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REQUIREMENTS FOR CAT SET-IMC CERTIFICATION

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Abstract

The diploma thesis deals with requirements for certification of single-engine turbine aircraft involved in commercial air transport and operated in instrument meteorological conditions or at night. The work in the first part introduces the theoretical background of the whole problem and presents to the reader the reasons why the approval of this type of operation in Europe was necessary. Subsequently, the second part of the work states all necessary requirements for obtaining approval for this type of operation, including the legislative framework and the risk analysis. The following section in work demonstrates different values of risk periods along the same route, depending on different conditions affecting aircraft performance. It also introduces possible new means for increasing safety in case of engine failure and subsequent drift down. The aim of the work is to provide a comprehensive overview throughout the certification process and offer existing operators new solutions for their SET-IMC operations, which could also improve their level of safety.

Keywords

SET-IMC. Commercial air transport. Certification process. Risk analysis. Reliability program. Glide advisor.

1. INTRODUCTION

Not so long ago, the commercial operation with single-engine turbine aircraft in instrument meteorological conditions was approved by European Union Aviation Safety Agency. Since then, this type of operation has enjoyed popularity and has been on an upward trend among operators. This was also the main motivation for the development of this work as a comprehensive study of process for obtaining approval for this type of operation. At the same time, the aim of the work was to evaluate the current state of the issue and to provide current as well as future operators with a number of operational recommendations.

The thesis is divided into several logical parts. In the first part, the thesis describes the background of this issue at home and in the world. Explains the reasons for the differences in conditions in different countries of the world and why the harmonisation of this rules was necessary. The following section sets out the legislative requirements, market analysis and lists available programmes supporting this type of operation. The legislative requirements section deals with the current legislative requirements for aircraft equipment as well as for individual operators. The task of the market analysis was to highlight the growing trend of this sphere and introduce current aircraft on the market. The number of these aircraft in Europe has increased over the last period since the approval of this operation. This has created an opportunity for new operators to emerge. The preview of available software provides potential operators with an overview of the available technologies and how they can be implemented in their operation. The last part of the thesis provides information on the process of obtaining this permission and analyses a sample risk analysis calculation for two different flights. The thesis provides recommendations for operators in the conclusion.

The work concludes with the provision of guidance material for the process of obtaining certification approval for this type of operation, together with non-binding recommendations obtained through study and from author personal experience.

2. THEORETICAL BACKGROUND

Commercial operations with single-engine aircraft in Europe were approved for years. This was valid only for visual flight rules (VFR) and by day. Understandably, the pressure was later put on the authorities to extend this operation to instrument flight rules (IFR) and night. The term CAT SET-IMC has been and still is a quite unknown concept. It stands for commercial operations under special approval for single-engine turbine aircraft operated in instrument meteorological conditions or at night. Until now, only multi-engine aircraft have been allowed to engage in such commercial operations in European Union Aviation Safety Agency (EASA) countries. With the increasing number of single-engine turbine aircraft and the increasing reliability of their powerplants came the requirement from contracting states to certify this type of operation.

Several member states have previously expressed the need to develop specific operational and airworthiness requirements to allow commercial air transport with single-engine aircraft at night or in IMC. Increased engine reliability has led to the development of single-engine aeroplanes which are more economical, less environmentally harmful and have lower maintenance costs than multi-engine aeroplanes. [1]

Later the EASA developed NPA 2014-18 dealing with issue of CAT SET-IMC certification in EASA countries. This document proposed new provisions specifically drafted for CAT SET-IMC, which will amend Annex II, IV and Annex V to Regulation (EU) No 965/2012. The specific objective was to enable CAT SET-IMC operations in Europe through cost-effective rules that mitigate the risks associated with one engine failure to a level comparable to or similar to twin-engine aircraft operations. [2]

2.1. NPA 2014-18

This Notice of Proposed Amendment proposed changes to currently effective regulations and decisions. The text of NPA has been developed by the Agency based on the input of the Rulemaking Group RMT.0232/0233. In general, the document contains procedural information related to this task, technical content, proposed new requirements and regulatory impact assessment showing which conditions were considered. [2]

The main issues which were covered in this NPA are following: [2]

- some Member States currently allowed some of their operators to operate CAT SET-IMC flights under an EU-OPS exemption. These exemptions were based on different sets of conditions, which prevented a level playing field for operators who may operate CAT SET-IMC. In addition, European union (EU) operators face competition from Third Country Operators (TCO) who have been authorised by their authorities to operate CAT SET-IMC.
- issue of harmonisation as some foreign aviation authorities allowed for quite a long time this kind of operations
- ICAO alignment issue since ICAO allows these operations since 2005
- an environmental issue, as there were many single-engine aircraft available on the market at the time with better fuel efficiency, lower emissions and better environmental footprint.
- an economic issue since the current situation prevented the opening of new routes which could be operated safely and efficiently only by some single-engine turbine aeroplanes due to performance or operating costs.

2.1.1. Affected parties

Parties affected by this problem were mainly aircraft manufacturers, operators and national aviation authorities. Until then, only exempted operators could operate these flights, and then only in the territory of their own States or in the territory of Contracting States after first obtaining an exemption. However, Member States had to inform the European Commission of any exemptions they granted to individual operators. Operators and producers alike have been disadvantaged by the legislative situation in Europe. Manufacturers were producing aircraft designed and capable of operating under CAT SET-IMC conditions. Unfortunately, under these conditions they could only be operated abroad. In Europe, they could only fly non-commercially. [2]

At the time, there were three main types of aircraft on the market meeting all these requirements, namely the Cessna C208, Socata TBM700/850 and Pilatus PC-12. It should be noted that these three types accounted for 78% of the single-engine turboprops operating in Europe at the time and 74% in the USA. Regarding data on the current status of single-engine and multi-engine aircraft in service, the General Aviation Manufacturers Association carried out an analysis of the current numbers of aircraft in service in Europe and in the USA. The analysis identified 368 single-engine turboprop aircraft and 557 multi-engine turboprop aircraft in Europe. By comparison, the United States has a fleet of single-engine turboprop aircraft consisting of 2 647 aircraft and a fleet of multi-engine turboprop aircraft registered in the United States consisting of 4 695 aircraft. The ratio of aircraft in service in Europe and the USA was fairly equal, but in the USA at that time there were no restrictions even on single-engine piston aircraft. It could be therefore assumed that the approval of this type of operation in Europe would result in the development of this industry. [2]

Evidence that the current legislation has not favoured either operators or manufacturers can be seen in the following table, where it is obvious that there has been a significant reduction in the number of single-engine turbine aircraft in operation in the recent period.

Table 1: Number of SET aircraft operated in Europe in CAT [2]

	2005/2006		2013	
	No	Operator	No	Operator
France	2 1 3 1	Finistair Atlantic Airlift (AAL) Air Caraibes Aviation Sans Frontières	1 1 2 3 1	Finistair CAIRE Aviation Sans Frontières Saint-Barth Commuter VolDirect
Finland	0	X	1	Hendell Aviation
Germany	2	OLT	0	X
Greece	4	Aeroland	0	X
Norway	7 2	BenAir Kato Air	3	BenAir
Spain	7	AirPack Express	0	X
Sweden	3	Nordflyg	1	Nordflyg
TOTAL ESTIMATED FLEET	**32**		**13**	

In 2005/2006 there were 10 operators in Europe with a total of 32 single-engine turboprops in CAT. However, by 2013, this number had dropped to 8 operators with only 13 aircraft. In the USA, the opposite trend has been observed, namely an increase in both the number of these aircraft and operators.

The US fleet of single-engine turbine aircraft in commercial service has grown in recent years. In 2006, there were 542 aircraft in use by Part 135 regulated operators, but in 2013 this fleet increased by 24% to 673 aircraft. The main type was the Cessna C208. The following table shows how the US Part 135 single-engine turboprop fleet changed between 2006 and 2013 by type. [2]

Table 2: Number of SET aircraft operated in US under part 135 [3]

	2006	2013
CE-208	472	488
Kodiak-100-100	0	6
PA-46-500TP	2	8
PC-12-45	64	99
PC-12-47/E	0	68
TBM-700-	4	4
TOTAL SET Aeroplanes	**542**	**673**

2.1.2. Safety risk assessment

With the passage of time, the reliability of turboprop engines used on single-engine aircraft has reached a level of less than 10 failures per million flight hours. This value was the propulsion reliability target according to QINETIQ and JAA NPA OPS 29 Rev.

2. This rate was considered as the basis for this risk assessment regarding engine reliability.

When considering fatal accident rate of CAT SET-IMC operations, the study considered the latest National Transportation Safety Board (NTSB) statistics which were showing over the last 10 years an average fatal accident rate for Part 135 operations of 5.51/million flight hours. The data coming from the Breiling 2012 Annual Single Turboprop Powered Aircraft Accident Review was then considered to make the comparison between single-engine turboprop and twin turboprop aeroplanes operations. The content of this study was the operation of twin-engine turboprop aircraft and single-engine turboprop aircraft in the US and Canada through 2010. For the purposes of this study, only the years 2005-2010 have been considered. The fatal accident rate has been shown to be 3.96/million flight hours for twin-engine turboprops and 5.61/million flight hours for single-engine turboprops. At that time, within NPA OPS 29 Rev 2, only three aircraft were able to meet these requirements, a Cessna C208, a Pilatus PC-12 and a Socata TBM700/850. The resulting fatal accident rate for these aircraft was 4.44/million flight hours. Consequently, the safety rate of twin-engine and single-engine aircraft designed for this type of operation was almost the same, approaching 4/million flight hours. This target fatal accident rate of no more than

4 per million flight hours has been later chosen as the basis for this National Safety Report. [2]

As CAT SET-IMC in Europe has not been approved as such until then, apart from exemptions granted to some States and operators, it has not been possible to determine the current level of safety of this type of operation in Europe. Also, individual States and operators had approvals issued under different conditions, whether based directly on ICAO Annex 6 or on JAA NPA OPS 29 Rev. 2. Thus, the safety performance results of this operation were not considered relevant for comparison. Some States have applied an uncontrolled environment for this operation and some have approached the requirements set out in JAA NPA OPS 29 Rev 2. In order to assess the risk of such operations, the rulemaking group conducted a risk assessment of CAT SET-IMC operations. To this end, the group identified 8 main scenarios and for each of them evaluated the consequences in terms of probability and severity, first without any specific mitigations and then taking into account the mitigations under NPA OPS 29 Rev. 2. The main objective of this risk assessment was to determine whether the sum of the residual risk for each scenario is less than the selected target for fatality rates as described before. This risk assessment was also based on the selected powerplant reliability rate of 10 per million flight hours. The JAA NPA OPS 29 Rev 2 Regulatory Impact Assessment and the QINETIQ risk assessment were used for the resulting risk assessment. This risk assessment concluded that the mitigation contained in the NPA OPS 29 Rev 2 were found sufficient to at least allow reaching the required target fatal accident rate for CAT SET-IMC and that no further mitigation was specifically required reach this target. [2]

2.2. Comment-Response Document 2014-18

This document contains the summary of comments on NPA 2014-18 and the responses provided by the Agency as well as full set of individual comments. By the end of the consultation period, 157 comments had been received from affected parties including aircraft manufacturers, air operators, organisations and national aviation authorities. [4]

In general, these comments supported the implementation of the SET-IMC concept of operations as presented by NPA 2014-18. As a result, these comments led to the modification or addition of the required changes to the regulations.

As a result, 26 commenters provided 157 comments including 2 manufacturers, 8 competent EU aviation authorities, 7 air operators and several associations. Of the 26 commenters, 10 expressed a clear affirmative position on the proposed concept and only one was opposed to the proposed SET-IMC operation. [4]

The Agency accepted or partially accepted 77 comments which was approximately 49 � and 35 comments (22�) were noted or the commentator had no comment to the NPA. Only 45 comments (29�) were not accepted. [4]

2.3. Commission Regulation (EU) 2017/363

This regulation was adopted on 1. March 2017 and modified the current version of Regulation 965/2012 regarding the operation of single-engine turbine aircraft in IMC conditions or night. In addition, this regulation addressed the modification of hazardous cargo transportation training for special commercial operations, non-commercial complex aircraft operations, and special non-commercial complex aircraft operations.

The document lays down provisions relating to single-engine turbine operations in IMC or at night. Among other things, these provisions contain conditions for the approval of this kind of operation, namely that the State must ensure compliance with all conditions for approval of this operation. These conditions require the provision of a certain level of aircraft equipment, additional flight crew training, operating procedures, engine monitoring and reliability. It mandates the harmonisation of the same conditions between Member States and places responsibility on individual States and their competent authorities to issue approvals to operators for this type of operation. This Regulation provides for a transitional period during which operators who have previously obtained an exemption for this type of operation will be allowed to operate their aircraft under the specified conditions. By the end of this period at the latest, operators will have to apply for a new approval for their operation already under the new conditions laid down in Regulation 965/2012. [5]

The attachment to this Regulation sets out the individual conditions of approval for this operation and also contains the wording of the individual paragraphs and clauses as they are to be amended. With the introduction of this regulation ended the era when commercial operations with single-engine aircraft in IMC or night were prohibited in Europe.

3. STATE OF THE ART

This part described the current situation regarding the conditions of operation and obtaining approval for this type of operation. These requirements for certification are contained in Regulation No. 965/2012. For the execution of commercial air transport operations with single-engine turbine aircraft in instrument meteorological conditions or night, the operator shall obtain an approval for SET-IMC from a competent authority.

3.1. Requirements for operators

The regulation sets out a number of conditions that must be met and submitted to the competent authorities in order for a SET-IMC approval to be issued. The main requirement is to achieve an acceptable level of turbine engine reliability in world fleet operations for a given airframe and engine combination.

Specific maintenance instructions and procedures shall be developed to ensure the planned level of continuing airworthiness and reliability of the aeroplane and its propulsion system, which shall be included in the operator's aircraft maintenance programme. This should also include an engine trend monitoring programme except for aircraft with automatic trend monitoring system and also propulsion and associated systems reliability programme. [6]

The operator should establish the conditions for the crew composition and the training programme for those crews participating in these operations. This type of operation requires additional crew training, as there are certain specificities associated with it.

The operator must submit to the Authority elaborated operating procedures including the following sections: [6]

- aircraft equipment list, including its limitations and appropriate entries in the Minimum equipment list (MEL)
- flight planning
- normal procedures
- contingency procedures including non-normal and emergency procedures following a propulsion system failure, as well as forced landing procedures in all weather conditions
- monitoring and incident reporting

3.2. Risk assessment

The risk analysis is based on a calculation of the anticipated risk of an emergency landing with fatalities in case of engine failure for each planned route. Based on this, the operator determines the risk period to which the passengers and crew on a given flight are exposed. Based on this analysis, if there is no suitable landing site in the area, the competent Authority may extend this maximum risk period.

The concept of SET-IMC is based on engine reliability rate for all causes of 10 per million hours. In compliance with SET-IMC requirements this allow for overall fatal accident rate of 4 per million flight hours. According to experience with engine failures contributing to fatal accidents with 33%, for the purposes of this risk assessment the target fatal accident rate was reduced to 1.3x10-6. [7]

3.2.1. Methodology

The methodology of this analysis focuses on determining the probability of failure to reach a suitable landing site to execute a successful landing in the event of an engine failure. A successful landing is considered to be one where the aircraft lands on a surface where it is expected that no serious injury or fatality will occur, even though the aircraft may be substantially damaged. The objective of this methodology is to create a risk profile for each individual route, including departure, en-route, arrival and landing dividing this flight into appropriate segments and estimating the risk for each of these segments when engine failure can occur. [7]

When considering these individual segments in the resulting risk period, the following aspects must be taken into account. At first standard procedures of operator should be considered including contingency procedures in case of engine failure. Next the height of the airplane and lateral position at which the engine failure occurs. Meteorological conditions should also be taken into account including actual ambient temperature, humidity and pressure as well as cloud ceiling and visibility.

The duration of each phase of the flight determines the exposure time to expected level of risk. By summing up all the individual flight segments risk periods, the cumulative risk period can be obtained. The estimated risk is based on the following calculation. [7]

Segment risk factor=

$$\frac{segment\ exposure\ time\ (s)}{3600 \times probability\ of\ unsuccessful\ landing \times assumed\ engine\ failure\ rate\ per\ hour}$$

This type of matrix is often used during risk assessments to determine the level of risk by considering both severity against likelihood. This helps in decision making and identifying the level of risk connected with this. Below is the example of matrix used for considering level of risk for engine failure during each segment of flight.

		Likelihood							
		A 99-100%	B 90-99%	C 65-90%	D 35-65%	E 10-35%	F 1-10%	G 0-1%	H 0%
Severity	1								
	2								
	3								
	4								
	5								

Table 3: Risk assessment matrix

3.2.2. Risk tolerability and mitigating measures

The operator must assess all risks associated with operating on the routes in IMC or at night. In assessing the current risk, he should take into account the current weather on the route, the weather forecast, the availability of navigation and flight services, the applicable NOTAMs and the traffic density. In the event that the operator cannot maintain an acceptable level of risk, he must take all available corrective measures to ensure a sufficient level of safety. [7]

Measures mitigating level of risk: [7]

- Re-route a flight within a range of more suitable landing sites
- Re-route flight to an area where the suitable weather is present

- Use higher cruise level to extend glide range

Delay the flight to avoid weather or busy traffic

3.3. Aircraft equipment requirements

The one step in obtaining a CAT SET-IMC approval is to develop a project plan and assess the ability to meet all of the requirements for this certification. Before submitting any documents to the Authority for assessment, the operator should assess whether it will be able to comply with the published requirements.

The following items should be considered to ensure suitability of aircraft for CAT SET-IMC operation:

- Electrical generating system
- Attitude indicators
- Safety belts
- Weather radar
- Oxygen
- Navigation to landing sites
- Radio altimeter
- Landing lights
- Emergency electrical supply
- Ignition system
- Lubrication and debris detection
- Emergency engine power control

Aircraft intended for CAT SET-IMC operation must have the above mentioned equipment installed and fully operational. These requirements are stated in EU Regulation No. 965/2012 subpart L/SPA.SET-IMC.110.

3.4. The number of aircraft

General Aviation Manufacturers Association (GAMA) is an association whose objective is to promote and develop the safety and interests of commercial and general aviation. GAMA obtains aircraft delivery data from 39 manufacturers, including detailed aircraft registration data in 47 countries, representing the majority of the market share. Annual data containing statistics about shipped aircraft, hours flown per type and fleet type statistics are provided in this document on a regular basis. [8]

Table 4: Aircraft Shipments and Billings [8]

Year-end Aircraft Shipments and Billings

Aircraft Type	2020	2021	% Change
Piston Airplanes	1,321	1,393	5.5%
Turboprops	443	527	19.0%
Business Jets	644	710	10.2%
Total Airplanes	2,408	2,630	9.2%
Total Airplane Billing	$20.0 B	$21.6 B	7.6%
Piston Helicopters	142	181	27.5%
Turbine Helicopters	517	645	24.8%
Total Helicopters	659	826	25.3%
Total Helicopter Billing	$2.9 B	$3.7 B	28.0%

In 2021, GAMA released 2021 General Aviation Aircraft Shipments and Billings Report. It is the latest annual report showing the actual number of aircraft delivered to customers, based on their categories. An initial comparison shows that all segments have seen an increase compared to the previous year. These figures also demonstrate a gradual return to pre-pandemic values and a recovery of the aircraft market.

Aeroplane shipments in comparison with 2020 saw an overall increase 9.2 ⍰ with 2 630 units. Of these segments, turboprops saw the largest increase of 19.0 ⍰ with 527 units at the end of 2021. It clearly shows that this segment of aviation is currently the most developing among the others. [8]

3.5. SET-IMC certified aircraft types

As seen in the previous table, turboprops have seen a rise in popularity in recent years. In Europe, this is mainly due to the approval of SET-IMC operation. There are several manufacturers on the market who offer individual models that meet the conditions for this type of operation. The next table shows chronologically arrival of individual models on the market.

Table 5: SET-IMC certified aircraft [author]

Aircrft type	Purchace price	Number of seats	Cruising speed	Range	Number of ACFT
Cessna 208	2,15 mil €	10-14	186 KTS	1 070 NM	1373
PC12	4,45 mil €	8-11	290 KTS	1 850 NM	1293
TBM850	3,1 mil €	6	250 KTS	1 500 NM	338
Piper M500	2,1 mil €	6	260 KTS	1 000 NM	445
TBM900/960	4 mil €	6	330 KTS	1 730 NM	408
Piper M600	3,05 mil €	6	274 KTS	1 658 NM	194

The data in the table are summarised for the period 2006-2021 and are based on worldwide statistics provided by GAMA. From the table, it can be seen at a glance that the aircraft with the longest history on the market is also the most represented. In Europe the predominant type of aircraft is Pilatus PC12 but on the other hand in USA the dominating aircraft is Cessna C208 in many variants. [8]

As this type of operation has been approved and is approved almost worldwide, more new aircraft types are expected to come to the market in the near future.

3.6. Available software

In today's electronic age, there are many programs and software used in aviation on the market. These programs offer many possibilities, whether they are planning programs, navigation programs or programs that calculate the performance of the aircraft. The largest share of the aviation market today is still held by multi-engine aircraft. Unfortunately, the aviation software market is also adapted to this.

Since commercial operations with single-engine turbine aircraft in IMC conditions has not been approved in Europe for so long, there are still not a large number of applications on the market supporting this type of operation regardless of whether they are planning software or electronic flight bag (EFB) software. This problem, on the one hand makes the process of obtaining an approval under consideration by the Transport Authority more difficult and otherwise reduces the options available to flight crews in selecting the appropriate software for their use.

There are currently several programs available on the market providing an environment for this kind of operation. The following chapters describe some of the features of these programmes.

3.6.1. ForeFlight

ForeFlight belongs to the Boeing company, which has many years of experience in the aerospace industry. ForeFlight Mobile is the integrated flight app that gives users all the essentials for visual VFR and IFR route planning, flight plan filing, and flying worldwide. This application offers users two different environments. For the planning department, it offers an interface ForeFlight Dispatch and for the flight crews, it offers the ForeFlight Mobile application.

It incorporates these sub applications:

- ForeFlight Dispatch
- Fore Flight Mobile EFB
- ForeFlight SETOPS

3.6.2. Garmin Autonomí

Garmin is one of the leading avionics manufacturers in the market. Every year it comes up with new instruments and features that increase the level of safety and reduce the workload for the crew. The latest innovation introduced at the turn of the year is the range of autonomous functions offered by its new avionics equipment.

It incorporates these programmes:

- Autoland
- Electronic stability and protection
- Emergency descend mode
- Smart glide

4. CERTIFICATION SPECIFICATIONS CAT SET-IMC CERTIFICACION

Obtaining certification for this type of operation is a complex and lengthy process. The content of this chapter should help potential candidates for this certification to speed up the process and to understand the specifics of this operation in more detail.

The previous chapters explained the background to this problem and then presented the legislative framework relating to it. This chapter demonstrates the practical application of the before-mentioned regulations and laws. The following figures should be taken as recommendations and information only. The final responsibility lies with the relevant authorities under what conditions and to what extent they will approve the operator for this type of operation.

As is already known from the regulation, it is operations requiring Specific Approval. This means that previously the operator should have been granted an Air Operator Certificate (AOC).

4.1. Operational manuals

It is a controlled document required within each organisation that has been granted an AOC. It is important that these manuals are prepared in accordance with the prescribed structure of this document and contain only the necessary items reflecting the type of operation of the organisation concerned.

4.1.1. OM-A

OM-A focuses in general on the organisation. It is a document that does not focus specifically on one type of aircraft. It contains the basic policies of the company, its structure and the division of responsibilities. It has a standardised structure and contains some of the following sections:

- Organisation and responsibilities
- Management system
- Crew composition
- Qualification requirements
- Flight time limitations
- Operating procedures

If the operator operates more than one aircraft type and not only SET-IMC aircraft, then a separate manual shall be issued for that operation. This manual has several changes and additions related to the specifics of this operation.

4.1.2. OM-B

OM-B is most often used directly by pilots. It contains type-related procedures. In the case of SET-IMC operations, it contains additional restrictions on the aircraft approved for the operator's type of operation. It also contains detailed procedures and workload distribution in the event of engine failure and subsequent drift-down.

4.1.3. OM-C

This contains route and aerodrome information. It can also contain some recommendations for contingency situations in SET-IMC flying. For example after lift-off crew shall consider delaying the landing gear retraction until the briefed altitude for safe straight forced landing on the rest of the same runway is reached. Also, in case of engine failure, the actual speed can be traded for altitude, until reaching a best glide speed. On the approach, crew shall keep higher speed during standard 3 degrees approaches to have sufficient energy available to reach a runway in case of engine failure.

4.1.4. OM-D

The last one is the training manual. In the case of SET-IMC operations, it incorporates additional requirement for flight crews. As mentioned before, minimum flight time requirements for flight crews are here. It states minimum flight time requirement for commander as minimum of 700 hours total time and a minimum of 400 hours as pilot in command.

This part focuses especially on training of emergency procedures and failures of individual systems. The regulation directs that, where a suitable full flight simulator is available, training and testing should be conducted on it. Unfortunately, since the SET-IMC operation is not available for a long time, there are not enough suitable devices available. In normal practice, training and checking are carried out on the aircraft themselves. However, the use of these training devices would have a great contribution to the safety of this operation and to the training of the crews, as various situations can be simulated on the simulator.

4.2. Validation flight

The validation flight is the last step before issuing an operational specification on the SET-IMC. After submitting all the required documents to the Authority and preparation of all operations manual, the validation flight can be conducted. The validation flight should be conducted under VMC conditions with a person authorised by the competent Authority.

It is a normal flight, where the loss of thrust of the engine is simulated at a given moment. This is simulated by running the engine at idle speed. At the same time IMC conditions are simulated for the pilot. The purpose of this flight is to demonstrate to the competent Authority the ability to meet all conditions in reality and to make a safe landing at the chosen alternate aerodrome.

Following the completion of this flight, the Authority is expected to issue a new operational specification to an operator with SET-IMC approval.

4.3. Risk period comparison

Part of the planning for each SET-IMC flight is a detailed analysis of its route. The flight path should be selected by taking into account the current availability of emergency areas during the flight. These areas should be chosen on the basis of predetermined priorities. Priority should be given to airports with instrument approaches to at least one runway. In the event that such an aerodrome is not available at some stage during the flight, airports with runway lighting and a non-instrument runway should be considered. If such an airport is not even available, the criteria are progressively reduced. The availability of suitable airports is not the only aspect to consider when planning. The level of risk is also influenced by other factors such as winds aloft, weather, aircraft performance, etc. To show how these factors affect the flight, two flights were compared.

4.4. Recommendations

4.4.1. Risk analyses

From the analysis it was found that changing aircraft performance is not taken into account when using ForeFlight's automated risk analysis. Only the standard model is used. To increase the accuracy of the calculation of this analysis, it is recommended to use actual performance models.

4.4.2. Glide advisor

Currently available glide advisor systems do not take into account the current wind drift and speed. This can cause major inaccuracies in the calculations at high altitudes. Integrating actual winds into these systems would significantly improve their accuracy.

5. CONCLUSION

The diploma thesis deals with the commercial operation of single-engine turbine aircraft in IMC in European countries. For a long time this type of operation was not approved in Europe, but recently there has been a change in the legislation and therefore the approval for this operation was granted. As this type of operation is characterised by lower operating costs, greater accessibility and low environmental footprint, it has great potential for growth in the future.

The first section of the thesis presents the history of this problematic, mainly in Europe and the USA. In the US, these operations have been approved for more than 20 years, but in Europe, on the other hand, they were prohibited until 2017. Due to safety concerns, this operation was approved with several restrictions and conditions. This is followed by another part of the paper which describes the current state of the art. This section is divided into several sub-sections, which further describe the legislative framework of this problem, the current situation on the SET-IMC aircraft market with brief description of these aircraft and finally a list of available software related to this type of operation.

The final section provides information directly related to the procedure for obtaining this special operation approval, including the process of obtaining AOC. For a better insight and understanding of the risk analysis, the last section provides a sample risk assessment and the principle of calculating the whole risk period for a given flight. The work provides several recommendations on flight planning but also some recommendation on flight software being used. From the above it can be concluded, that the objective of the work to analyse this operation and provide a guidance manual throughout the certification has been met.

This work can be used for the needs of various organizations or operators intending to establish this type of operation. As aviation and its technologies are rapidly evolving, the work also provides an opportunity for further risk analysis and the development of corrective actions along with further recommendations for use of new software and electronic devices. It also offers the possibility of extending the study on operations and risks to non-EU countries, as this work dealt with operations under EASA conditions only.

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