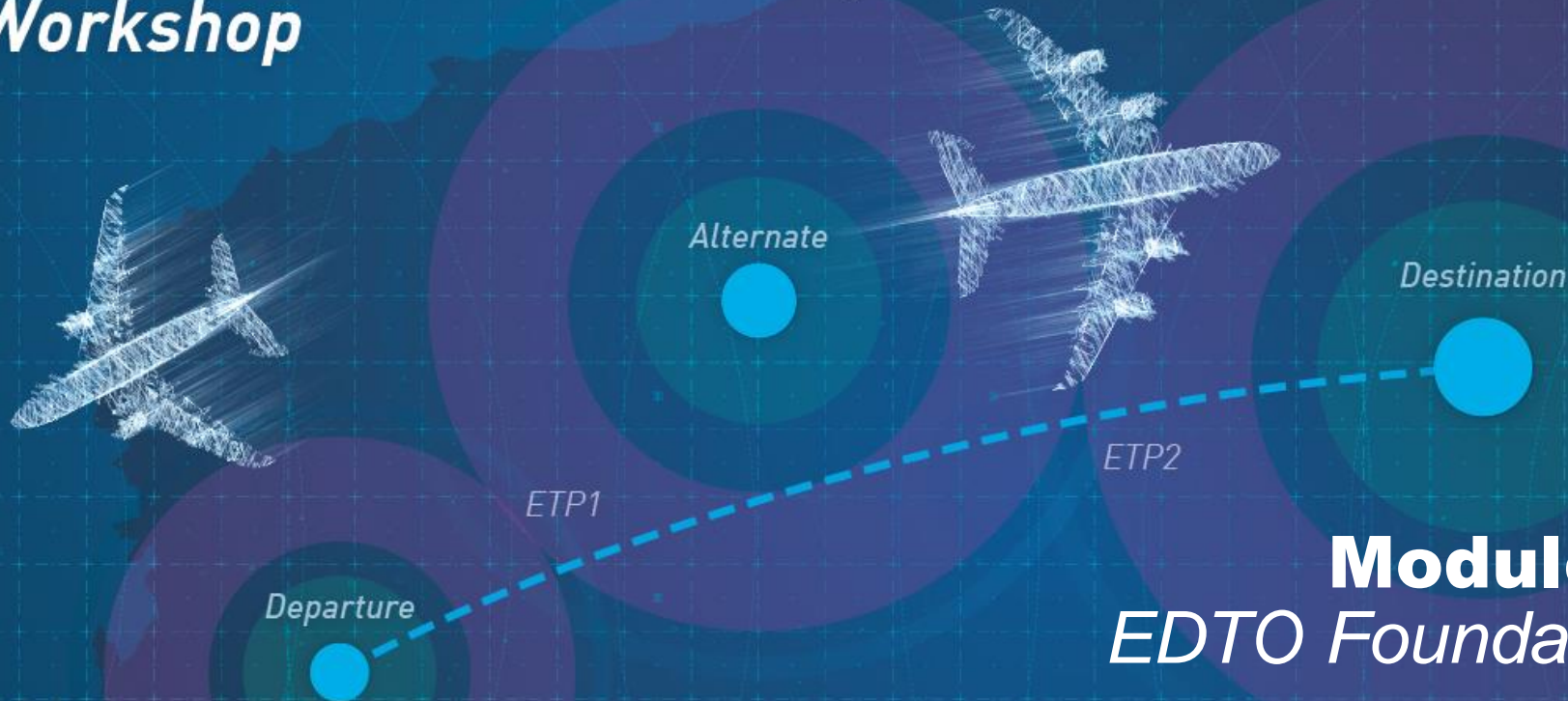


Extended Diversion Time Operations Workshop



Module 2 *EDTO Foundation*



ICAO

Proudly in partnership with

AIRBUS



**Module 1**

Course Introduction

Module 2

EDTO Foundation

Module 3

Approval Process

Module 4Type Design & Reliability
Considerations**Module 5**Flight Operations
Considerations**Module 6**Maintenance
Considerations**Module 7**

Continued Surveillance

Module 8Implementing EDTO
Regulations**Module 9**

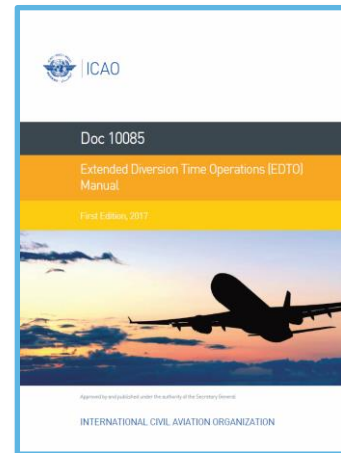
Assessment

Module 10 – Wrap Up



At the end of this module, participants will be able to understand the fundamentals concepts of EDTO

Doc 10085: Extended Diversion Time Operations (EDTO) Manual



The following symbol indicates a reference to the EDTO Manual throughout the modules of this workshop:



- Annex 6, Part 1:** Operation of Aircraft
Chapter 1: Definitions
Section 4.7: Additional requirements for operations by aeroplanes with turbine engines beyond 60 minutes to an en-route alternate aerodrome including extended diversion time operations (EDTO)
- Annex 8:** Airworthiness of Aircraft, Part 1. Definitions
- Doc 7300:** Convention on International Civil Aviation (Chicago Convention)
- Doc 8335:** Procedures for Operations Inspection, Certification and Continued Surveillance
- Doc 9734:** Safety Oversight Manual, Part A
- Doc 9760:** Airworthiness Manual, Part III and V
- Doc 10059:** Manual on the implementation of Article 83 *bis* of the Chicago Convention

Aeroplane symbol convention

The following aeroplane pictograms are used throughout the modules of this workshop with the following meaning:

Aeroplane with **2 engines**



Aeroplane with **3 engines**



Aeroplane with **4 engines**



Aeroplanes with **more than 2 engines**

Aeroplane with **2 or + engines**





Aeroplane information

The WonderPlanes® files!

For the purpose of this workshop, it has been decided to not refer to existing airplanes from OEMs such as Airbus or Boeing, but instead to use technical data of the aeroplanes from the fictitious airplane maker **WonderPlanes®** !

The technical data of these aeroplanes invented for the purpose of this training are based on realistic figures and provides typical yet generic examples of aeroplanes that may be operated on EDTO.

The **WonderPlanes®** product range:

Model	Engines	Category
WP-911	Greenpush RG3350-89	Aeroplane with 2 engines
WP-911SuperPlus	Greenpush RG3350-SP	Aeroplane with 2 engines (derivative from WP-911)
WP-Millennium	MegaThrust MT2050	Aeroplane with 2 engines (new design)
WP-3skies	MegaThrust MT2021	Aeroplane with 3 engines (new design)

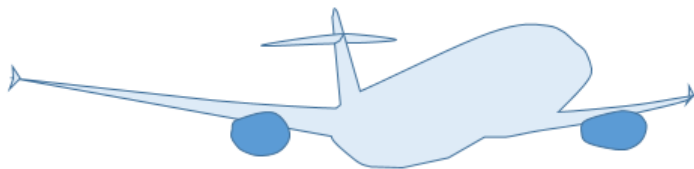


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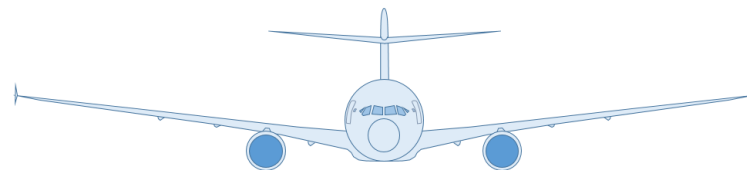
SAFETY

Aeroplane information

The WonderPlanes® product range

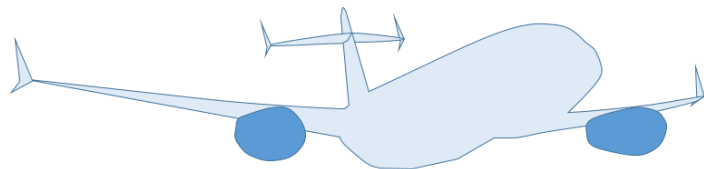


WonderPlanes®

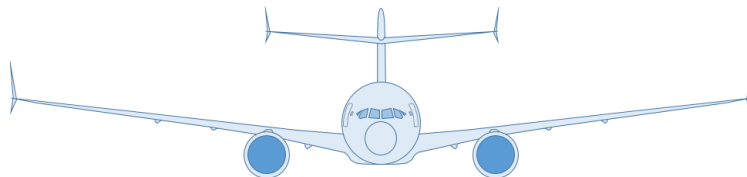


WP-911

Greenpush RG3350-89



WonderPlanes®



WP-911SuperPlus

Greenpush RG3350-SP

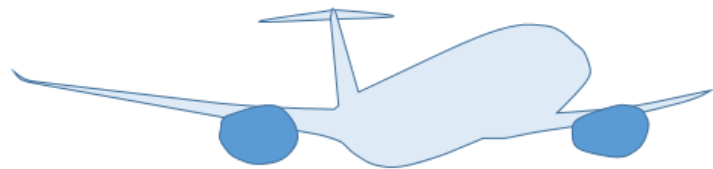


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SAFETY

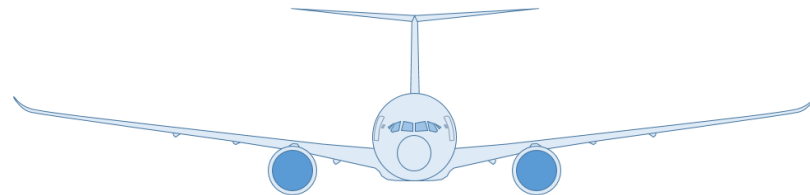
Aeroplane information

The WonderPlanes® product range

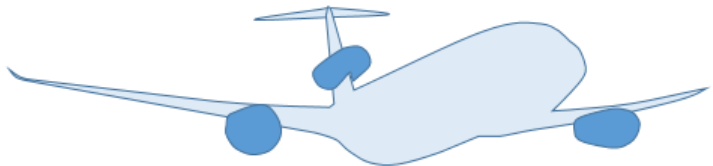


WonderPlanes®

WP-Millennium

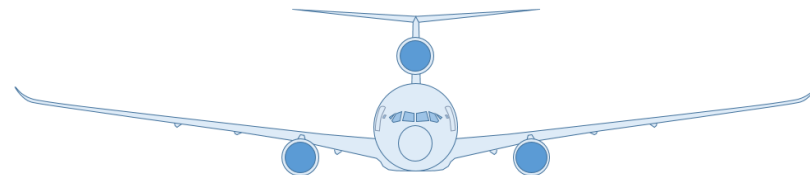


MegaThrust MT2050



WonderPlanes®

WP-3skies



MegaThrust MT2021

Part I

—

ETOPS or EDTO**Part II**

—

EDTO Timeline**Part III**

—

Intent of ETOPS / EDTO Rules**Part IV**

—

EDTO Important Concepts**Part V**

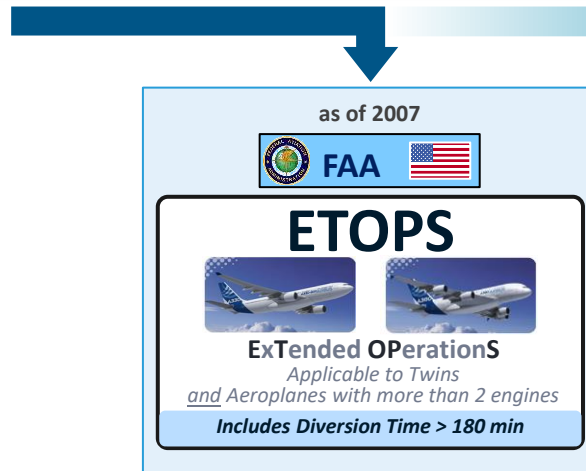
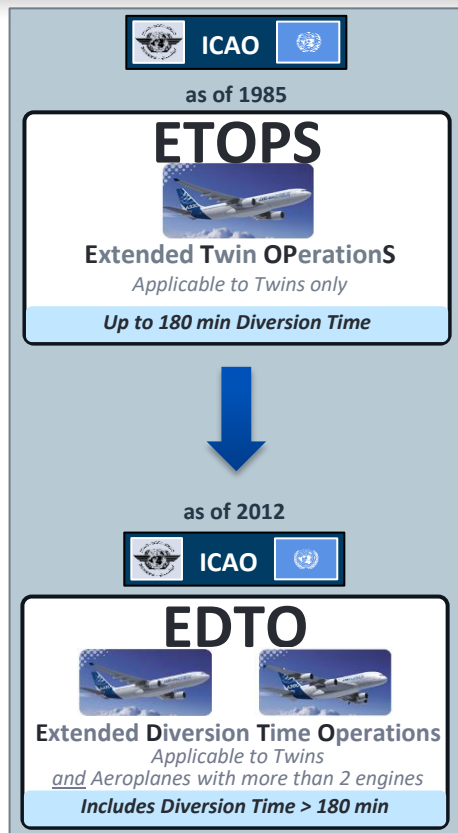
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Summary**Part VI**

—

Review Questions

Different acronyms, same subject





Question 2.1 :

A State has replaced its ETOPS regulation by a new EDTO regulation. Is it correct to say that an ETOPS certified airplane registered in this State must be re-certified for EDTO before it can be operated on EDTO ?

- Yes
- No





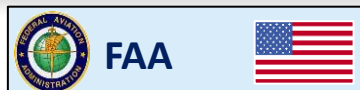
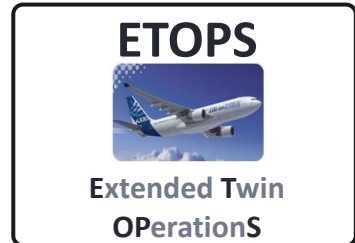
Question 2.2 :

The State of the Operator has replaced the ETOPS regulation by a new EDTO regulation. Is it correct to say that an Operator with an existing ETOPS approval would need to re-apply for EDTO approval ?

- Yes
- No



Different acronyms, same subject



Use of the term
“ETOPS” or “EDTO”
in the aircraft documentation

- Most of the Authorities in the world are still using the term “ETOPS”
 - It is not planned to replace the term “ETOPS” with “EDTO” in existing docs
 - This is in line with the note introduced in the new Annex 6 §4.7 which clarifies that the term “ETOPS” may still be used instead of “EDTO”

4.7.2.3 When approving the appropriate maximum diversion time for an operator of a particular aeroplane type engaged in extended diversion time operations, the State of the Operator shall ensure that:

- for all aeroplanes: the most limiting EDTO significant system time limitation, if any, indicated in the aeroplane flight manual (directly or by reference) and relevant to that particular operation is not exceeded; and
- for aeroplanes with two turbine engines: the aeroplane is EDTO certified.

Note 1.— EDTO may be referred to as ETOPS in some documents.

See for example this Note 1
in the Annex 6 extract copied here

Part I — ETOPS or EDTO

Part II — EDTO Timeline

Part III — Intent of ETOPS / EDTO Rules

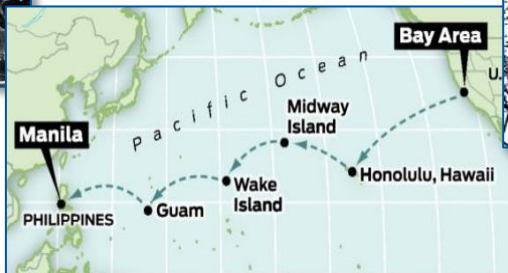
Part IV — EDTO Important Concepts

Part V — Summary

Part VI — Review Questions

The early days of long range operations (1936 onwards)

- “Extended range” commercial operations started in the late 1930s:
 - 1936: First Trans-Pacific commercial flights / 1939: First Trans-Atlantic commercial flights



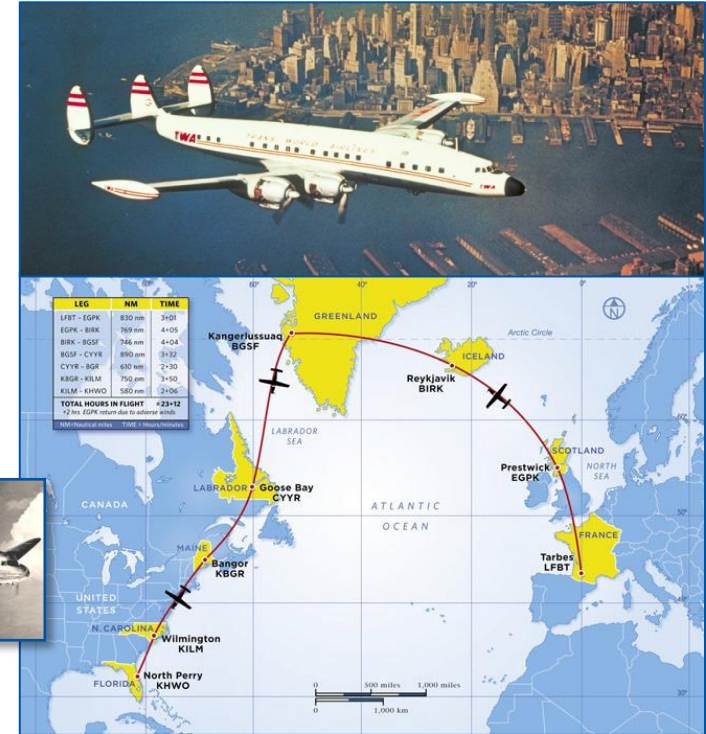
- These flights were mostly operated with large multi-engine flying-boats.
 - Poor engine reliability & performance could not allow design of equally efficient twin engine A/C





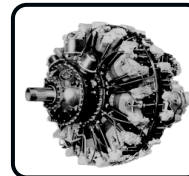
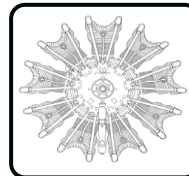
Initial « 90 min » recommendation (1953 onwards)

- ICAO issued the “90 minutes” recommendations in the early 50s:
 - no airplane shall be operated beyond 90 min from a diversion airfield, except if the route can be flown with two engines inoperative
- This criteria was limiting the operations of twins to 90 min flying time (and even 60 min in most countries) from an adequate airport.
 - Economically penalizing rule for twins as it prevented direct routings over oceans
- This was mainly due to reliability of **piston engine**, which was up to **100 times** worse than today's jet engines



Piston engine reliability

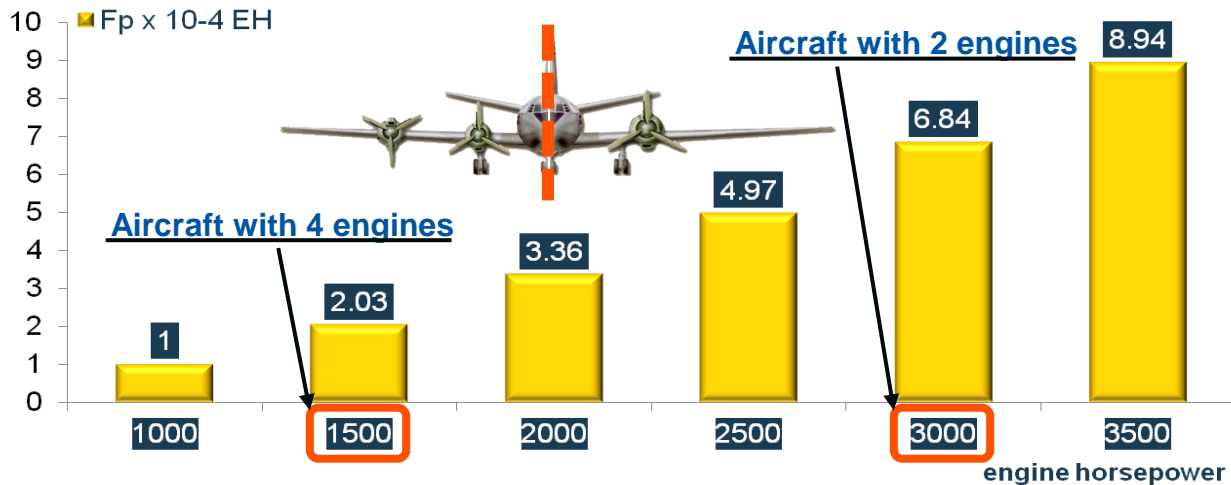
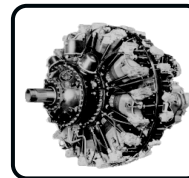
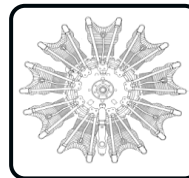
The following chart (1953 ICAO report) gives the **probability of failure** for piston engines vs. power at 1000 constant rpm:



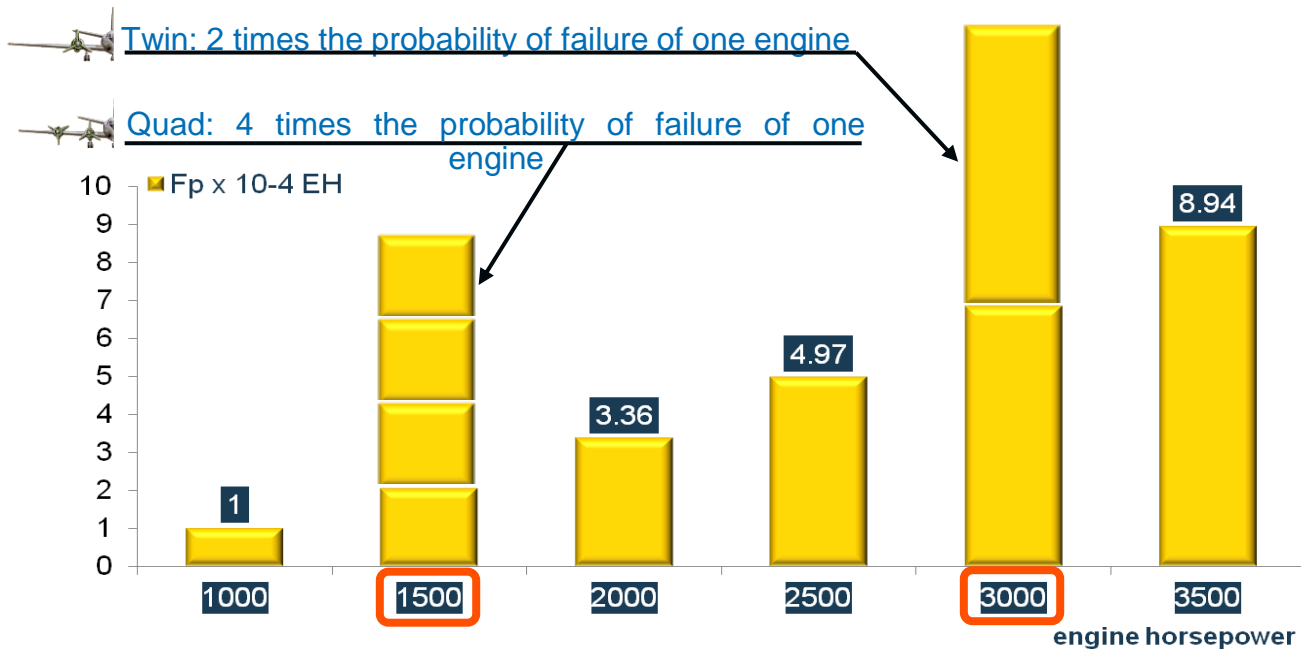
The probability of failure increases as power is increased

Probability of failure of first engine (Example)

- This probability is linked to the number of engines fitted on the A/C
- Let's do the comparison of this probability between two possible layouts, i.e.:



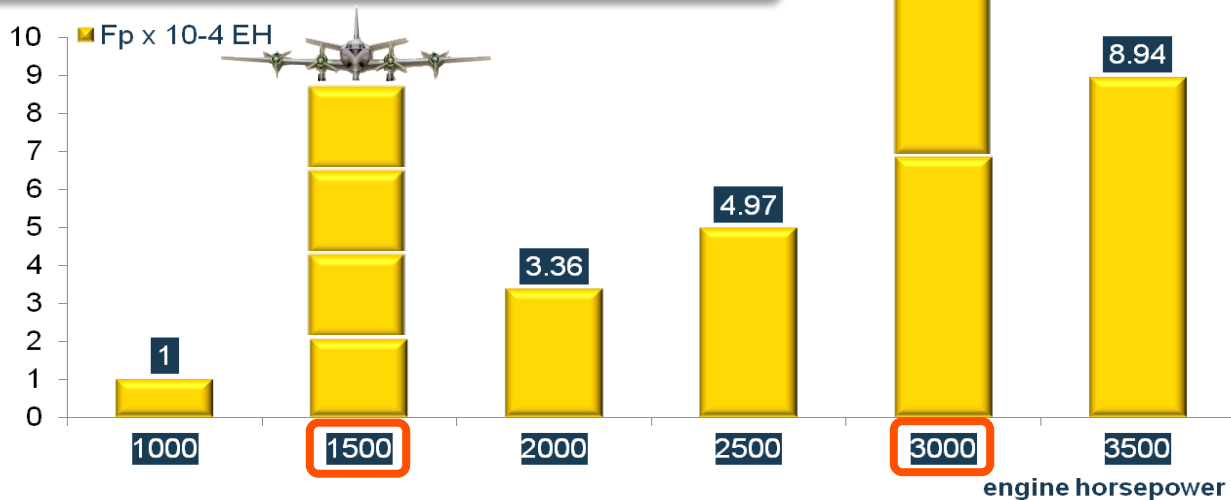
Probability of failure of first engine (Example)



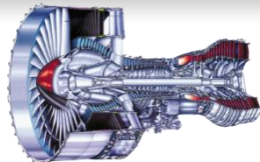
Piston engine reliability

Probability of failure of first engine (Example)

This example, based on the 1953 ICAO report, shows that for same amount of installed horse power, the risk of first piston engine failure is always lower on the quad design than on the twin design.

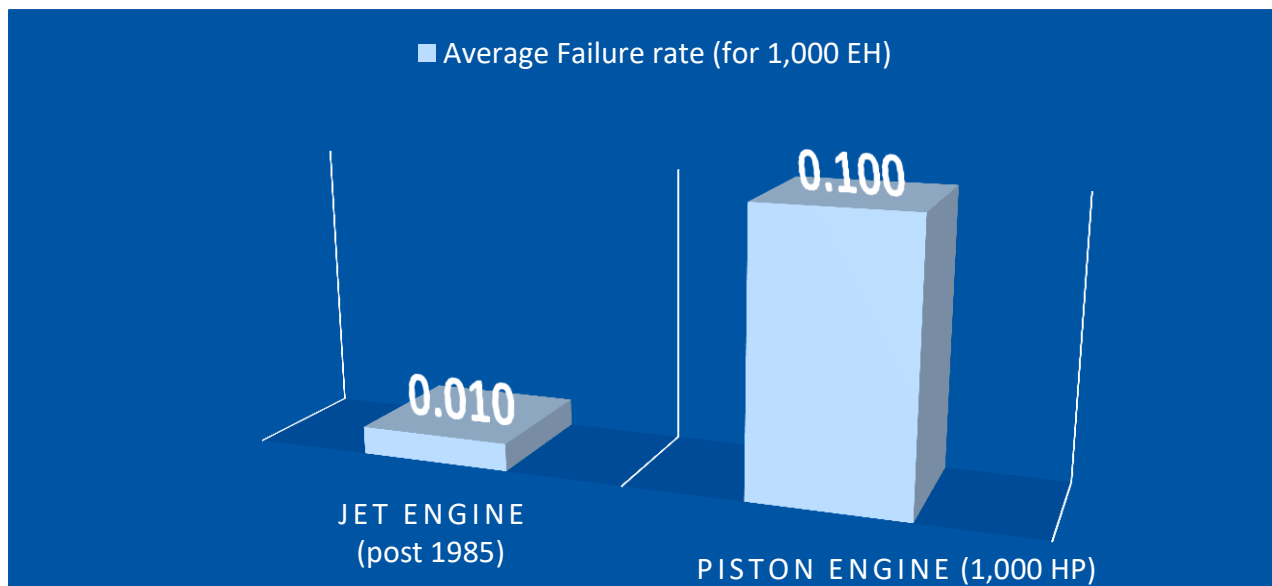
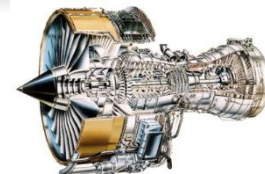


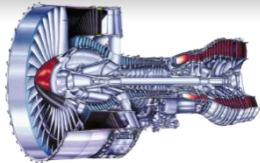
Probability of first engine failure is higher on the twin.



Jet engine reliability

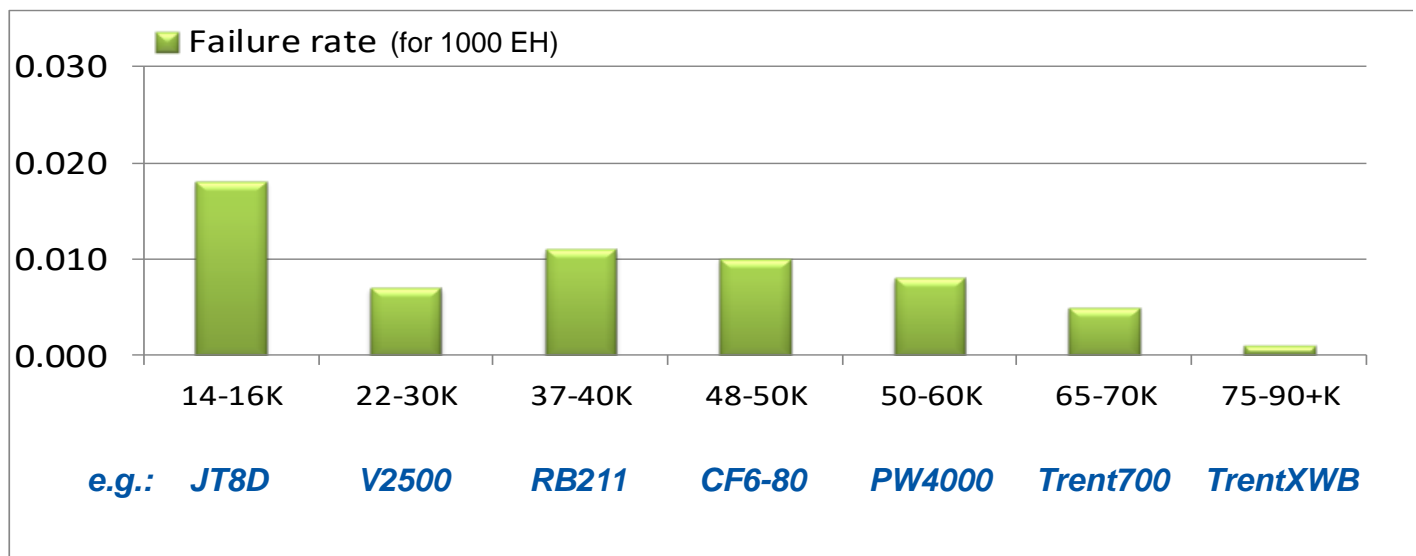
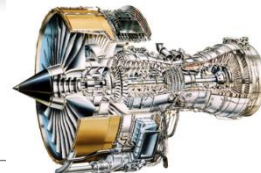
Modern Jet engines have a significantly better average reliability.





Jet engine reliability

More than 60 years of jet operations have also shown that unlike piston engines, jet engine failure probability is not affected by the thrust or the size of the engine:



Therefore, the **probability of first engine failure** is now **lower** on a **twin** than on **an aeroplane with more than 2 engines**



Inception of ETOPS 1985

(Extended Range Twin Engine Ops)

- This improvement in the engine reliability allowed to revisit the limitation to 60 min (or 90 min) maximum diversion time of twins
- This limitation was relieved in 1985 through enhanced requirements on:
 - Design and reliability of relevant aircraft systems and engine
 - Airline experience and processes :
 - selection of en-route alternates, critical fuel scenario, etc...
 - pre-departure service check, oil consumption monitoring, etc...
- These requirements were initially called ETOPS (and later renamed EDTO)
 - Initially allowed operations up to **120 min** maximum diversion time.
 - Revised in 1988 to allow operations up to **180 min**
 - ETOPS/EDTO became widely used (e.g. majority of flights across Atlantic and Pacific oceans are ETOPS/EDTO)



The world without ETOPS

60 minute threshold

60 minute restriction limits route opportunities



Regions beyond **60 minute** threshold (**400 nm** typical operational range)



The world with ETOPS

120 minute Maximum Diversion Time

120 minute MDT expands route opportunities



Regions beyond **120 minute** ETOPS area (**800 nm** typical operational range)



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The world with ETOPS

180 minute Maximum Diversion Time

180 minute MDT further expands route opportunities



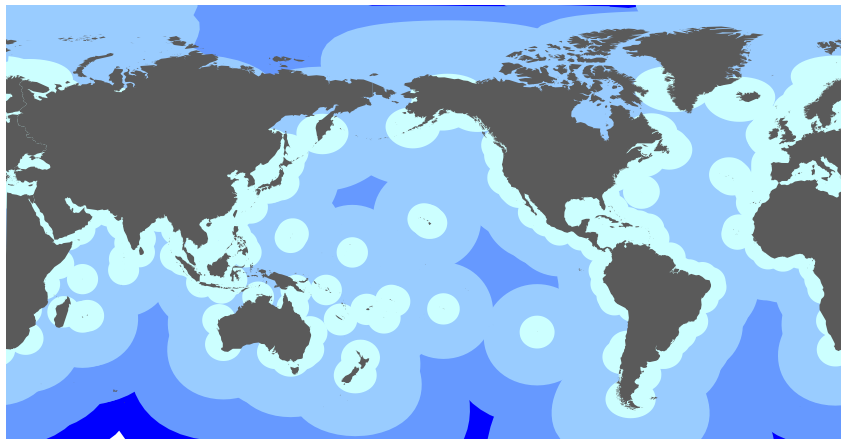
 Regions beyond **180 minute** ETOPS area (**1200 nm** typical operational range)



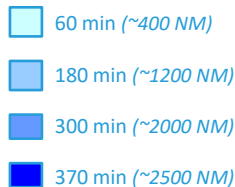
Evolution of ETOPS

(Extended Range Twin Engine Ops)

- From 2007 the ETOPS requirements have evolved, allowing certification and operations of twins beyond 180 min diversion time.
 - Current long range twins are all **certified** for ETOPS > 180 min
 - A330 ETOPS 285 min capability certified in 2009
 - B777 ETOPS 330 min capability certified in 2011
 - B787 ETOPS 330 min capability certified in 2014
 - A350 ETOPS 370 min capability certified in 2014



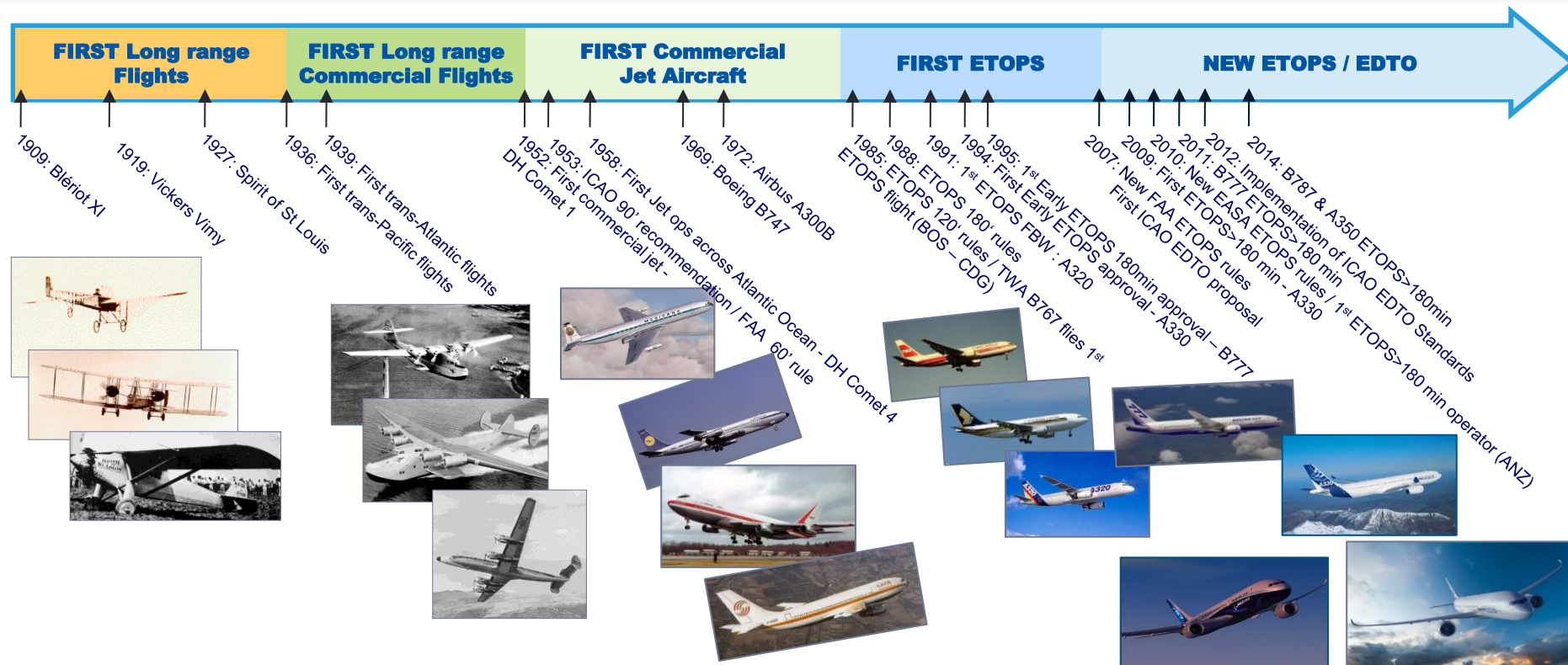
- Majority of current ETOPS operations remains within 180 min authority.
 - Currently around 10 operators have operational approval for ETOPS>180 min



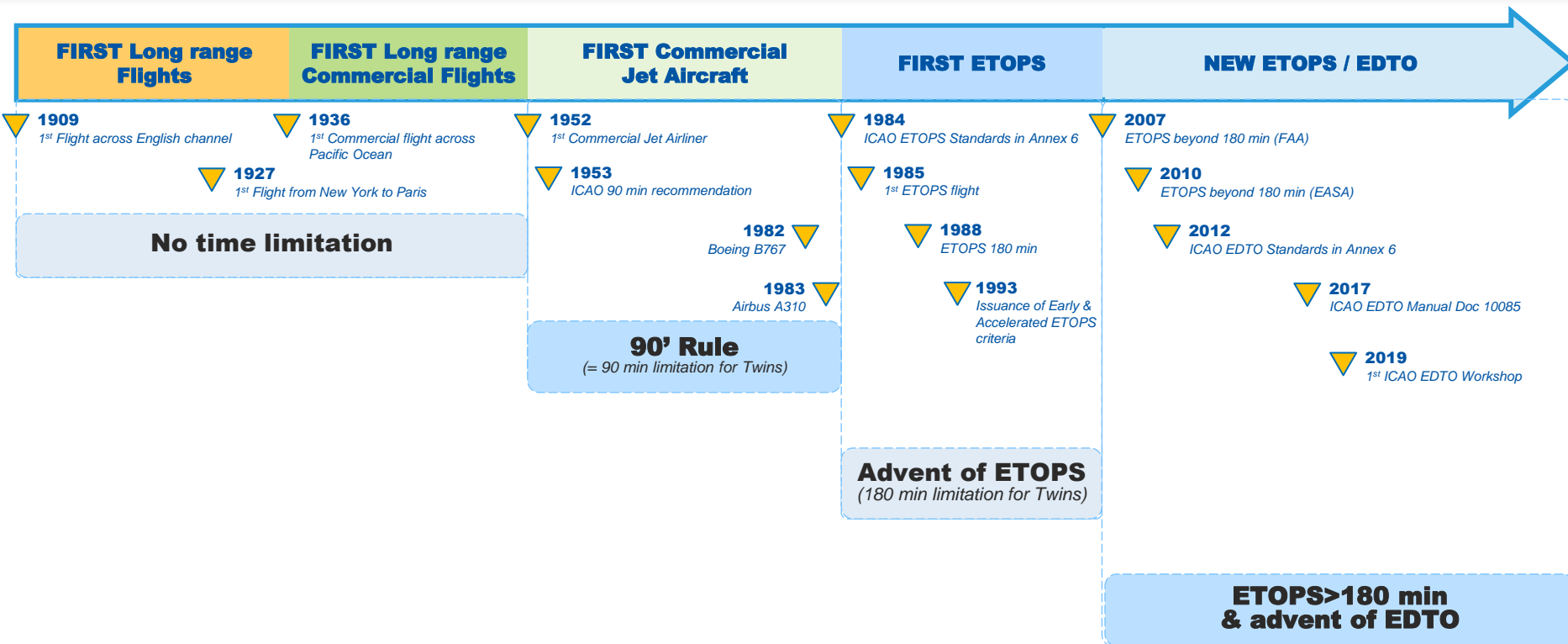


- **ETOPS standards** are renamed **EDTO** by ICAO in 2012:
 - Enable operations of **twins beyond 180 min diversion time**
 - Twins certified under the previous rules can operate up to 180 min DT.
 - **Applicability extended to aeroplanes with more than 2 engines :**
 - No additional maintenance requirements nor additional certification requirements
 - No change for the vast majority of current long-range operators
 - **Criteria for operations beyond 60 min** (EDTO or not) is also introduced
 - Applicable to twins and aeroplanes with more than 2 engines
 - No specific approval required unless if beyond EDTO threshold
- **EDTO requirements** are an evolution of existing rules
 - adapted to address the specificities of extended diversion time flights
 - Based on previous ETOPS requirements, which are optimized and completed

EDTO Milestones



B787 / A350 designed for "Non Limiting" EDTO





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Evolution of ETOPS and EDTO operations (from 1984 to 2018)





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Evolution of ETOPS and EDTO operations (from 1984 to 2018)





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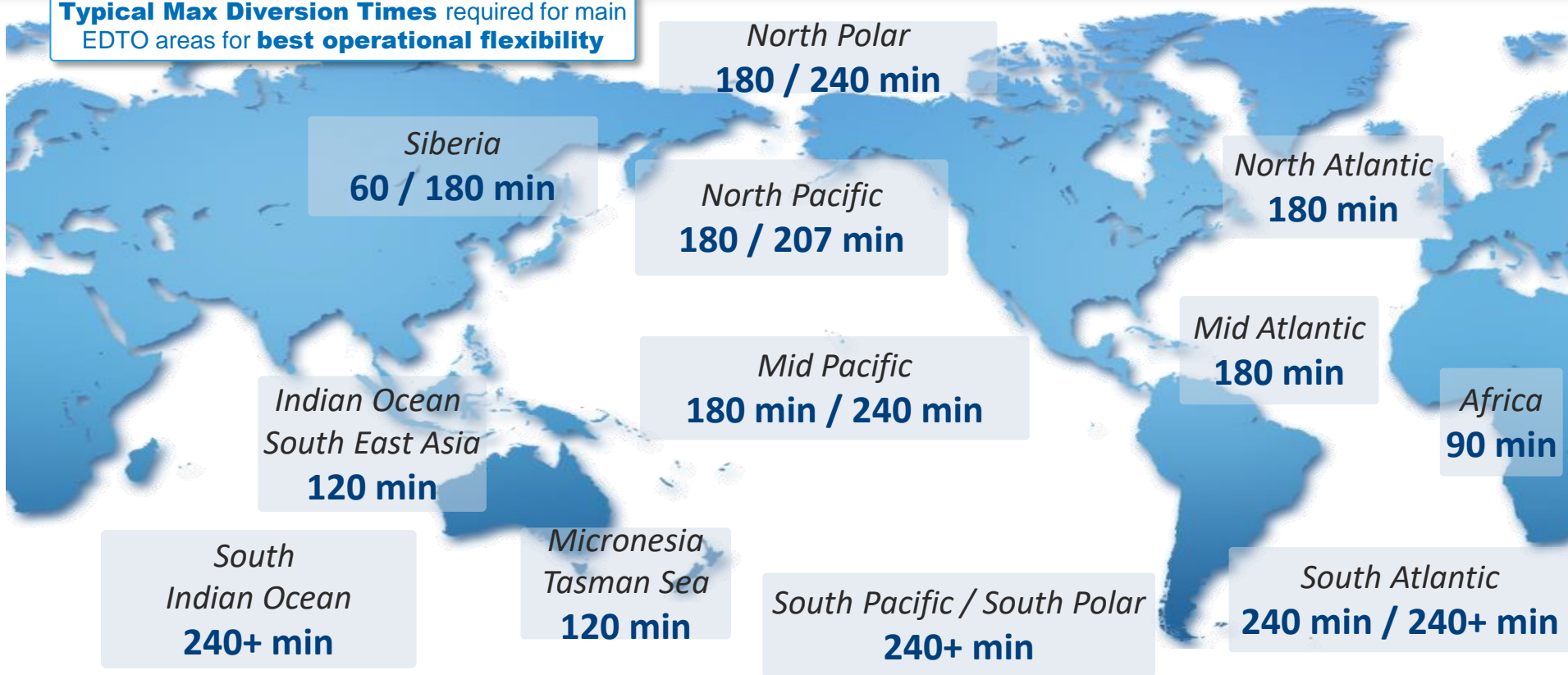
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Today's EDTO world for twins

Typical Maximum Diversion Times per areas

Typical Max Diversion Times required for main EDTO areas for **best operational flexibility**

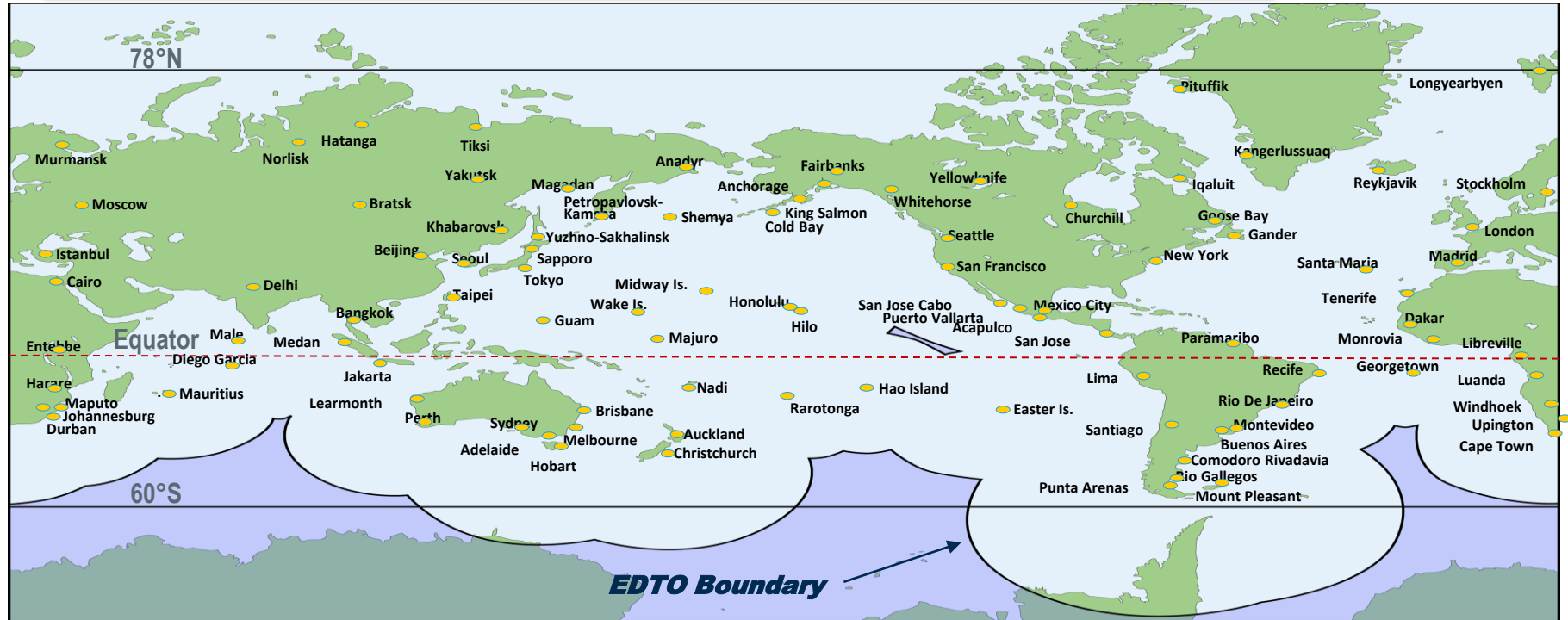




EDTO for aeroplanes with more than 2 engines

Typical EDTO threshold set at **180 min**

Very **few areas** impacted by EDTO, located mostly in southern hemisphere.



EDTO Boundary

Regions beyond **180 minute** threshold (**1500 nm** typical operational range)



Part I —	ETOPS or EDTO
Part II —	EDTO Timeline
Part III —	Intent of ETOPS / EDTO Rules
Part IV —	EDTO Important Concepts
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The logic that governed the drafting of initial ETOPS rules

The objective of initial ETOPS rules (1985):

“Overall level of operational safety consistent with that of **modern 3 and 4 engine aircraft**”

So let's compare a basic twin (non-ETOPS)...



... with a modern 3 or 4 engine aircraft!



Question 2.3 :

Let's compare an aeroplane with 2 engines – not designed and certified for ETOPS or EDTO – and an aeroplane with more than 2 engines...

What are the main differences (having an impact on the safety of EDTO) between these two aeroplanes ?

- List differences using few key words (e.g. “the quad has 4 engines”, “engine size”, etc...)



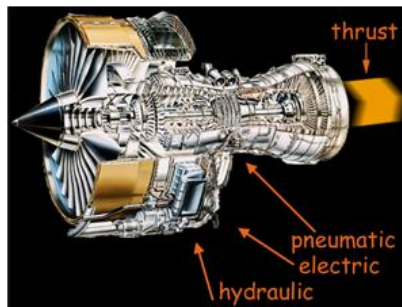
The logic of “2” versus “more than 2” engines

Purpose of the comparison of a basic (non EDTO/ETOPS) twin with an aeroplane with more than two engines is to :

- ê Identify the **main differences** in their architecture, and
- ê Understand how these differences may **impact the safety** of extended diversion time operations...



The most obvious difference is indeed the number of installed engines...



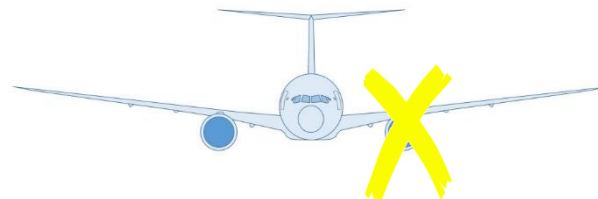
Recall: on top of thrust, engines provide as well:

- Electric power
- Hydraulic power
- Pneumatic power

The logic of “2” versus “more than 2” engines

Systems independence

Independence of some major aircraft systems is directly linked to the number of engines installed

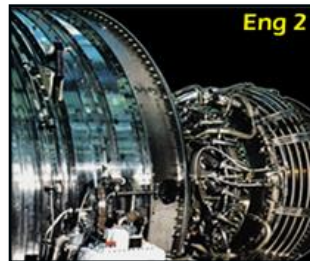
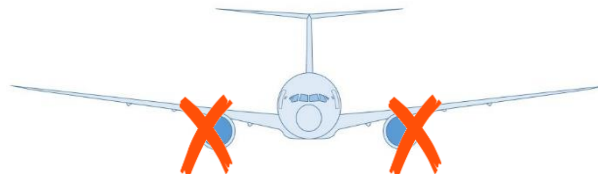
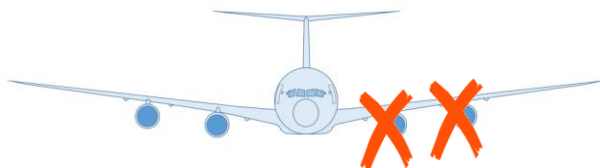


Example of Electrical System: Remaining source(s) after engine failure:
3 sources on Quad / 1 source on Twin

The logic of “2” versus “more than 2” engines

Maintenance actions

System redundancy has a direct impact on error consequence after simultaneous maintenance action on parallel systems



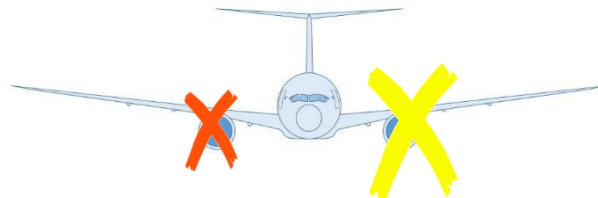
Example of dual maintenance on 2 identical engine mounted systems.

Potentially affected systems: 2 out of 4 on Quad / 2 out of 2 on Twin

The logic of “2” versus “more than 2” engines

Crew actions

System redundancy has also a direct impact on error consequence in system management after failure

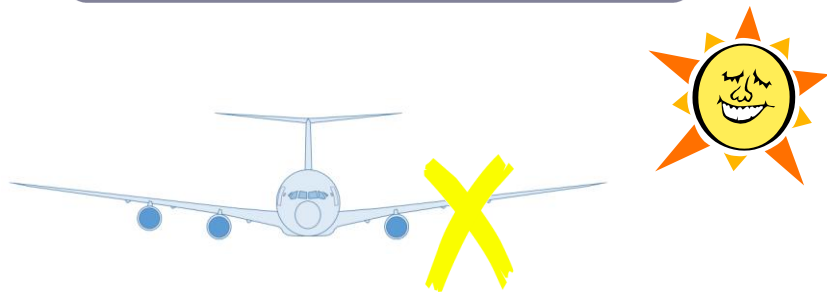


Example of inappropriate course of action after system failure.
Potentially affected systems: 2 out of 4 on Quad / 2 out of 2 on Twin

The logic of “2” versus “more than 2” engines

Exposure to weather

Level off altitude after an engine failure is often lower on twin



It may expose the twin to more adverse weather conditions...

This fact, combined with lower redundancy in the systems of (basic) twins, may have an adverse impact on crew workload.



Basically, the ETOPS concept first implemented in 1984 is not changed:

PRECLUDE a diversion by

Designing reliable A/C engines & systems

⇒ **minimize the occurrence**
of degraded operating modes

PROTECT the diversion by

Implementing systems/functions required for safe
ETOPS (EDTO) diversion & landing

⇒ **Ensure a high level of systems performance** in
normal & degraded operational modes

EDTO Type Design & Reliability Assessment or Certification of the Aircraft

Implementing specific maintenance precautions,
conservative practices & readiness demonstration

⇒ **retain a high level of reliability**

Having operational plans in place for readiness
demonstration, aiming at
the protection of passengers and crew

⇒ **cope with adverse operating conditions**

EDTO Operational Approval of the Airline

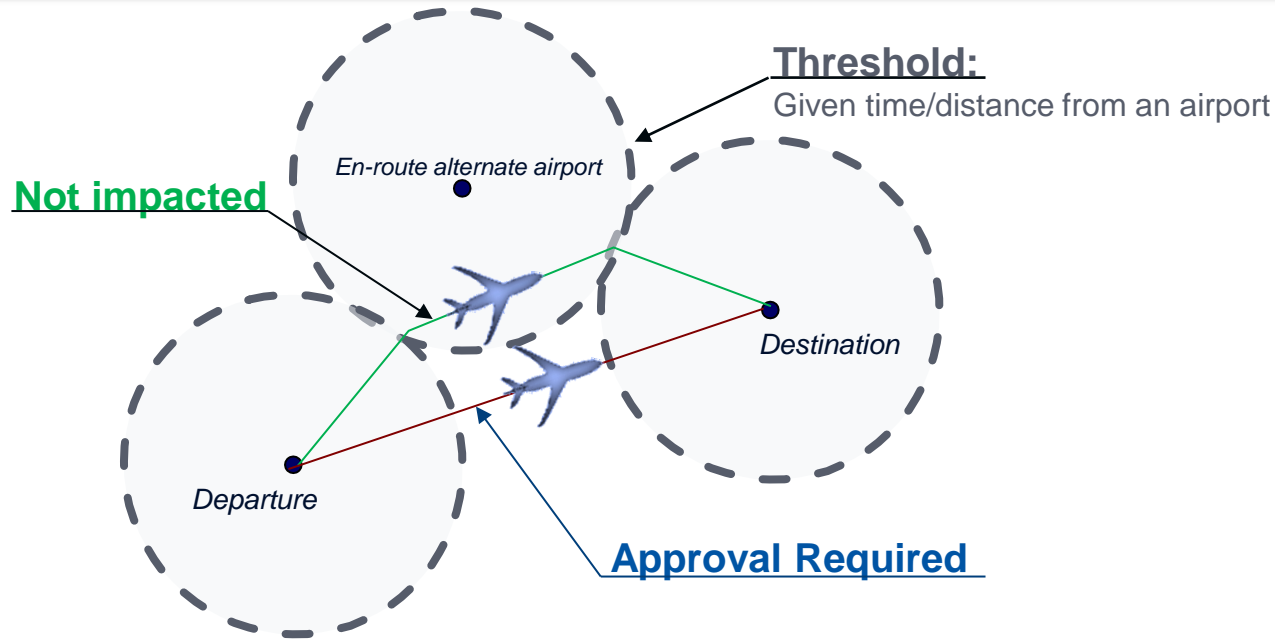


Part I —	ETOPS or EDTO
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Concept of EDTO threshold

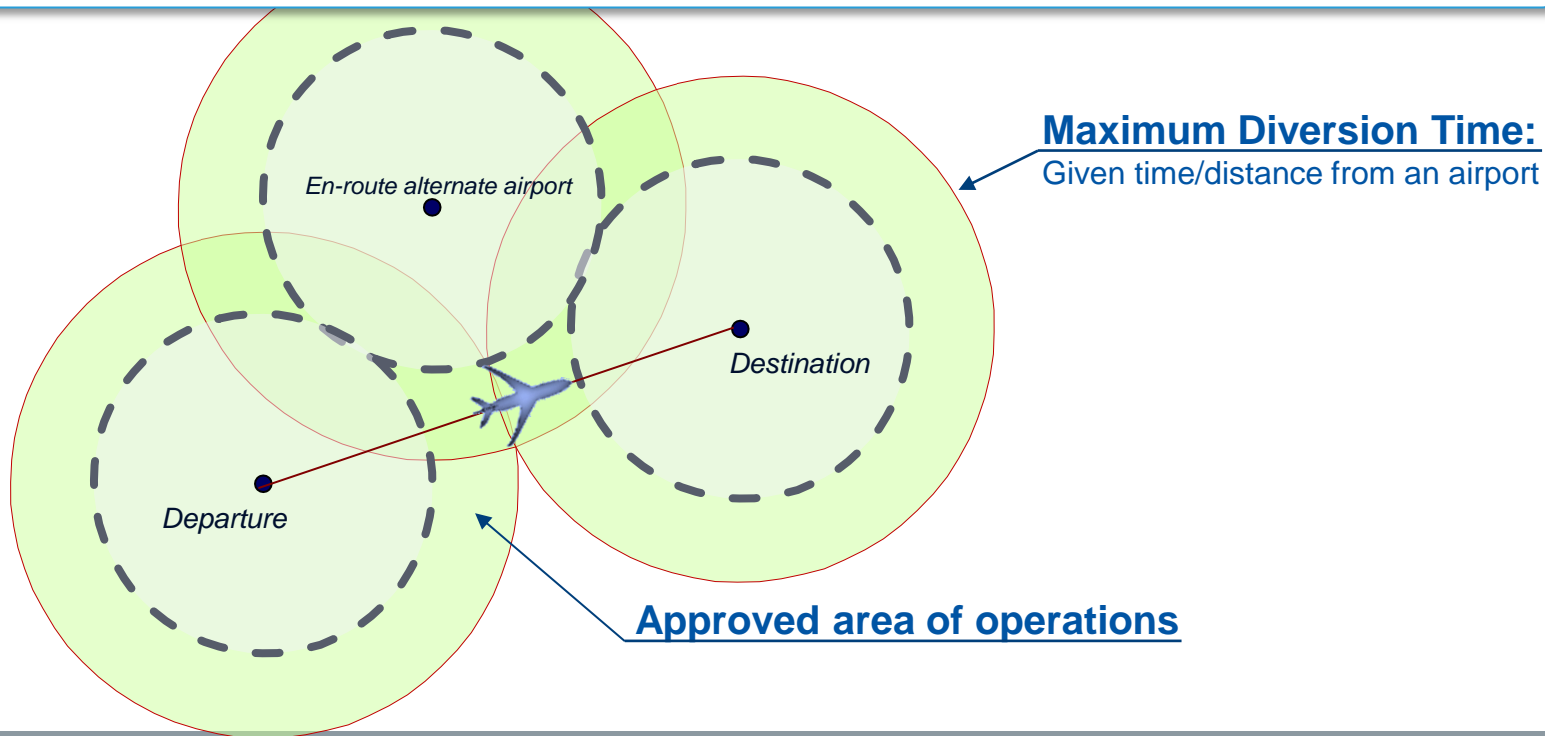
The sets of **Certification & Operational requirements**, called **EDTO** (or ETOPS), apply when an **aircraft is operated beyond applicable threshold**





Concept of Maximum Diversion Time

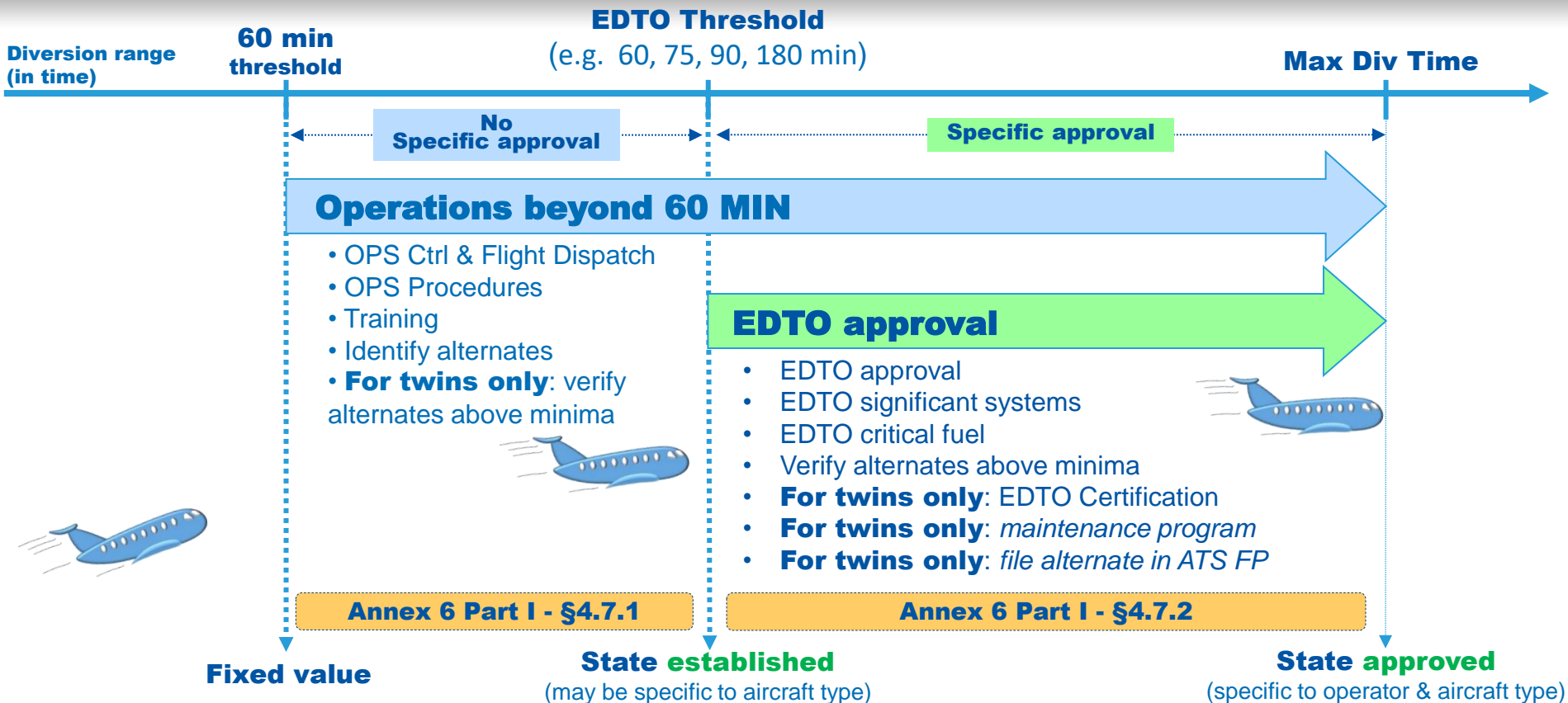
These Certification & Operational requirements also introduce the concept of **Maximum Diversion Time**, thus defining an **approved area of operations**.





Operations beyond 60 min and EDTO

Summarized view of Annex 6 Part I – **Section 4.7**





Operations beyond 60 min

Summarized view of Annex 6 Part I – **Section 4.7.1**



Twins & Aeroplanes with more than 2 engines

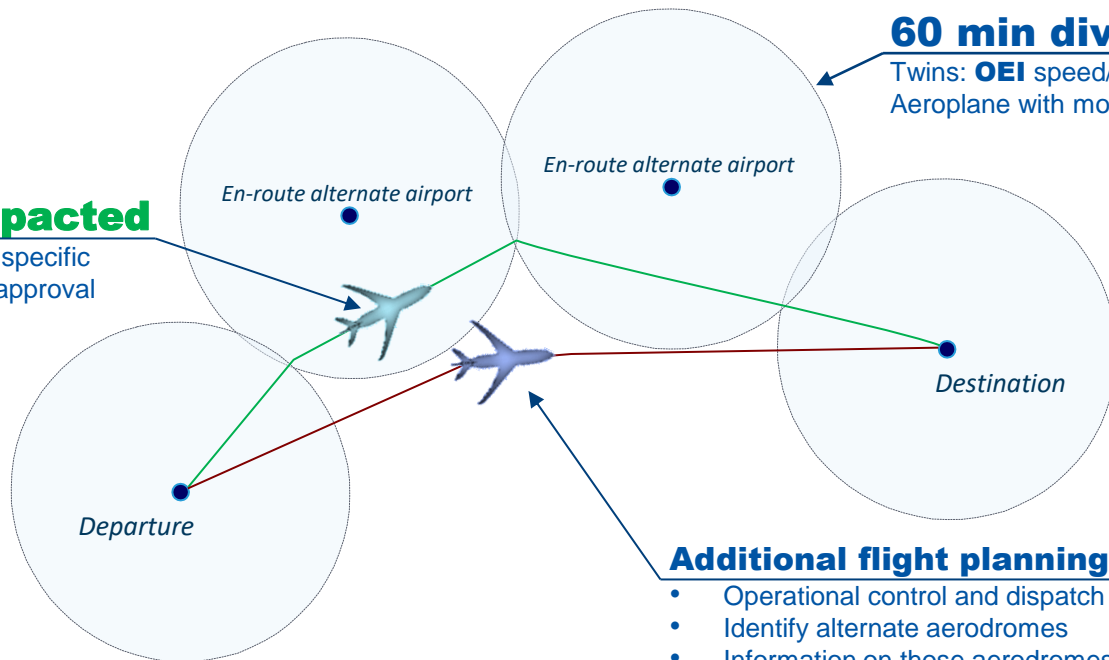
60 min diversion time

Twins: **OEI** speed/FL

Aeroplane with more than 2 engines: **AEO** speed /FL

Not impacted

No need for specific operational approval



EDTO approval is **Not Required** as long as the operation is conducted within **applicable EDTO threshold**

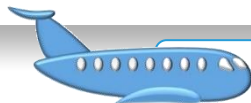
Additional flight planning principles apply

- Operational control and dispatch procedures
- Identify alternate aerodromes
- Information on those aerodromes
- For Twins, that the aerodrome will be available
- Training programs

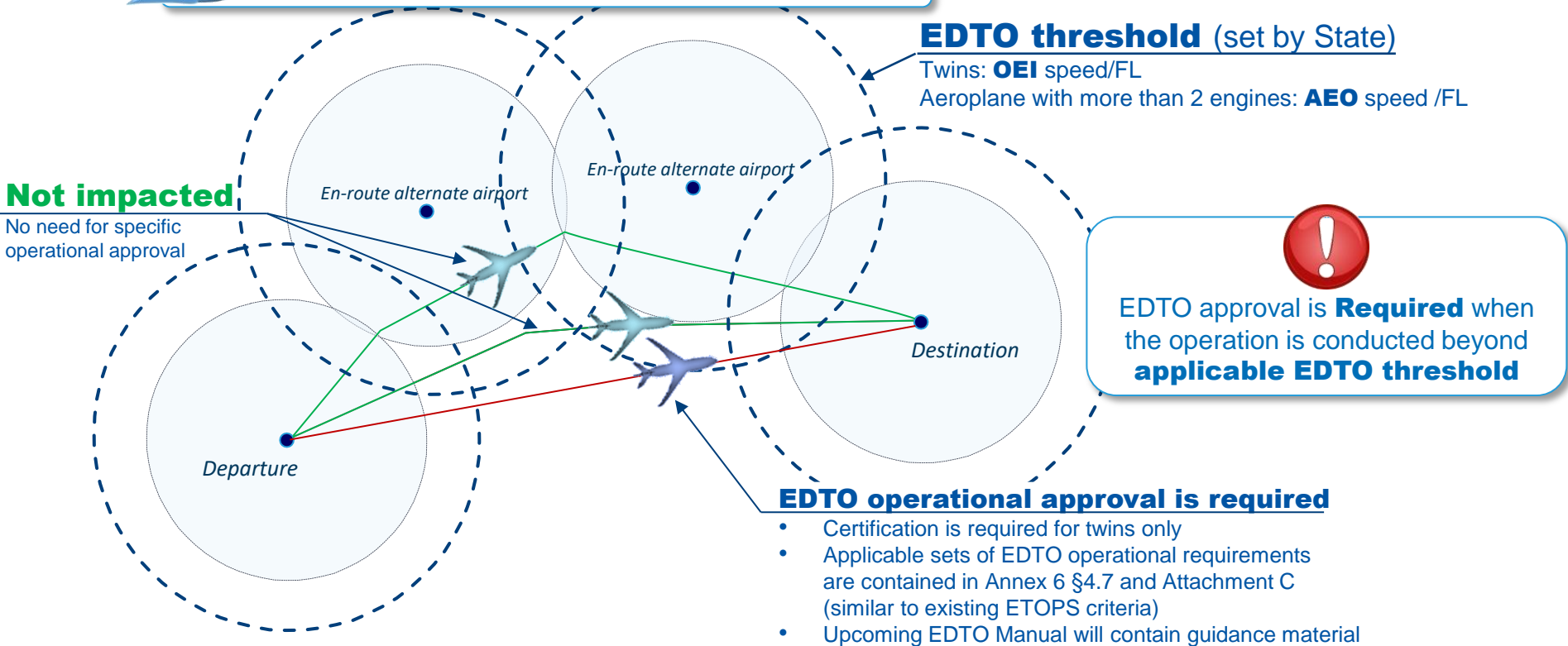


Operations beyond EDTO Threshold

Summarized view of Annex 6 Part I – **Section 4.7.2**



Twins & Aeroplanes with more than 2 engines



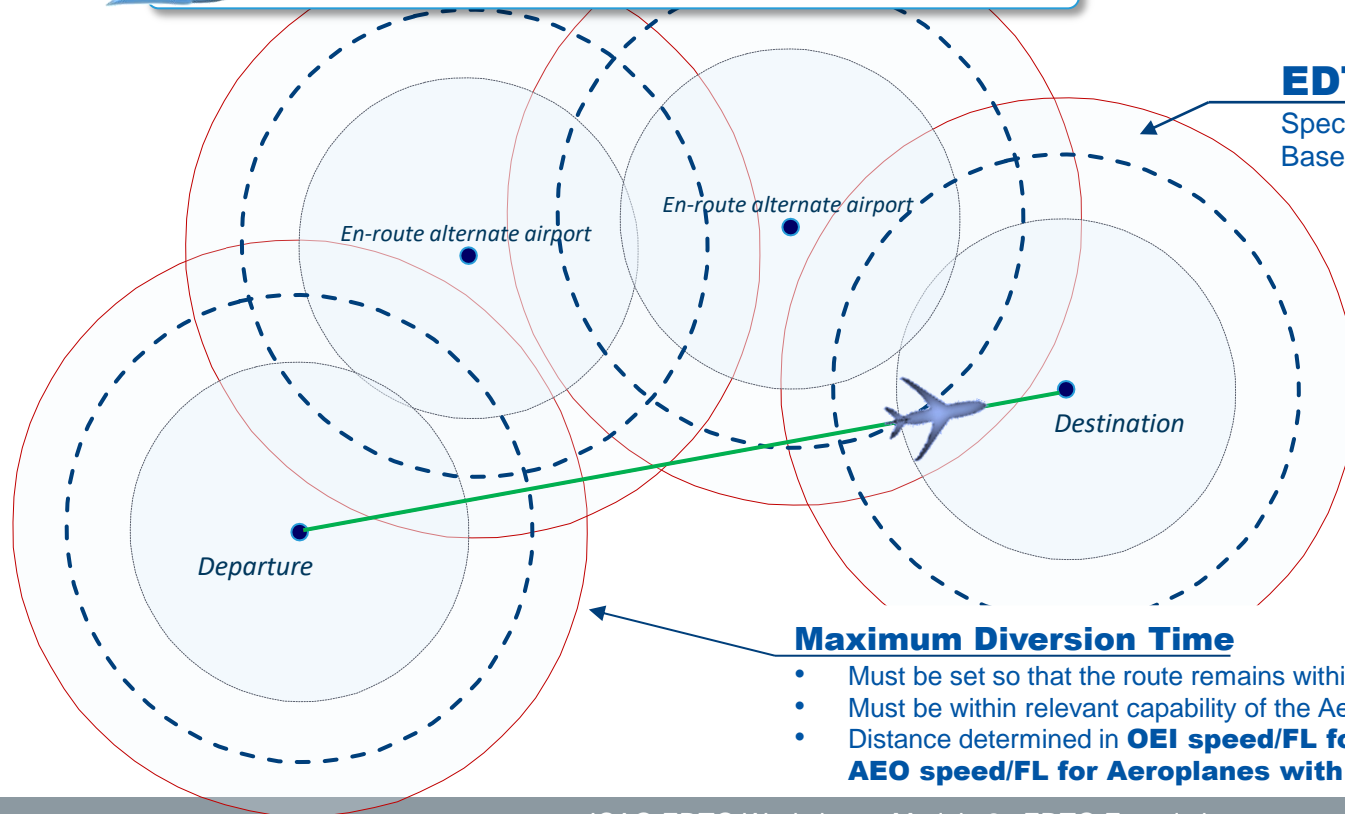


Operations beyond EDTO Threshold

Summarized view of Annex 6 Part I – **Section 4.7.2**



Twins & Aeroplanes with more than 2 engines



EDTO Area of operations

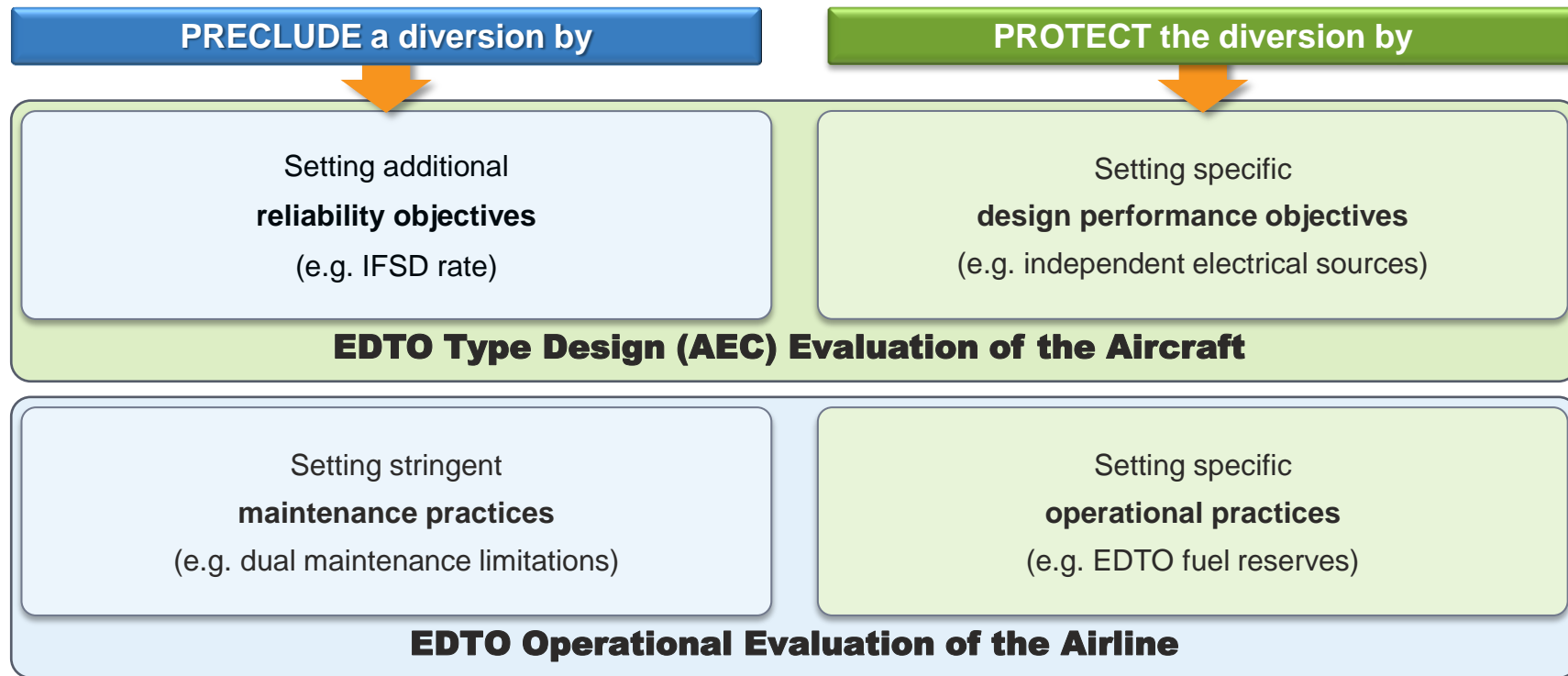
Specific to the Operator
Based on granted Maximum Diversion Time

Maximum Diversion Time

- Must be set so that the route remains within this EDTO area of operations
- Must be within relevant capability of the Aeroplane's Time Limited System(s)
- Distance determined in **OEI speed/FL for twins** and **AEO speed/FL for Aeroplanes with more than 2 engines**



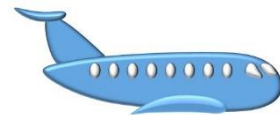
EDTO Standards are based on the same concept implemented in 1984 with initial ETOPS criteria:





Approval for EDTO must go through Two Steps:

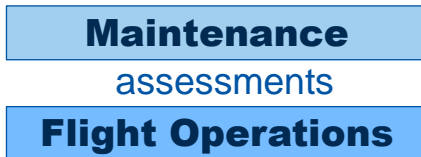
Step 1



The Aeroplane
is capable

State of Design

Step 2



The Operator
is ready

State of the Operator



Question 2.4 :

Can the Maximum Diversion Time value granted to the Operator exceed the EDTO capability of the aeroplane ?

- Yes
- No



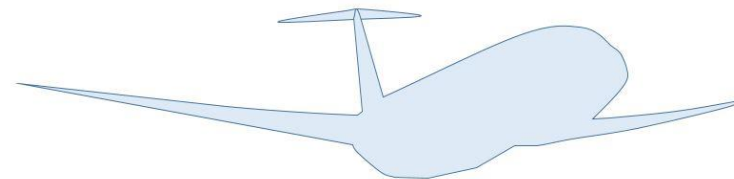


EDTO Operational Approval

Time limitation of **EDTO Significant Systems**

EDTO area of operations

Operator's granted **Maximum Diversion Time** must not exceed the EDTO capability of the Aeroplane



This EDTO capability of the Aeroplane is **sized** by:

- It **certified EDTO capability** (if applicable), and/or
- The **relevant time limitation(s)** of its EDTO Significant Systems

Corresponding max. diversion distance measured from an adequate airport is based on:

- OEI speed, ISA, Still Air for **aeroplanes with 2 engines**
- AEO speed, ISA, Still Air for **aeroplanes with more than 2 engines**



Part I —	ETOPS or EDTO
Part II —	EDTO Timeline
Part III —	Intent of ETOPS / EDTO Rules
Part IV —	EDTO Important Concepts
Part V —	Summary
Part VI —	Review Questions

- EDTO requirements apply whenever a commercial transport aeroplane is operated beyond the **applicable threshold** defined by the State
 - These requirements also introduce the concept of **Maximum Diversion Time**, thus defining an approved/authorized **EDTO area of operations**
- The basic **concept of EDTO** is to :
 - **preclude the diversion** (i.e. minimize occurrences); and
 - to **protect the diversion** should it occur.
- These objectives are achieved through :
 - Assessment or Certification of **EDTO capability of the aeroplane** and identification of applicable **time capability of concerned EDTO Significant System(s)**
 - EDTO operational approval of the airline



- Part I — ETOPS or EDTO**
- Part II — EDTO Timeline**
- Part III — Intent of ETOPS / EDTO Rules**
- Part IV — EDTO Important Concepts**
- Part V — Summary**
- Part VI — Review Questions**



Question 2.5 :

As per Annex Part I, Section 4.7, what is the **threshold time** for operations **beyond 60 minutes** ?

- Propose a value





Question 2.6 :

What is the **EDTO threshold time** for aeroplanes **with 2 engines** ?

- 60 min
- 90 min
- 180 min
- Established by the State of the Operator





Question 2.7 :

What is the **EDTO threshold time** for aeroplanes with **more than 2 engines** ?

- 60 min
- 90 min
- 180 min
- Established by the State of the Operator





Question 2.8 :

An Operator applies for an **EDTO approval** with an aircraft that is **certified for ETOPS**. Is this acceptable ?

- Yes
- No
- Maybe





Question 2.9 :

The **Maximum Diversion Time** which may be granted to an Operator is :

- A value approved by the state of design ?
- A value approved by the State of the operator ?
- A value established by ICAO ?





Question 2.10 :

The **Maximum Diversion Time** which may be granted to an Operator must be :

- No higher than the EDTO capability of the aircraft
- Always 180 minutes
- Less than 1000 minutes
- Approved by the state of design





Question 2.11 :

The **EDTO Type Design Approval** of the aeroplane:

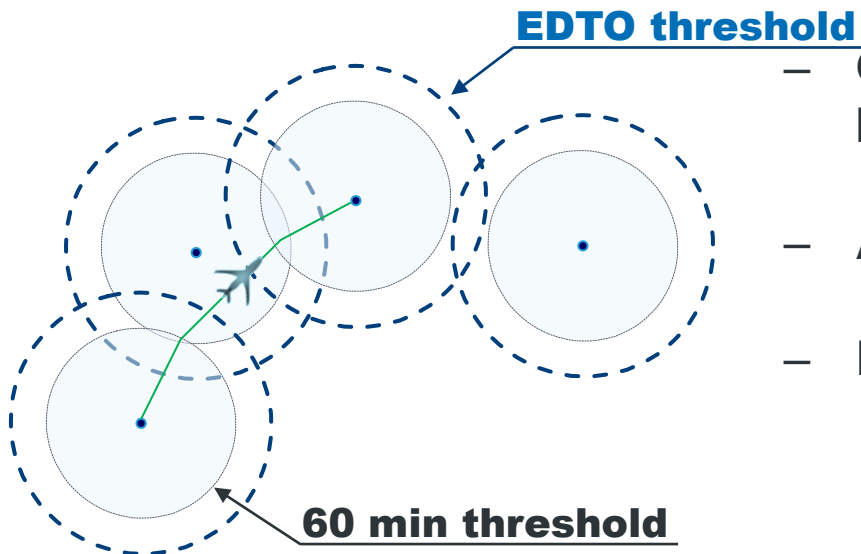
- Is always mandatory for any commercial transport aircraft
- May not be required in certain situations
- Is expensive and unnecessary
- Is granted after an operational approval is issued





Question 2.12 :

To operate on the indicated route (green line) which of the following apply?



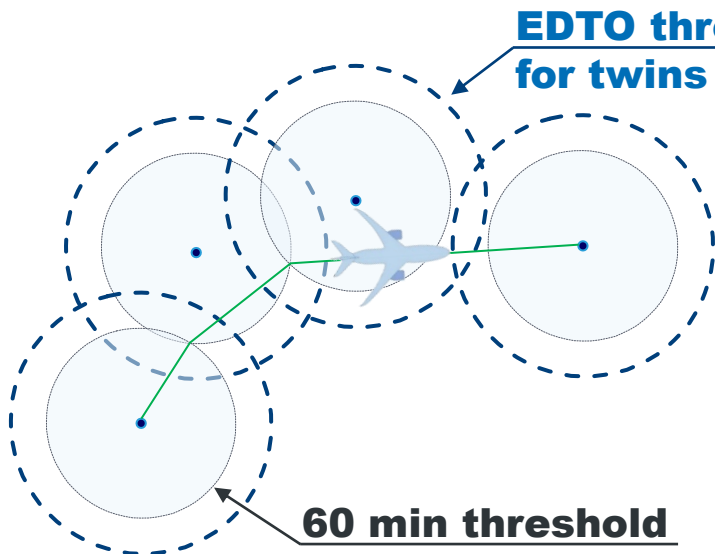
- Only additional requirements for operations beyond 60 mins apply
- An Operational Approval for EDTO is needed
- No additional requirements apply





Question 2.13 :

What is required to operate this route (green line) with a Twin:

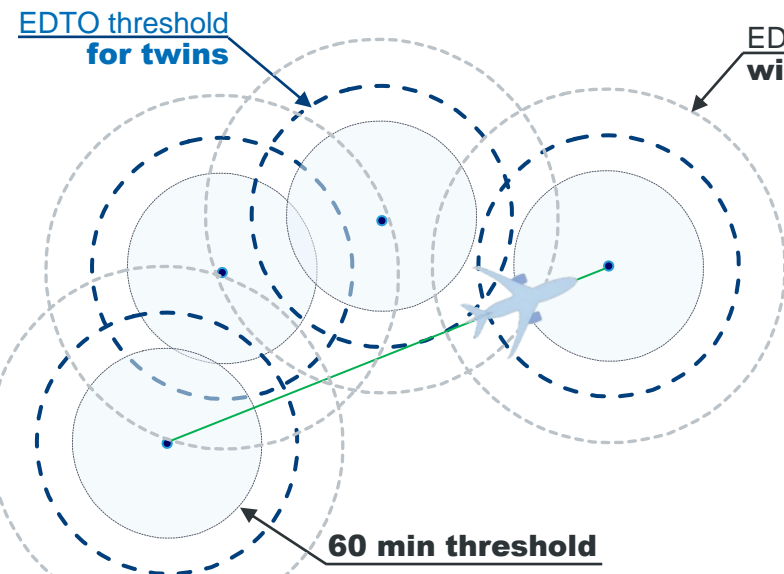


- Only additional requirements for operations beyond 60 mins apply
- An Operational Approval for EDTO is needed
- No additional requirements apply



Question 2.14 :

What is required to operate this route (green line) with a **Twin**:

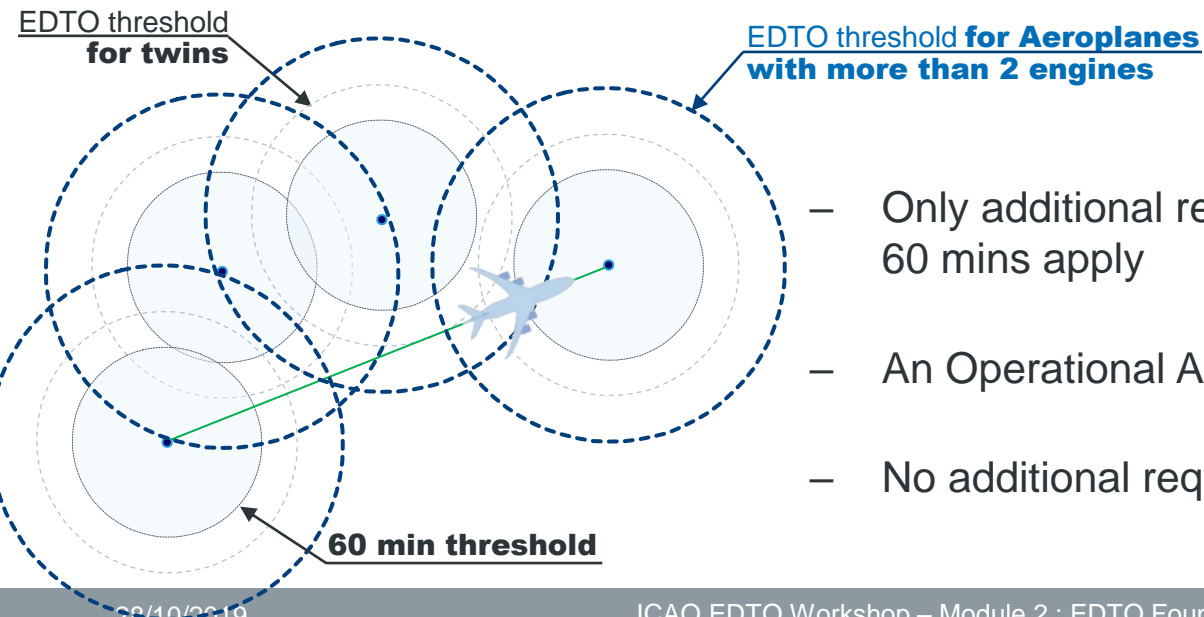


- Only additional requirements for operations beyond 60 mins apply
- An Operational Approval for EDTO is needed
- No additional requirements apply



Question 2.15 :

What is required to operate this route (green line) with a **Quad**:



- Only additional requirements for operations beyond 60 mins apply
- An Operational Approval for EDTO is needed
- No additional requirements apply





EDTO Workshop

End of Module 2 – EDTO Foundation

