAT indicator, and move vertically up he reads the maximum allowable ITT and compares it with the ITT he obtained on the same day. He will compare it with the value of the ITT displayed in the MFD. If the value displayed is less than the maximum allowable ITT, the engine can perform the mission without any problem, if not it can't.

On that day, the OAT was 16 °C. So, the pilot found the maximum allowable ITT that was 662°C and observed for engine N 01 that the ITT was 625°C, and 613°C for engine N 02. So the engine is acceptable for flight and accomplish the mission.

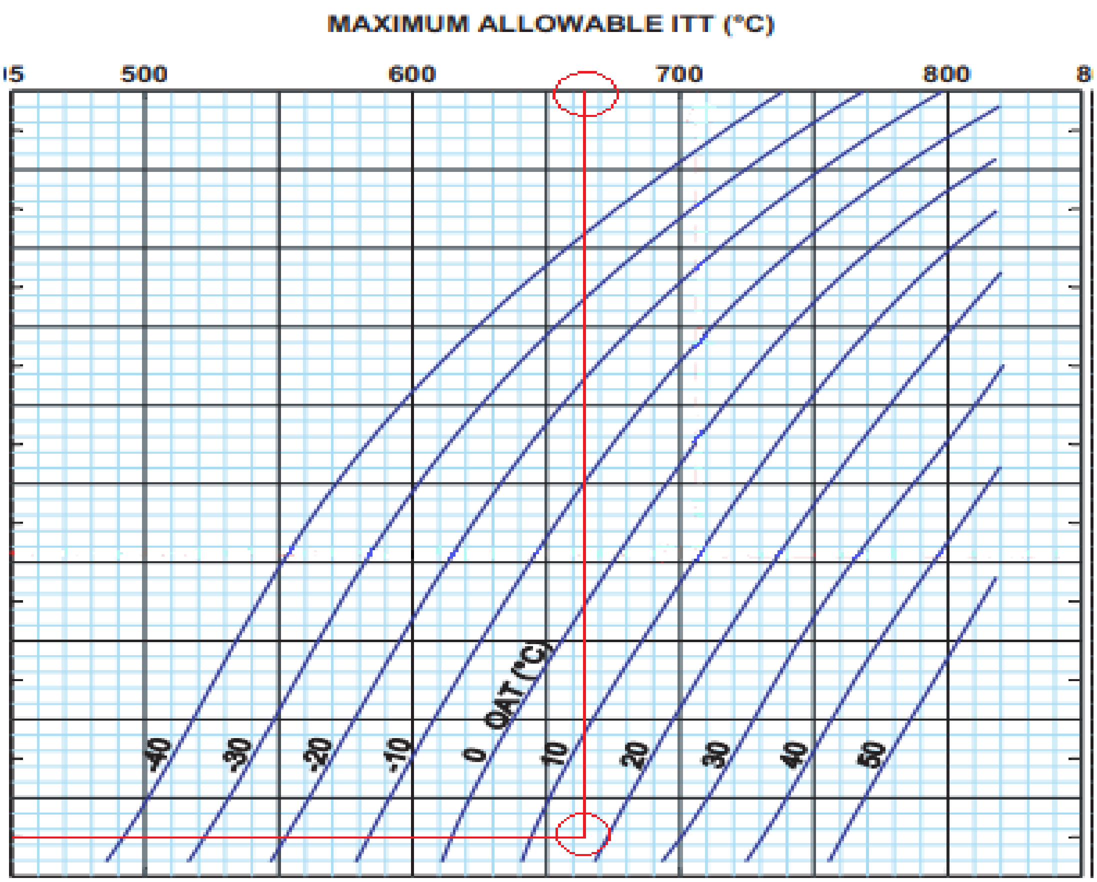

Figure 4.20: Projection of Outside Air Temperature on Maximum Allowable ITT

Afterward, he will determine the maximum allowable NG by projection on the OAT as well and moving vertically up. Then, he will compare it to the NG of the engine, which is operating. If the value displayed in the MFD is less than the maximum NG (%) allowable, the engine can perform the mission without any problem.

The maximum NG allowable, according to the pilot, was 91.8%, and the NG that has been read is 89.3% for engine N 01 and 88.1% for engine N 02, making it appropriate to complete the mission.

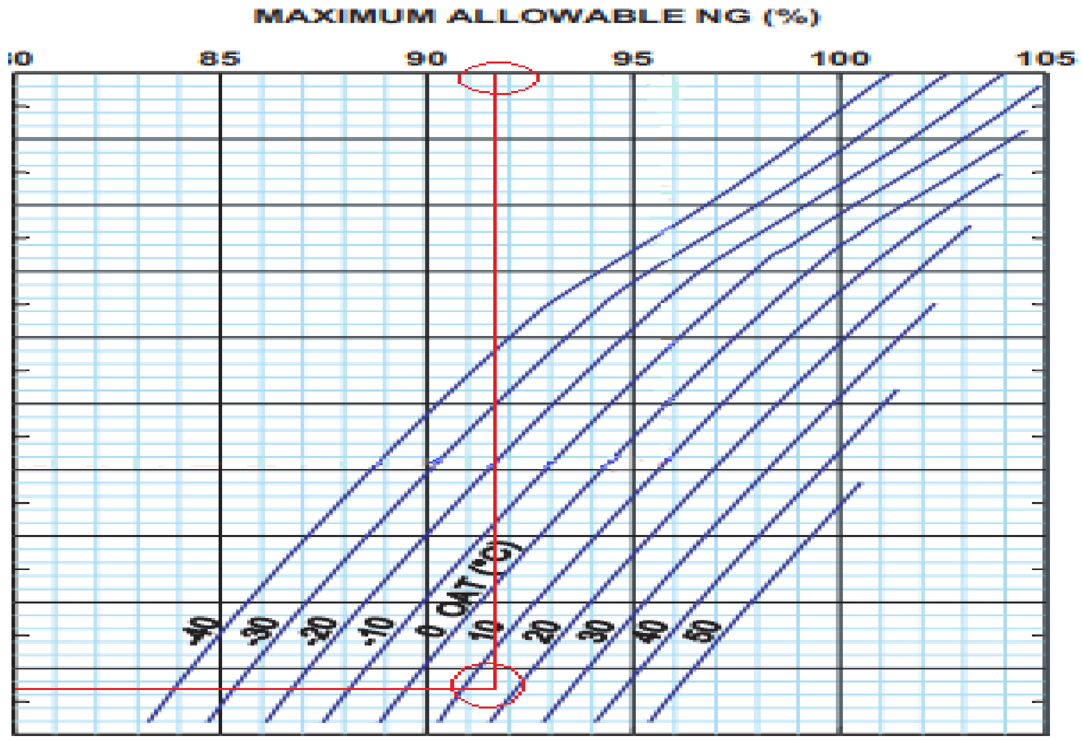

Figure 4.21: Projection of Outside Air Temperature on Maximum Allowable NG

The pilot will take a decision, whether the helicopter can fly or not to accomplish its mission safely even in OEI.

Afterward, to see if there has been a degradation of the parameters, the Flight Operations Office will enter its values into a database, introducing the date of the Power Assurance Check, the helicopter that has been checked, and the serial numbers of the engines. And then compare them with the values that have already been recorded in the previous days.

It allows us to do real monitoring of each engine and each helicopter.

The Flight Operations Office will alert the Engineering and planification Office to take the appropriate actions in the parameters.

4.6 Conclusion

Helicopters have the unique ability to take-off and land almost anywhere. It is the responsibility of the pilot to determine if a safe take-off and landing is possible and the availability of sufficient power.

Unfortunately, a significant number of helicopter accidents are performance related, with the majority of these accidents occurring during the take-off or landing phases of flight.

Many of these accidents occurred when the helicopters were being operated from sites that were elevated, out of wind, restricted by terrain, sloping, or had rough surfaces.

Often the helicopters were being operated at high all up mass, in high ambient temperatures and high density altitude. These accidents may have been prevented had the pilots been fully aware of the prevailing conditions, and determined the performance capabilities of their helicopter before commencing flight.

Such accident prevention relies on thorough pre-flight preparation, of which Flight Manual performance chart calculations are an integral part. Because the ambient conditions at the intended point of operation can be quite different from those planned for, calculated values must always be validated by an actual power check at the operating site.

This leaflet provides an overview on the major factors that influence performance and provide tools and checklists to the pilot to safely plan and perform a flight.

5

POWER ASSURANCE CHECK OF AW139:

A COMPUTATIONAL APPROACH

The objective of this chapter is the presentation of our application and its operation. We will take an example to calculates the parameters performed on the helicopter registered 7T-VWI, with its engine PCE-KB0989. This application was made using Python as well as Microsoft Office Excel.

Contents

5.1 Introduction

Over the past few years, applications have seen tremendous development to the point that they now play a very important role in each of our daily operations. These applications are executed by software based on specific programming languages and following a set of algorithms, allowing them to be encoded or decoded, to produce desired results. This enable information processing with remarkable efficiency and speed.

In this chapter, we will examine the process of digitizing operations related to Power Assurance Check of the helicopter AW139.

Throughout this chapter, we will create an application allowing to calculate the parameters performed on the helicopter registered 7T-VWI, with its engine PCE-KB0989, using Python as well as Microsoft Office Excel to automate our process.

Python is a high-level general purpose programming language. Its design philosophy emphasizes code readability with the use of significant indentation via the offside rule. Before presenting our application, an overview of the language Python is given.

5.2 Overview of the programming language Python

Python supports multiple programming paradigms, including structured (particularly procedural), object-oriented and functional programming. It is often described as a "batteries included" language due to its comprehensive standard library.

5.2.1 History and development of Python

Guido van Rossum began working on Python in the late 1980s as a successor to the ABC programming language and first released it in 1991 as Python 0.9.0. Python 2.0 was released in 2000. Python 3.0, released in 2008, was a major revision not completely backward-compatible with earlier versions. Python 2.7.18, released in 2020, was the last release of Python 2.

Python's development is conducted largely through the Python Enhancement Proposal (PEP) process, the primary mechanism for proposing major new features, collecting community input on issues, and documenting Python design decisions. Python coding style is covered in PEP 8. Outstanding PEPs are reviewed and commented on by the Python community and the steering council.

Since 2003, Python has consistently ranked in the top ten most popular programming languages in the TIOBE Programming Community Index where as of December 2022 it was the most popular language (ahead of C, C++, and Java). It was selected Programming Language of the Year (for "the highest rise in ratings in a year") in 2007, 2010, 2018, and 2020 (the only language to have done so four times as of 2020).

An empirical study found that scripting languages, such as Python, are more productive than conventional languages, such as C and Java, for programming problems involving string manipulation and search in a dictionary, and determined that memory consumption was often "better than Java and not much worse than C or C++".

5.2.2 Uses of Python

Python can serve as a scripting language for web applications, e.g., via mod_wsgi for the Apache webserver. With Web Server Gateway Interface, a standard API has evolved to facilitate these applications Web frameworks like Django.

Libraries such as NumPy, SciPy, and Matplotlib allow the effective use of Python in scientific computing,with specialized libraries such as Biopython and Astropy providing domain-specific functionality. SageMath is a computer algebra system with a notebook interface programmable in Python. Its library covers many aspects of mathematics, including algebra, combinatorics, numerical mathematics, number theory, and calculus. OpenCV has Python bindings with a rich set of features for computer vision and image processing.

5.2.3 Readability, Simplicity, and Limitations of Python

Python's clean and intuitive syntax makes it easy to read, write, and understand code. Its simplicity reduces the learning curve for new developers and allows for faster development cycles. Python's syntax is designed to prioritize code readability and maintainability. With its clean and intuitive syntax, Python code is often described as "executable pseudocode," making it easier for developers to express complex ideas with minimal effort. The language's use of whitespace indentation as a structural element promotes code consistency and readability, reducing the likelihood of syntactical errors.

While Python has numerous strengths, it also has certain limitations. The Global Interpreter Lock (GIL) can impact Python's performance in multi-threaded applications. Furthermore, Python's execution speed can be slower compared to statically-typed languages like C or Java. Nonetheless, ongoing efforts, such as the introduction of the GIL-free sub-interpreter and advancements in just-in-time compilation, continue to address these challenges and enhance Python's performance.

5.3 Power Assurance Check AW139 Interface presentation

In the application, the search for information is essential. It is therefore necessary to be able easily and quickly access the application to add or view data. So we have created an interface to facilitate our tasks. It is enough just to open the program so that it is displayed.

5.3.1 Power Assurance Check AW139 Algorithm

The Power Assurance Check application consists of several pages whose algorithm is structured as shown in Figure 5.1.

Login interface is necessary to verify permitted access to application program.

Once enter the parameters performing the engine selected by the user, all the calculations resulting from the program are saved in an excel file in order to simplify record-keeping and data storage.

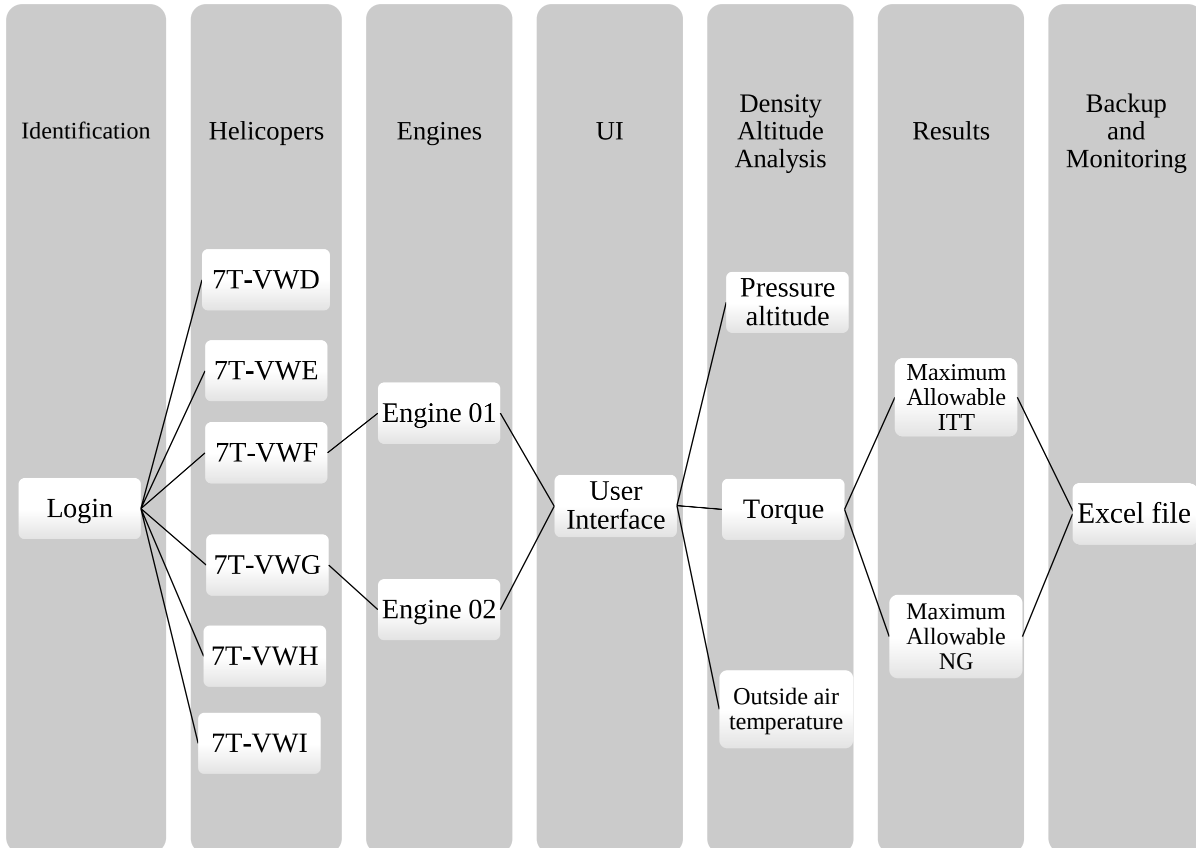

Figure 5.1: Application organizational chart

5.3.2 Application label

We named our program HELIOS , which is a cutting edge software application specifically designed for enhanced, digitize and monitor the PT6C-67C power chart for the AW139 helicopter to move from a complex sheet to a precise, efficient and effortless program.

Figure 5.2: Application LOGO

5.3.3 Login interface

Our interface consists of a single page login page as shown by Figure 5.3.

In order to access to the application, we should first enter a valid username and password.

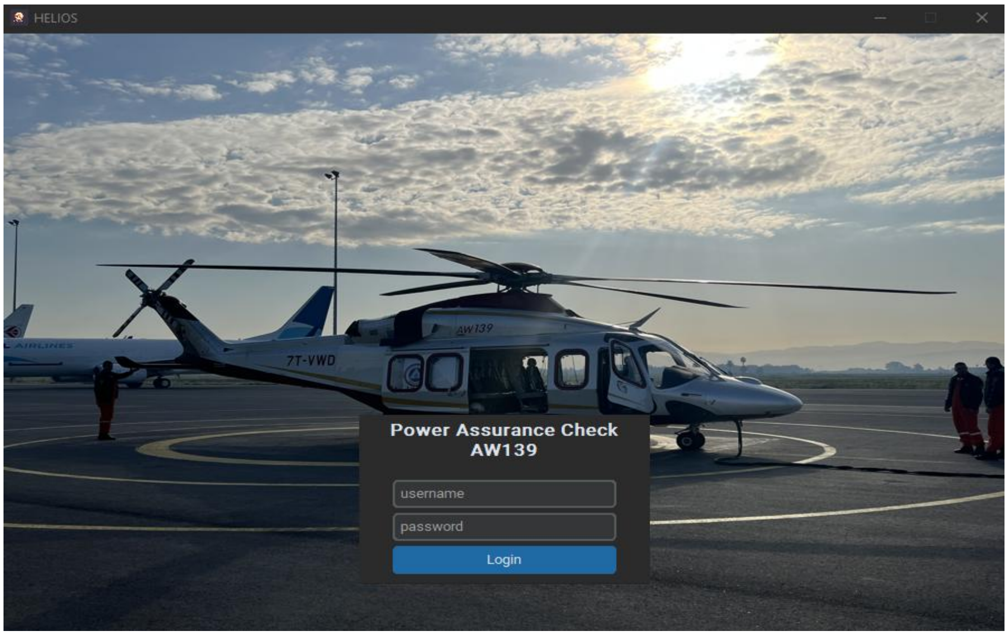

Figure 5.3: The “application interface” home page

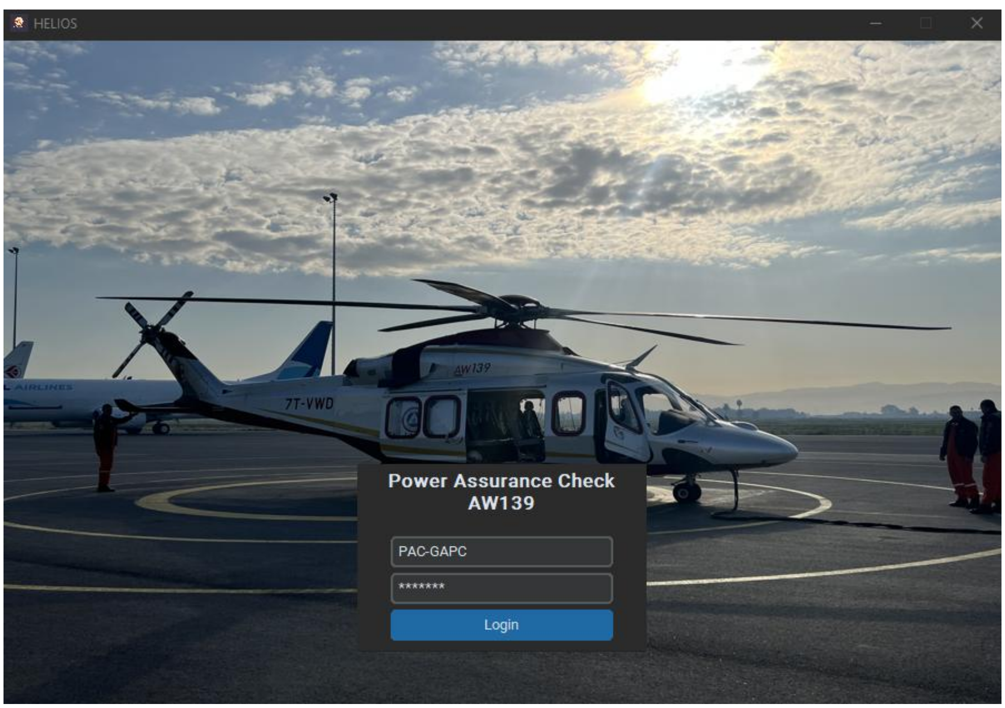

Figure 5.4: Dialog box contain a username and password

5.3.4 The fleet selection

In the fleet selection page, we should select one of the six helicopters indicated below. In our case, we will select 7T-VWI.

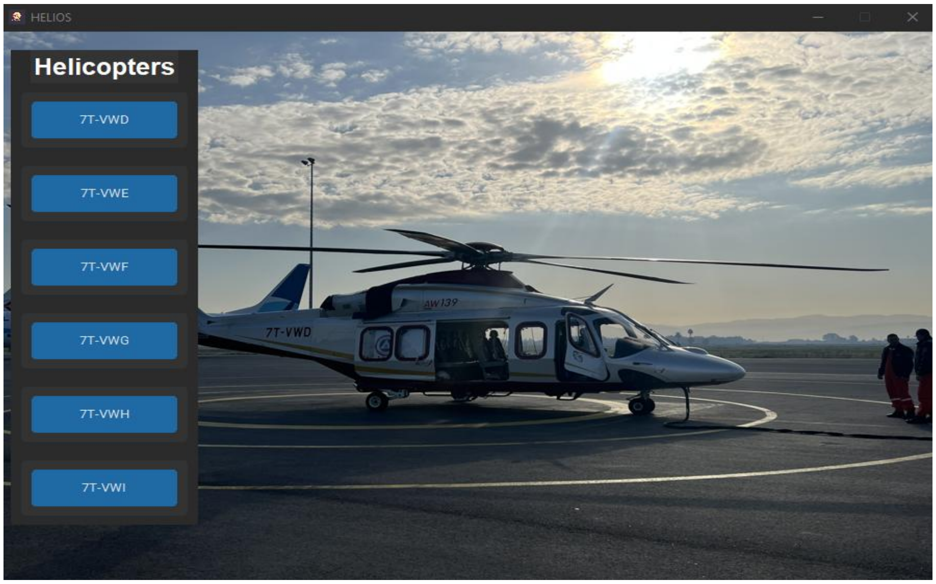

Figure 5.5: The Civil Protection Air Group fleet

5.3.5 The engines selection

In the engines selection page, we have to select one of the two helicopter's engines. In today's case, we will select Engine 1 of type PCE-KB0989.

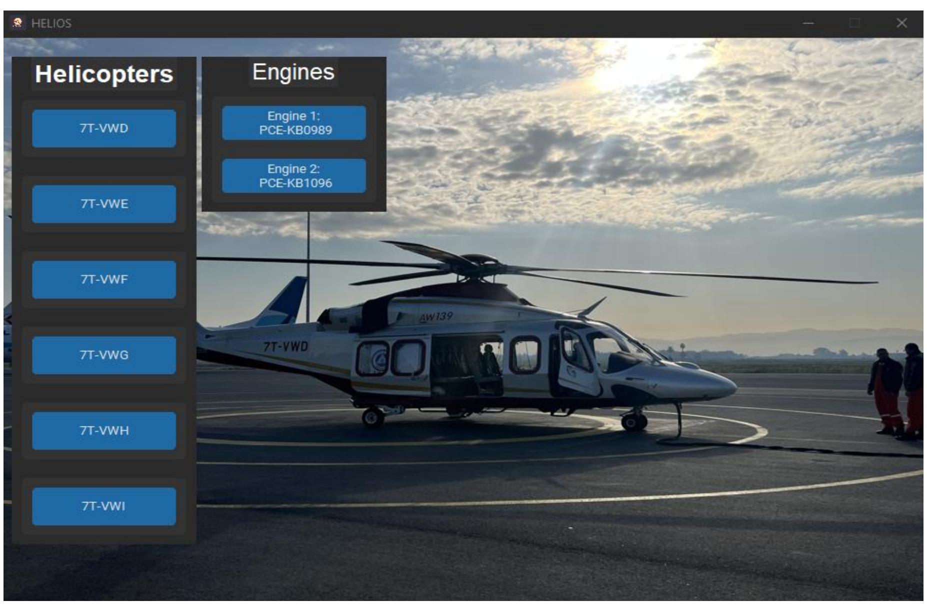

Figure 5.6: Helicopter's engines

5.3.6 Power Assurance Check AW139 main interface

Once both helicopter and engine selected, the page below will appear.

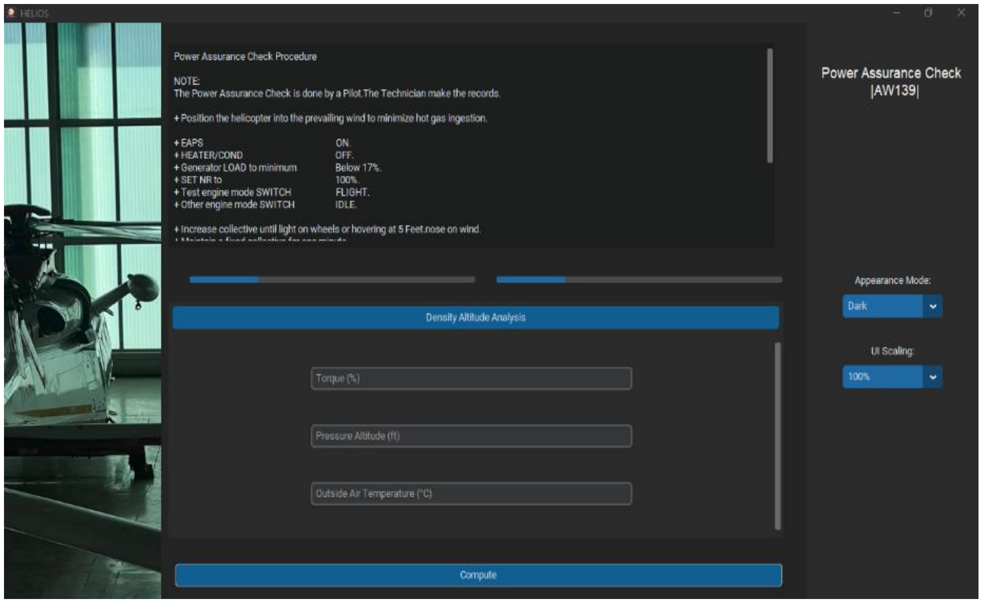

Figure 5.7: The first interface after logging in

5.4 Power Assurance Check Software presentation

5.4.1 Power Assurance Check procedures

In the main application interface, we mentioned the Power Assurance Check procedures as well as the deferent switches position.

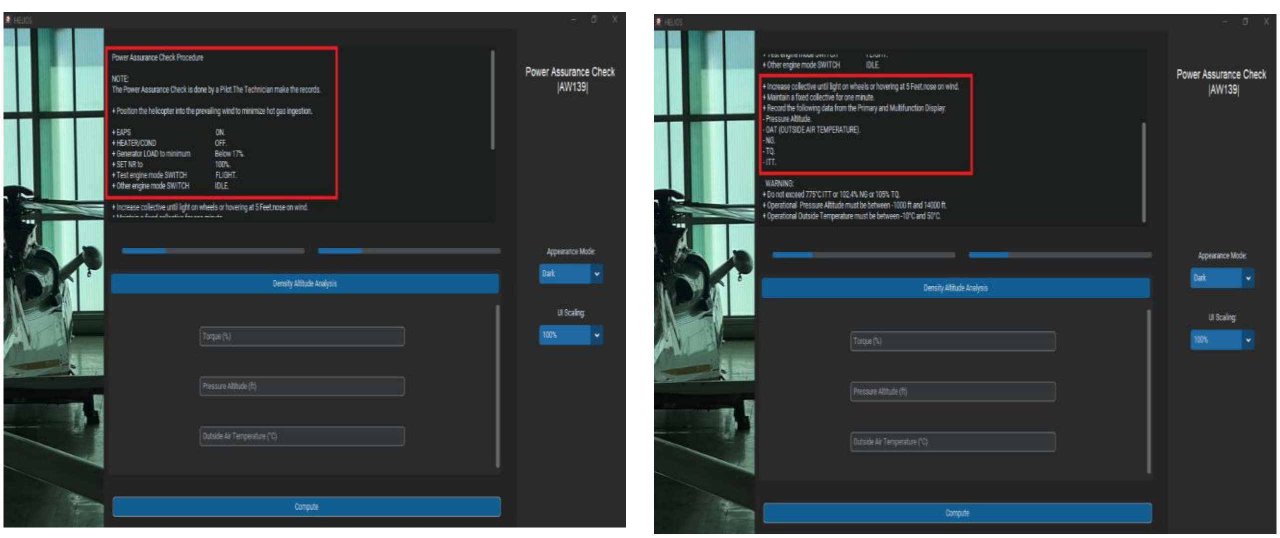

Figure 5.8: Power Assurance Check procedures as defined in the RFM

5.4.2 Warning case

In the Power Assurance Check, there is some entry values must be respect and should be belong the on the range which was defined previously by the constructor.

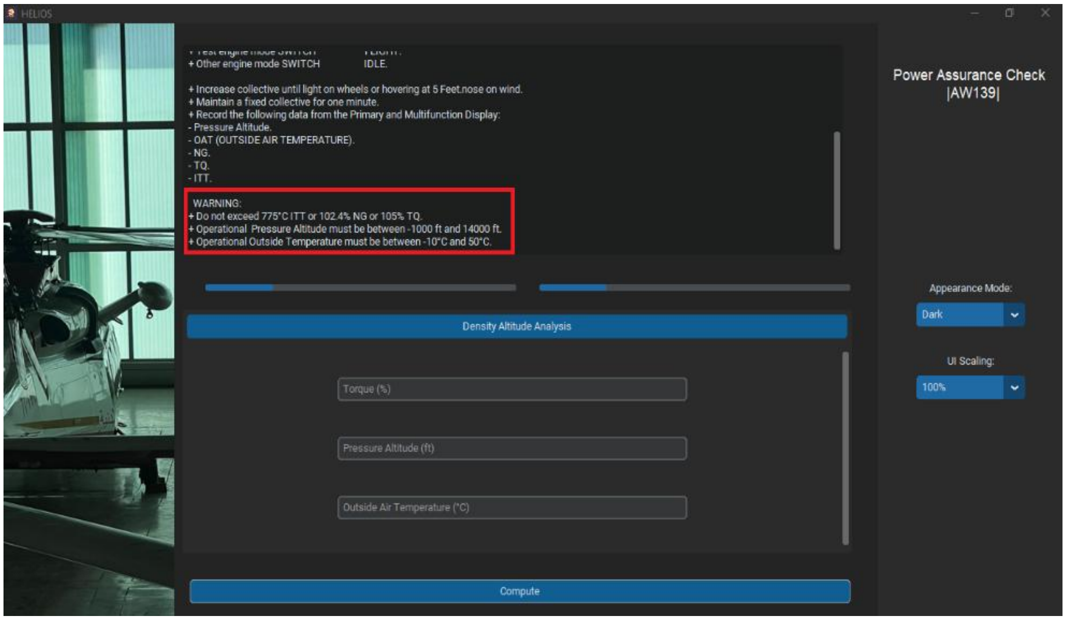

Figure 5.9: Warning case

5.4.3 The interface theme and size changing options

In order to change the display theme, we should select one of the following themes by clicking on Appearance Mode as mentioned bellow.

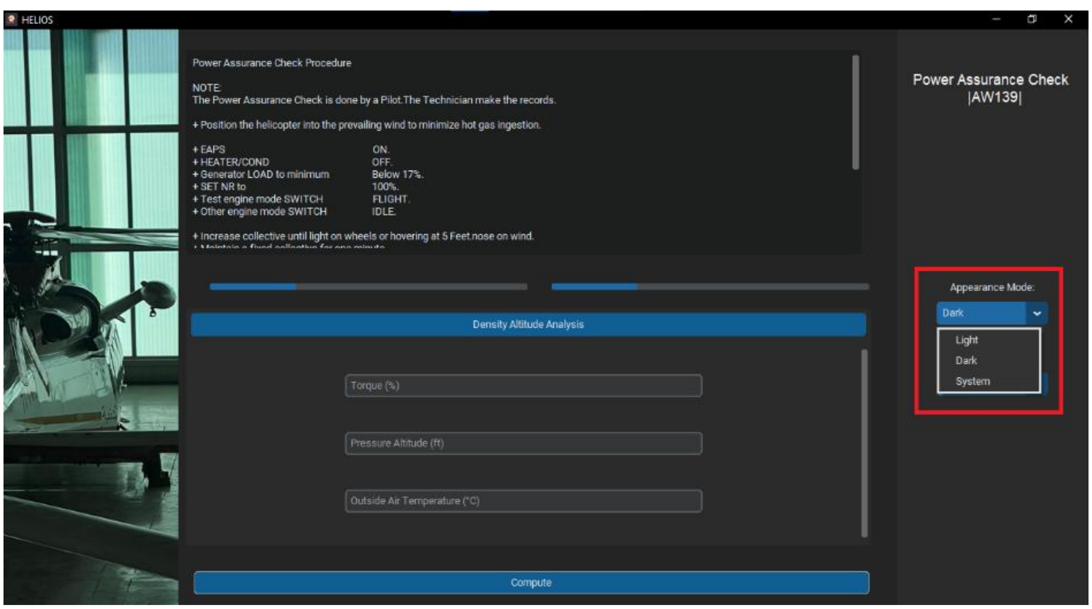

Figure 5.10: Interface Appearance Modes

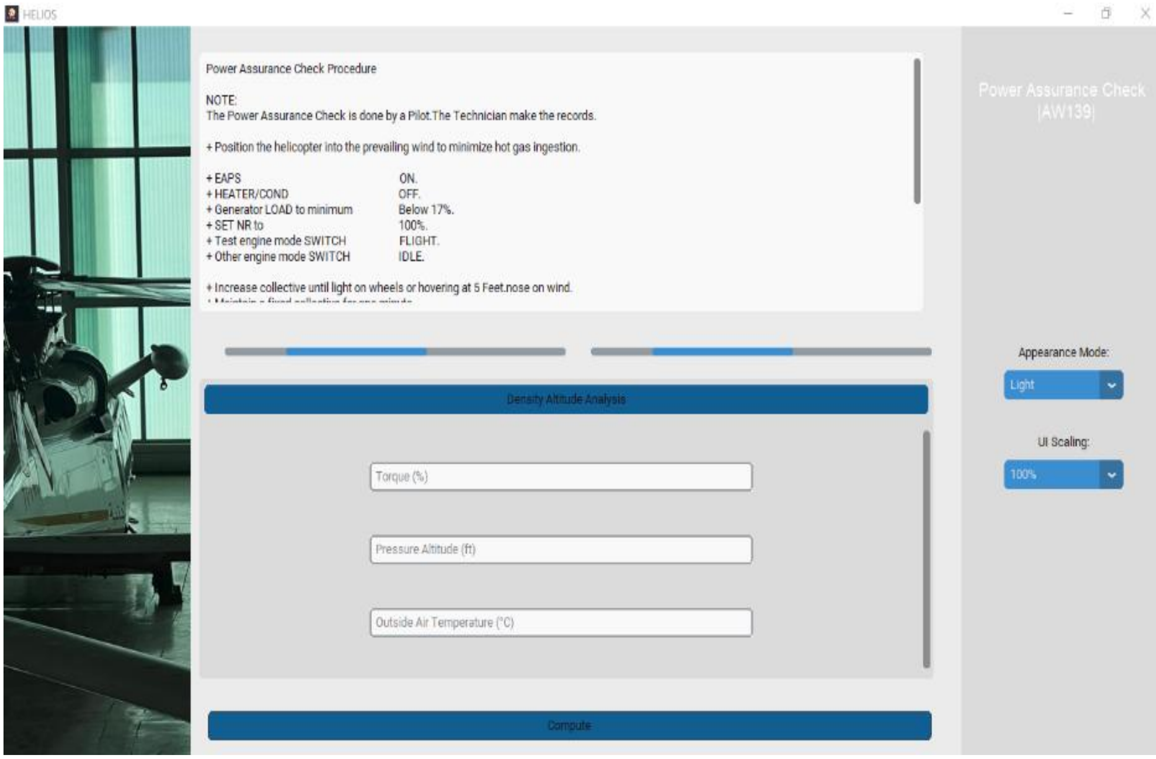

Figure 5.11: The main interface with light mode view

In order to change the interface size, we should click on the UI Scaling as follow:

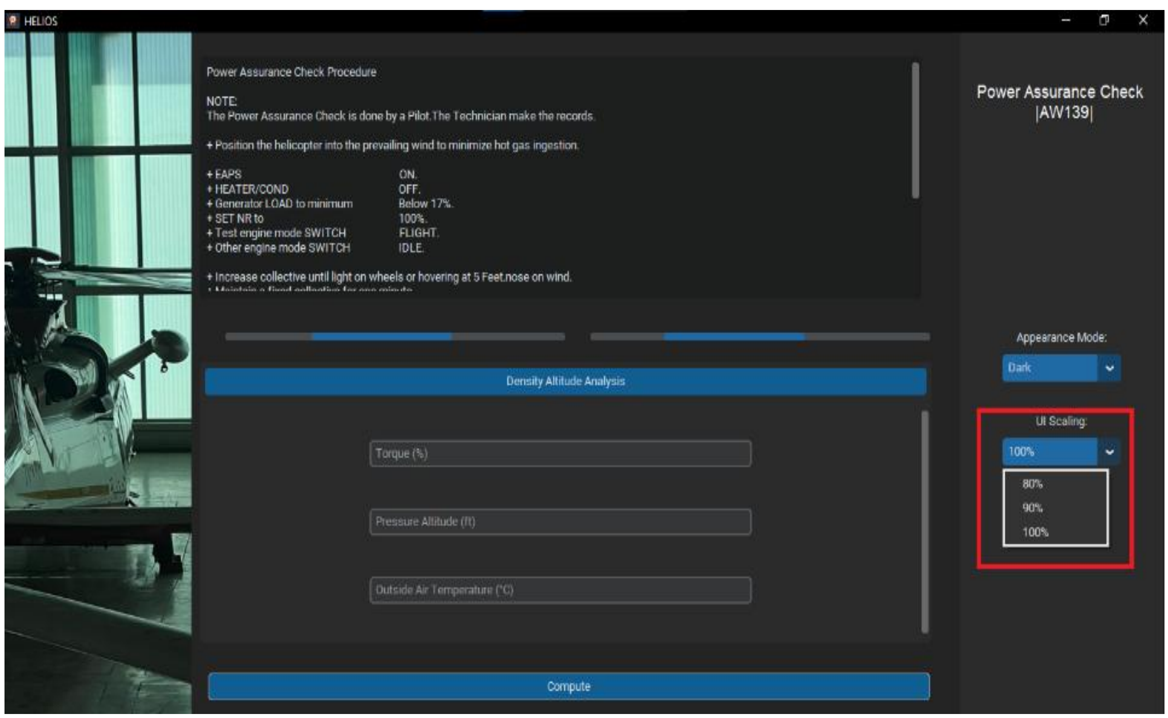

Figure 5.12: The main interface UI scaling

5.4.4 Values entry and calculation

On the lowest part of the following window, we can find the essential engine parameters.

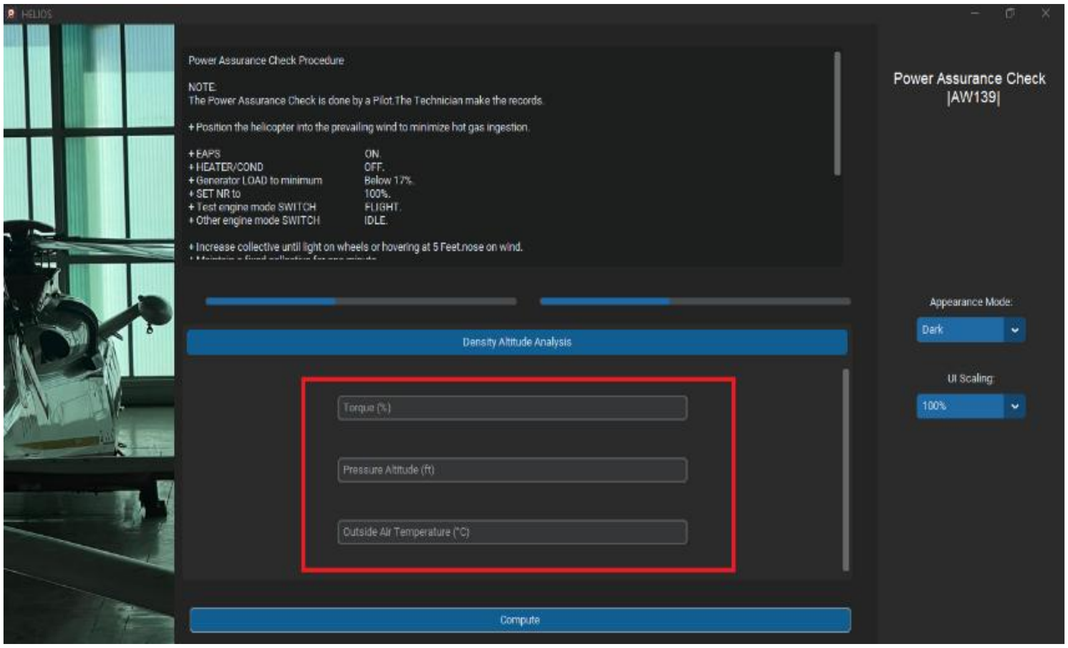

Figure 5.13: The main engine parameters

In the next window, we will enter the following values as example:

- Torque: 90 %
- Pressure Altitude : 1000 ft
- Outside Air Temperature : 30°c

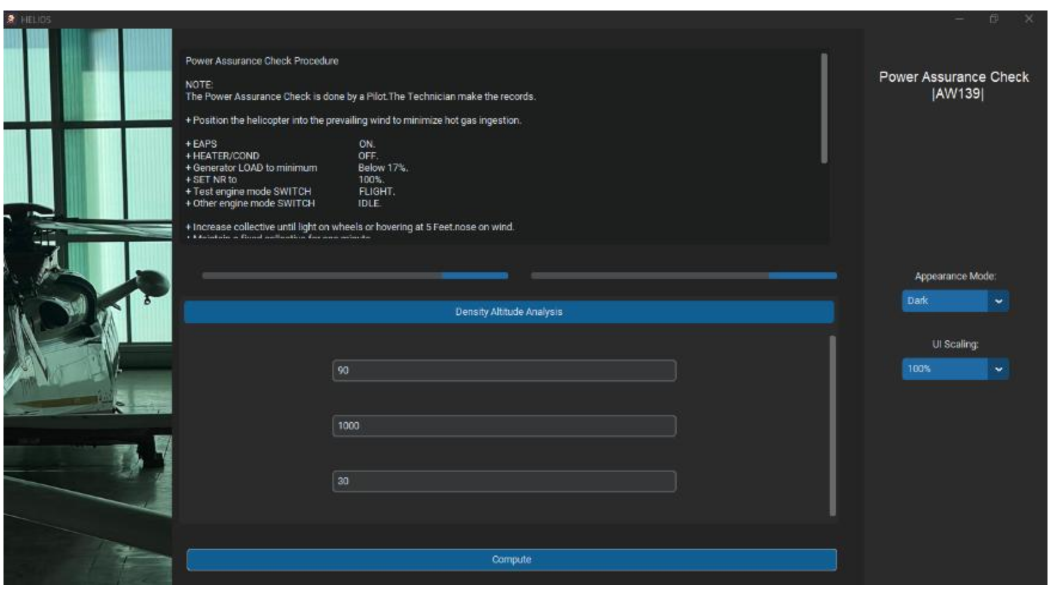

Figure 5.14: The tree values chosen by the crew

Then, we click on compute button as follow:

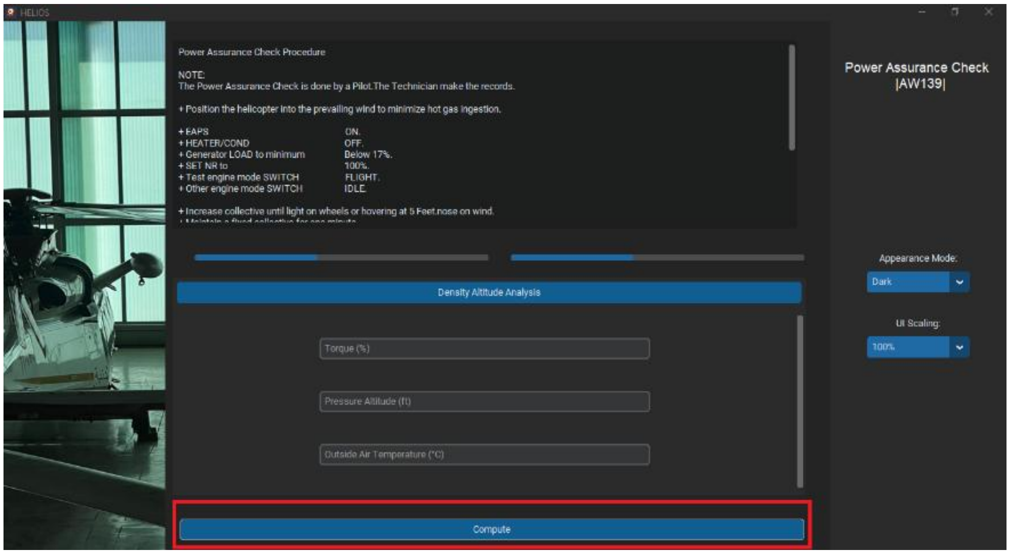

Figure 5.15: Compute button

5.4.5 Result saving options

A window bellow will appear from which we will get the results (ITT-NG) as mentioned bellow.

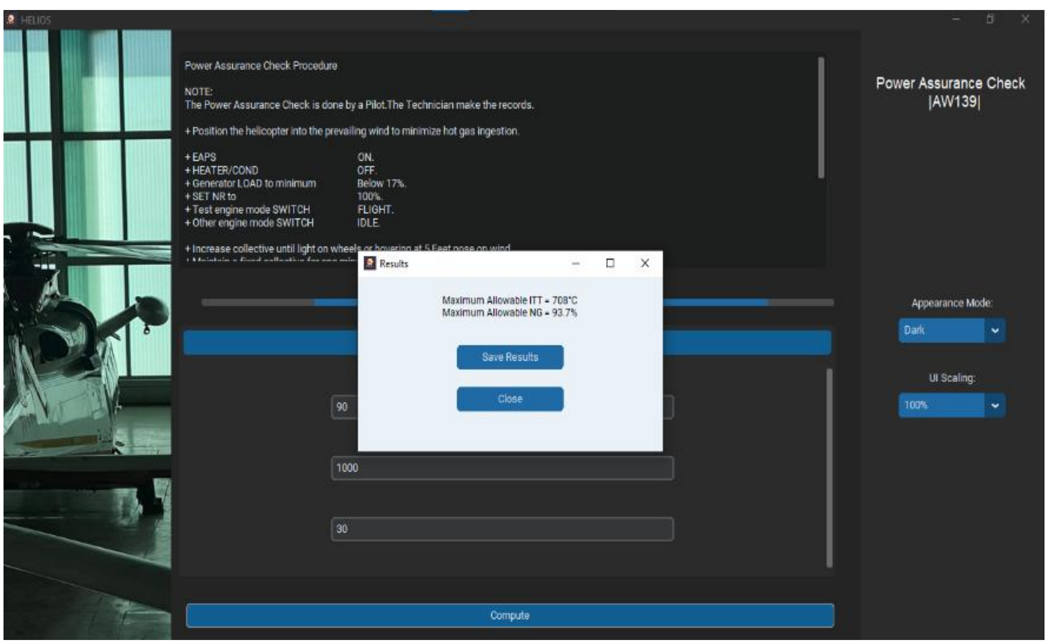

Figure 5.16: The results box

In order to get a good follow-up of the engines, we must save the information and data in order to perform some analyzes for each engine for carrying out the maintenance process.

We should than click on save results button as follow:

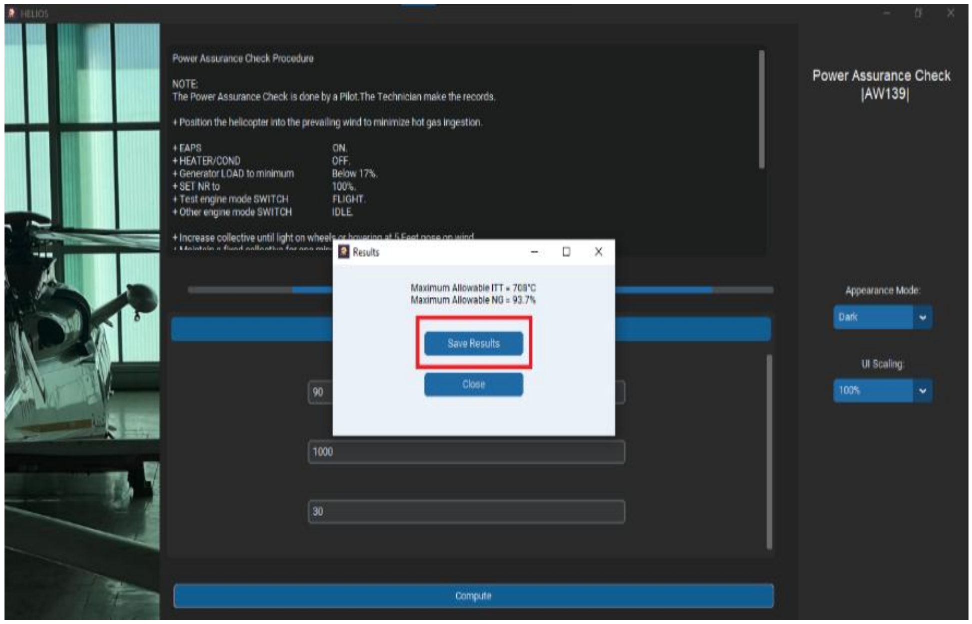

Figure 5.17: The results dialogue box

After we click on save results button, a dialog box will appear as mentioned bellow, and then we have to select a folder related to the concerned helicopter.

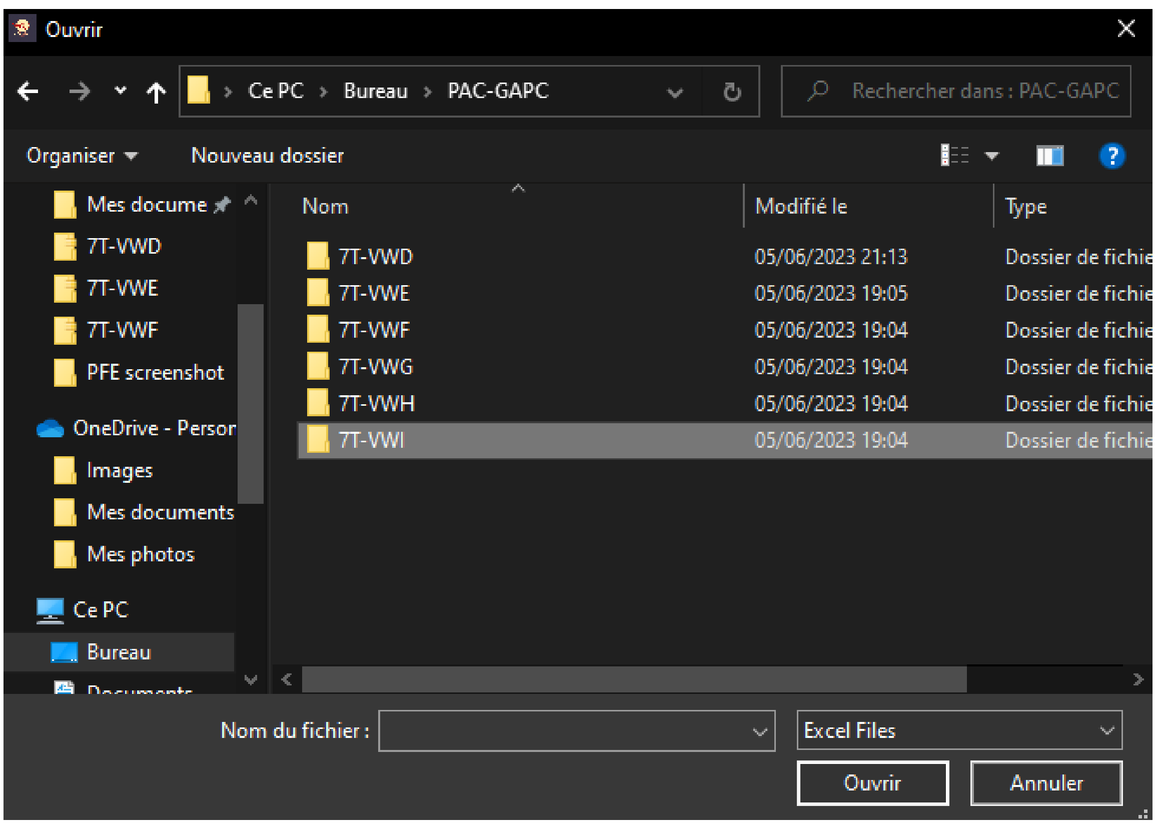

Figure 5.18: 7T-VWI saving folder selected

Then, we should select an excel file related to the concerned engine as follow:

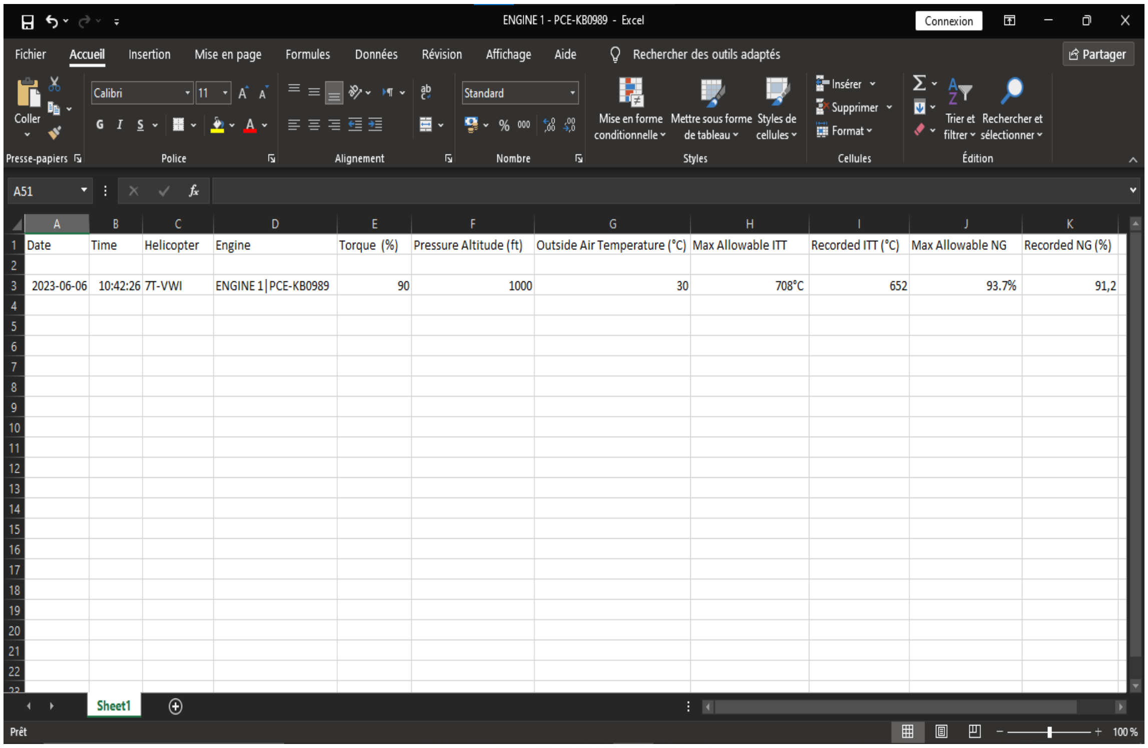

Figure 5.19: The two engines storage excel files

Once the concerned file selected, a dialogue box will appear as follow telling that the results was saved successfully.

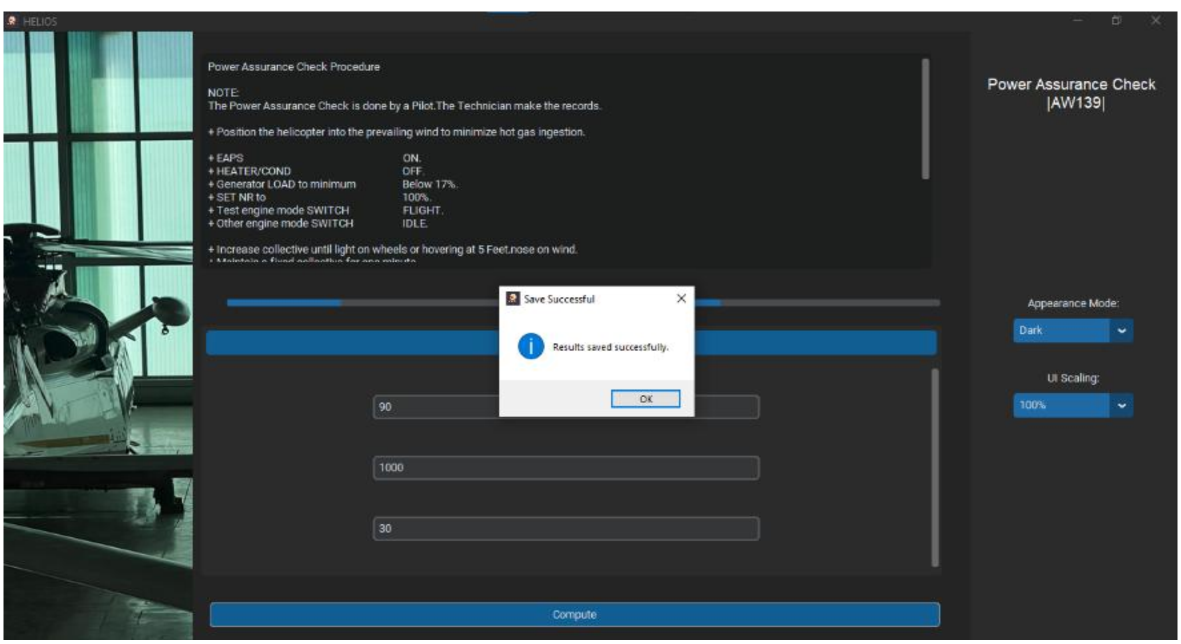

Figure 5.20: Save dialogue box indication

In the other case, if we will press the close button on the following interface.

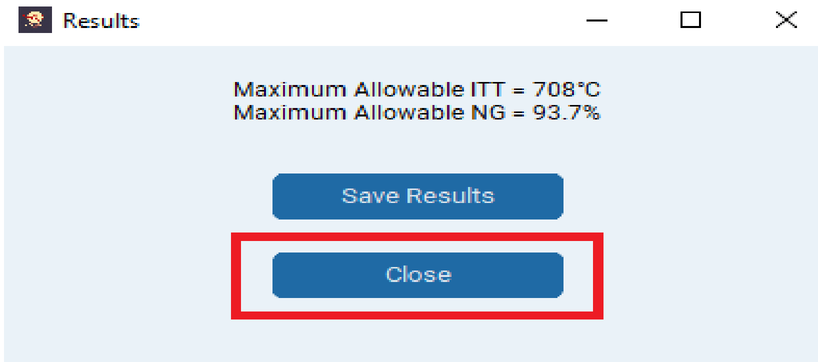

Figure 5.21: Close button

a dialogue box as follow will appear:

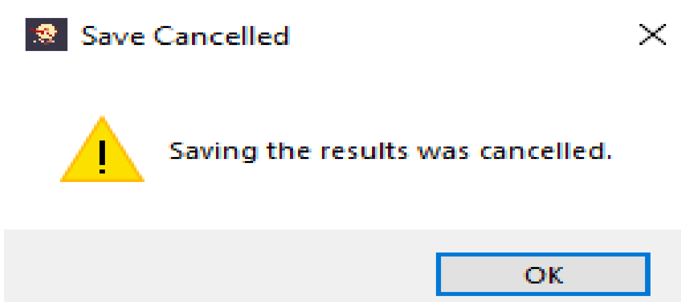

Figure 5.22: Save cancelled box

In case where the Air Operation Center engineer wants to re-enter to the recorded information for the engines of each helicopter, it must enter through the following desktop icon:

Figure 5.23: The desktop icon

In order to maintain the confidentiality of the database on the computer, we have provided the file with a special password.

Once we click on the icon and enter the correct password, the following window will appear:

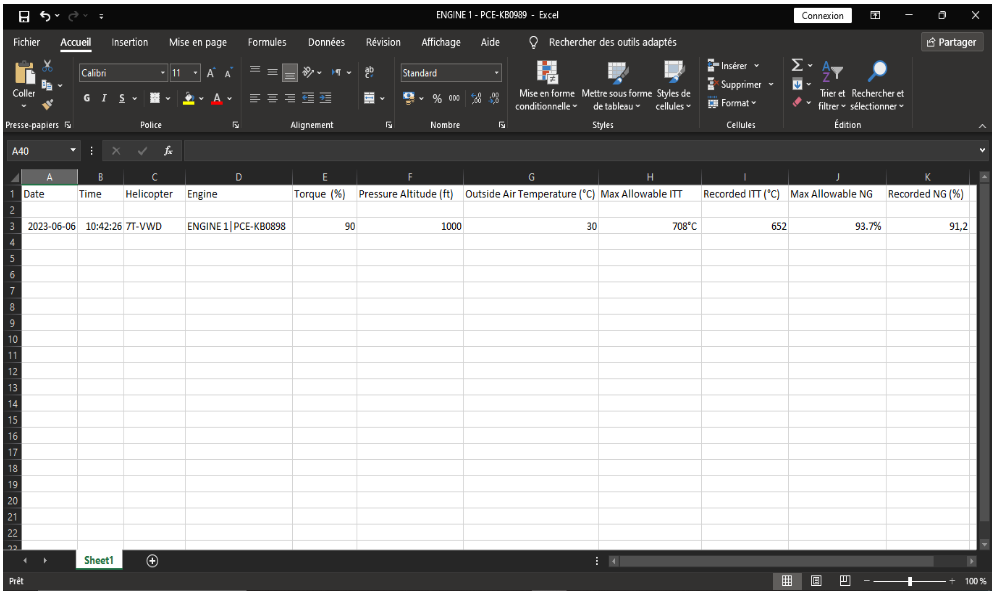

Figure 5.24: Database work sheet

The previous sheet contains the different data concerning the engines as well as the helicopters.

5.4.6 Graphic representations

With the aim of giving the program effectiveness and a clear view of engine performance values changing, users can show the results obtained in the form of charts as shown below.

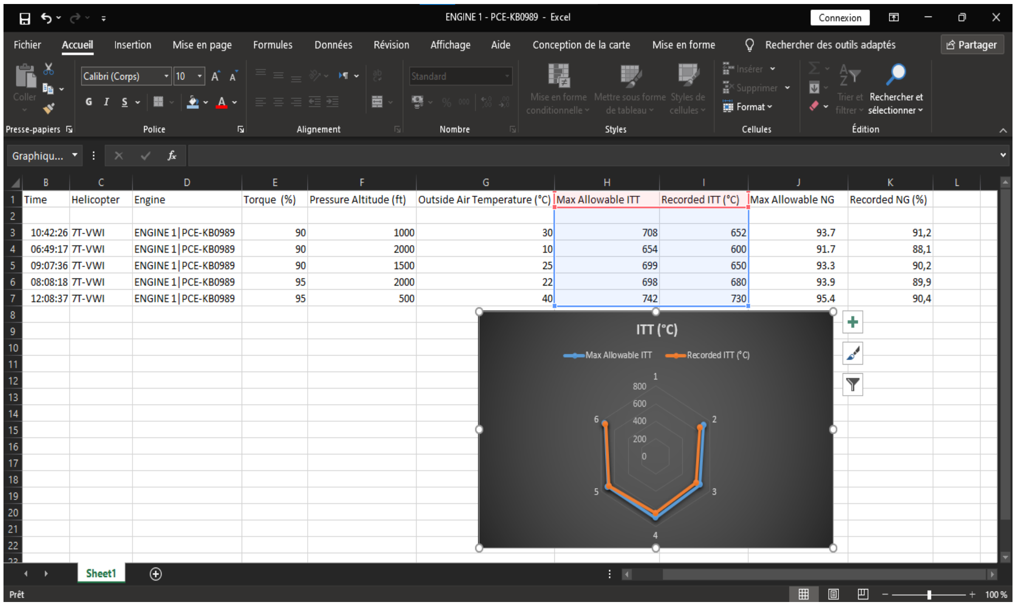

Figure 5.25: ITT Chart

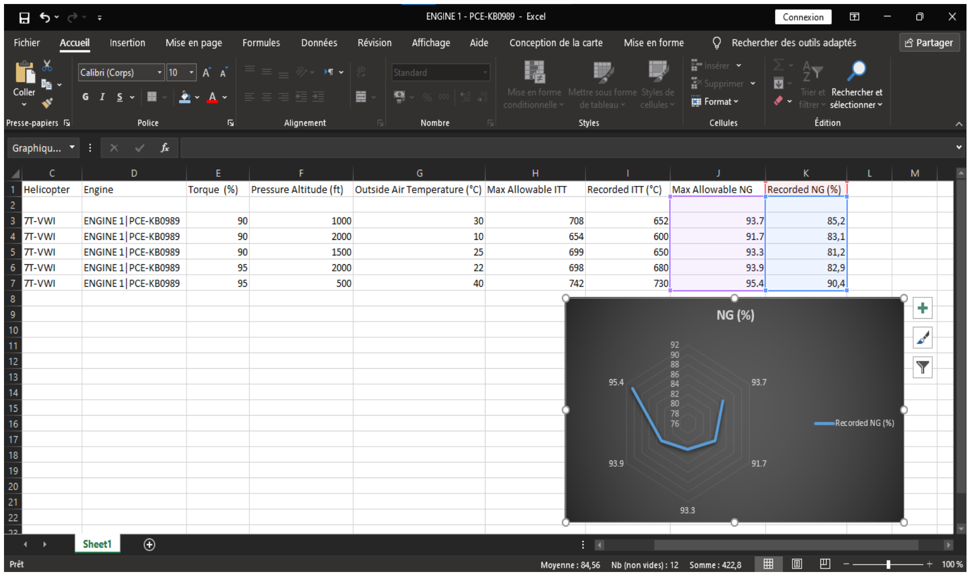

Figure 5.26: NG Chart

5.4.7 7T-VWD Helicopter case study

The 7T-VWD is one of the three helicopters of Civil Protection Air Group equipped with two engines under serial number as follow:

- ENG 1: PCE-KB0898
- ENG 2: PCE-KB0897

5.4.7.1 Engine 1 - PCE-KB0898

In order to check the ENG 1 and monitor them we should follow these steps:

First, we enter to our program (on the helicopter's fleet list) as shown below.

Figure 5.27: Helicopter's fleet list

After that, we select one of the two-helicopter engines.

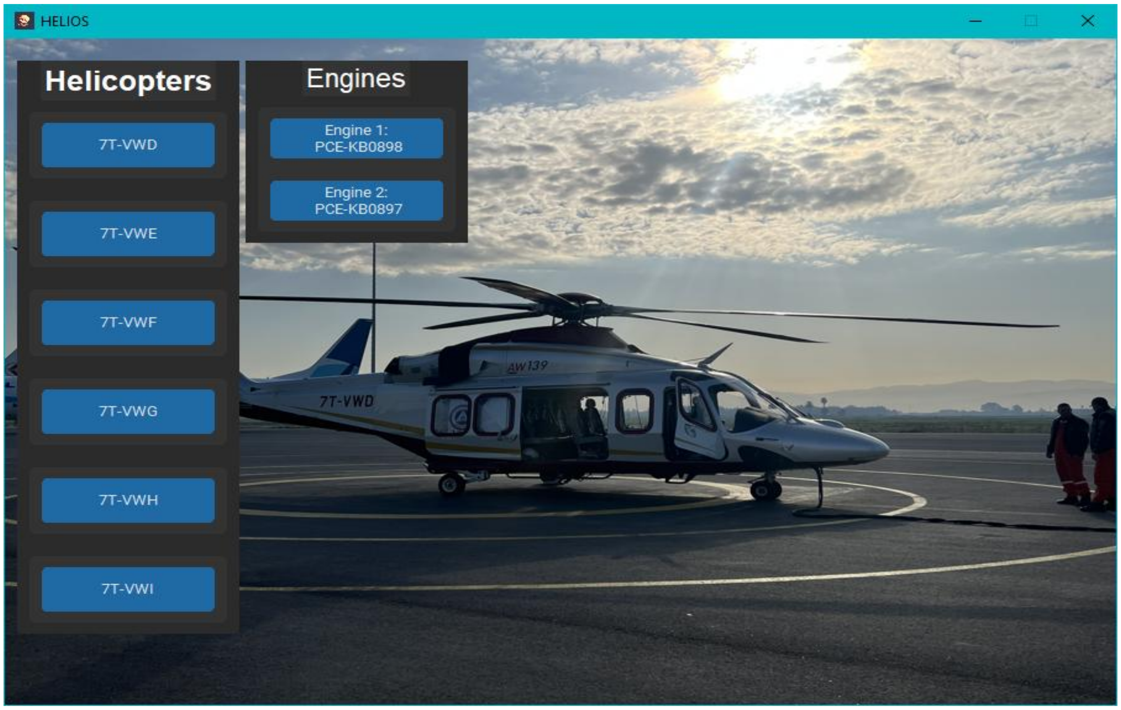

Figure 5.28: The helicopter engine 1 selection

A window as follow will appear:

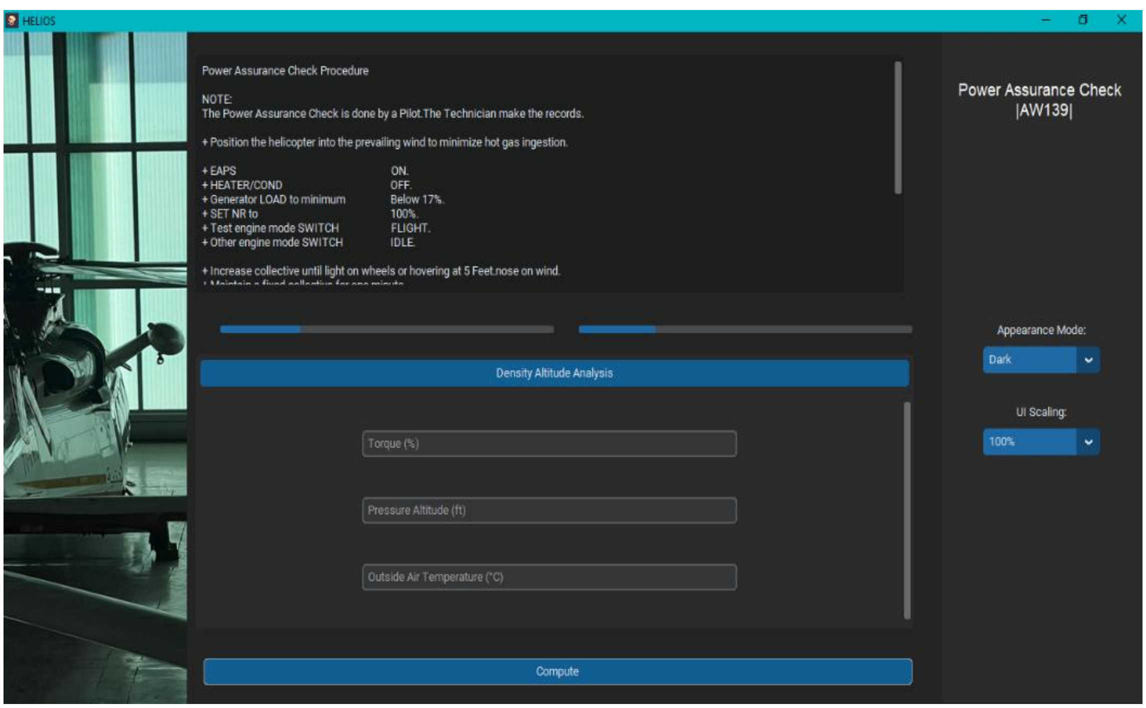

Figure 5.29: Main interface

In our case, we have to check the results with different OAT and Pressure altitude values bellow:

- TQ=90 %
- OAT=10°C
- Zp=1000 ft

then, we click on compute button as shown below:

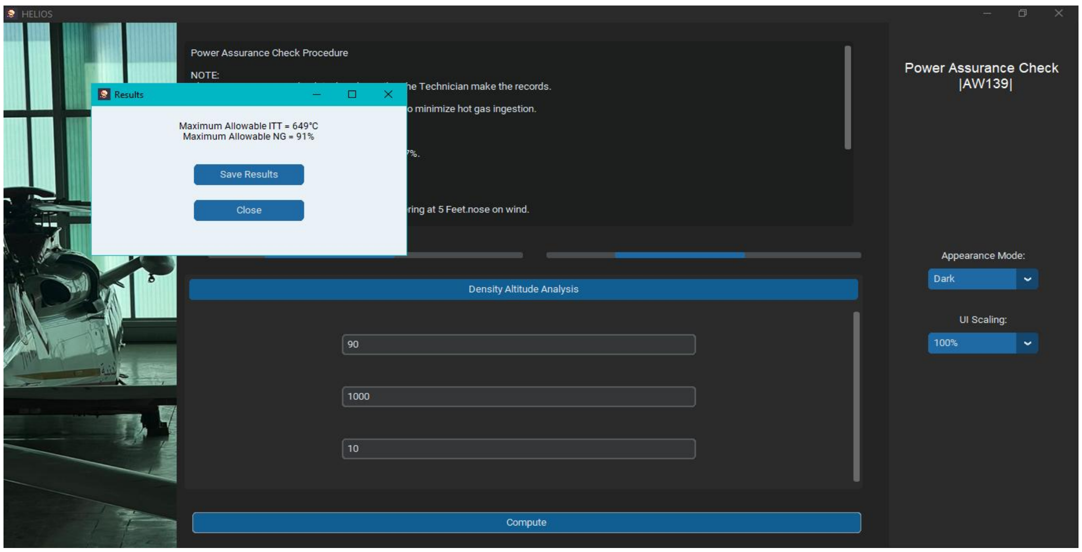

Figure 5.30: Result box for the case of engine 1

At this example, we obtained the following values:

- ITT=649°c
- NG=91%

Then, we will save these results obtained and compare them with the recorded ITT and NG like is indicated on the Multifunction Display.

Date	Time	Helicopter	Engine	Torque	Pressure Altitude	Outside Air Temperature	Max Allowable ITT	Recorded ITT (°C)	Max Allowable NG	Recorded NG (%)
		7T-VWD	ENGINE 1|PCE-KB0898	90	-1000	0	612°C		89%	
2023-02-09	09:49:00	7T-VWD	ENGINE 1|PCE-KB0898	90	1000	10	694°C	650°C	91%	84%
		7T-VWD	ENGINE 1|PCE-KB0898	90	6000	25	728°C		95,90%	
		7T-VWD	ENGINE 1|PCE-KB0898	90	2000	0	622°C		90,20%	
		7T-VWD	ENGINE 1|PCE-KB0898	90	2000	20	683°C		93%	
		7T-VWD	ENGINE 1|PCE-KB0898	90	0	25	688°C		92,40%	
		7T-VWD	ENGINE 1|PCE-KB0898	90	500	25	690°C		92,90%	
		7T-VWD	ENGINE 1|PCE-KB0898	90	1000	25	691°C		93%	

Figure 5.31: Excel sheet for engine 1

The recorded values are:

- ITT= 650°C
- NG=84%

Since the obtained values are little far from the maximum values. We can say that the engine is in good condition.

Then we will continue the same method with the other 7T-VWD engine and comparing the values obtained with the values given by the constructor on charts.

5.4.7.2 Engine 2 - PCE-KB0897

We select the engine two (PCE-KB0897)

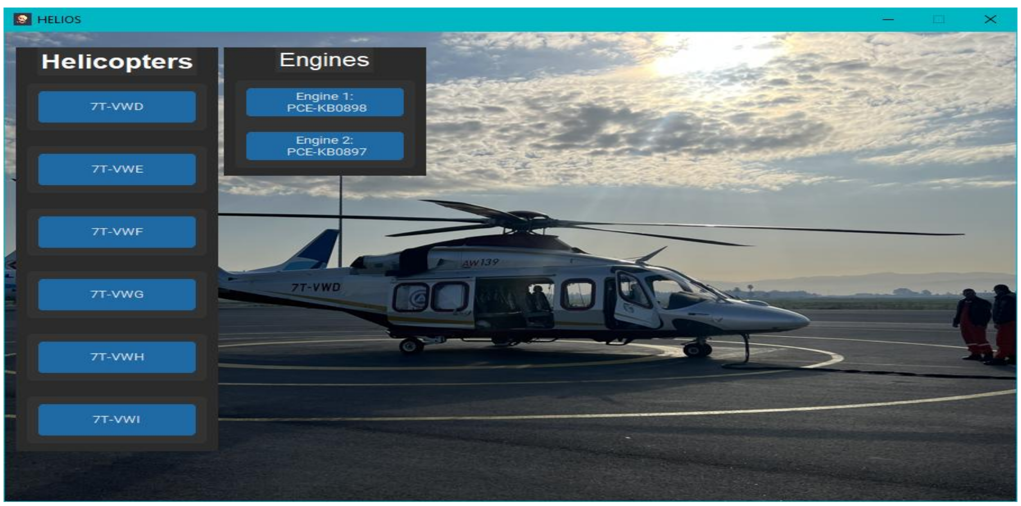

Figure 5.32: The helicopter engine 2 selection

With the same parameters (OAT=10/ TQ = 90 / Zp=1000), the following results will appear.

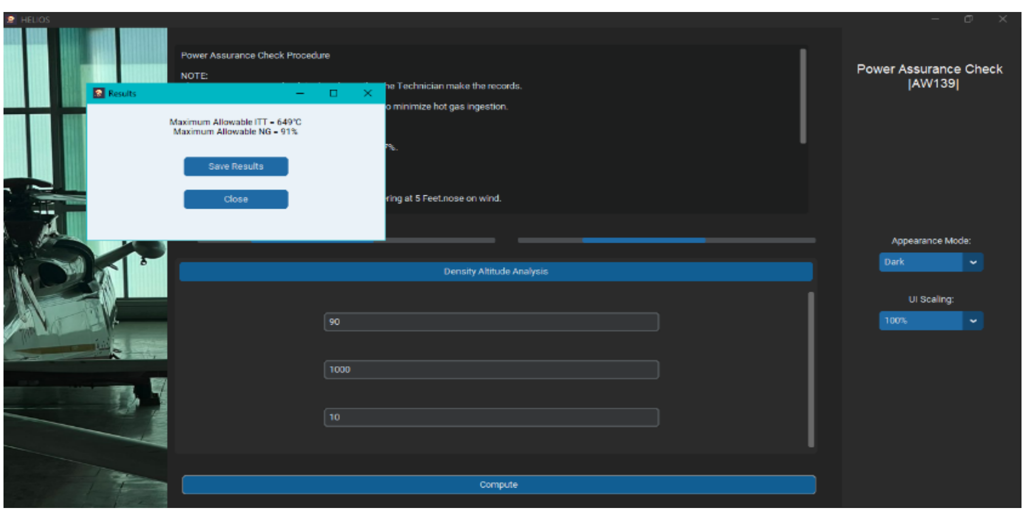

Figure 5.33: Result box for the case of engine 2

The same results are obtained as the engine 1 that will be compared with the values given by the constructor on charts.

Date	Time	Helicopter	Engine	Torque	Pressure Altitude	Outside Air Temperature	Max Allowable ITT	Recorded ITT (°C)	Max Allowable NG	Recorded NG (%)
		7T-VWD	ENGINE 2 | PCE-KB0897	90	3000	30	720°C		94,50%	
09/02/2023	09:53	7T-VWD	ENGINE 2 | PCE-KB0897	90	1000	10	694°C	691°C	91%	89%
		7T-VWD	ENGINE 2 | PCE-KB0897	105	2500	-10	625°C		91,30%	
		7T-VWD	ENGINE 2 | PCE-KB0897	100	14000	-10	760°C		101,80%	
		7T-VWD	ENGINE 2 | PCE-KB0897	90	6000	24	726°C		94,80%	
		7T-VWD	ENGINE 2 | PCE-KB0897	90	5000	15	688°C		93,60%	

Figure 5.34: Excel sheet for engine 2

In contrast to the first case, the results obtained are much more and much closer to the max allowable values. For this reason, the flight operation department should warn the maintenance department in order to start a series of inspections and resolutions in order to avoid helicopter grounding.

5.4.8 7T-VWE (ENG 2 - PCE-KB0934) Helicopter case study

Because of the daily air raids in the summer, and this is to carry out difficult tasks such as extinguishing fires mainly, and the consequent weakness in effectiveness, we note in the attached documents that the values have reached their maximum, which necessitated a number of maintenance operations at the air base.

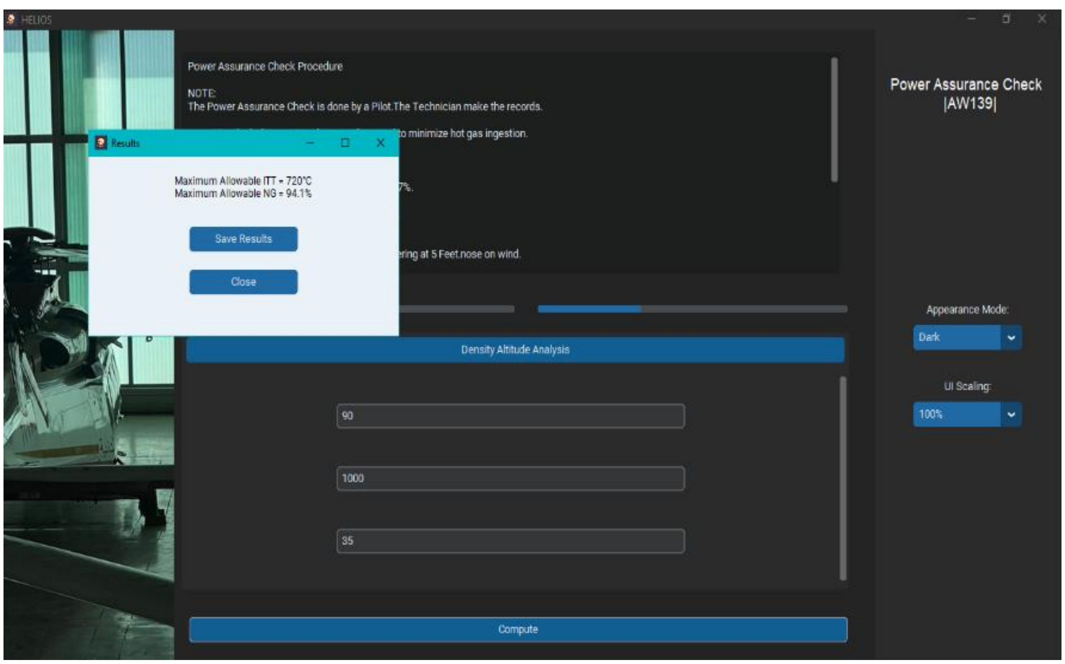

Figure 5.35: Result box for 7T-VWE helicopter

Comparing with the recorded values, we obtained the results bellow.

Date	Time	Helicopter	Engine	Torque	Pressure Altitude	Outside Air Temperature	Max Allowable ITT	Recorded ITT (°C)	Max Allowable NG	Recorded NG (%)
		7T-VWE	ENGINE 2|PCE-KB0934	100	1000	5	650°C		91,80%	
		7T-VWE	ENGINE 2|PCE-KB0934	90	1000	35	720°C		94,10%	
		7T-VWE	ENGINE 2|PCE-KB0934	105	2000	10	680°C		93,80%	
		7T-VWE	ENGINE 2|PCE-KB0934	100	1000	24	707°C		94,40%	
		7T-VWE	ENGINE 2|PCE-KB0934	90	1000	23	686°C		92,80%	
08/06/2023	14:06	7T-VWE	ENGINE 2|PCE-KB0934	90	1000	35	720°C	720°C	94,10%	94,09%

Figure 5.36: Excel sheet for 7T-VWE helicopter

After carrying out a set of technical checks for the engine and repairing the technical faults, the maintenance team put the helicopter into service. After which the pilots carried out a Power Assurance Check, we obtained the following results:

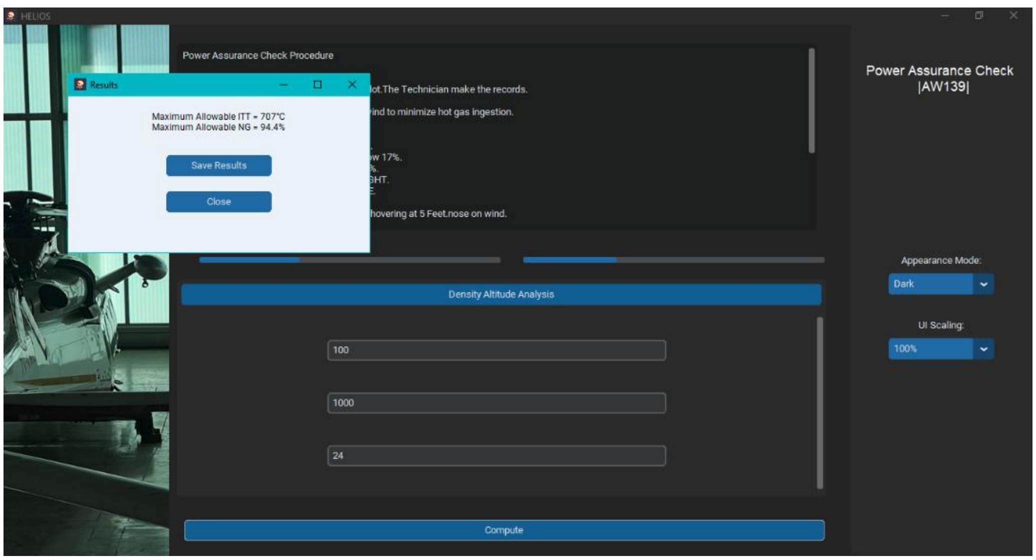

Figure 5.37: Result box for 7T-VWE helicopter after maintenance

And comparing these values with the recorded sheet.

Date	Time	Helicopter	Engine	Torque	Pressure Altitude	Outside Air Temperature	Max Allowable ITT	Recorded ITT (°C)	Max Allowable NG	Recorded NG (%)
		7T-VWE	ENGINE 2|PCE-KB0934	100	1000	5	650°C		91,80%	
		7T-VWE	ENGINE 2|PCE-KB0934	90	1000	35	720°C		94,10%	
		7T-VWE	ENGINE 2|PCE-KB0934	105	2000	10	680°C		93,80%	
		7T-VWE	ENGINE 2|PCE-KB0934	100	1000	24	707°C		94,40%	
		7T-VWE	ENGINE 2|PCE-KB0934	90	1000	23	686°C		92,80%	
08/06/2023	14:06	7T-VWE	ENGINE 2|PCE-KB0934	90	1000	35	720°C	720°C	94,10%	94,09%
16/06/2023	10:32	7T-VWE	ENGINE 2|PCE-KB0934	100	1000	24	707°C	621°C	94,04%	82%

Figure 5.38: Excel sheet for 7T-VWE helicopter after maintenance

We can notice that the obtained values are very far from the maximum values, and this is due to the repair of technical faults. We can say that the engine performs are well and the helicopter can perform its tasks in all conditions, and the engine can ensure sufficient lifting force for that.

5.5 Conclusion

In this chapter, we have seen the different tools for creating our application. We have used (python) for the creation of this calculation application. We have used GUI in order to guarantee the fluidity and responsiveness of our application. And for the storage of data from different helicopters and engines, we used excel.

At the end of this chapter, the implementation of the information system is materialized by the launch of the application.

General conclusion

The work carried out during the dissertation falls within the general framework of aeronautics

The results obtained indicate that the performance of the engines of the six helicopters are affected by the parameters that are undergone during the power assurance check (TQ-OAT-Zp).

At the end of this work, we will say that the follow-up of the degradations of the performances of an engine is an aspect, which proves to be imperative and must have the same importance as the regular technical control carried out on the fleet of the group.

Emerging technologies such as artificial intelligence, hypersonic, machine learning, nanotechnology, and robotics are expected to revolutionize the battlefields of the future. The complexity of modern warfare is also pushing operators to see how technology can advance familiar assets, such as helicopters, so they do things previously unimaginable.

The implementation of an engine performance calculation system within the civil protection air group will strengthen and facilitate the work of the air operations services as well as the maintenance services.

After a test phase, this software can be used by the group, allowing them to have an effective and efficient tool with better calculation precision.

Future Enhancements:

Our application can be developed and enhanced as follow:

Starting by Data Input Complexity: The input process for power assurance checks in the application requires manual entry of various parameters, such as pressure altitude, outside air temperature, and performance data.

The manual input process increases the chances of human error.

Explore options to simplify data input, such as integrating with external sources for real-time weather data and leveraging aircraft performance databases to pre-fill common parameters, reducing user effort and minimizing the risk of errors.

Improve the application by utilizing artificial intelligence to increase accuracy and obtain the entire data margin.

Using artificial intelligence to improve the application would allow more accurate information to be acquired, enhancing the reliability and efficiency of the power assurance check and engine monitoring.

Have knowledge of artificial intelligence or establish partnerships with other schools and institutes in the field of AI to improve the application

Storage of data within the application:

Improving the application by storing data within the application in the form of a table that can be translated into a graph.

Storing the data inside the application will increase the security of the application and also save time for the user.

Having the know-how and using other programs and libraries in Python.

Altering engines and adding helicopters, after enhancing the application's security, we can add features such as adding a helicopter with these engines or replacing a degraded engine with another new engine. Precise information on the condition of each engine and increase the capacity of their monitoring to reduce the rate of degradation Collaboration with the technical department to obtain information in real time.

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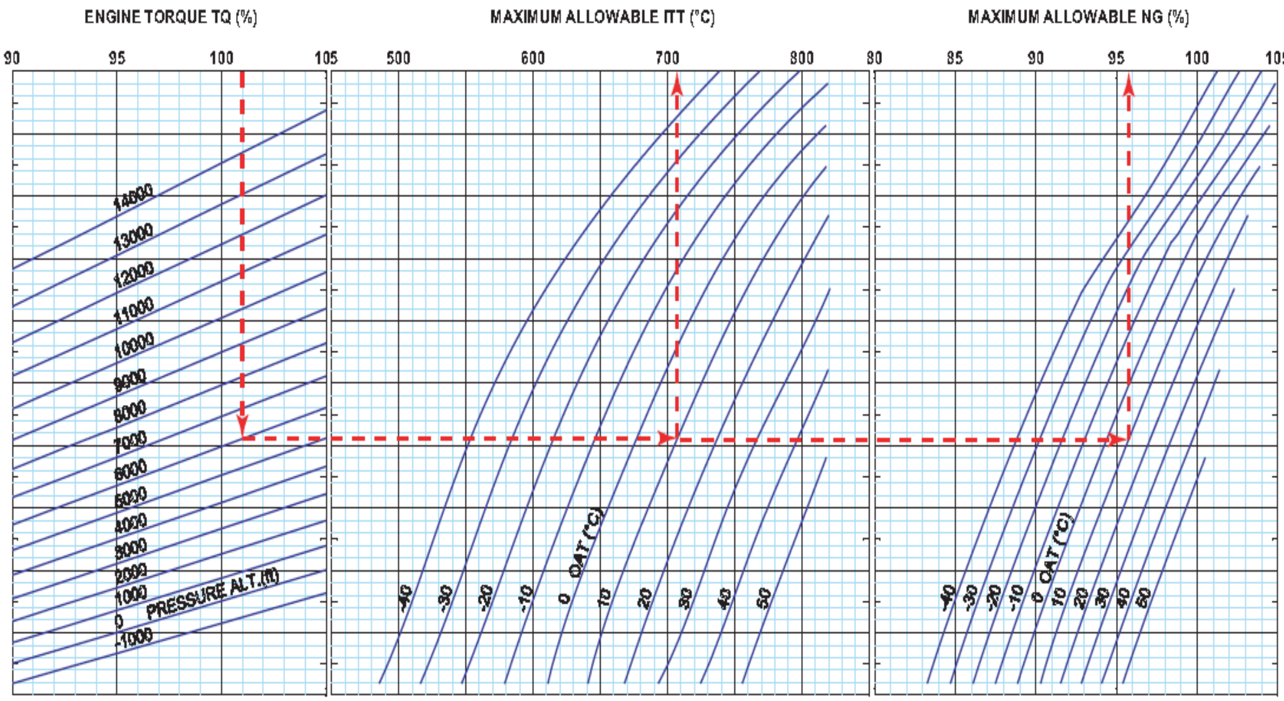
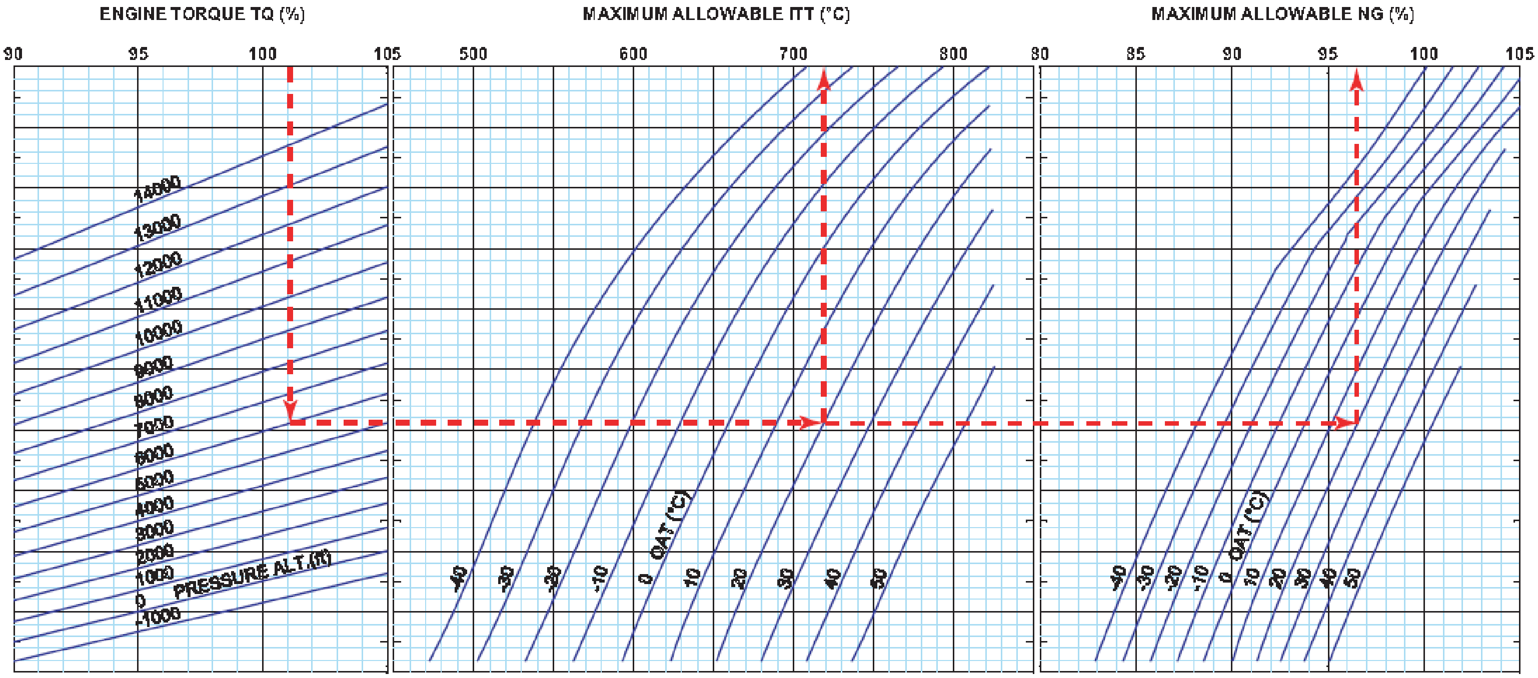
Appendix A



PWC PT&C-67C Hover Power Chart EAPS ON

Appendix B



Power Assurance Check Chart EAPS OFF

Appendix C

	AW139 / PT6C-67C **POWER ASSURANCE CHECK RECORD SHEET** *Relevé Point Fixe*	Rev : 00, Date :02/2023 **N°................**

- HELICOPTER AW139-

Registration :	MSN :	TSN :	CSN :	Station :	Reason for Power Assurance Check

- ENGINE -

Engine 1			Engine 2		
S/N	TSN	TSO	S/N	TSN	TSO

- STARTING DATA -

	ITT Peak °C	Starting time	NG %	NF %(65%±1)	NR % (65%±1)	Wind (KTS)	OAT (°C)	Press ALT (ft)
ENG. 1								
ENG. 2								

- POWER ASSURANCE CHECK IN HOVER MODE (NR=100%) -

NOTE: THE POWER ASSURANCE CHECK IS DONE BY A PILOT, THE TECHNICIAN MAKE THE RECORDS.

- EAPS ON
- HEATER/COND OFF
- GENERATOR LOAD TO MINIMUM (BELOW 17%)
- SET NR to 100%
- TEST ENGINE MODE SWITCH: FLIGHT
- OTHER ENGINE MODE SWITCH: IDLE
- INCREASE COLLECTIVE UNTIL LIGHT ON WHEELS OR HOVERING AT 5 FEET, NOSE ON WIND.

DO NOT EXCEED 775°C ITT OR 102.4% NG OR 105% TQ

- STABILIZE POWER 1 MINUTE, THEN RECORD OAT, PRESSURE ALTITUDE, ENGINE TORQUE, ITT AND NG
- ENTER CHART AT INDICATED TQ, MOVE DOWN TO INTERSECT PRESSURE ALTITUDE, PROCEED TO THE RIGHT TO INTERSECT OAT,
- THEN MOVE UP TO READ VALUES FOR MAXIMUM ALLOWABLE ITT AND NG
- IF INDICATED ITT OR NG EXCEEDS MAXIMUM ALLOWABLE, REPEAT CHECK
- REPEAT CHECK USING OTHER ENGINE
- IF EITHER ENGINE EXCEEDS ALLOWABLE ITT OR NG, PUBLISHED PERFORMANCE MAY NOT BE ACHIEVABLE. REFER TO EMM

NOTE: SEE RFM SUPPLEMENT 5 ENGINE AIR PARTICLE SEPARATOR (EAPS)

Recorded OAT:.........................°C PRESSURE ALTITUDE:.......................ft

	Engine TRQ (%)	Recorded ITT (°C)	Recorded NG (%)	Max. Allowable ITT (°C)	Max. Allowable NG (%)
ENG. 1					
ENG. 2					
	Engine NF (%)	Fuel Flow (Kps)	Oil Press (Psi)	Oil Temp (°C)	
ENG. 1					
ENG. 2					

FINDING	PERFORMED BY	CONTROLLED BY
YES ☐ NO ☐ N°..	Nom: .... Date: .... Visa	Nom: .... Date: .... Visa

PC/AW139/LC/03

Power Assurance check record sheet

A

- **Automatic direction finder (ADF):** Electronic navigation equipment that operates in the low- and medium-frequency bands. Used in conjunction with the ground-based nondirectional beacon (NDB), the instrument displays the number of degrees clockwise from the nose of the aircraft to the station being received.
- **Absolute pressure:** Pressure measured from the reference of zero pressure, or a vacuum.
- **Angle of attack (AOA):** The angle between the airfoil's chord line and the relative wind.
- **Altimeter:** An instrument that indicates flight altitude by sensing pressure changes and displaying altitude in feet or meters.
- **Axis of rotation:** The imaginary line about which the rotor rotates. It is represented by a line drawn through the center of, and perpendicular to, the tip-path plane.

C

- **Collective pitch control:** The control for changing the pitch of all the rotor blades in the main rotor system equally and simultaneously and, consequently, the amount of lift or thrust being generated.
- **Ceiling:** The height above the earth's surface of the lowest layer of clouds, which is reported as broken or overcast, or the vertical visibility into an obscuration.

D

- **Distance measuring equipment (DME):** A pulse-type electronic navigation system that shows the pilot, by an instrument-panel indication, the number of nautical miles between the aircraft and a ground station or waypoint.

G

- **Ground effect:** The condition of slightly increased air pressure below an airplane wing or helicopter rotor system that increases the amount of lift produced. It exists within approximately one wing span or one rotor diameter from the ground. It results from a reduction in upwash, downwash, and wingtip vortices, and provides a corresponding decrease in induced drag.

I

- **In ground effect (IGE) hover:** Hovering close to the surface (usually less than one rotor diameter distance above the surface) under the influence of ground effect.

- **Indicated airspeed (IAS).** Shown on the dial of the instrument airspeed indicator on an aircraft. Indicated airspeed (IAS) is the airspeed indicator reading uncorrected for instrument, position, and other errors. Indicated airspeed means the speed of an helicopter as shown on its pitot static airspeed indicator calibrated to reflect standard atmosphere adiabatic compressible flow at sea level uncorrected for airspeed system errors. Calibrated airspeed (CAS) is IAS corrected for instrument errors, position error (due to incorrect pressure at the static port) and installation errors.
- **Instrument landing system (ILS):** An electronic system that provides both horizontal and vertical guidance to a specific runway, used to execute a precision instrument approach procedure.

K

- **Knot:** The knot is a unit of speed equal to one nautical mile (1.852 km) per hour, approximately 1.151 mph.

M

- **Mass.** The amount of matter in a body.
- **Maximum takeoff weight:** The maximum allowable weight for takeoff.

O

- **Out of ground effect (OGE) hover:** Hovering a distance greater than one disk diameter above the surface. Because induced drag is greater while hovering out of ground effect, it takes more power to achieve a hover out of ground effect.
- **Outside air temperature (OAT).** The measured or indicated air temperature (IAT) corrected for compression and friction heating. Also referred to as true air temperature.
- **Overpower:** To use more power than required for the purpose of achieving a faster rate of airspeed change.

P

- **Pressure altitude:** The height above the standard pressure level of 29.92 "Hg. It is obtained by setting 29.92 in the barometric pressure window and reading the altimeter.
- **Resultant relative wind:** Airflow from rotation that is modified by induced flow.
- **Pilot in command (PIC).** The pilot responsible for the operation and safety of a Helicopter.
- **Power plant:** A complete engine and propeller combination with accessories.

- **Power:** Implies work rate or units of work per unit of time, and as such, it is a function of the speed at which the force is developed. The term “power required” is generally associated with reciprocating engines.
- **Pilot in command (PIC).** The pilot responsible for the operation and safety of a Helicopter.
- **Power plant:** A complete engine and propeller combination with accessories.
- **Power:** Implies work rate or units of work per unit of time, and as such, it is a function of the speed at which the force is developed. The term “power required” is generally associated with reciprocating engines.

R

- **Rotor:** A complete system of rotating airfoils creating lift for a helicopter.
- **Rotor force:** The force produced by the rotor, comprised of rotor lift and rotor drag.

S

- **Shaft turbine:** A turbine engine used to drive an output shaft, commonly used in helicopters.
- **Standard atmosphere:** A hypothetical atmosphere based on averages in which the surface temperature is 59 °F (15 °C), the surface pressure is 29.92 "Hg (1013.2 Mb) at sea level, and the temperature lapse rate is approximately 3.5 °F (2 °C) per 1,000 feet.

T

- **Tail rotor:** A rotor turning in a plane perpendicular to that of the main rotor and parallel to the longitudinal axis of the fuselage. It is used to control the torque of the main rotor and to provide movement about the yaw axis of the helicopter.
- **Torque:** In helicopters with a single, main rotor system, the tendency of the helicopter to turn in the opposite direction of the main rotor rotation.
- **Turbo shaft engine:** A turbine engine transmitting power through a shaft as would be found in a turbine helicopter.

W

- **Weight:** One of the four main forces acting on a helicopter. Equivalent to the actual weight of the helicopter. It acts downward toward the center of the earth.