

# ENAC / EETAC ATR

## FAA regulation analysis for ATR ETOPS validation

**Jordi CLARAMUNT SEGURA**

IENAC14 - Erasmus

**End of studies report / Treball Final de Grau**

11/08/2017



ECOLE NATIONALE DE L'AVIATION CIVILE



UNIVERSITAT POLITÈCNICA DE CATALUNYA  
BARCELONATECH

Escola d'Enginyeria de Telecomunicació  
i Aeroespacial de Castelldefels

# ATR

PROPELLING THE NEXT CONNECTION

Intentionally left blank

### Acknowledgements

With deepest gratitude and appreciation, I humbly give thanks to the people who helped me in making this end of studies project a possible one.

First of all, I would like to offer my special thanks to Souhir Charfeddine, my internship tutor in ATR, for choosing me among the other candidates and giving me the possibility to perform this internship. Thanks for her valuable and constructive help during the planning and development of this internship. I really appreciate all the time she has dedicated to me with all the different meetings we have had inside the company. I have learnt a lot at her side, she has been an amazing tutor. Thank you.

I am also grateful to all of those with whom I have had the pleasure to work with during this project. Each of the members I have worked with have provided me extensive and professional guidance and taught me a great deal about certification aspects, as well as other domains. Those include Antonio Paradies, Didier Cailhol, Eric Bédessem, Ciro Manco, Fabien Vançon, Jean-Paul Delpont, Nadège Gualina and Lucille Mitchell.

Also, I would like to offer my gratitude to ENAC for first, giving me the possibility to join their Erasmus programme in its great university and then, for allowing me having the chance to do the internship, which has been the best election of my life so far. I could have come back to Barcelona and finish my end of studies report after February, but the offer to stay in France and extend this dream 6 more months has been definitely a better election.

Thanks to the maintenance department, who received me warmly with the hands open on my arrival and helped me with all I needed. I stayed in their office during the first three months of the internship until the reallocation into another building in Blagnac. I discovered there amazing people who helped me integrate in the company and gave me the first steps to follow in order to succeed.

I would like to acknowledge as well Domenico FILOSA, Head of Certification, who always was there for the questions I could have and followed the progress and evolution of my internship.

Thanks to Vincenzo Panico for offering the internship opportunity in the Airworthiness department.

Finally, I would like to acknowledge with gratitude, the support and love of my family – my parents, Pere and Elisabet and my sister, Berta. They all kept me going, and this internship would not have been possible without them.

### **Abstract**

ATR is the current world leader in regional aviation. In order to maintain its leading role in the turboprop market and to expand its customers' portfolio in the United States, the granting of the Extended Twin-Engine Operations Performance Standards (ETOPS) certification by the Federal Aviation Administration (FAA) has been set as a mid-term goal.

The market forecast done by ATR anticipates that 250 ageing turboprops will need to be replaced in the US in the coming years. Additionally, from the operational point of view the US airlines would benefit from significant fuel savings and low operating costs thanks to the introduction of ATR aircraft. Consequently, the purpose of this internship is to perform a feasibility study to prove compliance with the ETOPS capability according to the American Authority.

In this framework, a comparison between the American and the European regulation has been completed. The methodology undertaken consisted of gathering all the requirements applicable to ETOPS on the FAA regulation and the identification of the equivalent condition on the European regulation. Afterwards, a study on the impact of the differences has been conducted and a proposal of means of compliance for each different FAA requirement is presented.

The final deliverable presented to ATR contains a matrix comparing the FAA and the EASA regulations with the whole ETOPS requirements.

Finally, a conclusion evaluating the feasibility of the ETOPS validation was done, stating the needs and future steps to proceed to get the FAA approval for ATR ETOPS capability.

## **Table of contents**

1. ATR .....	9
1.1 The product.....	9
1.1.1 ATR 42 .....	9
1.1.2 ATR 72 .....	9
1.2 The family concept.....	10
1.3 The ATR particular distinction.....	10
1.4 Facts & Figures .....	11
2. Context.....	12
2.1 Introduction to the regulatory authorities .....	12
2.1.1 The FAA .....	12
2.1.2 The EASA .....	12
2.1.3 Bilateral agreements.....	12
2.1.4 Validation process.....	13
2.2 Introduction to ETOPS.....	13
2.2.1 ETOPS: Definition and applicability.....	13
2.2.2 ETOPS history .....	14
2.2.3 Basic aspects of ETOPS Certification.....	16
2.2.4 ATR context.....	16
3. Introduction to the internship .....	18
3.1 Detailed objectives of the End of Study Project .....	18
3.2 Internship tutors .....	19
3.3 Internship environment .....	19
3.3.1 The certification office .....	20
3.4 Initial approach to handle the subject .....	21
3.5 Time-line of the internship .....	22
4. The core of the internship.....	23
4.1 Departure point / Starting point.....	23
4.2 The process / methodology: .....	24

4.2.1 STEP 1: Gathering all the requirements applicable for ETOPS capability .....	27
4.2.2 STEP 2: Analyze if the requirements are equivalent or not .....	30
4.2.3 STEP 3: Make an assessment on the ATR case and define the meetings with experts .....	33
4.2.4 STEP 4: Evaluate the conclusions of the meetings and decide whether the requirements are reachable / doable or not .....	34
4.2.5 Case study (requirements).....	36
• Electrical power sources requirement.....	36
• Icing requirements (see Annex 11.2) .....	36
• Time-limits / ETOPS Significant Systems requirement (see Annex 11.3).....	36
4.2.6 Electrical power sources requirement .....	37
Analysis and comparison of the requirement.....	38
Assessment on the ATR case and define the meetings with experts .....	39
Electrical power sources of ATR aircraft .....	39
a) Main power sources.....	40
b) DC generation .....	41
c) AC generation.....	42
Airplane functions needed to be powered .....	44
Crosscheck between airplane functions .....	46
Failure scenarios: .....	49
Redaction of the Exemption .....	51
Showing independency .....	53
Conclusion:.....	54
5. ENAC courses related with the internship .....	55
6. ETOPS real project and personal contributions .....	56
7. Risk and project limitations.....	60
8. Conclusion.....	61
9. Glossary.....	63
10. Bibliography .....	64
11. Annex .....	65
11.1 Exemption .....	65
11.2 Icing requirements .....	69
Icing requirements study .....	71

11.3 Time-limits – ETOPS significant systems requirements .....	75
11.4 Modification .....	79
12. Confidentiality questionnaire.....	86

## Table of figures

Figure 1. ATR funders .....	9
Figure 2. ATR 42 .....	9
Figure 3. ATR 72 .....	9
Figure 4. ATR models timeline .....	10
Figure 5. Jet vs Turboprop .....	11
Figure 6. ATR picture .....	11
Figure 7. ETOPS minute circles.....	14
Figure 8. Captain John Alcock (left) and Lieutenant Artur (right) before the 1 <sup>st</sup> time of an airplane to cross the Atlantic .....	14
Figure 9. ETOPS route .....	14
Figure 10. ATR Engineering organizational chart .....	19
Figure 11. ATR Certification office organizational chart.....	20
Figure 12. Extract of the Part 25 of the FAR (Federal Aviation Regulation).....	28
Figure 13. Extract of the feasibility matrix - Appendix K .....	31
Figure 14. Extract of the feasibility matrix - AC25.1535-1X .....	32
Figure 15. Extract of th ETOPS feasibility matrix developed by myself .....	35
Figure 16. Extract of the Appendix K to part 25.....	37
Figure 17. Extract of the Information Leaflet No. 20.....	37
Figure 18. Extract of the IL No. 20 with my notes .....	38
Figure 19. Direct current.....	40
Figure 20. Alternative current (constant frequency).....	40
Figure 21. Alternative current (variable frequency).....	40
Figure 22. DC Starter-Generator .....	41
Figure 23. DC-Starter Generator .....	41
Figure 24. Static inverter .....	41
Figure 25. DC generation electrical circuit.....	41
Figure 26. Main battery .....	42
Figure 27. Emergency battery .....	42
Figure 28. AC Wild Frequency Generator .....	43
Figure 29. AC Wlld Frequency Generator .....	43
Figure 30. Transformer Rectifier Unit.....	43
Figure 31. ACWF generation electrical circuit.....	43

---

Figure 32. ATR aircraft with the different electrical power sources.....	44
Figure 33. Failure scenarios studied .....	49
Figure 34. ATR main electrical power sources .....	54
Figure 35. Extract of the draft of the ETOPS Compliance Matrix .....	59
Figure 36. Extract of the Appendix K .....	69
Figure 37. ATR flight profile after an aircraft depressurization and an engine failure. FCOM document, see bibliography [9] .....	70
Figure 38. Flight route in order to prove compliance with icing requirements for ETOPS.....	72
Figure 39. ATR unprotected zones.....	72
Figure 40. Ice accretion at the end of the wing .....	73
Figure 41. Extract of the Appendix K (FAA).....	75
Figure 42. Extract of the Appendix K (FAA).....	75
Figure 43. Extract of the Information Leaflet No. 20 (EASA) .....	75

## 1. ATR

ATR (“Avions de Transport Regional”) is a French-Italian turboprop aircraft manufacturer and a world leader in the market for regional aircraft up to 90 seats.

It was created in 1981 by Aérospatiale of France (now Airbus Group) and Aeritalia of Italy (now Leonardo). Both companies hold the 50% share of ATR. Although its main tasks are the ones related to the conception, production and sales of aircraft, ATR also participates in the after-sales services with the provision of maintenance contracts as well as the pilots and technical maintenance training in the different ATC (ATR Training Centers) that they have all over the world.



Figure 1. ATR funders

### 1.1 The product

ATR offers two sizes of turboprop aircraft, the 70-seat ATR72 and the 50-seat ATR42.

#### 1.1.1 ATR 42

The ATR42 has a capacity between 40 and 50 seats. It offers a high performance aircraft for the lowest trip cost. Since its creation in 1984, 6 different versions have been developed: the ATR 42-200, ATR 42-300, ATR 42-320, ATR 42-400, ATR 42-500 and the current version ATR 42 ‘600’.



Figure 2. ATR 42

#### 1.1.2 ATR 72

The ATR72 offers a seat range up to 78 seats and has the lowest seat mile cost in its category. The main difference between the ATR72 and the ATR42 is the fuselage increase of 4,5m. This aircraft appeared as a consequence of the seat limitations of the ATR 42 and the need of the market to have a bigger aircraft. The latest version is the ATR 72 ‘600’ with the introduction of the New Glass Cockpit (as on the 42), which enhances a reduction on the pilot workload as well as no component obsolescence in the long-term given its modular and flexible architecture.



Figure 3. ATR 72

In the picture below, a timeline with the different ATR models and versions is shown (from 1985 to 2012).

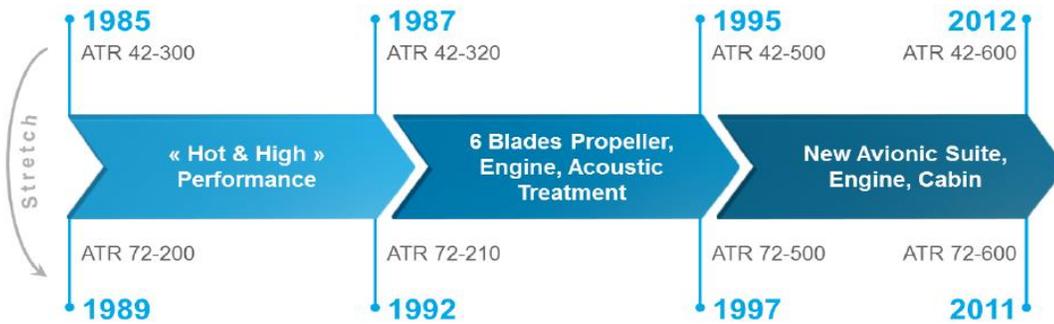


Figure 4. ATR models timeline

## 1.2 The family concept

The first aircraft manufacturer that created the “family” concept was Airbus with the A320 series.

Meanwhile, ATR has developed its own “family” with the ATR 72 and the ATR 42. This concept provides different advantages such as the followings:

- ✈ Same cockpit (the cockpit is the same for both ATR 42 or ATR 72)
- ✈ Same crew (personal trained for one aircraft can operate the other one → common type rating)
- ✈ Same engines & propellers (easiness for maintenance, engine monitoring)
- ✈ Same spare parts (90% of common spare parts → represents a lower cost because there is no need to buy 2 different components)

The high commonality allows operators to adapt capacity to demand → FLEXIBILITY. This means that for routes where they expect a lower demand they can put the ATR 42 while in routes with a higher demand the ATR 72 works better. That said, airlines can increase their revenues thanks to the adjustment of the demand.

## 1.3 The ATR particular distinction

In comparison with the other aircraft in the market, ATR provide some differences. Nowadays, most aircraft have turbofan engines equipped. ATR aircraft though, has the peculiarity of using turboprop engines. Turboprop and turbofan use the same turbine jet engine, but the turboprop uses the energy of the engine to rotate a propeller meanwhile the second one to rotate a fan. As a consequence,

the turboprop engine burns 40% less fuel than a turbofan on short distances and this is one of the main reasons why ATR is so successful in the regional market.

Also, another reason for preferring turboprop engines over jet engines is that the first ones deliver a greater efficiency and more power at slower speeds than jet propulsion. Fuel represents a huge percentage of the DOC (Direct Operating Costs) of an airline, so they try to minimize it whenever possible.

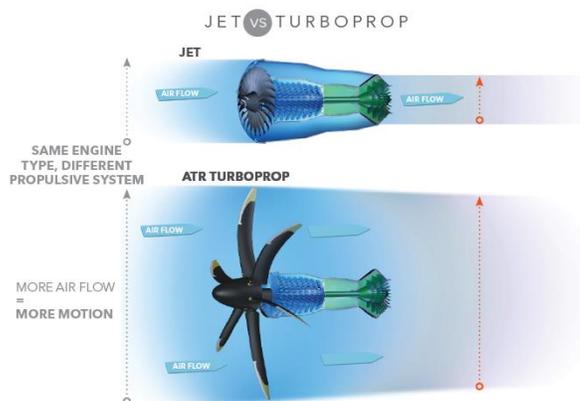


Figure 5. Jet vs Turboprop

Finally, Turboprops require remarkably little runway for takeoff and landing, providing the unique flexibility to serve airports with shorter runways. Everything else being equal, and for the same engine power, a turbofan will need more distance, since turboprops give more thrust than turbofans at small airspeeds.

### 1.4 Facts & Figures

To understand better this company and know some useful and interesting data about it, some information is given below (Figures as of April 2017):

- ✈ Workforce: More than 1,300 (beginning of 2017)
- ✈ Turnover: 1.8 US\$ Billion (2016)
- ✈ Headquarters: Toulouse
- ✈ More than 1,500 aircraft sold
- ✈ More than 1,300 aircraft delivered
- ✈ +30 Million flight hours
- ✈ +5,000 flights per day
- ✈ +200 operators
- ✈ +100 countries
- ✈ Every 8 seconds, an ATR aircraft takes-off or lands somewhere around the world



Figure 6. ATR picture

With this we can conclude saying ATR has a big presence in the regional market and we expect an increasing trend for the future years.

## 2. Context

### 2.1 Introduction to the regulatory authorities

The aeronautical industry is controlled and regulated by the authorities. They set and impose the different regulations the players in this field have to comply with.

Before advancing in this report, a brief description of the two main rule makers and authorities who regulate the civil aviation in the world need to be described. Moreover, they are going to be the two most important players in this internship. These are the FAA (Federal Aviation Administration) in the United States and the EASA (European Aviation Safety Agency) in Europe.

#### 2.1.1 The FAA



The FAA (Federal Aviation Administration) is the authority who regulates all aspects of civil aviation in the United States. It is responsible for the safety of civil aviation. As well as EASA, their major roles include the regulation of civil aviation to promote and ensure safety, regulation of the U.S. commercial space transportation and encouraging and developing civil aeronautics.

#### 2.1.2 The EASA



The EASA (European Aviation Safety Agency) is the authority of the European Union for aviation safety. Its main goal is to promote the highest common standards of safety and environmental protection in civil aviation. Moreover, other activities of the Organization include the strategy and safety management, the certification of aviation products and the oversight of approved organisations and EU Member States.

#### 2.1.3 Bilateral agreements

To harmonize and facilitate the aeronautical industry, bilateral agreements are defined between these two regulators. Bilateral agreements facilitate the reciprocal airworthiness certification of civil aeronautical products imported/exported between two signatory countries.

Essentially they mean that one country recognizes the airworthiness authority of the other. It takes a long time to define the specifics spelled out in the agreement, but once they are in place they are well worth the effort.

#### 2.1.4 Validation process

One agreement includes the Type Validation and Post-Type Validation Principles that the FAA and EASA have agreed to apply when certificating and validating each other's products and design changes.

The vision and goal of the validation activities are to create a simple process based on mutual authority trust, which leads to design acceptance in compliance with the airworthiness standards. On the ATR case, the aircraft manufacturers, benefit of a reduced workload when a validation of a product or a design change is done because there is not the need of re-doing and going through all the certification process again.

## 2.2 Introduction to ETOPS

### 2.2.1 ETOPS: Definition and applicability

ETOPS (Extended Twin Operations Performance Standards) is the operation of twin-engine aircraft over a route that contains a point further than one hour's flying time from an adequate airport at the approved one-engine inoperative cruise speed.

Basically, the ETOPS capability is a set of regulations and standards which must be met if an airline wishes to fly its airplanes in routes containing points more than 60 minutes away from a suitable emergency airport.

The "60 minute rule" was established in 1953, restricting the operations to an en-route area within 60 minute flying time of an adequate airport. It was as well due to the engine reliability of piston power plants available at that time.

The purpose of these rules was to restrict flying time to an alternate airport, and hence reduce the risk of a catastrophe by lowering, to an acceptable level, the probability that all engines would fail. In other words, the lower level of reliability in piston power plants required that aircraft remain within 60 minutes of an adequate airport to ensure that, if one engine failed at any point along the route, a landing could be made before the remaining engine failed.

ETOPS regulations are applicable to routes over water as well as remote land areas. Its main purpose is to provide high levels of safety while facilitating the use of twinjets on routes which were previously restricted to three and four-engine aircraft.

An ETOPS route is defined by different elements. First of all, we have the airport of departure and arrival. All along the route, different alternate airports are defined in case of a diversion (due to an engine failure, etc).

The ETOPS segment is defined basically by an entry point and an exit point. The “ETOPS Entry Point (EEP)” is the start of the ETOPS segment where no suitable airport is found at a distance less or equal to one flying hour. On the other side, the “ETOPS Exit Point (EXP)” is the point on route when the ETOPS segment ends. Finally, it exists the “ETOPS Equal Time Point (ETP)” which is the point between two suitable diversion alternates



Figure 7. ETOPS minute circles

### 2.2.2 ETOPS history

It may seem that ETOPS operations are quite new. However, it all started in 1919 when two Britons, Captain John Alcock and Lieutenant Artur Whitten Brown crossed the Atlantic in a twin-engine Vickers Vimy.

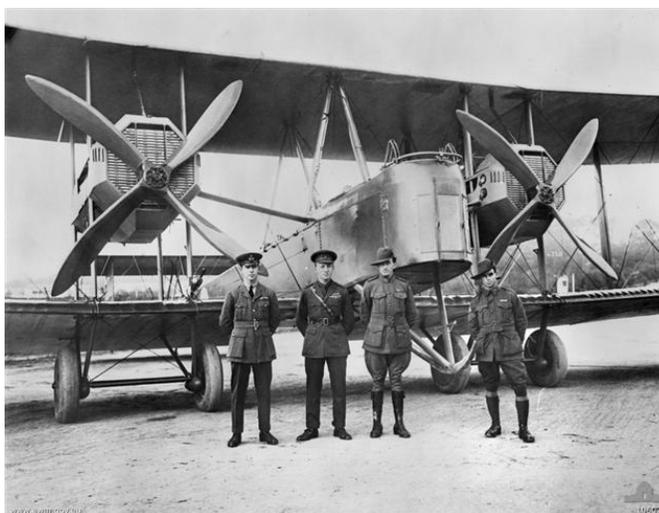


Figure 8. Captain John Alcock (left) and Lieutenant Artur (right) before the 1<sup>st</sup> time of an airplane to cross the Atlantic

In 1953, the United States created regulations that prohibited two and three engine airplanes from flying routes of more than 60 min from an adequate airport unless approved by the U.S. Federal Aviation Administration (FAA). This restriction was based mainly on the reliability of piston engines used on airplanes in the 1940s and early 1950s.

By the 1970s, advances and improvements in engine technology led to a reliability increase. In 1983, the new generation of twinjets powered by high-bypass turbofan engines became the subject of extensive discussions involving international aviation regulatory activities, airframe and engine manufacturers. The discussions culminated in 1985 with the release of new requirements for obtaining the American Authority approval beyond the 60 minute rule. This new exigencies were published in the FAA Advisory Circular 120-42 and allowed operators to seek approval for routes up to 120 minutes from an adequate airport.

In 1988 and thanks to three years of successful ETOPS experience, the Advisory Circular was modified to include provisions for 180 minutes extended twin operations. In addition, several countries revised their regulations to incorporate similar provisions and the Information Leaflet 20 was published by the European Authorities for 180-min ETOPS.

A successful record of ETOPS operations has proven that the world's aircraft manufacturers can design, build, and test airplanes suitable for such operations, and that operators can successfully maintain and fly them on this kind of routes. In 1995, following nearly 10 years of successful ETOPS, the FAA and JAA accepted the Accelerated ETOPS Operational Approval method. This allows new twinjets to fly these procedures from the first day of revenue operations and has been used extensively around the world.

The latest news in terms of ETOPS comes with the EASA approval for the A350 XWB to operate ETOPS flights up to 370min. This significant achievement marks the A350 XWB as being the first new aircraft type ever to receive such a level of ETOPS approval prior to entry into service (EIS). Moreover, this means that operators will benefit from the most efficient, reliable and direct long-range routings of any two-engined aircraft.

### 2.2.3 Basic aspects of ETOPS Certification

ETOPS certification requires both the aircraft and the airline to comply with a set of standards. For the aircraft, the manufacturer must demonstrate that flying with only one engine is relatively easy for the flight crew, safe for the airframe, and an extremely remote event. However, as an operator, you cannot just buy an ETOPS capable aircraft and start flying straight away from Paris to New York.

The airline must show that its flight crew training and maintenance procedures are up to a higher standard. Pilots, engineers and staff must be specially qualified for ETOPS.

Recently, more operators are adopting the ETOPS approach to non-ETOPS routes. They discovered that this way offers significant improvements in reliability, performance and dispatch rates. The cost of application is later offset by reduced maintenance expenses, and costs associated with diversions, delays and turn backs.

### 2.2.4 ATR context

ATR has the EASA certification for ETOPS but not for the FAA yet. However, this capability is very important in the aviation world, and in particularly for ATR. Without it, airlines seeking to fly routes over the sea where no diversion airports are found they could not do it. Furthermore, some routes flown with a twinjet that could be covered in a straight line, if no alternate airports are found in the route, the airline would have to fly the entire route (in blue) as seen in the Figure 9. This creates huge consequences, both for the airline and the passenger. Routes are longer, which increases the travel time as well as the trip cost, you burn more fuel and the maintenance of the aircraft increases as more hours are flown.

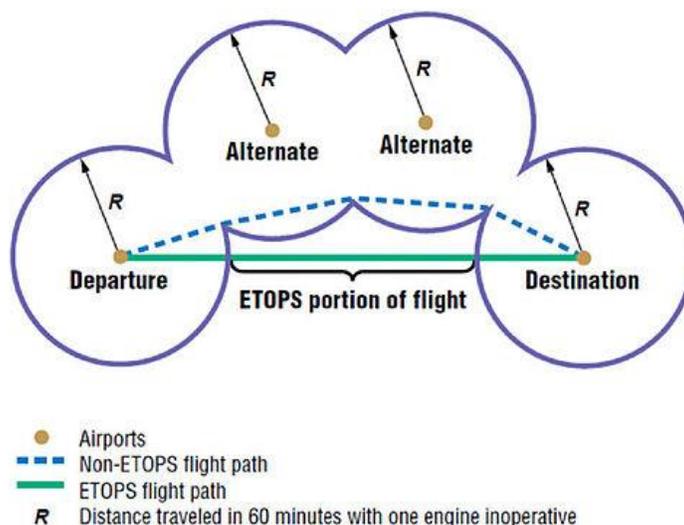


Figure 9. Etops route

ATR aircraft is expanding nowadays. It is serving to a lot of countries around the world, such as Japan, Brasil, Spain, India and Italy. However, in the United States it is facing some difficulties to find airlines interested in its products, as explained before.

Despite this fact, the sales department of the company is trying to enter into this market offering what ATR has: the best aircraft for the regional market. And the problem comes when customers, that is, airlines and operators, ask ATR if the aircraft has some features and capabilities such as ETOPS.

The answer is no, and this is a weakness ATR commercials have to deal with. This is the reason why this project was created, as stated in the abstract, because ATR needs to obtain the validation of the ETOPS capability by the FAA to be more competitive and attract potential customers in the US market.

Moreover, some airlines have already been interested in this capability. For instance, there is an operator from Florida which could be interested in buying ATR aircraft, but as they do not have ETOPS capability they refuse to make the purchase. With this new type of operation, ATR would have an important bargaining power in front of the potential customers and could try to increase its market share in the North-American sector. This market is expected to grow and there is a potential need of short routes between cities that could be provided by an ATR aircraft. In addition, fleet in North-America is ageing so when the need of airlines to purchase a new aircraft will arrive, which one will they choose?

### 3. Introduction to the internship

#### 3.1 Detailed objectives of the End of Study Project

The main goal of this internship is to create an ETOPS feasibility matrix which will help ATR to obtain the ETOPS type certificate provided by the FAA. A list of different steps is going to be defined in order to fulfill this objective.

First of all, the first step will consist in gathering all the requirements applicable for the ETOPS capability. This implies looking at all the documents and guidance material released by the Authorities, both FAA and EASA, such as current Federal Aviation Regulations, ETOPS type design approval and operations material and so on.

Once all the information will be gathered, the analysis process will start, looking if the implementation of ETOPS certification for ATR in the FAA framework would be achievable or feasible. To do it, the construction of a set of matrices will be done, stating requirement by requirement whether it is equivalent or not. If the requirements are equivalent and there is no need to provide an extra justification they will be highlighted as such. However, those different will be analyzed in detail and a compliance solution plan is going to be implemented in order to address them.

This part is going to be the most challenging because all ATR departments with the different experts of the various subjects will be involved and will have to cooperate to be able to continue the project. For example, if a discrepancy in terms of a maintenance task is found in the comparison between FAA and EASA, a study and discussion with the maintenance experts will be done to try to find a solution for this requirement. And this applies to all the different departments of the company.

The final deliverable expected by ATR in the end of the internship is a matrix with the comparison of both FAA and EASA regulations with the whole requirements applying to ETOPS. For each FAA requirement detected as not equivalent to EASA one, a mean of compliance demonstration will be proposed. In addition, a document containing the conclusions of the internship and my personal comments regarding the next steps and how to proceed for ATR will be defined.

### 3.2 Internship tutors

Two different tutors take part in this internship, one from the company and the other one from the university. From the company side, the tutor is going to be Souhir CHARFEDDINE, certification manager in ATR and, from the ENAC side, Michaël BENHAMED, flight operations courses director.

### 3.3 Internship environment

The department in which I take part is the Airworthiness-Certification department. This department is inside the Engineering division in ATR. Here below, the organizational chart of the engineering department of ATR is shown, with all the different hierarchical relations between the different offices.

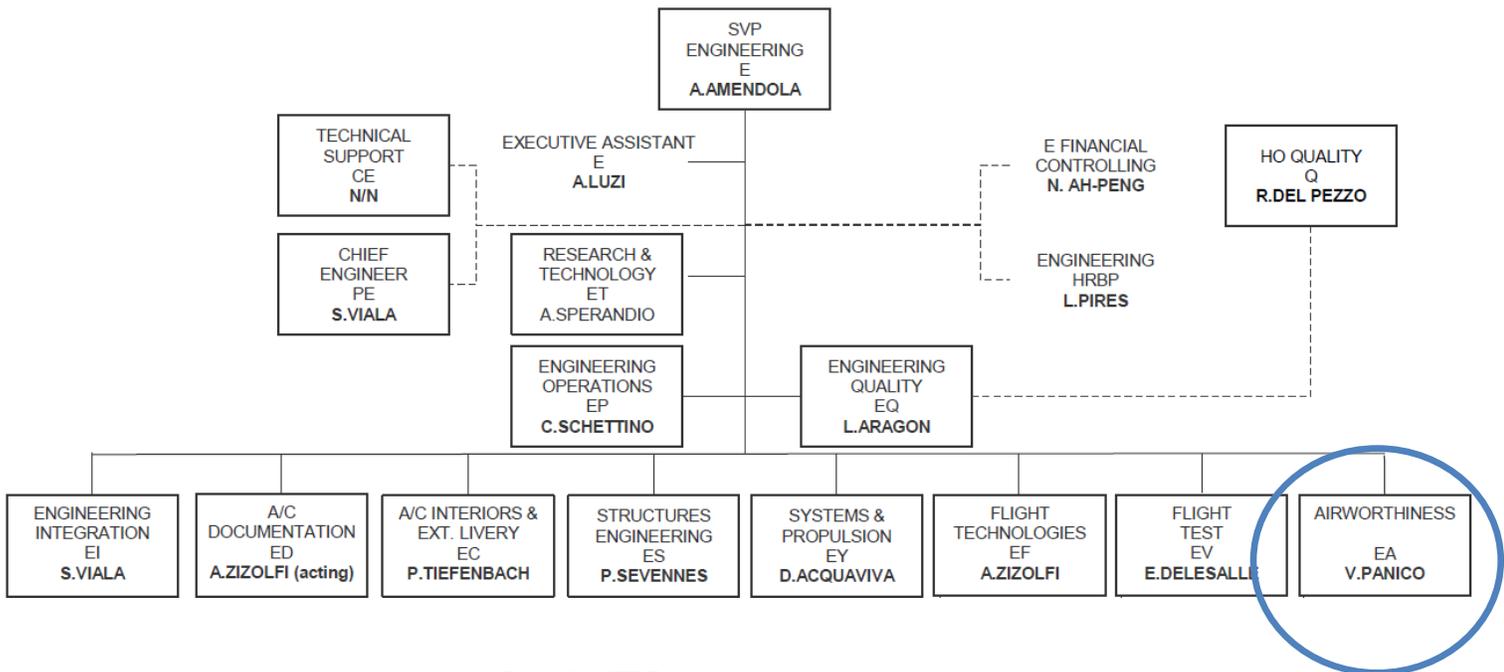


Figure 10. ATR Engineering organizational chart

This project is enrolled in the Certification & Airworthiness (EA) domain, inside the Engineering department (E), particularly in the Certification Office (EAC).

There are different experts inside the certification office that can help. The most important and the ones that are going to help to make this project advance are:

First of all, there is my tutor, the Certification Manager Souhir CHARFEDDINE. In the same office there is also Ciro MANCO, responsible for individual certification and above them, there is the Head of Certification Domenico FILOSA. Also there is Antonio Paradies, Foreign Authorities Certification Manager, who is going to be the link and connection with the FAA experts.

So here below, a schema of the different members of the Certification Office is shown, with my internship tutor marked in blue:

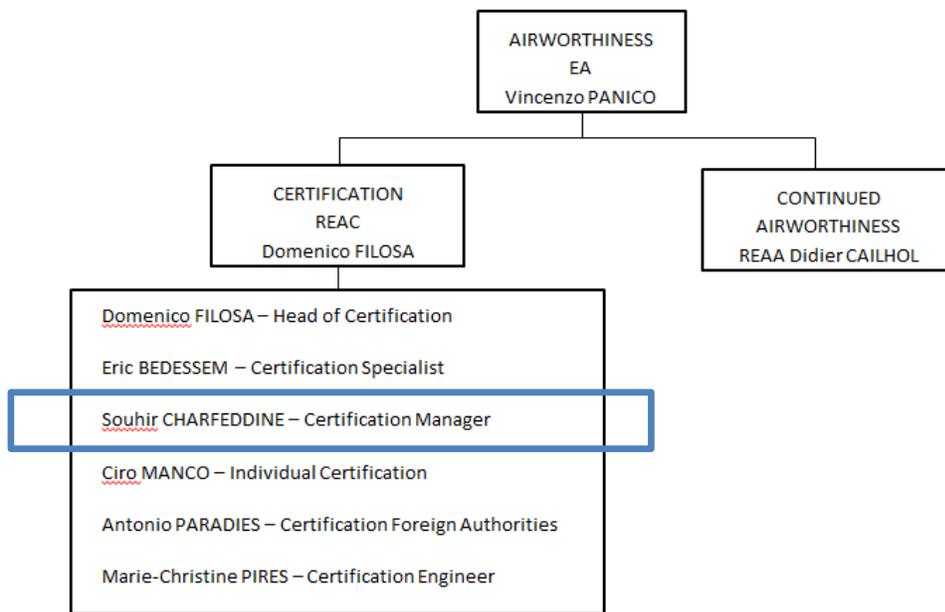


Figure 11. ATR Certification office organizational chart

### 3.3.1 The certification office

The certification office ensures a transversal role within the different competence centers of the Engineering Department. It is the interface with the specialists of each area in order to provide expertise in terms of regulatory requirements and to ensure compliance with the proposed technical solutions. It also supports the teams in the different stages of approval or validation processes of the modifications.

In addition, the certification office is also the interface with the airworthiness authorities (AA's) that approve ATR products as well as the aircraft modifications.

Although EASA (European Aviation Safety Agency) is its main interlocutor as a primary certification authority, ATR aircraft are largely operated in Non-European countries, so the certification team is also required to work with a number of foreign validation authorities.

Finally, the certification office is also present in parallel with the production activities in order to ensure compliance of the aircraft with the requirements in force in the state in which it is registered.

### 3.4 Initial approach to handle the subject

To handle this subject, the most important part will be, as said before, the creation of the matrix comparing the European and the American regulation. This tool will have several columns. One for the description of the requirements imposed by the FAA, another one for the EASA equivalent exigencies (if there are) and the third one will state whether the FAA requirements are the same or different with respect to the EASA regulation. Then, in the fourth column early comments will be stated, giving my own opinion on how we should handle a requirement which is not compliant (what to do, talk to who, how...), the fifth will provide the need or not to give more justification to address the requirement and finally the last but not least column will state the specialist or the department where the exigency shall be treated and analyzed.

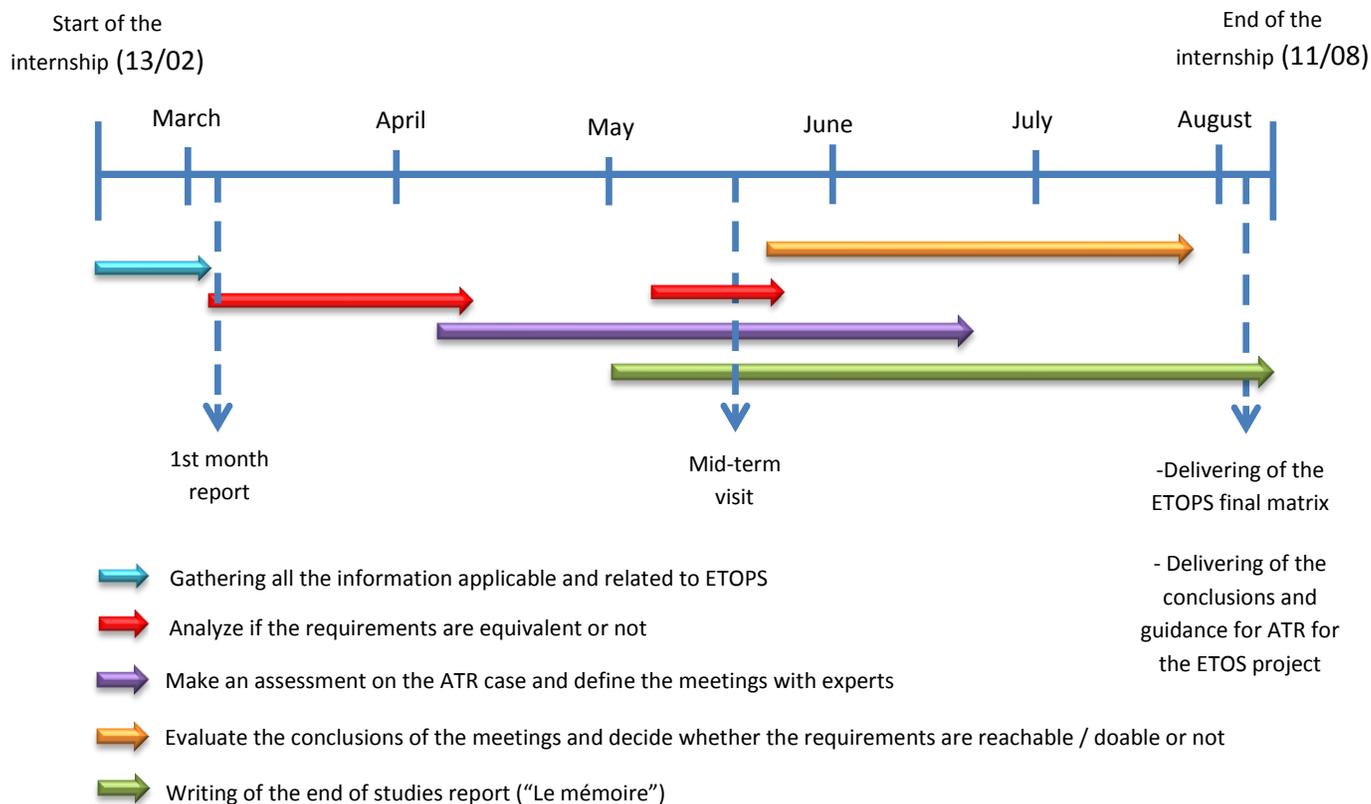
Depending whether the requirements are equivalent or not, or if they are just not applicable, different colors will be set in order to differentiate them. Those that are already compliant and there is no need to do further investigation are colored in green. Those requirements easy to make them compliant and that will need some extra things or the need of an expert but that are reachable (with my point of view) have light green color. The requirements that do not apply to ATR are colored in white; those challenging requirements which seem difficult to comply with and that there is not too many information in EASA regulation have orange color and those requirements that they just provide information or refer to another requirement are catalogued as “noted” and are painted in white as well.

When the whole matrix is completed, I will start studying how we can address the requirements that are not equivalent with the European regulations. To do it I will use the personal notes, comments, the help of the documentation and meetings with the officials of the different departments (that can be the Powerplant department, the Systems department...). In addition, meetings with the experts will be held to try to reach a solution that can make this project advance.

The study will finish when all the matrices have no blocking item. If unfortunately, some American regulations are impossible to be satisfied by ATR we would have to conclude with the unaffordability of the project.

### 3.5 Time-line of the internship

Here below the project plan is defined with the main milestones and deliverables. It has been done in accordance with the different steps defined at the beginning of this internship in order to manage and control the progress of it.



A meeting with the tutor will take place each week to check the progress of the project and to solve the doubts that can appear.

## 4. The core of the internship

### 4.1 Departure point / Starting point

ATR obtained its ETOPS capability by the EASA in 1996.

For the ETOPS change to type design approval, the certification basis was set by the EASA: a CRI (Certification Review Item) was released to provide which were the applicable requirements ATR had to fulfill to get the ETOPS capability. A CRI is a term used by the EASA in connection with the certification procedure for products, parts and devices in the aeronautic industry. The CRI is a document used for the certification of an object that it still needs to be clarified.

The certification basis is a set of rules defined by the authority that will apply for the certification of a specific aircraft type.

For ETOPS, ATR and EASA finally agreed on how they would assess the ETOPS 120 min type design approval through the Information Leaflet No.20 (More information on this regulatory document 2 pages below). The following was set in the CRI

- For eligibility  
Requirements of chapter 8 with the following exemption concerning chapter 8b(7): Weather radar, landing lights, static heating and windshield de-icing not supplied in case of electrical generation system failure not extremely improbable.
- For aptitude  
Requirements of chapter 9 and Appendix 1

These are all the paragraphs containing the requirements applicable to ETOPS ATR had to comply with (by the EASA side). This will help me because in case the FAA asks for a regulatory specification similar to the one already addressed to EASA, I will have the possibility to validate directly the requirement without the need to prove anything else.

## 4.2 The process / methodology:

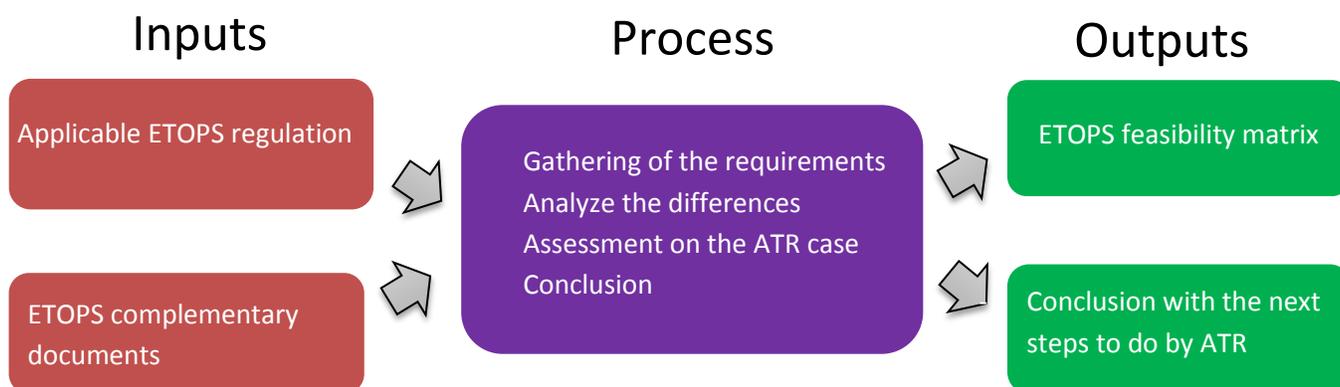
The main core of the internship comes here. A methodology and a way to proceed was agreed by me and my internship tutor, shown here below. The process followed in this internship is going to be described. Mainly, it is composed of 4 different steps:

- ✈ STEP 1: Gathering all the requirements applicable for ETOPS capability
- ✈ STEP 2: Analyze if the exigencies are equivalent or not
- ✈ STEP 3: Make an assessment on the ATR case and define the meetings with experts
- ✈ STEP 4: Evaluate the conclusions of the reunions and decide whether the requirements are reachable / doable or not

This process has its own inputs and outputs. The inputs include mainly all the applicable regulation concerning ETOPS. Moreover, for those discrepancies between requirements, the need of some other documentation will be needed. This means that I will have to look at material such the FCOM (Flight Crew Operating Manual), the CMP (Configuration, Maintenance and Procedures document) or the SDN (System Description Note) in order to solve and give an answer to the discrepancy.

When looking for documentation, the importance to check the validity of the documents is going to be fundamental. A traceability is going to be done to make sure all documents are applicable and apply to the case I am working on. I am going to well list the different documents found, putting the proper name and stating where do they come from so as if one day someone needs to see the original reference of the document they can find it.

As outputs of my internship, an ETOPS feasibility matrix will be provided as well as the conclusions of the whole ETOPS study I did with the next steps to do for ATR in order to get the approval of this capability by the FAA.



Now, a brief description of each step of the process is going to be done.

### **STEP 1: Gathering all the requirements applicable for ETOPS capability**

As stated in the beginning of this report, the first task of this project will consist of gathering all the information applicable and related to ETOPS. This means looking at all the regulatory documents containing ETOPS requirements, means of compliance, issue papers or useful information that could help in the certification process.

We will focus mainly on the FAA documentation. However, EASA regulation will also be taken into account.

Note that we cannot underestimate this first step of the project that could seem easy a priori. The gathering process of information is very important because it will allow having an overview of the project and the documents we are going to deal with.

If I define a given list of documents as the ones applicable for ETOPS and after 2 years of the start of the certification program an Advisory Circular published by the FAA before is found, it may imply modifying all the things already done. It would cause several inconveniences, especially in economically terms.

This is the reason why there is a need to look carefully for all the possible information where ETOPS capability is mentioned.

### **STEP 2: Analyze if the requirements are equivalent or not**

Once all the applicable requirements are found, the analysis of them will start.

The methodology will consist of reading the FAA requirement, line by line, summarizing it in a paper, looking for extra information if I need it and then, once I well understand and analyze the requirement and what it asks for I will look for a similar requirement in the European Regulation.

If the exigencies are asking for the same they will be identified as “equivalent”. However, in the case where a little discrepancy is found between them or the requirement does not exist in the European side, the requirement will be identified as “not-equivalent”.

It may seem as well this work is going to be easy to do, but it is not as simple as that. Always in certification it is very important to go carefully through all requirements and interpreting what they ask for.

### STEP 3: Make an assessment on the ATR case and define the meetings with experts

Here, the not-equivalent requirements are analyzed deeply. All single specifications are evaluated and assessed on the ATR case, meaning that a different solution to address each requirement is going to be proposed.

In the case I can find or propose the answer from myself it will be enough. However, those requirements implying some difficulty I cannot handle will be solved both by me and the corresponding specialist. Moreover, some requirements may need some extra training to well understand the issue. For instance, I am not an expert with ice accretion and icing conditions, so depending if the requirement asks for some technical things or not concerning ice, I will have to review how the anti-ice systems of the ATR work as well as how the ice accretion gets attached to the airframe of the aircraft.

This means I will set up different meetings for the requirements seeking help. For the requirements concerning electrical systems, meetings with the electrical specialists will be set up and so on.

### STEP 4: Evaluate the conclusions of the meetings and decide whether the requirements are reachable / doable or not

In this step the final answer to the requirements analysis is given. After the assessment on the ATR case and the different meetings defined with the specialists I will give the conclusions of each not-equivalent requirement. The conclusions can be actions to be done by them as well as the redaction of technical notes or simply an answer that we can directly comply with the requirement.

In addition of the 4 different steps defined in the process, to make sure things are clear and useful, 4 basic questions have been proposed to assure the process goes in the right way.

<u>Questions to ask myself</u>	
✈ What was important in this step and why?	✈ How did I do it? How did I contribute?
✈ What did I achieve? What did I learn	✈ What were the risks? Limitations?

So later below, in the last paragraph of each section the answers to these questions are going to be evaluated and discussed.

#### 4.2.1 STEP 1: Gathering all the requirements applicable for ETOPS capability

In the gathering of information process, different regulatory documents or paragraphs have been found. I looked for them in the internal documentation from ATR as well as by internet in the Authorities webpage, that is, FAA and EASA websites.

The validity and applicability of the documents is vital for whatever study. You always need to make sure the documents you take are the ones applicable to your study in order to avoid future issues.

The first thing I did was to look at the Authorities website. There, especially In the FAA one it was difficult to find the information. I went to the FAA regulations tab and there I found plenty of different regulatory documents. I started looking at documents such as the Part 21, Part 25, and so on so as to find some information related to ETOPS. However, I could list just some documents, such as the Appendix K contained in the Part 25 or an Advisory Circular 120-42B.

For the validity, I had to check that the document applied to the aircraft I am studying, as well as the date and signature of the document. Some material was found in the ATR intranet, so I checked and confirmed with the specialists that the documents were valid for my study.

#### **FAA REGULATION**

First, the FAA documentation is going to be studied and analyzed.

One of the most important documents published by the FAA and that is going to be our main guideline is the Appendix K of the FAR Part 25.

This appendix is included in the FAR 25 and specifies the airworthiness requirements for the approval of an airplane-engine combination for extended operations. This document is the one I will mainly have to focus on because it provides all the requirements defined by the FAA to obtain the ETOPS change to type design approval for the manufacturer side.

However, this is not the only document regarding ETOPS approval capability.

An Advisory Circular Number 120-42B which dates 6/13/08 with the name “Extended Operations (ETOPS and Polar Operations)” was also found. This document also provides some guidance and requirements concerning ETOPS. .

Basically, an Advisory Circular is a guidance material produced by the FAA to inform and guide institutions and individuals within the aviation industry. It gives some clarification and extra information as well to interpret a federal aviation regulation. Advisory Circulars are intended to be informative in nature and not regulatory.

For the European side, there is an equivalent document called AMC (Acceptable Means of Compliance). AMC are standards adopted by EASA to provide means to establish compliance with the regulation. However, they cannot create obligations on the regulated persons, who can decide to show compliance with other means.

Reading and analyzing the Advisory Circular AC 120-42B published in 2008 (American side), it states that “Airplane certification guidance for ETOPS can be found in 121.162 and 25.1535.

These 2 paragraphs come from different regulations, meaning that the one in Part 25 (25.1535) applies to the aircraft type design approval and part 121 is for operators.

This difference makes sense, because the ETOPS certification process requires both the aircraft and the airline to comply with a set of standards.

Just by reading the front page of the AC, a reference to the part 25 was found. Particularly, a reference to the chapter 25.3 was mentioned.

Chapter 25.3 gives “Special provisions for ETOPS type design approvals”, where it says that an applicant seeking ETOPS approval up to and including 180 minutes must comply with 25.1535 requirements.

Taking a look at the certification guidance in 25.1535 we find the following:

**25.1535 ETOPS approval.** Except as provided in §25.3, each applicant seeking ETOPS type design approval must comply with the provisions of Appendix K of this part.

Figure 12. Extract of the Part 25 of the FAR (Federal Aviation Regulation)

So finally, we end up with the appendix K to Part 25 that is going to define the requirements needed to obtain the ETOPS capability by FAA. It is going to be our main guidance document.

## APPENDIX K to PART 25

This appendix is divided in 3 parts. In the first one we can find the Design Requirements (K25.1).

The second one is called TWO-ENGINE AIRPLANES (K25.2)

The third one is referred to AIRPLANES WITH MORE THAN TWO ENGINES (K25.3)

**Note:** *an AC25.1535 in draft status was found two months later after the internship started. An ETOPS engineer from Airbus provided us with the draft, which had to be released some years ago but is still in an unpublished mode. That is the reason why in the time-line of the internship an extra red arrow appears, to give time to study the requirements contained in this AC.*

### EASA REGULATION

For the European side, the main document found is the Information leaflet 20, which specifies the acceptable means but not the only means for obtaining approval under applicable operational rules for two-engine airplanes to operate over a route that contains a point further than one hour flying time at the approved one-engine-inoperative cruise speed (under standard conditions in still air) from an adequate airport. This document was already used to certify the ETOPS capability by EASA for ATR. This is the reason why the comparison between this document and the FAA side will be done, because all the equivalent requirements if ATR already was certified by the EASA, we will be able to ask for just a validation.

The Information Leaflet as well contains operational guidance material for the operators to be able to perform ETOPS operations.

This phase helped me to learn how I should proceed when looking for the applicable requirements and regulations for whatever project, modification and so on. The information you find has to be contrasted as well as valid. It has to apply, in my case, to the two aircraft models I am working on.

It was important to find the exact regulation applicable to ATR for the ETOPS certification by FAA. It was vital to find the correct amendments and revisions for the different regulatory documents as well as making sure no document was missed.

Here the difficulties could be to miss some files somewhere. Normally, I found the basic documents applying to ETOPS, but I had no guarantee that these were the only documents regarding ETOPS and

who knows if in the advance of the project new documents could appear and that would change all our plans. Normally there are some guidelines and so on, but here, we mainly found the Appendix K but no direct document containing the means of compliance with this Appendix, so we were a little surprised with this.

This exposed risk in this part has to be mitigated: I contacted Airbus and we checked with FAA who confirmed that that the Appendix K is the rule to follow.

#### 4.2.2 STEP 2: Analyze if the requirements are equivalent or not

Once all the applicable requirements were found, the analysis of them started.

The methodology I used was reading the FAA requirement, line by line, analyzing it, looking for extra information if I needed it and then, once I well understood the requirement I went to the European Regulation: Basically the IL, where similar information was searched. In case I found something similar with the same words or meaning exactly the same, the requirement was identified as “equivalent”. However, in the case a little discrepancy was found between regulations or just the cases where there was no information at all, the requirement was considered different, meaning not-equivalent.

It is important to note that in the process analysis of the requirements, a special attention has to be given to each requirement, sentence by sentence, identifying the key points. Once the requirement is well-understood, I went through the entire IL20 document to try to find something similar. Sometimes you find some matching words but that they have nothing related between them. Sometimes, you find some requirements talking about the same but with some little differences. Here, a deeper analysis has to be done, identifying element by element if all things are equivalent or not.

#### **Applied case**

The first document I started analyzing was the AC 120-42B. Once read and understood I did the comparison with the IL 20. For all the equivalent requirements, the green color was marked and for those not-equivalent, the different specialists or comments on how to proceed were defined.

However, when the comparison matrix between the AC and the IL was finished I found out that the requirements in the AC mainly apply to the operators and not the manufacturer (ATR). It is true that

there are some operational requirements for which the airline may need some help from ATR, but in an overall view, the requirements specified there were mostly dedicated to operators. Just to make sure I was right and to avoid the appearance of some inconveniences in the advance of the project, we decided to confirm this information with Airbus. So I contacted an ETOPS engineer in Airbus, who confirmed and gave me more information on the requirements applicable to ETOPS for FAA.

As regards to the difficulty or the challenge of the not-equivalent requirements, as stated in the introduction, two different colors are introduced in order to differentiate the easiness or not to accomplish the requirements.

- ✈ For those requirements were a priori it seems easy for me to find a solution and comply with the requirement, the light-green color is set.

AMERICAN REGULATION	EUROPEAN REGULATION	
K25.2.1 Service experience method	Information Leaflet No.20	Comparison
<p>(1) For type design approval up to and including 120 minutes: An IFSD rate of 0.05 or less per 1,000 world-fleet engine-hours, unless otherwise approved by the FAA. Unless the IFSD rate is 0.02 or less per 1,000 world-fleet engine-hours, the applicant must provide a list of corrective actions in the CMP document specified in section K25.1.6 of this appendix, that, when taken, would result in an IFSD rate of 0.02 or less per 1,000 fleet engine-hours.</p>	<p><b>IF No.20 App.1 - a</b> This service experience should have demonstrated a level of propulsion system reliability in terms of in flight shut down rate of the order of 0,05 per 1000 engine hours.</p>	<p><b>Different</b></p>

Figure 13. Extract of the feasibility matrix - Appendix K

In this case, the American regulation asks for a given IFSD reliability rate of 0.05 or less per 1000 engine hours for manufacturers seeking 120 minutes type design approval. Also, they ask to provide a list of corrective actions in the CMP document if they cannot guarantee a rate of 0.02. On the other hand, the European requirement asks just to demonstrate an IFSD rate of 0.05 per 1000 engine hours. The American regulation is more restrictive and I will have to look for the list of corrective actions in the CMP to check if we are in-line with the requirement or not.

- ✈ However, for those requirements which either I do not know anything about them or they seem difficult to proof, they are identified in orange color.

AMERICAN REGULATION		EUROPEAN REGULATION	
AC No: 25.1535-1X (Draft mode)	Appendix K	Information Leaflet No. 20	Comparison
(4) Considering the maximum flight time per § K25.1.1 does not mean that the numerical probability objectives (for example, 1 x 10 <sup>-9</sup> /hr for a catastrophic failure condition, 1 x 10 <sup>-7</sup> /hr for a hazardous failure condition, etc.) for showing compliance with § 25.1309(b) must be met solely by using the maximum flight time. For ETOPS group 1 significant systems, an applicant may use the “maximum ETOPS mission time” instead. For ETOPS group 2 significant systems, an “average ETOPS flight duration” may be used. The average ETOPS mission time should be determined from potential ETOPS routes available within the maximum range of the airplane. This normally results in a longer average flight time than would be used for basic part 25 certification of non-ETOPS airplanes. For ETOPS group 1 significant systems, a numerical probability analysis should always be calculated with an assumption that a diversion following a system failure is a maximum length ETOPS diversion. For ETOPS group 2 significant systems, the average ETOPS mission time used in numerical probability analyses may be inclusive of all diversion times up to the maximum. The exception for group 2 ETOPS significant systems would be for failure conditions that are diversion time dependent. In those cases, the maximum ETOPS diversion time should be used.	K25.1.1	No information	Different

Figure 14. Extract of the feasibility matrix - AC25.1535-1X

In this requirement, no equivalent information in the IL has been found. Moreover, the ETOPS Significant Systems is a concept not yet used in ATR. This requirement will require some extra help from the specialists and I do not know a priori if the requirement is going to be challenging or not, so I decide to categorize it with the orange color.

This second step helped me to develop my comprehension skills, as well as to know how to summarize and understand a requirement. I sometimes found complicated to fully understand some requirements because sometimes sentences are long and written in a “not common” English format.

On the other hand, I learnt how to trigger the requirements and look for both similarities as well as differences. The importance here was to well distinguish if the requirements were equivalent or not. I had to be really sure about it because one mistake here could change all the project in itself.

I took requirement by requirement, sentence by sentence and looking for an equivalent requirement in the European regulation.

#### 4.2.3 STEP 3: Make an assessment on the ATR case and define the meetings with experts

When the assessment was done, I looked carefully at each not-equivalent requirement. Before coming up with a conclusion, I looked deeper on the information that was required. I used the internal material from ATR and some documents, such as the MMEL, the AFM, the CMP, FCOM and the SDN chapters, in order to know more and have the information to conclude. Then, in case of a not-equivalent requirement where similar information was not found in the IL, the need of extra analysis should be done. If I was not able to find the exact information by myself, meetings with the experts were defined in order to find the answer.

Here, I set up meetings with different specialists depending on the requirement. For instance, I contacted safety, electrical, icing, certification and maintenance specialists to answer some of my question or doubts regarding the requirements.

In the meetings I set up, a previous preparation was done. In each meeting I defined well all the problematic I had and my possible solutions. Then in the meetings, a power point presentation was done or a paper to explain my problem and then we treated and dealt with it all together to reach a conclusion. Sometimes the answers were found quickly but in some cases long discussions took place.

This part was the most interesting for me. I could translate the requirements “in paper” to the real world of the aircraft itself. I learnt a lot of different things of the aircraft, I could go deeper in aspects such as the electrical power sources or how the ice is attached to the wings.

To do it, what helped me a lot was the previous preparation of the meetings with the specialists. I had to find the information in the different technical documents of ATR where information concerning the electrical systems is found and so on.

Then, if questions appeared in this learning process, I noted them down and then they were discussed with the specialists. I commented my doubts and possible approaches to the solution and they finally gave me the answers.

#### 4.2.4 STEP 4: Evaluate the conclusions of the meetings and decide whether the requirements are reachable / doable or not

Once the assessment was done for each not-equivalent requirement, together with the meeting conclusions, I was able to decide whether the requirements were reachable or not for ATR.

With all the information gathered, I had to give a final answer for each requirement, that is, how we were going to show compliance with each requirement.

I could say this last step was the most important one. I learnt to evaluate the conclusions of the meetings or my analysis and reach or deliver a final answer to each requirement. I had to be very precise on my answer because it could change all the study depending if I said we could achieve it or not.

This study implied a high difficulty with the dealing of all the requirements because there were a lot of them. This implied a high workload and here below an extract of the matrix I developed is shown:

K25.1 DESIGN REQUIREMENTS		ETOPS COMPARISON BETWEEN APP K PART 25 AND IL No.20				
AMERICAN REGULATION						
K25.1.1 Part 25 compliance		Information Leaflet No. 20	Comparison	Comments	Justification needed	Department
The airplane-engine combination must comply with the requirements of part 25 considering the maximum flight time and the longest diversion time for which the applicant seeks approval.	IL No.20 - 10.f (1) (ii) In the case of operations cleared up to 120 minutes maximum diversion time, small increases in the diversion time for specific routes may be approved if it can be shown that the resulting routing will provide an enhancement of overall safety. Such increases: (A) Will not exceed the limitations given in the ETOPS type design approval. (B) Will not be more than 15 per cent of the original maximum diversion time approved in accordance with 10.f.	Different	The only information in the IL related to this paragraph of the appendix K is the one stated in the left. However, this compliance should be easy to proof. Is what we are looking for in this certification progress	Yes		
K25.1.2 Human factors		Information Leaflet No. 20 - 7.e - Human Factors				
An applicant must consider crew workload, operational implications, and the crew's and passengers' physiological needs during continued operation with failure effects for the longest diversion time for which it seeks approval.	System failures or malfunctions occurring during extended range operation could affect flight crew workload and procedures. Since the demands on the flight crew may increase, an assessment should be made to ensure that exceptional piloting skills or crew coordination are not required.	Equivalent				
K25.1.3 Airplane systems						
(a) Operation in icing conditions						
(1) The airplane must be certified for operation in icing conditions in accordance with § 25.1419.	No information provided	Different	ATR aircraft already comply with 25.1419	Yes		
(2) The airplane must be able to safely conduct an ETOPS diversion with the most critical ice accretion resulting from: (i) Icing conditions encountered at an altitude that the airplane would have to fly following an engine failure or cabin decompression. (ii) A 15-minute hold in the continuous maximum icing conditions specified in Appendix C of this part with a liquid water content factor of 1.0. (iii) Ice accumulated during approach and landing in the icing conditions specified in Appendix C of this part.	IL No. 20 8b11. Airframe and propulsion ice protection should be shown to provide adequate capability (aircraft controllability, etc) for the intended operation.  This should account for prolonged exposure to lower altitudes associated with the single engine diversion, cruise, holding, approach and landing.	Different	Possible with the implementation of technical notes and analysis to justify ATR aircraft comply with these requirements. ATR did an Assessment of ice accretion on a feathered propeller as well as an Assessment of performance effect of prolonged ice accretion (icing scenario, handling qualities), so we should see if FAA accepts as well this studies and there is no need to do a further analysis	Yes	DIODER CAILHOL	
(b) Electrical power supply. The airplane must be equipped with at least three independent sources of electrical power	IL No. 20 8.b (8) Three or more reliable and independent electrical power sources should be available. As a minimum, following failure of any two sources, the remaining source should be capable of powering the items specified in paragraph 8.b.(7).	Equivalent	The electrical power sources available on the ATR72-212A & ATR42-500 are: one A.C. Wild Frequency Generator which can be connected to a Transformer Rectifier Unit (TRU) and a D.C. Starter-Generator, both symmetrically and independently installed on each engine. The segregation of the generators cable versus rotorburst introduced in the ATR72-200 ETOPS definition is included in the ATR72-212A basic definition. An A.C. Wild Generator associated to the T.R.U. is capable of supplying the services specified in paragraph 8b.(7), but not a D.C. Starter-Generator. The D.C. Starter Generator supplies all services required for the previous ATR ETOPS certification, that is paragraph 8b.(7) excluding the weather radar, the landing light, the static heating and the windshield de-icing. The DGAC has accepted this deviation based on the derivative nature of the ATR72-212A & ATR42-500. The auto pilot is powered in emergency configuration with a specific modification included in the ATR72-212A CMP.	No		
(c) Time limited system The applicant must define the system time capability of each ETOPS significant system that is time-limited.	IL No.20 - 8.c - (1) General The analysis and demonstration of airframe and propulsion system failure effects and reliability provided by the applicant as required by paragraph 8b, should be based on in-service experience as required by paragraph 9, and the expected longest diversion time for extended range routes likely to be flown with the aeroplane. If it is necessary in certain failure scenarios to consider less time due to time limited systems, the latter will be established as the maximum diversion time.	Different	In the CMP the time capability of the ETOPS significant systems is described so we could use this to address the FAA requirement	Yes	MAINTENANCE / MICHAEL BOLIS (AIRBUS)	
K25.1.4 Propulsion systems						
(a) Fuel system design Fuel necessary to complete an ETOPS flight (including a diversion for the longest time for which the applicant seeks approval) must be available to the operating engines at the pressure and fuel flow required by § 25.955 under any airplane failure condition not shown to be extremely improbable. Types of failures that must be considered include, but are not limited to: crossfeed valve failures, automatic fuel management system failures, and normal electrical power generation failures.	IL No. 20 8.c (1) The analysis and demonstration of airframe and propulsion system failure effects and reliability provided by the applicant as required by paragraph 8b, should be based on in-service experience as required by paragraph 9, and the expected longest diversion time for extended range routes likely to be flown with the aeroplane. An assessment of the propulsion systems reliability for a particular airframe/engine should be made in accordance with paragraph 9 and Appendix 1. (ii) The analysis should consider: (A) Effects of operation with a single-propulsion system (ie highpower demands, bleed requirements, etc) and include possible damage that could result from failure of the first propulsion system. (B) Effects of the availability and management of fuel for propulsion system operation (ie cross-feed valve failures, fuel mismanagement, ability to detect and isolate leaks, etc.).	Exempted	Following sec. 25.3, ATR is exempted from this requirement	No		
(1) If the engine has been certified for limited operation with negative engine-fuel-pump-inlet pressures, the following requirements apply: (i) Airplane demonstration-testing must cover worst case cruise and diversion conditions involving: (A) Fuel grade and temperature. (B) Thrust or power variations. (C) Turbulence and negative G. (D) Fuel system components degraded within their approved maintenance limits. (ii) Unusable-fuel quantity in the suction feed configuration must be determined in accordance with § 25.959.	No information provided	Not applicable to ATR	ATR PW engines do not operate with negative engine fuel pump inlet pressures, so this requirement is not applicable. However, would be interesting to check with powerplant department to know more about the topic	No	POWER PLANT	
(2) For two-engine airplanes to be certified for ETOPS beyond 180 minutes, one fuel boost pump in each main tank and at least one crossfeed valve, or other means for transferring fuel, must be powered by an independent electrical power source other than the three power sources required to comply with section 25.13(b) of this appendix. This requirement does not apply if the normal fuel boost pressure, crossfeed valve actuation, or fuel transfer capability is not provided by electrical power.	No information provided	Not applicable to ATR	ATR aircrafts want to certify 120 minutes, there is no need to certify more than 180 minutes	No		
(3) An alert must be displayed to the flightcrew when the quantity of fuel available to the engines falls below the level required to fly to the destination. The alert must be given when there is enough fuel remaining to safely complete a diversion. This alert must account for abnormal fuel management or transfer between tanks, and possible loss of fuel. This paragraph does not apply to airplanes with a required flight engineer.	No information provided	Exempted	Following sec. 25.3, ATR is exempted from this requirement	No		
(b)APU design. If an APU is needed to comply with this appendix, the applicant must demonstrate that: (1) The reliability of the APU is adequate to meet those requirements; and (2) If it is necessary that the APU be able to start in flight, it is able to start at any altitude up to the maximum operating altitude of the airplane, or 45,000 feet, whichever is lower, and run for the remainder of any flight.	No information provided	Not applicable to ATR	ATR aircraft do not have APU	No		
(c)Engine oil tank design. The engine oil tank filler cap must comply with § 33.71(c)(4) of this chapter. (d) -> 33.71(c)(4) Each oil tank cap must provide an oil-tight seal. For an applicant seeking eligibility for an engine to be installed on an airplane approved for ETOPS, the tank must be designed to prevent a hazardous loss of oil due to an incorrectly installed oil tank cap.	No information provided	Exempted	Following sec. 25.3, ATR is exempted from this requirement	No		

Figure 15. Extract of th ETOPS feasibility matrix developed by myself

#### 4.2.5 Case study (requirements)

In this internship I analyzed a lot of requirements. However, in this report I am going to just study the most important ones as well as the ones that have been more challenging for me. Please note that I am just going to go deeper in the explanations for a requirement concerning the electrical power sources.

The other ones will be discussed in the Annexes.

- ✈ Electrical power sources requirement
- ✈ Icing requirements (see Annex 11.2)
- ✈ Time-limits / ETOPS Significant Systems requirement (see Annex 11.3)

#### 4.2.6 Electrical power sources requirement

Analyzing the different requirements in the Appendix K to Part 25 (FAA regulation), I found one concerning the electrical power supply systems for ATR aircraft. It asks the following:

##### FAA requirement

###### **K25.1.3 Airplane systems**

**b. Electrical power supply.** The airplane must be equipped with at least three independent sources of electrical power.

**Figure 16. Extract of the Appendix K to part 25**

A priori, this requirement seems easy to understand. It basically asks the aircraft to have three independent sources of electrical power at minimum. However, the interpretation of “independent” can be somehow tricky depending on some considerations.

Therefore, let’s see if there is some equivalent information in the Information Leaflet (EASA side).

##### EASA requirement

The information found is the following:

Three or more reliable and independent electrical power sources should be available. As a minimum, following failure of any two sources, the remaining source should be capable of powering the items specified in paragraph 8.b(7). If one or more of the required electrical power sources are provided by an APU, hydraulic system, or ram air turbine, the following criteria apply as appropriate:

- (i) The APU, when installed, should meet the criteria in paragraph 8 b (4).
- (ii) The hydraulic power source should be reliable. To achieve this reliability, it may be necessary to provide two or more independent energy sources (e.g. bleed air from two or more pneumatic sources).
- (iii) The Ram Air Turbine (RAT) should be demonstrated to be sufficiently reliable in deployment and use. The RAT should not require engine dependent power for deployment.

**Figure 17. Extract of the Information Leaflet No. 20**

In the first sentence, some equivalent information with respect to FAA requirement can be identified. They basically ask for the same, to have a minimum of 3 independent electrical power sources.

However, analyzing the whole requirement I noticed that there are some points that they are not applicable for ATR aircraft. Let’s have a look:

Three or more reliable and independent electrical power sources should be available. As a minimum, following failure of any two sources, the remaining source should be capable of powering the items specified in paragraph 8.b(7). If one or more of the required electrical power sources are provided by an APU, hydraulic system, or ram air turbine, the following criteria apply as appropriate:

(i) ~~The APU, when installed, should meet the criteria in paragraph 8 b (4).~~ → **ATR aircraft does not have an APU**

(ii) ~~The hydraulic power source should be reliable. To achieve this reliability, it may be necessary to provide two or more independent energy sources (e.g. bleed air from two or more pneumatic sources).~~  
→ **ATR aircraft does not use hydraulic power as an electrical power source**

(iii) ~~The Ram Air Turbine (RAT) should be demonstrated to be sufficiently reliable in deployment and use. The RAT should not require engine dependent power for deployment.~~ → **ATR aircraft does not have a RAT**

Figure 18. Extract of the IL No. 20 with my notes

In red my justifications on the different requirements not applicable to ATR are found. For the first one, I had to check the different power units to produce energy on the aircraft and I found that ATR has no APU. For the second one, I had to check the different type of sources on the ATR to produce power. On ATR though, there is no use of hydraulics to generate electrical power. All the electrical power is produced mainly by the Starter Generators and Alternative Current Frequency Generators. Finally, concerning the Ram Air Turbine, ATR aircraft do not need and do not use the RAT.

### Analysis and comparison of the requirement

Therefore, a final comparison between both requirements can be done, and resuming we have:

FAA	EASA
Electrical power supply. The airplane must be equipped with at least three independent sources of electrical power.	Three or more reliable and independent electrical power sources should be available. As a minimum, following failure of any two sources, the remaining source should be capable of powering the items specified in paragraph 8.b(7).

The only difference right now remains in extent of the EASA requirement asking for a list of items that should be powered by the remaining source in case of failure of any two sources.

As a first approach, I would categorize this requirement as equivalent. However, this list of items should be checked just in case a problem could appear.

Moreover, to make sure ATR already complied with this requirement, I decided to look at how did ATR show compliance to EASA in the previous ETOPS certification. There, the answer given was not so straightforward and not clearly documented concerning the independency of the electrical power sources. This is the reason why I decided to go deeper and understand how the electrical systems of ATR aircraft work. This means, doing an assessment on the ATR case so as to verify if the aircraft is still compliant with the FAA regulation.

#### [Assessment on the ATR case and define the meetings with experts](#)

Here below, a study of how the electrical systems of ATR work is done, in order to be able to reach a conclusion of the requirement discussed before. Meetings will also take place, depending on the needs I have.

#### Electrical power sources of ATR aircraft

In order to analyze the electrical requirements of the American regulation concerning ETOPS it is necessary to understand which the electrical power sources of the ATR aircraft are.

The information used to acquire knowledge of the electrical power sources comes from the visits to electrical power generation specialists, the ATA Chapter 24, previous technical notes, presentations and studies done by ATR as well as a visit to the aircraft itself in the Final Assembly Line of ATR in Saint-Martin.

The study done is summarized here below:

a) Main power sources

The equipment and systems on board the ATR aircraft use different type of current depending its purpose and function. The power sources are the equipment in charge of supplying the current that the systems need to work. Three main types of current exist, the direct current, the alternative current (constant frequency) and alternative current (variable frequency).

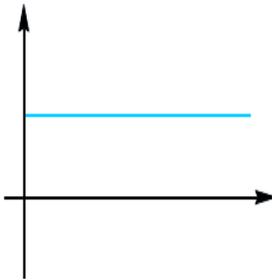


Figure 19. Direct current

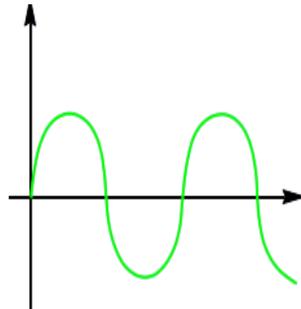


Figure 20. Alternative current (constant frequency)

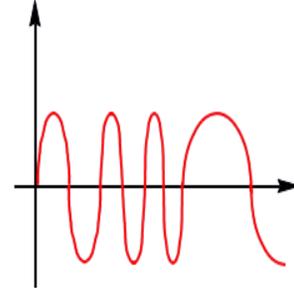


Figure 21. Alternative current (variable frequency)

As said, each current has its own properties and depending on the function we need, a system will work properly with one type of current or another.

Basically, on the ATR, the current can be obtained from the following sources (data obtained from bibliography [8]):

- DC supplying
  - Batteries (main & emergency)
  - DC generators driven by the accessory gearboxes
  - DC GPU (Ground Power Unit DC)
  - TRU (Transformer Rectifier Unit)
- AC supplying
  - The AC (115/26V 400Hz) is supplied by
    - Static Inverter (from the DC)
  - The ACW (115V variable frequency) is supplied by
    - ACW generators driven by the reduction gearboxes
    - AC GPU (Ground Power Unit AC) (ACW GPU doesn't exist. The AC GPU supply the ACW busses, with the 115V/400Hz, that is suitable)

These are all the sources of obtaining electricity on the ATR aircraft.

*b) DC generation*

The Starter Generator is the normal DC power source; it is driven by an engine's turbine through a reduction gearbox. It is also used to start engines. In addition, it is connected to a Static Inverter, which allows to convert DC to AC current.



Figure 22. DC Starter-Generator



Figure 23. DC-Starter Generator

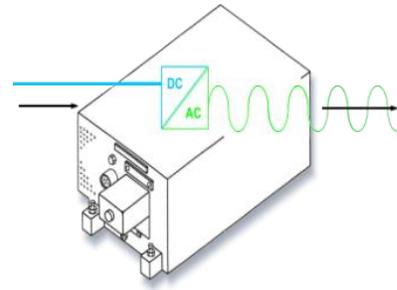


Figure 24. Static inverter

Depending on the equipment, they can be powered by DC (Direct Current) or AC (Alternative Current) thanks to the different buses distributed in the aircraft.

For the DC generation, the electrical circuit associated is the following one:

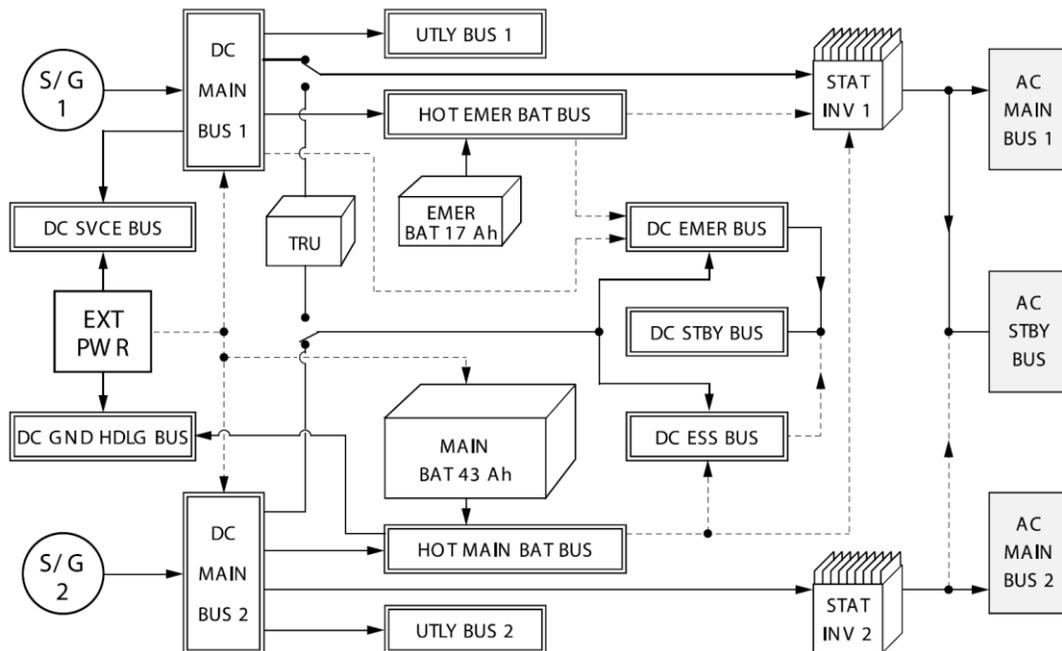


Figure 25. DC generation electrical circuit

On the left side there are the 2 DC Starter-Generators and then all the different buses they supply, as well as the Static Inverters which helps to provide AC current through the AC Main and Standby buses.

## Batteries

Moreover, there are two batteries capable of providing DC current installed on the aircraft, the main battery and the emergency battery. The MAIN battery has a nominal capacity of 43 Ah and the EMER battery of 15 Ah

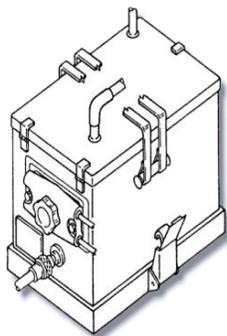


Figure 26. Main battery

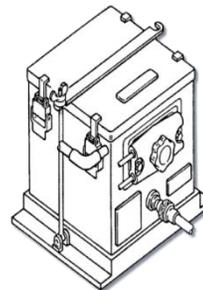


Figure 27. Emergency battery

These batteries provide DC power to the emergency network when starter generators and TRU are no more available. The Main battery is used as well to supply Starter Generators during engine starting.

In the event of an emergency the batteries are used as follows:

- The main battery supplies
  - o DC ESS BUS
  - o DC STBY BUS
  - o INV 1 (which supplies 115 and 26VAC STBY buses only)
- The EMER battery supplies
  - o DC EMER BUS

### c) AC generation

On the other side, The AC Wild Frequency Generator can convert AC to DC thanks to the TRU. Each ACW Generator is driven by a reduction gearbox on propeller.



Figure 28. AC Wild Frequency Generator



Figure 29. AC Wild Frequency Generator

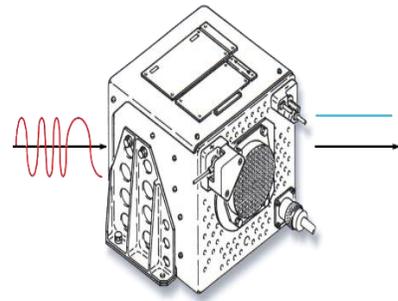


Figure 30. Transformer Rectifier Unit

On the other hand, for the AC generation with the ACWF generators, the electrical circuit is the following:

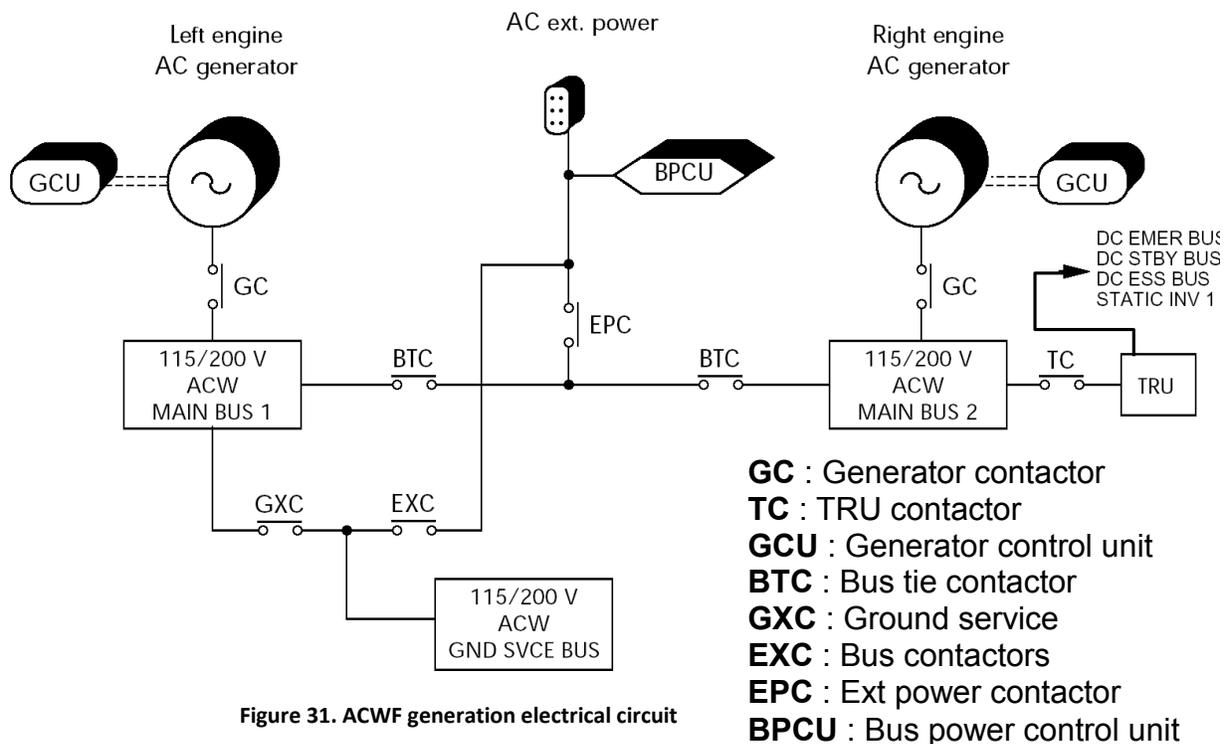


Figure 31. ACWF generation electrical circuit

In this case there are the two AC generators, both connected with a GCU. The GCU provides a permanent protection, control and monitoring of the generators. One Bus Power Control Units (BPCU) is connected to both AC GCUs. In case DC power is needed, there is the TRU (Transformer Rectifier Unit) which allows to convert ACW power into DC power.

Summing up, in the figure below the schema of the different electrical power sources of ATR aircraft can be seen:

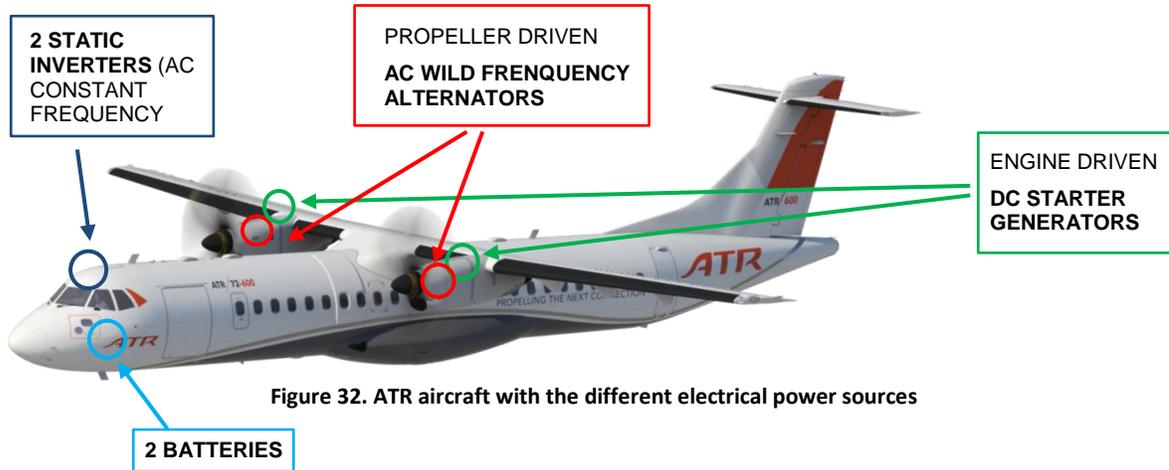


Figure 32. ATR aircraft with the different electrical power sources

Now, after this preliminary study we can retake the analysis of the electrical requirement concerning the different airplane functions that need to be powered by the European regulation.

Airplane functions needed to be powered

Airplane functions that need to be powered by EASA

Now there is the need to see which systems must be powered by a single electrical source (specified in the original requirement from EASA discussed before).

So, I went to look at the paragraph 8.b(7) in the IL20 to see which the items required are:

“Functions to be provided may differ between airplanes and should be agreed with the Authority. These should normally include:”

Item	Airplane functions
i	Attitude information
ii	Adequate radio communication and intercommunication capability
iii	Adequate navigation capability (including weather radar)
iv	Adequate cockpit and instrument lighting, Emergency lighting and landing lights
v	Sufficient captain and first officer instruments, provided cross-reading has been

	evaluated
vi	Heading, airspeed and altitude including appropriate pitot/static heating
vii	Adequate flight controls including auto-pilot
viii	Adequate engine controls, and restart capability with critical type fuel (from the stand-point of flame out and restart capability) and with the
ix	Airplane initially at the maximum relight altitude
x	Adequate fuel supply system capability including such fuel boost and fuel transfer functions that may be necessary
xi	Adequate engine instrumentation
xii	Such warning, cautions, and indications as are required for continued safe flight and landing
xiii	Fire protection (cargo, APU and engines)
xiv	Adequate ice protection including windshield de-icing
xv	Adequate control of cockpit cabin environment including heating and pressurization
xvi	ATC Transponder

Airplane functions that need to be powered by FAA

Here, I decided to look in the AC25.1535 in draft status to see if there was some extra information on it.

In the Advisory Circular in draft status from FAA (AC 25.1535) they also list the different set of airplane system functions needed to be powered by an electrical power source:

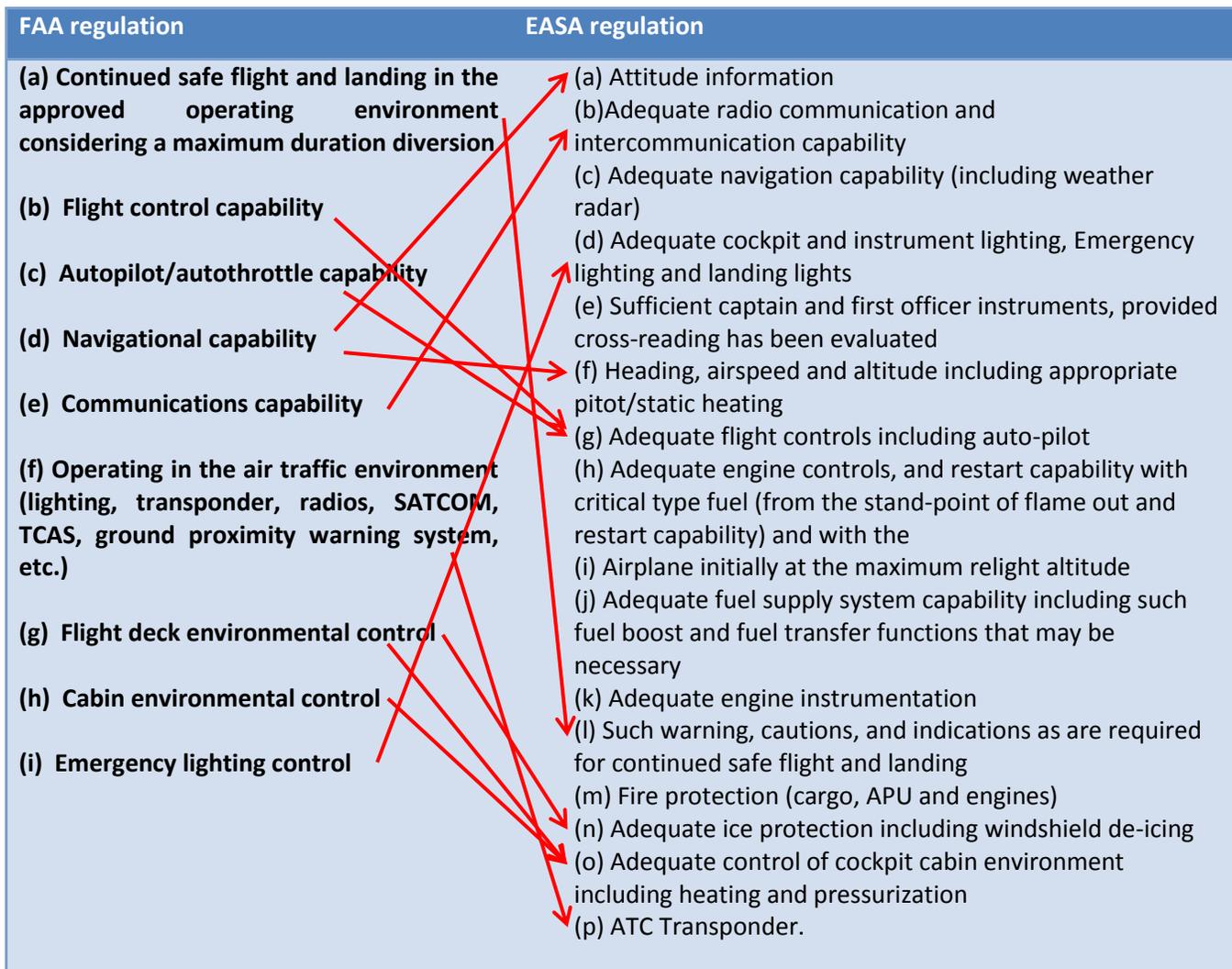
“(7) An applicant should propose and justify the minimum set of airplane system functions required for: “

Item	Airplane functions
1	Continued safe flight and landing in the approved operating environment considering a maximum duration diversion;
2	Flight control capability;
3	Autopilot/auto throttle capability;
4	Navigational capability;

5	Communications capability;
6	Operating in the air traffic environment (lighting, transponder, radios, SATCOM, TCAS, ground proximity warning system, etc.);
7	Flight deck environmental control;
8	Cabin environmental control; and
9	Emergency lighting control.

### Crosscheck between airplane functions

So, after analyzing and understanding which were the functions required, I decided to realize a crosscheck between both regulations to see if all the items could be covered or not. In case there was an item not covered, the need for further analysis would be required.



The conclusion of the crosscheck I did is that all the different functions requested by FAA regulation were already covered by the IL regulatory document. In addition, I could say the list asked by the European side was even more restrictive than the American one, so with this issue we should not have any problem to show compliance for the ETOPS type design approval by the FAA:

That said, the only problem that could appear could be in terms FAA's interpretation of the requirements. Some experts I contacted from Airbus or inside ATR said the FAA sometimes is special in this kind of things. For us though, there is no blocking item. I checked all items one by one, meaning that I took each aircraft function from the FAA list, for instance, *"(d) Navigational capability"* and I tried to look if a similar information was found in the EASA list.

To navigate, you need to know your position, speed, altitude and so on in order to navigate through the airspace. Once I understood what the regulation meant by *"Navigational capability"* I went to look in the EASA list if equivalent information was written. What I found was *"(a) attitude information"* and *"(f) heading, airspeed and altitude including appropriate pitot/static heating"*.

With this equivalent information, I consider this requirement covered, and the same procedure was done for all the items required.

Up to now, everything was fine. However, when I finished the comparison between these two requirements from the FAA side and the one in the EASA, I looked in the ETOPS compliance matrix done by ATR in the previous ETOPS certification process to see which means of compliance they used and how they justified each requirement. And here I found some vital information that cannot be underestimated. In the previous ETOPS certification process ATR had one exemption on the requirement concerning the electrical power supply.

*An exemption is a grant of relief to an applicant from the requirement of a specified airworthiness standard. A petition for exemption follows the procedures for public comment on rulemaking that are described in FAR 11. The applicant should submit a petition for exemption to the FAA accountable directorate through the ACO. The FAA considers the following before granting an exemption: the requested exemption must benefit the public as a whole; and, granting this relief would either not*

*adversely affect safety or the exemption would provide a level of safety at least equal to that provided by the rule from which relief is sought.*

After this definition, the answer ATR gave (and that EASA accepted) to address this requirement was:

*“The electrical power sources available on the ATR72-212A & ATR42-500 are: one A.C.Wild Frequency Generator which can be connected to a Transformer Rectifier Unit (TRU) and a D.C. Starter-Generator, both symmetrically and independently installed on each engine. The segregation of the generators cable versus rotor burst introduced in the ATR72-200 ETOPS definition is included in the ATR72-212A basic definition. **An A.C.Wild Generator associated to the T.R.U. is capable of supplying the services specified in paragraph 8b(7), but not a D.C. Starter-Generator. The D.C. Starter Generator supplies all services required for the previous ATR ETOPS certification, that is paragraph 8b(7) excluding the weather radar, the landing light, the static heating and the windshield de-icing.** The DGAC has accepted this deviation based on the derivative nature of the ATR72-212A & ATR42-500. The auto pilot is powered in emergency configuration with a specific modification included in the ATR72-212A CMP.”*

EASA accepted this exemption.

It is important to notice that this exemption is going to be a key point when validating ETOPS by the FAA. We have a constraint and ATR will ask for the same treatment to FAA in order to proceed. The exemption allows ATR to be exempted of a specific regulatory paragraph that cannot comply with, so if the FAA rejects the exemption petition, difficulties will appear to continue this ETOPS project.

After the appearance of this exemption, I wanted to know why the four equipment listed in this document could not be powered, because if we had to justify to FAA why we should be granted this exemption, we had to have the information. So I looked for the previous ETOPS certification for ATR where all the applicable technical notes and documents are kept.

There, I found some useful information for trying to solve the issue and for me to be able to reach a conclusion.

First of all, there was a document, the Emergency Loads Analysis, which concluded saying that the DC Starter-Generator could supply all services except the weather radar, meanwhile the ACWF generator

could supply all services except the static heating, windshield de-icing and landing lights in case of failure.

This information was not in line exactly with the answer in the ETOPS compliance matrix that ATR did, there were some ambiguities between the documents.

So I had to find out which was the correct statement about this exemption, to know which were specifically the systems that could not be powered as well as which type of current they needed to be powered, because it depends if there is a loss of DUAL AC or DUAL DC.

*Failure scenarios:*

Before the setting of the meetings with the electrical specialists, I decided as well to deeply analyze the 4 systems that could not be powered in case of failure because it was not clear in which case they were not supplied.

In the ETOPS analysis, different failure scenarios must be considered. Normally, the worst possible scenarios should be studied. In our case, in terms of electrical power sources, the studies always take into account the loss of one engine and then, the failure of another electrical power source from the remaining engine.

If even within this scenario safety levels remain inside the margins, this means we are compliant.

The 2 worst possible scenarios that can happen in flight are the dual DC Generation loss or the dual AC Generation loss, because you lose the DC or the AC current from the two sources that produce this type of current. In practical terms, is the same as if you lose one engine and one power source of the other engine available.



Figure 33. Failure scenarios studied

I looked carefully at each of the four equipment, especially in the SDN, where I found the type of current they needed to work as well as their specific functions and the connections.

Once I had the information, I then decided to set up a meeting with the electrical systems specialists to clear out this issue.

A meeting was held with the electrical systems specialists, where I showed them my questions as well the slight discrepancy and they took the action to solve the issue.

In the meeting, basically I checked if the hypothesis we did concerning the 4 equipment were good or not, and about the static heating they were not sure whether it was powered with AC or DC current. Moreover, with the new aircraft versions, maybe the loads analysis were changed and the aircraft could already power this equipment without the need of the exemption. So an open action was let to them to check this issue.

In the end, after some weeks of exchanges and the contact of some Airbus specialists, I reached the final answer.

I came up with the following conclusions, confirmed by the electrical specialists.

- In the case where there is a dual DC Generators loss, the equipment that CANNOT be powered is:
  - Static heating
  - Weather radar
- In the case where there is a dual AC Generators loss, the equipment that CANNOT be powered is:
  - Landing lights
  - Windshield de-icing

This is the reason why an exemption was sought by ATR when applying for the ETOPS capability by EASA/DGAC.

As said before, FAA should accept the same exemption in order to avoid redesigning the electrical circuit design or the electrical system architecture of the ATR aircraft.

	Dual DC Starter-Generator loss	Dual AC Wild Frequency Generator loss
Static heating	NO	YES
Weather radar	NO	YES
Landing lights	YES	NO
Windshield de-icing	YES	NO

In parallel with the meetings held with the electrical specialists, in the weekly meeting done with FAA the topic of the exemption came out (see Annex 11.1) and they advertised us to ask for the exemption as soon as possible in order to make sure no blocking item would be found as the certification process advances.

As soon as I heard that an exemption should be prepared, I was enthusiastic about the idea of doing it, at least, writing a draft that then could be used by ATR. So I asked with no hesitation the Foreign Authorities Certification Manager of ATR, to see whether I could do it or not. He answered yes, so I started looking information regarding the exemption (see Annex 11.1).

#### Redaction of the Exemption

Once I received the confirmation from the Manager, I first looked for some exemptions already granted by FAA, some examples by internet and I gathered some information from books and websites.

Once I had all information and I understood how it worked and the different steps to do, I started to work on it.

I structured the exemption (Annex 11.1) in 4 different parts: an introduction, the applicable regulation, a discussion and the conclusion and petition.

First of all, I did some brainstorming to collect all the information I had together.

Information coming from documentation such as the ATA Chapters, as well as previously certification items such as the ETOPS compliance matrix was gathered.

In addition, the conclusions of the meetings I did were compiled, where I could ask the questions I had concerning this issue, as well to get a confirmation of my comments.

Also, I need to justify why the exemption would not compromise safety levels, so with the help from the CRI I could justify each equipment like that:

- ✈ For the **weather radar**, due to the fact that the ATR 42-500 has slower one engine operative speed (about 200 kts TAS at 10 000 ft ISA) than jets which have the same requirements, the weather situation and forecasted data are much more reliable for the closer diversion airport of turboprops than they are for jets with the same diversion duration.
- ✈ For the **landing light**, in case of failure of both A.C. Wild Frequency generators, the DC generation would still be able to power the following exterior lights allowing the aircraft to be seen: the navigation lights, the anti-collision light and the wing and engine scanning lights. Moreover, crews are trained for night landing without landing light on classic runways.
- ✈ For the **static ports**, their location and shape with regard to the relative wind are such that they should never get clogged by ice accretion in flight in normal icing conditions.
- ✈ For the **windshield de-icing**, in case of failure of both A.C. Wild Frequency generators, the remaining D.C. generator is still able to power both side windows heating and both windshield wipers. In addition, during the basic certification process of the ATR 42-300, the flight test program reference 1265/85 and the corresponding certification card 25-10-06 demonstrated that landing with both windshield obstructed was possible and safe using lateral windows.

All these justifications were agreed both by me, my tutor and the specialists. These justifications were found according to experience, technical notes, previous knowledge and studies done.

Therefore, I came up with the draft of the exemption and forwarded to the certification team. Now, it needs to be reviewed by the managers and then submitted to FAA.

The realization of this exemption made me win more knowledge as well as knowing another aspect done in the certification office of a company. I was able to produce a technical note with lot of different agents involved, meaning certification specialists, electrical specialists, documentation and regulation.

So, with all this analysis, I can proceed to obtain the conclusions. Now, a final study of the independency of the different electrical power sources of ATR aircraft can be done.

First of all we can neglect the batteries as a mean of being an independent electrical source. One could wonder that why not the batteries could be another electrical independent power source. Well, the answer to this question is that looking in the technical specifications of the batteries in the SDN Chapter 24 concerning electrical power, they have an endurance around 30 minutes. However, for ETOPS they should be available the minimum time that the manufacturer seeks approval, this is, 120 minutes, because with an endurance of 30 minutes if the engine of the aircraft fails when the aircraft is at the maximum diversion time (120 minutes) the airplane would not be able to arrive to the closest diversion airport and would have to land to the water or the earth with catastrophic consequences.

### *Showing independency*

Therefore, to show independency between each power source, the generation of electrical power must be done alone without any interdependency with other elements which are used for another circuit.

The justification of 3 electrical power sources is not trivial. A big effort was done in this study because it was not clear.

**1<sup>st</sup> electrical power source:** The first power source identified is the DC Starter-Generator of the left engine, the Engine 1. This generator can be connected to the Static Inverter to transform DC to AC current too. It has its own electrical circuit independent of the others, with the different buses associated and tie contactors, but guaranteeing the circuit is completely independent of the other electrical installations.

**2<sup>nd</sup> electrical power source:** The second power source is the DC Starter-Generator of the right engine, the Engine 2. As for the DC of the engine 1, this engine can be connected to another independent Static Inverter to produce as well AC current.

**3<sup>rd</sup> electrical power source:** The third and last power source is both the ACWF generators connected to the TRU. ATR aircraft have just a single TRU (Transformer Rectifier Unit), meaning that when showing independency, one ACWF connected with the TRU can supply AC and DC current but then, with the remaining ACWF generator, there is not a second TRU associated so no DC power can be supplied. That said, the independency of a possible 4<sup>th</sup> power source cannot be considered.

I sent all my studies to the electrical specialists, who confirmed positively my hypothesis and analysis.

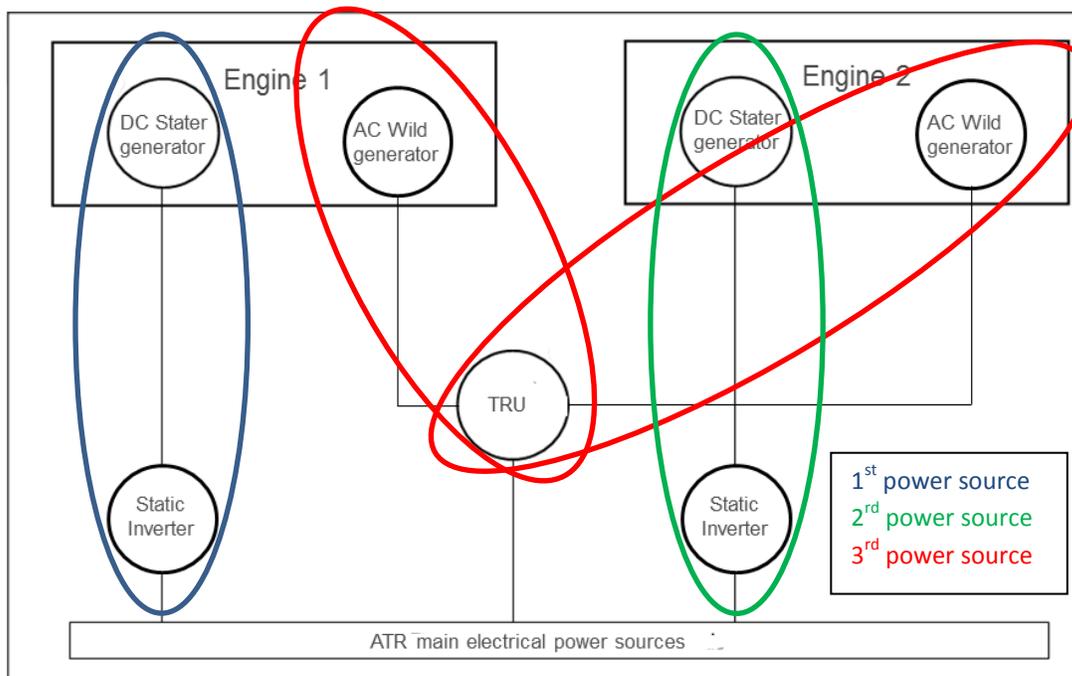


Figure 34. ATR main electrical power sources

**Conclusion:**

Summing up, I can confirm that ATR have three independent electrical power sources. ATR could comply with the requirement of FAA subject to the approval of the exemption on the 4 equipment that cannot be powered in case of any failure not shown to be extremely improbable. This requirement is not a blocking item. However, the exemption should be obtained as well as ATR received the exemption from the EASA.

## 5. ENAC courses related with the internship

This internship was the perfect way to give continuity to the studies I did at ENAC.

The last year of the “Ingénieur ENAC” program I did had different subjects related to airworthiness, where a direct link can be made with my internship.

This internship allowed me to use and implement all the knowledge learnt at class.

The major in Air Operations and Safety offers a huge variety of courses, giving special attention to airworthiness and certification. There is a main block of courses called Aeronautical Safety where subjects as structures airworthiness, engine certification and aircraft systems certification are taught.

These subjects offer the possibility to get familiarized with certification aspects as well to see how the certification of different systems or parts of the aircraft is done.

Specially, there was one subject that I found really interesting and from which I learned a lot that was the structures airworthiness course. Teachers from EASA came to teach us how structures are certified and an overall description of the aircraft structures was done. Also, aspects such as fatigue limits, aero elasticity, corrosion or ditching were studied.

Apart from the exam in the end of the lessons, we had to perform an EASA training “Structure airworthiness” case study.

There, there was a task which has helped me a lot in this internship, and it was about the comparison between different requirements.

The case study asked to “List and describe with your own words the differences between CS-25.571 and CS-23.571 and following paragraph (23.572, 23.573, 23.574, 23.575) for both requirements and acceptable means of compliance.”

This requirements comparison has a direct similarity with the second step of the process defined in my internship in ATR, so it really helped me the study and analysis of this exercise done at class.

## 6. ETOPS real project and personal contributions

ATR sent the application letter for Modification 4711 (ETOPS operations) to the FAA on ATR 42-500 and 72-212A on 13<sup>th</sup> February 2017. The same day my internship started.

In the application letter, more documents were attached, such as the EASA approval for ETOPS, the CMP or the AFM. The idea is to validate the ETOPS capability by the FAA because ATR already followed the certification process by EASA.

There is a permanent contact between ATR and the FAA. Moreover, each month a meeting with the FAA takes place, where all open actions are discussed and the next steps are agreed.

On 4<sup>th</sup> May, a mail from the FAA was received in answer to the application ATR did in February. They asked to provide the individual certification plans for a given list of the applicable sections of the appendix K. (Remember that the appendix K is the document containing all the requirements concerning ETOPS type design approval).

Here, I was in charge of the answer to this email, so as I had already done the preliminary analysis of the comparison between FAA and EASA requirements, I could identify the crosscheck between the items they were requesting and the ones in the European regulations. That said, a reply was sent from ATR the 30<sup>th</sup> May containing the information I had prepared.

After this email sent to the FAA I started attending the FAA monthly meetings organized between FAA and ATR, where ETOPS subject appeared as one of the main points of the meeting. All progresses, questions, or topics related to the ETOPS subject were treated and discussed.

Thanks to the Foreign Authorities Certification Manager, I had the possibility to attend these meetings done by conference call. The application used to connect all the participants is called WebEx.

These meetings are always attended by ATR members and EASA and FAA representatives. ATR has some focal points inside the Authorities (Project Certification Managers) who help manage all the coordination between institutions.

So in this meeting there were both EASA PCM and FAA PCM and 4 certification engineers from ATR.

The working principle of these meetings is always the same. There is a list of open actions between ATR and FAA reviewed monthly to check their progress. There were subjects submitted for validation such as ongoing projects submitted for FAA validation (including ETOPS), TCDS updates, etc.

Here I had the chance to participate and join the discussion with FAA with the ETOPS issue.

First of all, we discussed our answer with FAA PCM. He told us he had already forwarded the information to the specialists. Moreover, an important aspect we discussed about was the possibility to be granted an exemption concerning a requirement for the type design approval for ETOPS. This exemption concerns 4 equipment which cannot be powered in case of any failures not shown to be extremely improbable. ATR was already granted this exemption by EASA but we will need FAA to accept it as well.

Here, FAA PCM said that if this exemption was accepted by EASA, a priori FAA should do the same, but the application for the exemption should be done anyway.

He finally concluded that he would talk us back when he had news from his specialists about our email.

On June 14<sup>th</sup> we received the answer. What they finally want is ATR to provide a full ETOPS compliance matrix with all the applicable requirements as well as the means of compliance that are going to be used. Furthermore, the service experience data ATR plans to use for showing compliance to the sections of appendix K should also be provided.

Here below, the ETOPS subject between ATR and FAA is shown, with all the actions needed to be done. In blue, the action for the application for the exemption was introduced in the last meeting, where we discussed that the exemption should be written.

Priority	Subject	Mod	Action	Owner	Status
Medium	3 ETOPS (MAJOR SIGNIFICANT)	4711	ATR to provide application letter (Mail from Manuel dated 13 February 2017)	ATR	Closed
			FAA to continue discussion and exchange of documents with ATR	FAA	Open

		FAA to provide IP's	FAA	Open
		ATR to provide position on FAA IP's	ATR EAC	Open
		FAA to close IP's	FAA	Open
		FAA to provide delegation letter to EASA	FAA	Open
		ATR to provide DoC	ATR EAC	Open
		EASA to provide SoC to FAA	EASA	Open
		Application for exemption	ATR EAC	Open
		FAA to provide approval letter	FAA	Open

So, I let all my matrix prepared with all the information needed to create the final ETOPS compliance matrix with a folder as well containing all the different documents I produced and technical notes, as well as data to attach to the compliance matrix to show compliance.

It was not expected, but the ETOPS project became an important subject in the certification office. That said, the last month of the internship the certification team agreed to start designing the final ETOPS compliance matrix, and with the help of another member in the certification, we started the ETOPS compliance matrix with the help of my ETOPS feasibility matrix.

I really appreciated that the ETOPS issue got prioritized, because I could see how my work was useful for the company and that all the things I did were valued by the team. It was really rewarding.

Here below, an extract of the ETOPS compliance matrix can be seen, not ready yet because it will take still some time to be finished, with all the different means of compliance that exist to prove conformity with the requirements:



## 7. Risk and project limitations

This project has also some limitations. All the requirement analyses and studies have been done by our side, with our own interpretations. These interpretations have to be checked and confirmed with the Authorities. However, it is true that some requirements have already been discussed with FAA, some visits to specialists have been done as well as discussions with ETOPS engineers from Airbus.

But this does not prevent us that when agreeing with FAA, differences can appear.

Concerning the difficulties, one of the main difficulties I had to face was the analysis of some requirements which I did not find any direct equivalent information in the European regulation. Sometimes I could not advance because I did not know how to proceed. Then, I took it calmly and looking for documentation and with the help of my manager, little by little I was able to justify or find a solution for the requirement.

The main difficulty was to handle the electrical power sources requirement, because it had a lot of different factors involved in it. These were meetings with FAA, meetings with electrical specialists, the exemption ATR was granted and some ambiguities between documents that had to be studied with more details.

Also it was important to manage well my time, because the regulatory documents were very big and the excel sheets I created have more than 100 requirements analyzed, so it implied to have a well organization and a well time-management to fulfill and accomplish the deliverables.

Moreover, an unexpected document applicable to ETOPS appeared two months after the start of the internship, an Advisory Circular in draft status for giving guidance to the Appendix K. We could have decided to not analyze the AC because it is still not an official document. However, we decided to analyze it because it could provide us maybe more help and extra guidance, which was interesting.

Here though, I had to re-organize my planning in order to give time to all the activities and still be in-line with the expected deliverables for ATR. In the end, I managed without problems.

## 8. Conclusion

The main conclusion of this internship is that the achievement of the FAA ETOPS capability is feasible for ATR. After the whole analysis of the ETOPS applicable requirements, no direct blocking item has been found, so ATR is prepared to continue the ETOPS certification process.

No need of a significant change is needed to validate the ETOPS capability by FAA.

The only point where ATR should focus on is the requirement concerning the electrical power sources of the aircraft. ATR should agree with the American authority on the interpretation of this requirement in the certification program. Moreover, they should ask what FAA is expecting from this requirement, because there is no more information in the American regulation concerning this issue and it can create some ambiguity.

However, for our interpretation, ATR perfectly complies with the requirement. However, the exemption on the 4 different equipment that cannot be powered in case of failure should be granted.

From now on, the perspective and the next steps to do are to transform my feasibility matrix into the final ETOPS compliance matrix with the different means of compliance ATR is going to use to certify the ETOPS capability. In the column in my matrix where the comments are written, a guidance can be found in order to identify the means of compliance for each requirement.

As well, all the requirements which have some documents associated, the name of the document is referenced inside a folder created for this project "ETOPS validation folder".

Summing up, this internship allowed me to implement what I learned during this year especially in the Ingénieur ENAC programme. Moreover, it has allowed me to discover new centers of interest and to reveal skills that I had not yet had the opportunity to put into practice.

I never expected that this internship would have been so important to me, but having had the opportunity to work in this great company has opened me the eyes to the professional world. This internship will definitely give me the experience and preparation to do the transition from the academic world to the professional one.

I learnt how to integrate and adapt myself to a new environment, have the initiative and proposal and follow a rigorous organization while being in autonomy over the mission I was entrusted with. I learnt a

lot from my professional life through my observation of the environment that surrounded me, the people I met and the structure of the service in which I was integrated.

Also, this project has allowed me to develop transversal skills by being the interface with the specialists of each area and the certification office. Also, it has allowed me to enhance my aeronautical cultural awareness, as well as the preparation and participation of meetings with workers from different culture and countries.

Finally, I am satisfied with the work done, the matrix I developed and my contribution to the ETOPS project in ATR, and I am ready to continue my master studies in Barcelona to enter in the professional world that is waiting for me outside.

## 9. Glossary

<b>AC</b>	Advisory Circular
<b>AC</b>	Alternative Current
<b>ACWF</b>	Alternative Current Wild Frequency
<b>AMC</b>	Acceptable Means of Compliance
<b>ATA</b>	Air Transport Association
<b>CMP</b>	Configuration, Maintenance and Procedures document
<b>CRI</b>	Certification Review Item
<b>DC</b>	Direct Current
<b>DGAC</b>	Direction Générale de l'Aviation Civile
<b>EASA</b>	European Aviation Safety Agency
<b>EEP</b>	ETOPS Entry Point
<b>ELA</b>	Emergency Loads Analysis
<b>ETOPS</b>	Extended Twin-Engine Operations
<b>ETP</b>	Equal Time Point
<b>EXP</b>	ETOPS Exit Point
<b>FAA</b>	Federal Aviation Administration
<b>FAR</b>	Federal Administration Regulation
<b>FCOM</b>	Flight Crew Operations Manual
<b>GPU</b>	Ground Power Unit
<b>IFSD</b>	In-Flight Shut-down
<b>IL</b>	Information Leaflet
<b>IP</b>	Issue Paper
<b>JAR</b>	Joint Aviation Requirements
<b>MAS</b>	Modification Approval Sheet
<b>MMEL</b>	Master Minimum Equipment List
<b>MOD</b>	Modification
<b>P/N</b>	Part Number
<b>PW</b>	Pratt & Whitney
<b>SDN</b>	System Description Note
<b>TCMAS</b>	Type Certificate Modification Approval Sheet
<b>TDCCCF</b>	Type Design Change Compliance Check Form
<b>TN</b>	Technical note
<b>TRU</b>	Transformer Rectifier Unit

## 10. Bibliography

- [1] Filippo de Florio. *Airowrthiness: An Introduction to Aircraft Certification and Operations*. 3<sup>rd</sup> edition ed. Butterworth
- [2] "StackExchange," 2017. [Online]. Available: [https://www.skybrary.aero/index.php/Extended\\_Range\\_Twin\\_Engine\\_Operation\\_%28ETOPS%29](https://www.skybrary.aero/index.php/Extended_Range_Twin_Engine_Operation_%28ETOPS%29).
- [3] "Airliners," 2017. [Online]. Available: <http://www.airliners.net/forum/viewtopic.php?t=736205>.
- [4] "European Aviation Safety Agency (EASA)," 2017. [Online]. Available: <https://www.easa.europa.eu/system/files/dfu/Annex%20II%20-%20AMC%2020-6.pdf>.
- [5] "Federal Aviation Administration (FAA)," 2017. [Online]. Available: [https://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&tpl=/ecfrbrowse/Title14/14tab\\_02.tpl](https://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&tpl=/ecfrbrowse/Title14/14tab_02.tpl).
- [6] "Wikipedia," 2017. [Online]. Available: <https://es.wikipedia.org/wiki/ETOPS>.
- [7] "Skybrary," 2017. [Online]. Available: [https://www.skybrary.aero/index.php/Extended\\_Range\\_Twin\\_Engine\\_Operation\\_%28ETOPS%29](https://www.skybrary.aero/index.php/Extended_Range_Twin_Engine_Operation_%28ETOPS%29).
- [8] ATR internal documentation. "SDN Chapter 24 Electrical power," 2017.
- [9] ATR internal documentation. "Flight Crew Operating Manual" (FCOM), 2017
- [10] ATR internal documentation. "Configuration, maintenance and procedures document" (CMP), 2017
- [11] ATR internal documentation. "EASA previous ETOPS compliance matrix", 2017

## 11. Annex

### 11.1 Exemption

The exemption I wrote is found here below:

EACXXXXXXXXXXXXXXXXXX

20/06/2017

**Engineering Department**

**Certification Office**

1, allée Pierre-Nadot

31712 Blagnac Cedex – France

Tel +33 (0)5 62 21 64 03

To: **U.S.Department of Transportation**

**Docket Management System**

1200 New Jersey Ave., SE

Washington, DC 20590

SUBJECT: PETITION FOR EXEMPTION FOR THE TRANSPORT CATEGORY ATR 42/72 TURBOPROP AIRCRAFT – ELECTRICAL SUPPLY OF 4 EQUIPMENT IN CASE OF FAILURES NOT SHOWN TO BE EXTREMELY IMPROBABLE

Dear Sir or Madam:

1- This is a petition for exemption to the airworthiness requirement expressed in FAR 25 appendix K section K25.1.3 (b) as far as the independency of the electrical power sources is concerned.

Exemption on 4 equipment needed to be powered by the electrical power sources in case of any single failure or combination of failures not shown to be extremely improbable is deemed necessary by FAA to permit ETOPS validation of ATR 42/72, without requiring a significant change in the aircraft electrical circuit design.

2- APPLICABLE REGULATION

FAR 25 Appendix K → k25.1.3 (b) paragraph requires that “The airplane must be equipped with at least three independent sources of electrical power”.

### 3- DISCUSSION

ATR aircraft have 3 independent electrical power sources: one A.C. Wild Frequency Generator which can be connected to a Transformer Rectifier Unit (TRU) and a D.C. Starter-Generator, both symmetrically and independently installed on each engine.

ATR already obtained the type design ETOPS approval in 1996 by EASA.

In addition, ATR was granted as well an exemption concerning the electrical supply of the following equipment in case of a failure not shown to be extremely improbable:

- Weather radar
- Landing lights
- Static heating
- Windshield de-icing

ATR expects FAA to accept the exemption as well as EASA did in the previous DGAC/EASA ETOPS certification.

ATR applied the JAA IL20 (dated July 1995, revised, EASA regulation) requirements chapter 8 for the eligibility, and chapter 9 and appendix 1 for the aptitude with deviations concerning the requirements of chapter 8b(7). This chapter gives a list of aircraft functions for which electrical power should be supplied in case of failures not shown to be extremely improbable. These are:

Item	Airplane functions
i	Attitude information
ii	Adequate radio communication and intercommunication capability
iii	Adequate navigation capability (including weather radar)
iv	Adequate cockpit and instrument lighting, Emergency lighting and landing lights
v	Sufficient captain and first officer instruments, provided cross-reading has been evaluated
vi	Heading, airspeed and altitude including appropriate pitot/static heating
vii	Adequate flight controls including auto-pilot
viii	Adequate engine controls, and restart capability with critical type fuel (from the stand-point of flame out and restart capability) and with the
ix	Airplane initially at the maximum relight altitude

x	Adequate fuel supply system capability including such fuel boost and fuel transfer functions that may be necessary
xi	Adequate engine instrumentation
xii	Such warning, cautions, and indications as are required for continued safe flight and landing
xiii	Fire protection (cargo, APU and engines)
xiv	Adequate ice protection including windshield de-icing
xv	Adequate control of cockpit cabin environment including heating and pressurization
xvi	ATC Transponder

The ATR 42-500 and ATR 72-212A cannot meet this requirement for the following items:

- 8b(7)(iii) "Weather radar"
- 8b(7)(iv) "Landing lights"
- 8b(7)(vi) "Static heating"
- 8b(7)(xiii) "Windshield de-icing"

It must be noted that this JAA IL20 paragraph also states: "Functions to be provided may differ between aeroplanes and should be agreed with the Authority". In addition, the foreword paragraph (a)(2)(ii) of the JAA IL20 also provides provision for such deviation.

In order to satisfy these additional requirements (compared to the ones defined in CTC 20 / FAA AC120-42A), a new AC Wild Frequency generator and a new Transformer Rectifier Unit should be developed specifically. The manufacturer considered that such modifications were not justified due to the ATR 42-300 and ATR 72-200 ETOPS experience.

- In addition, for the **weather radar**, due to the fact that the ATR 42-500 has slower one engine operative speed (about 200 kts TAS at 10 000 ft ISA) than jets which have the same requirements, the weather situation and forecasted data are much more reliable for the closer diversion airport of turboprops than they are for jets with the same diversion duration.
- For the **landing light**, in case of failure of both A.C. Wild Frequency generators, the DC generation would still be able to power the following exterior lights allowing the aircraft to be seen: the navigation lights, the anti-collision light and the wing and engine scanning lights. Moreover, crews are trained for night landing without landing light on classic runways.
- For the **static ports**, their location and shape with regard to the relative wind are such that they should never get clogged by ice accretion in flight in normal icing conditions.
- For the **windshield de-icing**, in case of failure of both A.C. Wild Frequency generators, the remaining D.C. generator is still able to power both side windows heating and both windshield wipers. In addition, during the basic certification process of the ATR 42-300, the flight test program reference 1265/85 and the corresponding certification card 25-

10-06 demonstrated that landing with both windshield obstructed was possible and safe using lateral windows.

Finally, the JAA ETOPS working group in charge of issuing the final JAA IL20 Regulation introduced a modification of this chapter 8b(7) of the IL20. It was agreed during the JAA 75 / 90 minutes ETOPS meeting of August 28th, 1996 that for ETOPS diversion time up to 90 minutes, compliance with JAR 25.1351(d)(2) at change 14, as interpreted by ACJ 25.1351(d)(4) and (5) would be an alternative means of compliance with the current list of 8b(7).

Although the ATR 42-500 DGAC ETOPS certification is requested for 120 minutes maximum diversion time, **none of the four equipment listed above** is included in the JAR 25.1351 requirements mentioned above.

That said, this exemption would provide a level of safety equal to the existing rule.

This request as well would benefit the public as a whole. The approval of this exemption would allow ATR to continue in its process to obtain the ETOPS capability by FAA. Thus, meaning that American airlines and operators could fly ATR aircraft and help to develop the regional market mainly in the USA.

#### 4- CONCLUSION AND PETITION

ATR therefore apply for an exemption from FAA regarding compliance of the electrical power supply requirement of Appendix K section K25.1.3 (b) of the FAR25.

It basically seeks exception for the 4 equipment that cannot be powered in case of failures not shown to be extremely improbable.

Yours faithfully,

For any further question please contact:

XXXXXXXXXXXXXXXXXX

ATR Certification Office

XXXXXXXXXX

ATR Certification Engineer

## 11.2 Icing requirements

When it comes to icing, the appendix K contains a requirement concerning icing aspects.

### **K25.1.3 Airplane systems**

#### **a. Operating in icing conditions.**

- (1) The airplane must be certificated for operation in icing condition in accordance with 25.1419.
- (2) The airplane must be able to safely conduct an ETOPS diversion with the most critical ice accretion resulting from
  - (i) Icing conditions encountered at an altitude that the airplane would have to fly following an engine failure or cabin decompression.
  - ii) A 15-minute hold in the continuous maximum icing conditions specified in Appendix C of this part with a liquid water content factor of 1.0.
  - (iii) Ice accumulated during approach and landing in the icing conditions specified in Appendix C of this part.

**Figure 36. Extract of the Appendix K**

This requirement asks us to be certificated for operations under icing conditions according to the chapter 25.1419 as well as to have an airplane capable of conducting an ETOPS diversion safely with the most critical ice accretion scenario resulting from 3 given conditions.

The first thing done was to check if ATR aircraft were already certified for operation in icing conditions in accordance with subpart 25.1419. I went to the internal documents of ATR, looking at the type design approval and the different modifications and found that yes, ATR is already certified with this requirement and also in the FAA side for the glass-cockpit version.

For the other part of the requirement, the regulations ask to study three different scenarios and take the worst possible ice accretion.

Here, as I did not know too many things about icing I had to document myself and try to understand what they were asking. So I decided to look for information by internet, old documents from ATR, etc. to be prepared to understand what the requirement was asking.

The 3 different scenarios were:

**Scenario 1:** Icing conditions encountered at an altitude that the airplane would have to fly following an engine failure or cabin decompression

This scenario requires to study the case where an engine failure or a cabin decompression appears. To find this information, I looked the FCOM (Flight Crew Operations Manual) where a chapter dedicated to ETOPS is found.

Here, the important thing I wanted to find is the altitude where the airplane would have to fly following an engine failure or a cabin decompression, so I found the graph below where I found the altitude:

**Aircraft depressurization + engine failure**

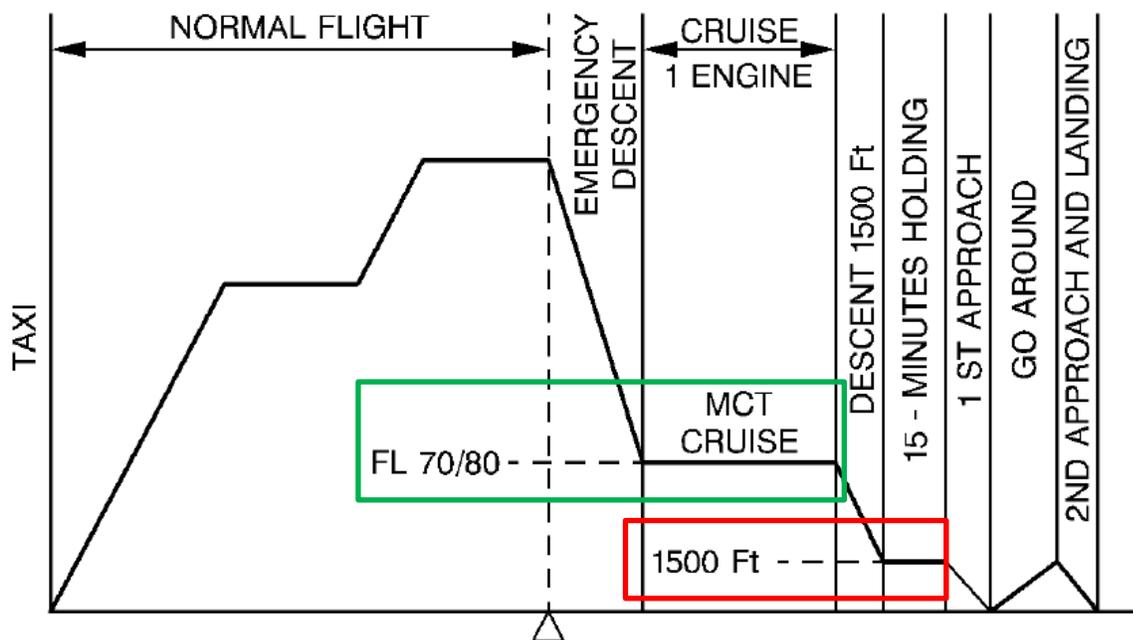


Figure 37. ATR flight profile after an aircraft depressurization and an engine failure. FCOM document, see bibliography [9]

This means the icing conditions encountered at FL70/80 should be taken into account.

**Scenario 2:** A 15-minute hold in the continuous maximum icing conditions specified in Appendix C of this part with a liquid water content factor of 1.0

In the Figure34 the holding altitude can be found as well. I will need to see which are the maximum icing conditions encountered at 1500ft of altitude with a liquid water content factor of 1.0

**Scenario 3: Ice accumulated during approach and landing in the icing conditions specified in Appendix C of this part**

Here, all the transition phase from the approach and landing should be studied.

At this point, once I well understood what they were asking, I set up a meeting with the Icing specialist in ATR to discuss how we could approach or justify that we are compliant with these icing requirements.

In parallel, I contacted Airbus as well in order to know how they showed compliance for these aspects.

The conclusions we reached are the following:

[Icing requirements study](#)

To prove compliance with the icing requirements for ETOPS described above, the two main players in the aeronautical industry, Airbus and Boeing utilized the following approach (agreed with the authorities):

What they do is to study a scenario in flight where different icing conditions are encountered. Basically, we can distinguish three different parts in it:

First, the scenario considers the possibility to find three standard clouds in flight. Meaning that the aircraft should be able to cross three standard clouds in cruise with the maximum icing conditions specified in the appendix C (from the JAR/FAR 25). These standard clouds are described in the regulation, and are 17.4NM long. There is no need to cross the 3 clouds in a row, they can be encountered in all the cruise phase.

After the crossing of the 3 clouds, the descent starts until the aircraft reaches the holding altitude, where it will do a 15-minute holding. There, they consider that in the holding pattern another standard cloud is found.

Finally, the approach and landing takes places, closing the last standard cloud when reaching the runway.

Here below, a drawing of the flight study they do is described, trying to make easier the understanding of how does Airbus and Boeing show compliance for the icing requirements for ETOPS.

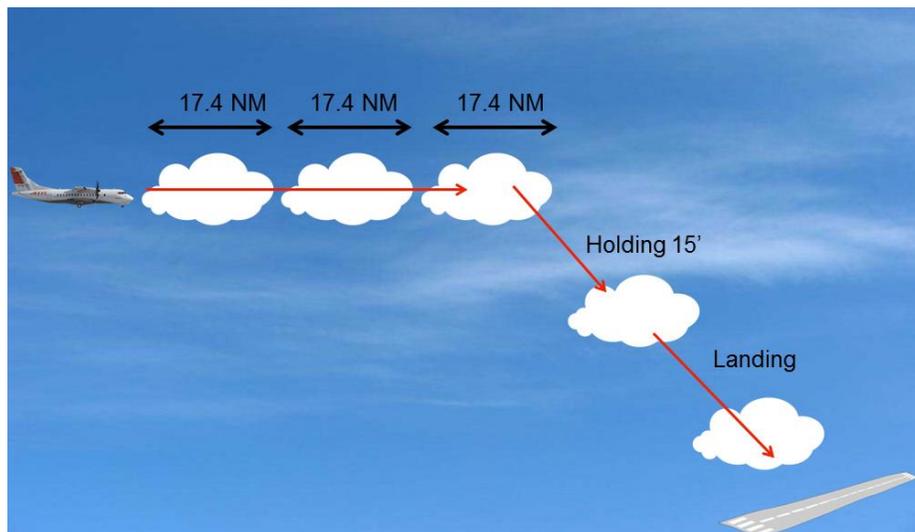


Figure 38. Flight route in order to prove compliance with icing requirements for ETOPS

Summing up, with this study what Airbus and Boeing try to guarantee is that even with some adverse meteorological conditions, in this case icing aspects, the performances of the Aircraft do not decrease, and the safety levels remain valid as well as the safety of the flight. This scenario is the one they used to show compliance and EASA and FAA agreed.

ATR already showed compliance for the icing requirements for the EASA side. They showed compliance in another way. They first did a study on how the ice was attached to the airframe so they could identify the different ice shapes all along the aircraft.

In this study, they differentiated two types of zones on the aircraft, the protected and unprotected areas.



Figure 39. ATR unprotected zones

For each zone, the ice was attached in a different way. For example, the ice shapes of the ice in the end of the wing (number 1 in the Figure35) would be:

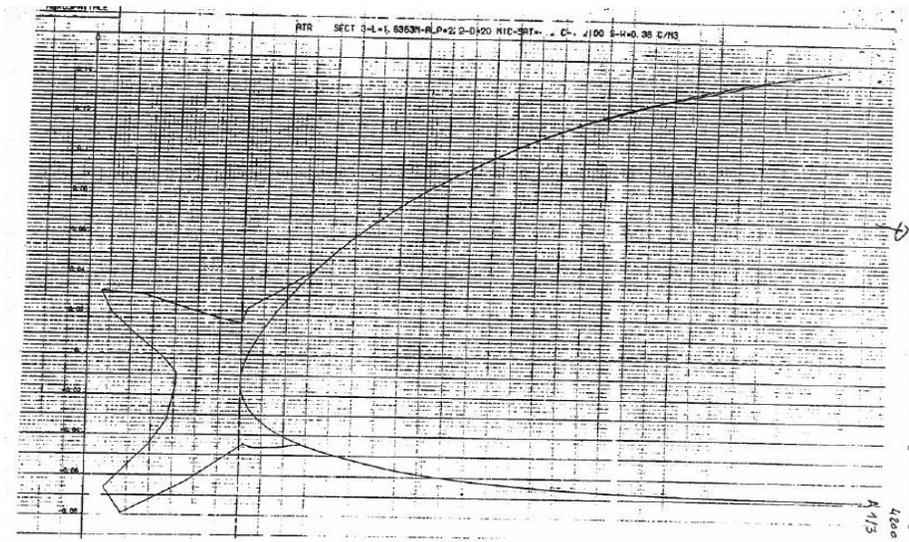


Figure 40. Ice accretion at the end of the wing

For the ATR icing certification, a conservative value of 3 inches of ice accretion was considered. In the conclusions, EASA accepted the 3 inches thickness because it was a very conservative value.

Then, for ETOPS, what they did basically is to study different scenarios and compute how many time did it need for the ice to get attached to the airframe up to 3 inches. In the case this time was lower than the ETOPS 120minutes they were seeking it would mean something should be done.

However, with the studies, the time for the ice to get attached was far away from the 120 minutes, so EASA accepted the means of compliance for the ETOPS icing requirements.

That said, I did a theoretical study applying the methodology Airbus and Boeing applied to certify the icing requirements for ETOPS.

For the ATR case, an average speed of 200kt is taken, so we can compute the time inside the clouds where ice can be attached to the wings.

With this speed, in the first part, the time to cross each of the 3 clouds is:

$$time = distance/TAS = (17.4 NM)/200kt = 5.22 minutes$$

So, taking the first phase of 3 clouds, a total time of  $5.22 \times 3 = 15.66$  minutes is found.

Then, the holding time is 15 minutes, so the time accumulated is

$$15.66 \text{ minutes} + 15 \text{ minutes} = 30.66 \text{ minutes}$$

Finally, to cross the final cloud as it is going to go through it in diagonal and not straightforward, because for the approach the aircraft descent at an angle approximately of 3 degrees, the time could be a little bit more. However, in this preliminary theoretical study we are just doing a rough estimation, so we could estimate and agree on the value of 8 minutes to cross the cloud.

Summing up, what we would have is that the aircraft encounters during 39 ~40 minutes icing conditions in flight.

If we compare these values with the studies previously done by ATR, the other ones are even more complete and restrictive, so we are going to use these one to ask for the FAA validation.

All in all, this is the final answer I found together with the specialists to be able to justify to the FAA why we are compliant with their requirements.

### 11.3 Time-limits – ETOPS significant systems requirements

In the appendix K there are 2 requirements concerning the Time-limits systems of the aircraft that say:

#### **K25.1.3 Airplane systems**

**b. Time limited systems.** The applicant must define the system time capability of each ETOPS significant system that is time-limited.

Figure 41. Extract of the Appendix K (FAA)

#### **K25.1.7 Airplane flight manual**

The airplane flight manual must contain the following applicable to the ETOPS type design approval:

(d) The system time capability for the following:

- (1) The most limiting fire suppression system for Class C cargo or baggage compartments.
- (2) The most limiting ETOPS significant system other than fire suppression systems for Class C cargo or baggage compartments.

Figure 42. Extract of the Appendix K (FAA)

ETOPS significant systems that are time-limited.

Going through all the Information Leaflet 20 the only information that has some relation with it is the following one:

**8c. 1 (1) General.** The analysis and demonstration of airframe and propulsion system failure effects and reliability provided by the applicant as required by paragraph

8b, should be based on in-service experience as required by paragraph 9, and the expected longest diversion time for extended range routes likely to be flown with the aeroplane. If it is necessary in certain failure scenarios to consider less time due to time limited systems, the latter will be established as the maximum diversion time.

Figure 43. Extract of the Information Leaflet No. 20 (EASA)

Comparing both requirements, there is no direct correspondence so this requirement is identified as different / not-equivalent.

And as commented in the process guidelines an answer will have to be done to this requirement, saying how we could be compliant or what can be done.

Analyzing the requirements asked for FAA, I went first of all to the technical documentation of the aircraft, where I looked at all the different configurations that the aircraft is certified and can use and I found out that ATR aircraft do not use Class C cargo, so we can directly neglect the part of the requirement asking to list the most limiting fire suppression system for class C cargo compartments.

Then, for the ETOPS significant systems, reading by internet and looking for information, I expected to find a list concerning the different ETOPS Significant systems for ATR but I found nothing. I contacted first my certification colleagues, but they did not know anything about this issue. Afterwards, I went to see the ETOPS responsible in ATR and no positive answer was found.

In the end, I contacted an ETOPS specialist in Airbus to ask some more information on this issue.

What we discovered is that there is not such a list in the regulation (neither EASA nor FAA) regarding the ETOPS Significant Systems. This list actually depends on the aircraft and its systems architecture and redundancies. Moreover, it is a request done by the operator to get this list, as they have to produce their own list for approval by their National Authority and it has a big impact on their ETOPS maintenance program, policies as well as for their ETOPS Flight Ops procedures.

Within those systems which are generally on ATR aircraft the engines, power generation systems (electrical, hydraulic, pneumatic, fuel), air conditioning, autoflight, communications systems (HF/SATCOM), anti-icing, navigation system... very few or even maybe none of them show a time limitation which has an importance for ETOPS.

You may say that batteries have a time limitation, but the scenarios where you are using your batteries in flight as primary source of electrical generation are when you have lost all your electrical sources, including back up ones except the batteries, and generally batteries provide a flight time of around 30 min, which does not change whether you are 30 min or 120 min away from the nearest airport. This is

the rationale used to claim that batteries are not an ETOPS significant system, and which is accepted by both EASA and FAA.

In those aircraft fitted with lower deck cargo compartments Category C, i.e. equipped with fire detection and fire extinguishing systems, the cargo fire suppression system made of 2 bottles of extinguishing agent (HALON) is the only one limited in time and which needs to be size to protect a maximum duration diversion with an additional margin of 15 minutes. In order to comply with K25.1.3(c) requirement, a flight test of the capacity of this system has to be established, and it needs to identify its time limitation in the ETOPS CMP document (which also complies with K25.1.6), and the Airplane Flight Manual (AFM) (which complies with K25.1.7).

Both ATR 42 and 72 aircraft are not fitted with such a system, so it may mean, for us, that ATR 42 and 72 do not have time limited systems, which simplifies a part of the compliance demonstration with K25.1.7.

Then the FAA requirement K25.1.7 also requires identifying the time limitation of the most limiting system other than the cargo fire suppression system. And here is where in the CMP, the time-limited systems are listed below:

MRBR REFERENCE	MPD REFERENCE	DESCRIPTION	TASK INTERVAL	AMM TASK
<b>243100-11</b>	243181-OPT-10000-1	Operational test of Transformer Rectifier Unit (TRU) system	48 FH	JIC: 243181-OPT-10000
<b>243100-02</b>	243100-OPT-10000-1	Operational test of battery override function & associated indicating	300 FH	JIC: 243100-OPT-10010
<b>282000-04</b>	282300-OPT-10000-1	Operational test of cross feed valve and indications	600 FH	JIC: 282300-OPT-10000
<b>282000-13</b>	284272-OPT-10000-1	Operational test of back-up low level indication	4000 FH	JIC: 284272-FUT-10020

---

The time-limit systems have a maintenance task associated, which state the maximum time interval that can be the system in-flight before being checked.

They define a max time interval that cannot be overpassed. If the time arrives and no maintenance task has been done, the aircraft cannot takeoff.

## 11.4 Modification

During all the internship period, immersed in the certification office, I saw that one of the main tasks they are responsible for are the modifications certification on the aircraft.

The modifications allow to change the design of some parts of the aircraft, the introduction of new functionalities or capabilities, the replacement of some equipment by a newer one and so on.

Normally, modifications are requested by the customer side. For instance, the airline can want to customize their cabin with a specific galley or a seat-configuration, and all this changes need to be approved and certified.

On the other hand, the company itself can be the one willing to certify some modifications, to make its product more competitive or for whatever reason.

That said, as I saw that it was a very important process in the daily routine of the certification office, I asked to the office if I could participate and follow a modification certification process to know how it worked and how it was done.

So in parallel, I continued my internship subject and the certification office gave me a modification to work on.

Please note that, for confidentiality issues, some information might be hidden.

MOD XXXX - EQUIPMENT/FURNISHING - UPDATE [REDACTED] CABIN CUSTOMIZATION

This modification was requested by an operator, who wanted to introduce a new galley installation on its aircraft. The modification consisted of the replacement of a galley already installed on the aircraft by another one. The new galley had a blanking plate installed in between in order to reduce the size of the oven, because the customer was not interested anymore in having a bigger one.

The certification office is in charge of checking that the justification the specialists give on the impact of this modification is airworthy and satisfies all the applicable requirements to the aircraft.

With this information, I needed to understand how the replacement of this galley could affect the aircraft. I had to find the regulatory documents applicable to the aircraft model of the customer, and to go through all the CS25 to check requirement by requirement if this modification affected whatever requirement.

The specialist in charge of the modification had already identified which were the chapters impacted, but in the certification office we need to guarantee that the specialist is right and that no other requirements are missed because it could compromise the safety levels. The chapters identified by the specialist were the 25.853(a)(b) and the 25.1301.

So I went through all the CS25 and noted down all the requirements related or that could be affected due to the replacement of a new galley apart from the ones identified by the specialist.

I found a lot of different chapters affected, and after the discussion with one certification specialist, some requirements were deleted because they could be justified somehow:

- ✈ **25.365 « Pressurised cabin loads »**: Not applicable because no galley compartment is pressurized and closed hermetically. There are no consequences on the galley in case of a depressurization.
- ✈ **25.609 « Protection of structure »**: Not applicable because the protective means against the erosion, corrosion and abrasion have already been installed in the cabin at a galley level. This paragraph concerns the aircraft structure itself and not on the equipment such as the galley.
- ✈ **25.793 « Floor surfaces »**: This paragraph is not applicable because the new galley version has the same dimension that the one replaced.
- ✈ **25X899 « Electrical bonding and protection against lightning and static electricity »** : The electrical connections of the new galley are the same as the previous ones, so no additional justification is required for this paragraph.
- ✈ **25.1351(a) « Electrical systems and equipment »**: After the technical note provided by the specialist, the electrical consumption of the new galley does not exceed the one of the previous galley.
- ✈ **25.1359 « Electrical system fire and smoke protection »**: This requirement conditions are already covered by the paragraph 25.853.
- ✈ **25.1431(a)(c) « Electronic equipment »** : This paragraph says that no electronic equipment should interfere with the radio installation. The galley is found in the rear part of the aircraft, so it does not interfere with the radio.

In the end, the chapters identified by the specialist were the ones really applying for the new modification, but as members of the certification office, our role is to make sure the specialist did not forget any extra requirement that could cause a problem in the future.

Afterwards, when we knew the technical note provided by the specialist was correct, the redaction of the documents started. Basically, in the certification office 2 different documents are created for each modification, the MAS (Modification Approval Sheet) and the TDCCCF (Type Design Change Compliance Check Form) to justify that the modification is in-line with the regulation and to specify which chapters of the regulation are affected as well as extra information that could be necessary.

In the end, this documents and all the Modification folder are reviewed and signed by an authorized Engineer, as well as the Head of Office of Airworthiness.

Here below, I show the documents I filled in with the help and supervision of a certification specialist:

First of all, there is the Type Certificate Modification Approval Sheet (TCMAS):



Form

Identification: [REDACTED]  
Validated on : 25/2/2016

---

**Type Certificate Modification Approval Sheet**

Type Certificate Change ref : [REDACTED] issue : 01

**TITLE:** EQUIPMENT/FURNISHING - UPDATE [REDACTED] CABIN CUSTOMIZATION

Type Certificate Change Classification MINOR  MAJOR

---

Type Design Change n° [REDACTED] PM n°: [REDACTED] issue: 01

Type Design Change Classification \* MINOR  MAJOR

\* for TD classification refer to TDRS MOD n°: [REDACTED]

Type design Change with effects on OSD: YES\*  NO

\* if YES :

<p><b>Cabin Crew</b> YES <input type="checkbox"/> NO <input checked="" type="checkbox"/></p> <p>OSD Chrono Ref <input type="checkbox"/></p> <p>Issue <input type="checkbox"/></p> <p>OSD Report rev n° <input type="checkbox"/></p> <p>Date <input type="checkbox"/></p>	<p><b>Flight Crew</b> YES <input type="checkbox"/> NO <input checked="" type="checkbox"/></p> <p>OSD Chrono Ref <input type="checkbox"/></p> <p>Issue <input type="checkbox"/></p> <p>OSD Report rev n° <input type="checkbox"/></p> <p>Date <input type="checkbox"/></p>	<p><b>MMEL</b> YES <input type="checkbox"/> NO <input checked="" type="checkbox"/></p> <p>OSD Chrono Ref [REDACTED]</p> <p>Issue 01</p> <p>OSD Report rev n° <input type="checkbox"/></p> <p>Date <input type="checkbox"/></p>
--	---	--

<p>Classification MINOR <input type="checkbox"/> MAJOR <input type="checkbox"/></p> <p>OSD ref <input type="checkbox"/></p> <p>Issue <input type="checkbox"/></p>	<p>Classification MINOR <input type="checkbox"/> MAJOR <input type="checkbox"/></p> <p>OSD ref <input type="checkbox"/></p> <p>Issue <input type="checkbox"/></p>	<p>Classification MINOR <input type="checkbox"/> MAJOR <input type="checkbox"/></p> <p>OSD ref <input type="checkbox"/></p> <p>Issue <input type="checkbox"/></p>
---	---	---

---

[REDACTED] must be attached to this document for approval of the change:

---

**Stand Alone OSD Change:** YES  NO

OSD Change Classification \* MINOR  MAJOR

\* for OSD classification refer to OSD Classification Form ([REDACTED] and/or [REDACTED] and/or [REDACTED])

<p><b>Cabin Crew</b> YES <input type="checkbox"/> NO <input type="checkbox"/></p> <p>OSD Chrono Ref <input type="checkbox"/></p> <p>Issue <input type="checkbox"/></p> <p>OSD Report rev n° <input type="checkbox"/></p> <p>Date <input type="checkbox"/></p>	<p><b>Flight Crew</b> YES <input type="checkbox"/> NO <input type="checkbox"/></p> <p>OSD Chrono Ref <input type="checkbox"/></p> <p>Issue <input type="checkbox"/></p> <p>OSD Report rev n° <input type="checkbox"/></p> <p>Date <input type="checkbox"/></p>	<p><b>MMEL</b> YES <input type="checkbox"/> NO <input type="checkbox"/></p> <p>OSD Chrono Ref <input type="checkbox"/></p> <p>Issue <input type="checkbox"/></p> <p>OSD Report rev n° <input type="checkbox"/></p> <p>Date <input type="checkbox"/></p>
---	--	---

---

OSCF form(s) [REDACTED] must be attached to this document for approval of the change:

---

<b>Reason for revision :</b>	<b>Issue 1 (Initial issue)</b>

This document is based on TDCF form and OSCF form

Writer Name: [REDACTED]

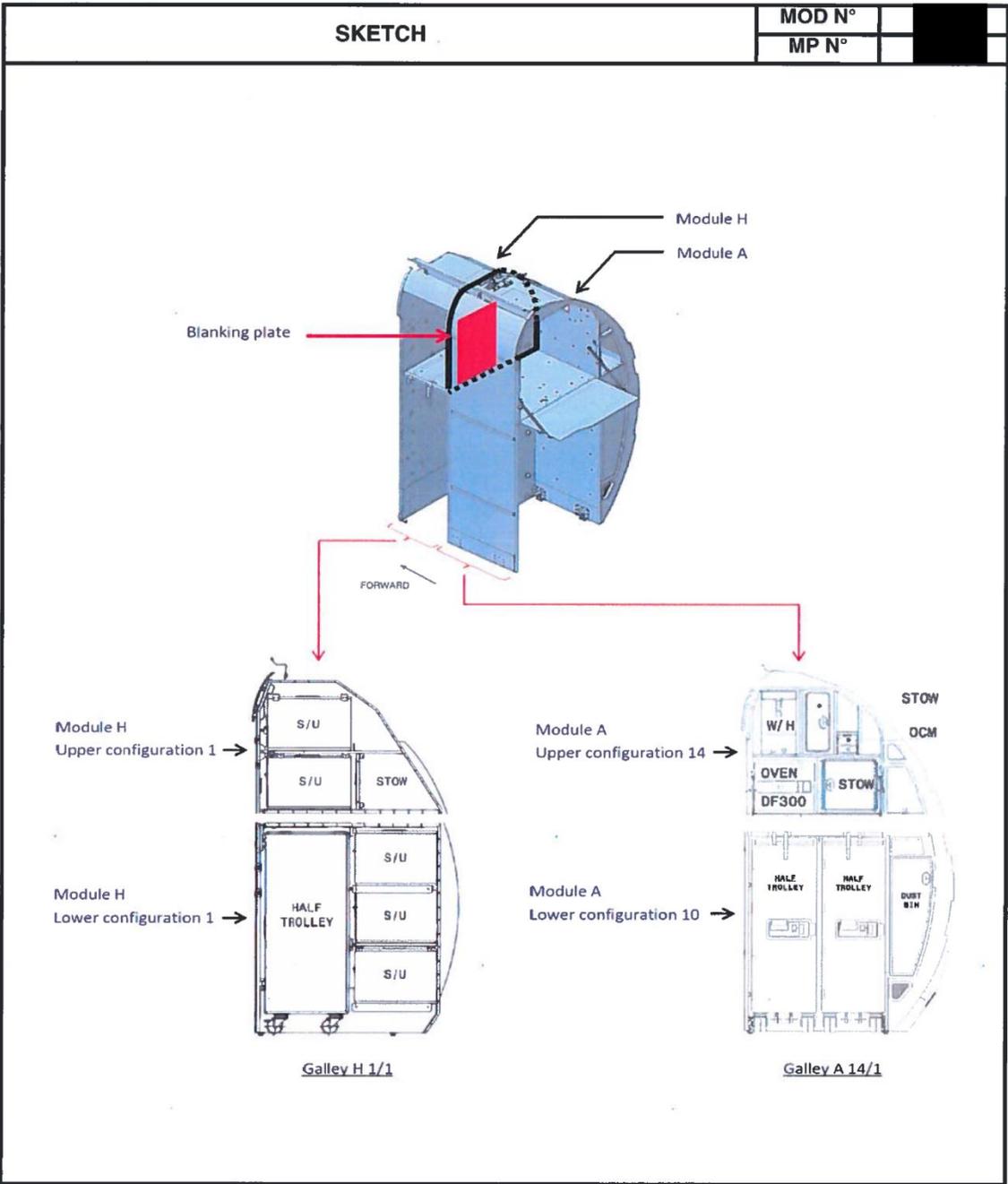
And here below an extract of the Type Design Change Compliance Check form

		Form	Identification : [REDACTED]
			Validated on : 2/25/2016
<b>Type Design Change Compliance Check Form</b>			
<b>TITLE :</b> EQUIPMENT/FURNISHING - UPDATE [REDACTED] CABIN CUSTOMIZATION		<b>MOD N°</b>	[REDACTED]
		<b>MP N°</b>	[REDACTED]
<b>ATA :</b> 25-30	<b>(1) Classification :</b> minor	<b>Retrofitable :</b> Yes	
	<b>(2) Level :</b> FAA: N/A TCCA: N/A		
<b>(3) AIRCRAFT NOISE :</b> No	<b>(3) FUEL SAFETY :</b> No	<b>(3) EWIS ICA :</b> No	
<b>Models :</b> ATR 72-212A			
<b>To be embodied before :</b> N/A		<b>Restrictions cancelled by this MOD :</b> N/A	
<b>Reason :</b> The customer requests to have an adaptation of the cabin customization (New galley installation).			
<b>General Description :</b> The modification consists in replacing the smart galley type [REDACTED] P/N [REDACTED] by a smart galley type [REDACTED], P/N [REDACTED]. The pre and post MOD galley differ from the installation of a blanking plate between the "A" and "H" module.			
MOD [REDACTED] - EQUIPMENT/FURNISHINGS-INSTALL A [REDACTED] OVEN. MOD [REDACTED] - EQUIPMENT/FURNISHINGS - UPDATE [REDACTED] CABIN CUSTOMIZATION.			
<b>Reason for revision :</b> Issue 1 (Initial issue)			
<b>Associated Modifications :</b> [REDACTED] and [REDACTED]			
<small>(1) Classification of Minor /Major according to PART 21A.91. If Major, for significant / not significant classification At the product level, does this change affects : 1) The general configuration : Yes / No * 2) The principles of construction : Yes / No * 3) The assumption used for certification Yes / No * Therefore according to PART 21A.101b (1), this change is classified : Significant / Not Significant * If Significant: Do exceptions as per PART 21A.101b (2) and b (3) apply Yes / No * If Yes : Change Product Rules process is not applicable → see nota in page 3 of this document If No : Change Product Rules process is applicable → see nota in page 3 of this document (2) According to FAA Technical Implementation Procedures for Airworthiness and environmental certification original issue dated May 5th, 2011 &amp; TCCA Technical Implementation Procedures for Airworthiness and environmental certification original issue dated September 20th, 2011. (3) According to [REDACTED] criteria</small>			
<b>* Strike whichever is not applicable</b>			
			<b>Issue 1</b> <b>Page 1 / 4</b>
<b>Submitted MOC</b>			

As well as the drawing we did to make easier the understanding of this modification and the change done with the replacement of the galley. The red plate is the one installed on the galley in order to make the oven smaller as the operator wants.

Type Design Change Compliance Check Form

Identification : [REDACTED]



In the end, the modification was approved by the Head of Airworthiness and it was really interesting to see how my work was useful to the company and get familiarised on the modification certification process of ATR.

MOD	Class	PM	Model	Date appro. MAS / appro. EASA	MAS ISSUE	FRT issue	TITRE
█	minor	█	72-212A	4-août-17	1	1	EQUIPMENT/FURNISHINGS - UPDATE █ CABIN CUSTOMIZATION

## 12. Confidentiality questionnaire

**Name or the Intern:** Jordi CLARAMUNT

**Company:** ATR

**Course:** IENAC14

**Internship subject:** FAA regulation analysis for  
ATR ETOPS validation

# CONFIDENTIALITY QUESTIONNAIRE

The internship will include the writing of a thesis and its defence before a board of examiners. Some confidential information on your Company might be included in it.

- Please let us know of your requirements regarding the circulation of the thesis and the organisation of the oral presentation. In the absence of a reply from your company, the thesis will be considered non confidential and the oral presentation will be public.
- We would like to draw your attention to the fact that a thesis is a precious source of information on companies and employment opportunities for our students. It is also a mean to enhance communication on your company towards future students.
- A confidential thesis is referenced but not accessible despite its technical and scientific value. We encourage our students to include confidential information in an annex to enable access to the thesis without disseminating confidential data.

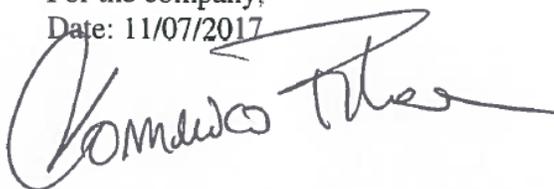
### 1-Thesis Confidentiality

- This thesis is not confidential
- This thesis is confidential for a period of 5 years after the oral presentation
- This thesis is confidential indefinitely

### 2-Oral Presentation

- All professionals interested by the subject matter can attend
- Only members of the jury and participants vetted by the company can attend

For the company,  
Date: 11/07/2017



The student,  
Date : 11/07/2017

