Continuing Airworthiness of Type Design – EU Products Large Transport Aeroplanes

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Introduction

Agenda

- ICAO Continued Airworthiness Definition
- State of Design Responsibilities
- Regulations
- Occurrence Reporting
- Definition of Unsafe Condition
- Airworthiness Directive
  - Compliance Time Determination
- Differences with other FAA system

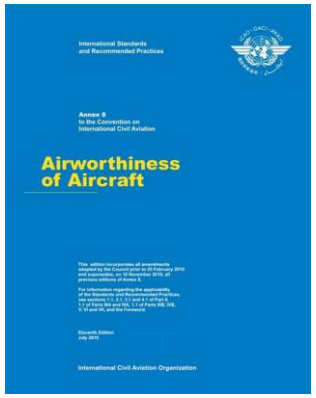
ICAO Definition

- ICAO Doc N° 9760-2001 defines the Continued Airworthiness as:
  - ‘The processes that ensure, at anytime in it’s life, an aircraft complies with the technical conditions fixed to the issue of the Certificate of Airworthiness and is in a condition for safe operation.’
- and recommends:
  - ‘Contracting states are required to have a system that… ensures aircraft are in a condition for safe operation.’

EU and National Regulations on CAW are built on this OACI recommendation

State of Design Responsibilities

- As per ICAO Annex 8 Chapter 4
  - The State of Design of an aircraft shall transmit to every Contracting State any generally applicable information which it has found necessary for the CAW of an aircraft, including its engines and propellers when applicable, and for the safe operation of the aircraft (mandatory continuing airworthiness information – MCAI) and notification of suspension or revocation of a Type Certificate.
  - The term "MCAI" is intended to include mandatory requirements for modification, replacement of parts or inspection of aircraft and amendment of operating limitations and procedures. Among such information is that issued by Contracting Statues in the form of airworthiness directives.



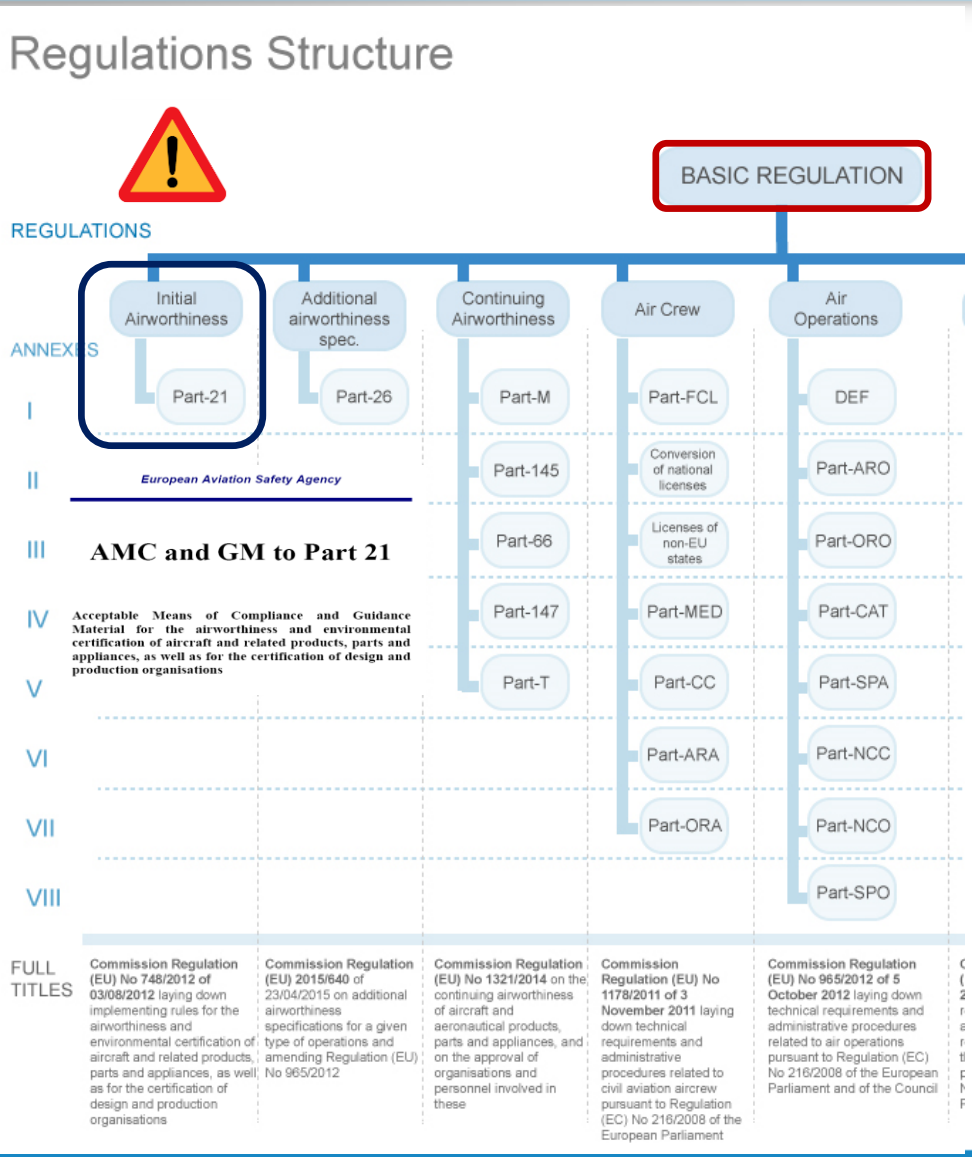
MCAI = AD

Continued Airworthiness Scope

- Continuing Airworthiness covers all the processes ensuring that all aircraft comply with the airworthiness requirements in force and are in condition for safe operation, at any time during their operating life

- CAW of Type Design is one of those processes

EU CAW Legal Framework



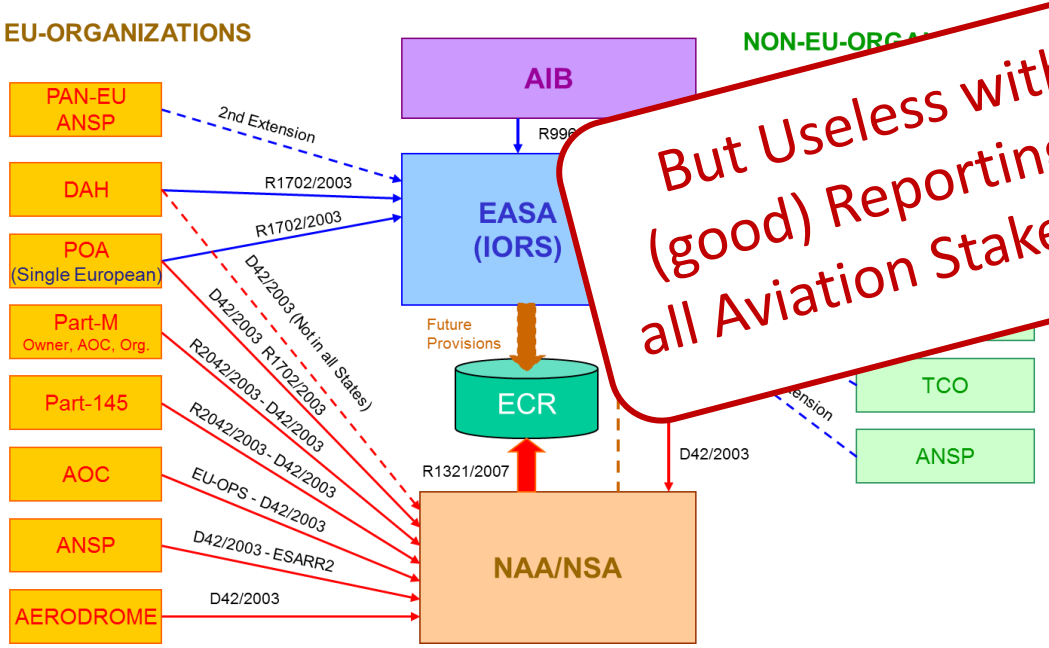
- Article 20 – Airworthiness and Environmental Certification
  - Transfer of SoD tasks
  - React without undue delay to a safety problem and issue/disseminate the applicable mandatory information

- Part 21
  - 21A.3 Failures, malfunctions and defects
    - Obligations of DAH
  - 21A.3B Airworthiness Directives
    - Obligations of DAH and EASA
  - Associated AMC and GM, and AMC 20-28

Occurrence Reporting Lines

Occurrence Reporting Lines

- ICAO Annex 8, EU Directive 2003/42/EC, BR Article 15, Part 21, Part M, OPS regulations,…



Areas of Improvement

- Complexity of reporting lines
- Inconsistency of EU regulations
- STC occurrences, Equipment occurrences
- NAA reporting line to EASA
- POA reporting: second channel towards EASA

Central Role played by the TC Holder

Occurrence Reporting

- Occurrence Reporting Criteria (DAH->EASA)
  - AMC 20-28
  - 21A.3(b) Failures, malfunctions and defects
    - Has resulted in or may result in an unsafe condition
- Occurrence may be:
  - An event that occurred during operation
  - A finding during maintenance, inspection…
  - A finding during review or audit of records
    - Design,manufacturing, assembly, maintenance…
  - Results of new test, updated analysis

Part 21 – Annex 1
21A.3 - Failures, malfunctions and defects

TC/STC Holders Must

21A.3 Failures, malfunctions and defects

(a) S… rtificate, E… n issued u… unctions, defects or other occurrences which cause or might cause adverse effects on the continuing airworthiness of the product, part or appliance covered by the typ… ant approv… the produc…

System for Collection, Investigation and Analysis of Data

Information about this system shall be made available to all known operators

(b) Reporting to the Agency.

1. The hold… other r… occurrence of which it is aware related to a product, part, or appliance covered by the type-certificate, restricted type-certificate, supplemental type-certificate, ETSO authorisation, major repair design approval or any other relevant approval deemed to have been issued under this Regulation, and which has resulted in or may result in an unsafe condition.

shall report to the Agency any failure, malfunction, defect or other occurrence

2. These report… **hours** after…

72 hours after the identification of the possible unsafe condition

(c) Investigation of Reported Occurrences.

1. When an occurrence reported under paragraph (b), or under 21A.129(f)(2) or 21A.165(f)(2) results from a deficiency in the design, or a manufacturing… approval, ETS… appropriate, shall **investigate** the reason for the deficiency and report to the Agency the results of its investigation and any action it is taking or proposes to take to correct that deficiency.

shall investigate the reason

2. If the Agency finds that an action is required to correct the deficiency, the holder of the type-certificate, restricted type-certificate, supplemental type-certificate, major repair design approval, ETSO authorisation, or any other relevant approval deemed to have been issued under this Regulation, or the manufacturer as appropriate, shall submit the relevant data to the Agency.

Definition of Unsafe Condition

AMC 21.A.3B(b) Unsafe condition

An unsafe condition exists if there is **factual e** ervice experience, analysis or tests) that:

Factual

(a) An event may occur that would result in **fatalities**, usually with the **loss of the aircraft**, or **reduce the capability of the aircraft** or the **ability of the crew** to cope with adverse operating conditions to the extent that there would be:

Catastrophic or Hazardous

(i) A large reduction in safety margins or functional capabilities, or

(ii) Physical distress or excessive workload such that the flight crew cannot be relied upon to perform their tasks accurately or completely, or

(iii) Serious or fatal injury to one or more occupants

unless it is shown that th **vent is within the limit defined by the applica** **ments**, or

Unless meeting Certification Basis

Definition of Unsafe Condition

AMC 21.A.3B(b) Unsafe condition

(b) There is an unacceptable risk of serious or **fatal injury to persons other than occupants**, or 

(c) **Design features** intended to minimise the effects of **survivable accidents** are **not performing their intended function**. 

AMC 21.A.3B(b) - Notes

AMC 21.A.3B(b) Unsafe condition *(cont'd)*

Note 1: **Non-compliance with app s requirements** is generally considered as an unsafe condit wn that possible events resulting from this non-compliance **do not constitute an unsafe condition** as defined under paragraphs (a), (b) and (c).

Non-Compliance

Note 2: An unsafe conditi rworthiness **requirements are co**

Unsafe different than compliance

Note 3: The above definition covers the **majority of cases** where the Agency considers there is a **considerations may lead the Agency to issue an airworthiness directive**.

Definition not exhaustive, overriding consideration may exist

Note 4: There may be cases where **events can be considered as an unsafe condition if they occur too frequently** (significantly beyond the applicable safety objectives) and could eventually lead to consequences listed in paragraph (a) in **specific operating environ** e listed in paragraph (a), the referenced events may reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions to the extent that there would be, for example, a **significant reduction in safety margins or functional capabilities, a significant increase in crew workload**, **or in conditions impairing crew efficiency, or discomfort to occupants, possibly including injuries**.

Need to reconcile Safety objectives and real failure case rate

CS25.1309/AMC25.1309 - Classification

Effect on airplane	No effect on operational capabilities or safety	Slight reduction in functional capabilities or safety margins	Significant reduction in functional capabilities or safety margins	Large reduction in functional capabilities or safety margins	Normally with hull loss
Effect on occupants excluding flight crew	Inconvenience	Physical discomfort	Physical distress, possibly including injuries	Serious or fatal injury to a small number of passengers or cabin crew	Multiple fatalities
Effect on flight crew	No effect on flight crew	Slight increase in workload	Physical discomfort or a significant increase in workload	Physical distress or excessive workload which impairs ability to perform tasks	Fatalities or incapacitation
Allowable qualitative probability	**No probability requirement**	**Probable**	**Remote**	**Extremely remote**	**Extremely improbable**
Allowable quantitative average probability per FH	No probability requirement	$<10^{-3}$	$<10^{-5}$	$<10^{-7}$	$<10^{-9}$
Classification of failure conditions	**No safety effect**	**Minor**	**Major**	**Hazardous**	**Catastrophic**

Definition of Unsafe Conditions – Usual Issues

- Who is responsible for making the determination?
  - TC/STC Holders
- CAT or HAZ events, importance of probability
- MAJOR events, classification and probability
  - Frequency
  - Interpretation of *« overriding safety considerations »*
- Which criteria for “risk to non-occupants”
  - 1kg, large parts, runway safety
- Unsafe condition with no aircraft malfunction
- Crashworthiness issues

Corrective action(s)

- GM 21A.3B(d)(4)
  - To be used to determine AD compliance time
  - Recognises the need to manage risk
  - Recognises the need to maintain aviation services
  - First need to restore adequate level of risk through inspection, limitations
  - Method not intended to avoid shorter reaction times
  - Upper limit for probability level, 2.10-6/FH for CAT
  - Fleet criteria is also included (0,1 for CAT)

Corrective action(s)

- GM 21A.3B(d)(4) Defect Correction
  - Different steps to be considered for hazardous to catastrophic failure conditions:
    - i - Establish **all possible alleviating action** su Risk Alleviation crew drills, route restrictions, and other limitations
    - ii - **Identify that part of the fleet,** v Impacted Fleet the residual risk
    - iii - **Using reasonably cautious assumptions**, calculate the likely hazardous/catastrophic **rat** Individual Risk **carrying the risk** in the affected fleet
    - iv - Compare Proposed Campaign Risk Acceptability aign will correct the deficiency wi
    - v - Also ensure that the expected probability of the catastrophic event during the rectification period on t Fleet Risk **in accordance with Fleet risk** (fig.4 of GM)

GM 21A.3B(d)(4) – Assumptions Individual Risk

Occurrence Classification	**Catastrophic**	**Hazardous**
	If Probability abobe – Fleet grounded Maximum Allowance per aircraft:	Maximum Allowance per aircraft:
	1 in 10^7 flight hours	1 in 10^5 flight hours
75% of this allowance is considered to be "basic design risk". That leaves only 25% for unforeseen campaign situations	Maximum Allowance per aircraft: $25\% * 1 * 10^{-7} = 0.25 * 10^{-7}$	Maximum Allowance per aircraft: $25\% * 1 * 10^{-5} = 0.25 * 10^{-5}$
10 Rectification Campaigns	Maximum Allowance per aircraft per campaign: $\frac{0.25 * 10^{-5}}{10} = 0.25 * 10^{-6}$	Maximum Allowance per aircraft per campaign: $\frac{0.25 * 10^{-7}}{10} = 0.25 * 10^{-8}$
Aircraft Design Life – 60,000 FH	Event Level per campaign: $60\,000 * 0.25 * 10^{-8} = 1.5 * 10^{-4}$	Event Level per campaign: $60\,000 * 0.25 * 10^{-6} = 1.5 * 10^{-2}$

Probability of Occurrence for a given Failure Condition (PO): $PO * RT1 \leq Event\ Level\ per\ campaign$

Reaction Time	Reaction Time 1:	Reaction Time 1:
	$RT1 = \frac{1.5 * 10^{-4}}{PO}$	$RT1 = \frac{1.5 * 10^{-2}}{PO}$

GM 21A.3B(d)(4) – Assumptions Fleet Risk

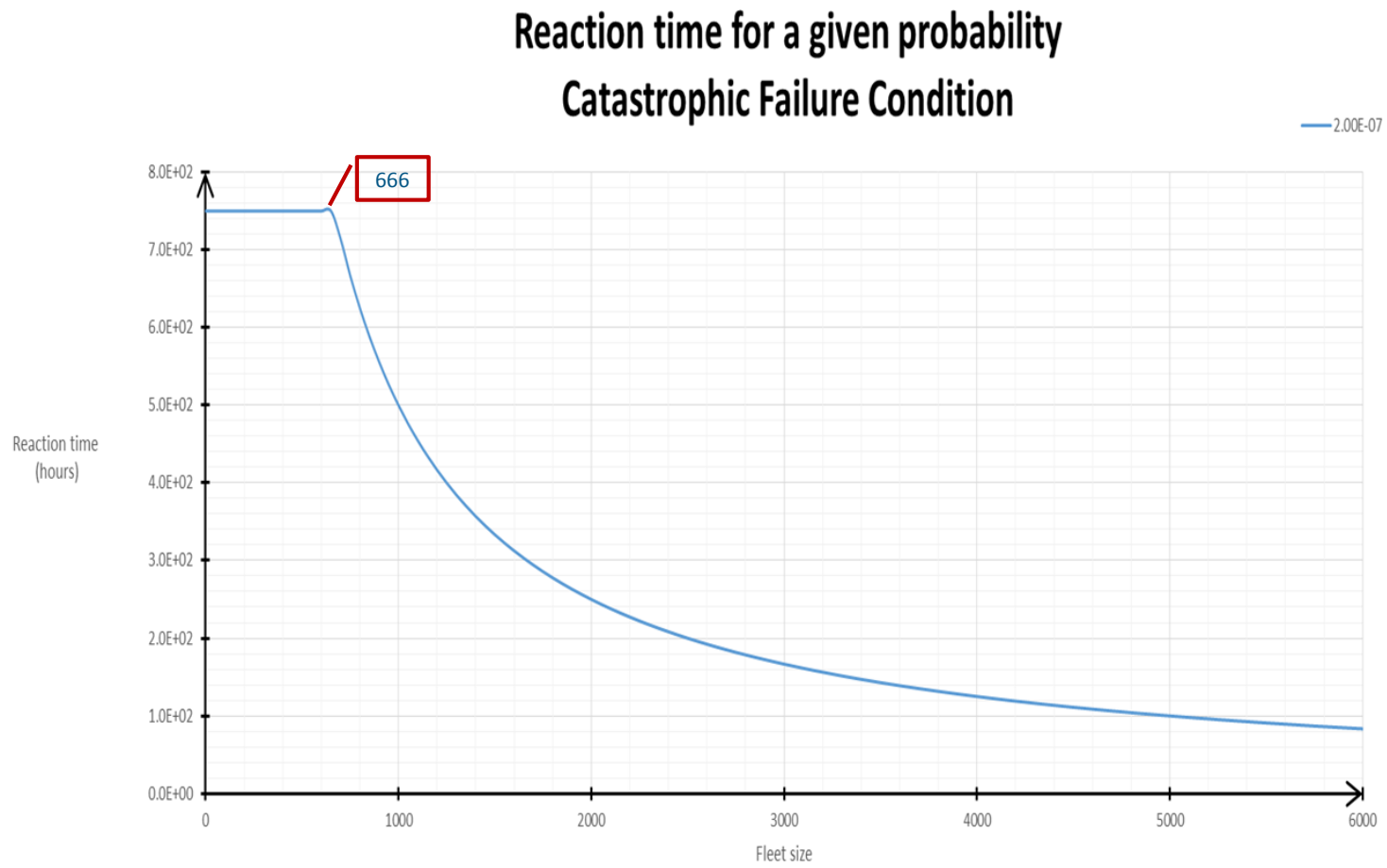
Occurrence Classification	**Catastrophic** Large fleet criterion: 0.1	**Hazardous** Large fleet criterion: 0.5

For a given Failure Condition (PO) and a number of affected A/C (N): $PO * RT2 * N \leq Large\ fleet\ criterium$

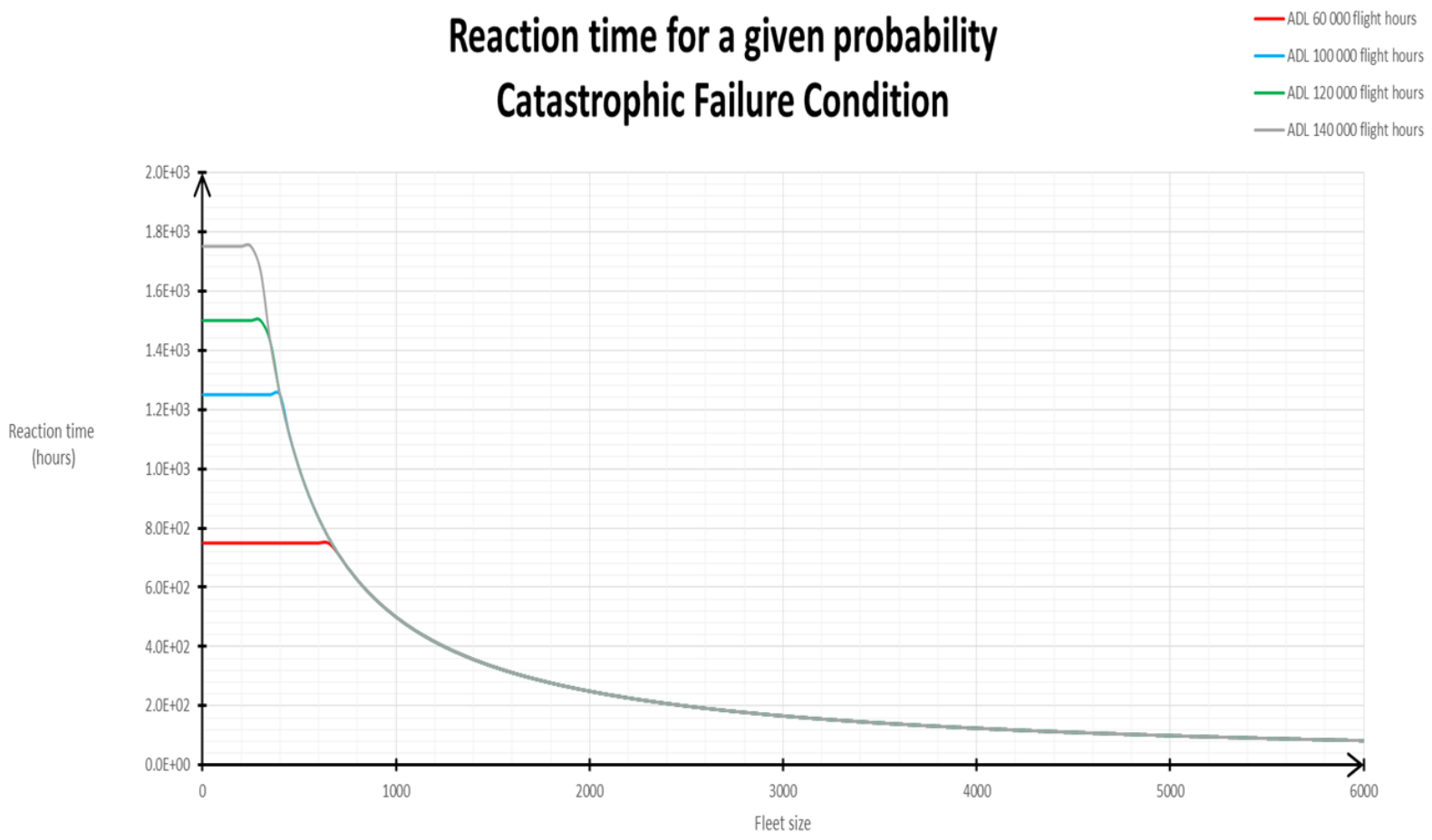
Maximum average reaction time for the fleet	Reaction Time RT2 $RT2 = \frac{0.1}{N * PO}$	Reaction Time RT2 $RT2 = \frac{0.5}{N * PO}$
Threshold of fleet size criteria becoming predominant	N=666	N=33

WATHEVER THE METHOD, IT GIVES THE MAXIMUM AVERAGE REACTION TIME for THE WHOLE AFFECTED FLEET

Example – P0=2.10-7 ADL=60,000FH



Effect of the Design Service Life



Reaction Time Table

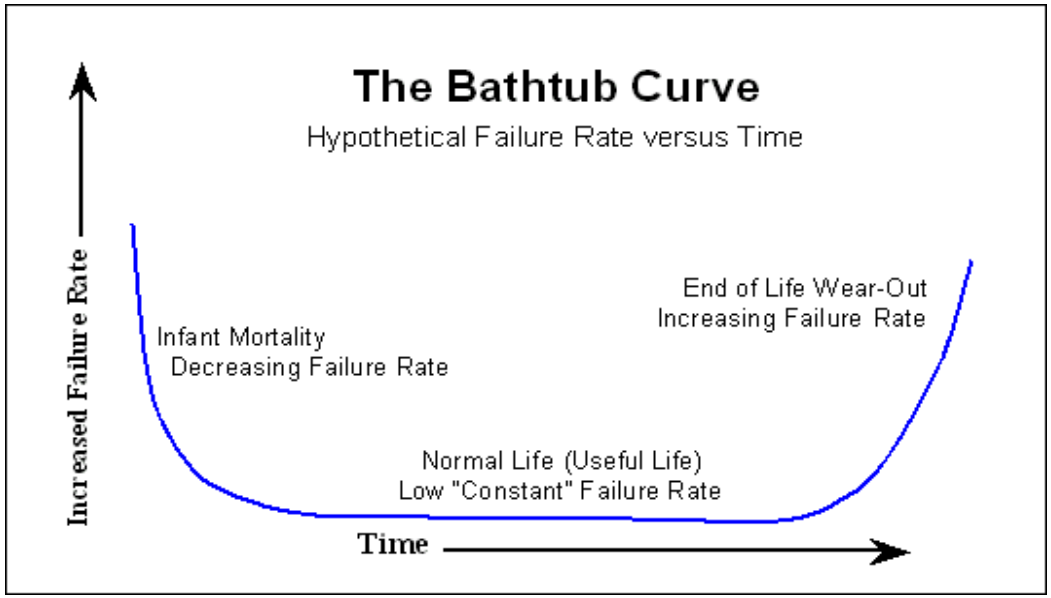
Estimated catastrophe rate to aircraft due to the defect under consideration (per a/c hour)	Average reaction time for aircraft at risk (hours)	On a calendar basis
4×10^{-8}	3 750	15 months
5×10^{-8}	3 000	12 months
1×10^{-7}	1 500	6 months
2×10^{-7}	750	3 months
5×10^{-7}	300	6 weeks
1×10^{-6}	150	3 weeks
1×10^{-5}	15	Return to base

However…

- The Guidance Material
  - Is a Guidance!
  - Is not intended to avoid quicker reaction times without high expense or disruption of service
- A considerable amount of engineering judgement is necessary to take into account the multiple real life factors
- Final Decision may be tempered by non numerical considerations

Other Consideration

- The Guidance may not be adequate to tackle
  - Aging issues – Old A/C prioritisation
  - Infant mortality issues – new A/C prioritisation
  - Fatigue – depend on FC and FH considerations



Typical Issues encountered

- TCH/STCH tend to use the method for all issues
  - As described, not always adequate
- Not necessarily intended to be used for structure issues and for safety features
- Need to be cautious in estimation of probability
  - Some fancy statistical approaches
- When to start the clock?
  - Date of the Unsafe Condition, of the occurrence…
  - SB availability

USE COMMON SENSE

Decision making

- Team: PCM with experts – primary level
  - Identify Unsafe Condition and discuss corrective actions
  - Together with TC/STC Holder
- Product Line Section Manager
  - Endorsement (or not) of the proposal
  - Check and agree PAD
  - Sign AD
- Escalation Process
  - Large Aeroplane Safety Board
  - CT management
  - ISC

Difference with FAA System - TARAM

- TARAM =Transport Airplane Risk Assessment Methodology
- TARAM Methodology
  - Meant to calculate risks and not really compliance times
  - Part of a method also requiring engineering judgment
  - Is more complex than the Part 21 GM
  - Cost related

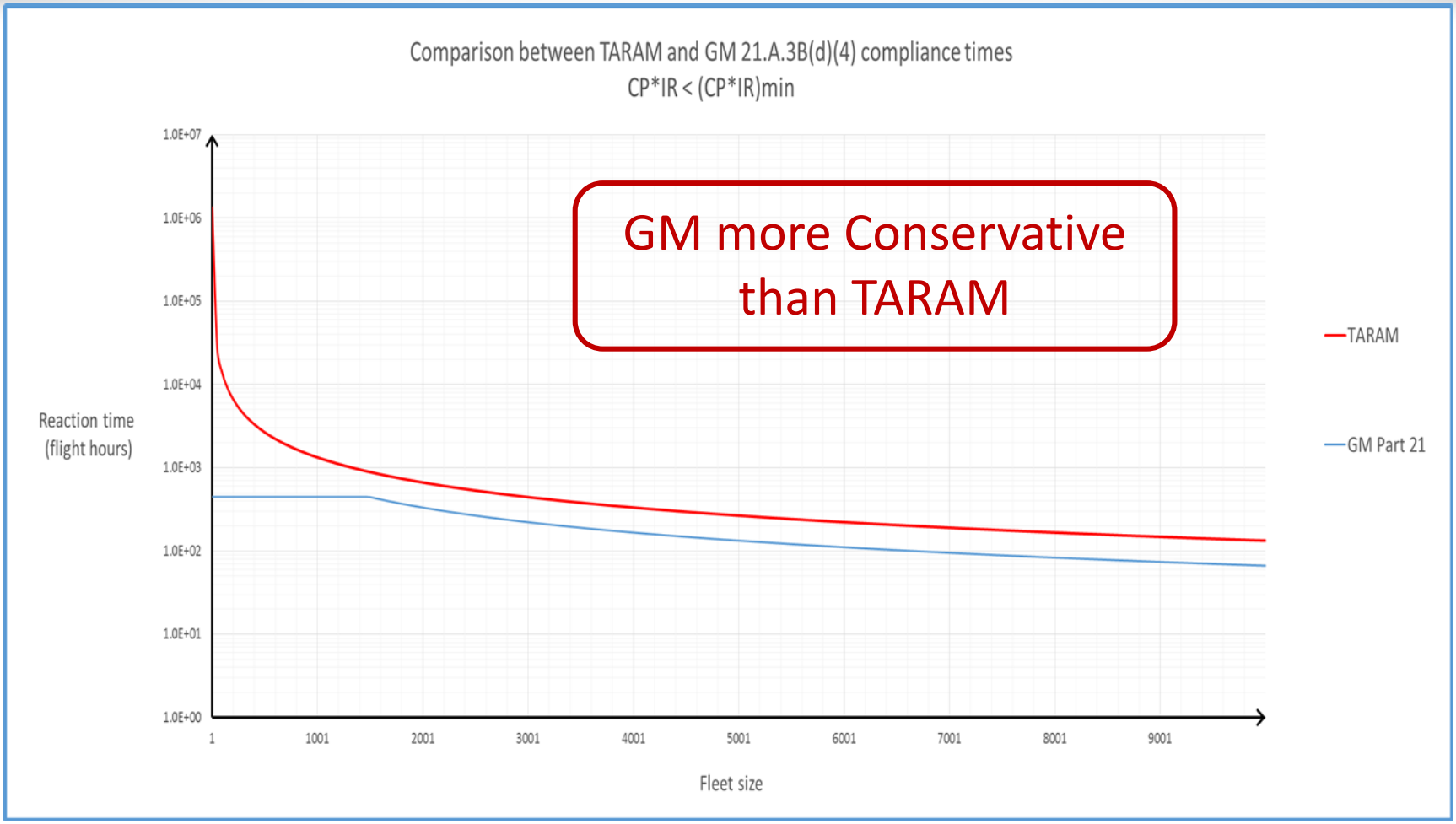
TARAM – The tool – Risks Description

- 5 different risks
  - **Uncorrected Individual Risk**: “probability of individual fatal injury per flight hour, during a reasonable number of flights that occur any time in the remaining life of affected airplanes, if no mandatory action(s) is required”
  - **Uncorrected Fleet Risk**: “number of severity-weighted events due to a specific condition in the remaining life of affected airplanes if no mandatory action is required”
  - **90-Day Fleet Risk**: “number of fatal injuries expected to occur due to a specific condition in affected airplanes in the 90 days following the determination that a specific condition is a safety issue”
  - **Control Program Individual Risk**: “probability of individual fatal injury per flight hour occurring during a reasonable number of flights within the control program time”
  - **Control Program Fleet Risk:** “number of fatal injuries (or severity-weighted events) expected due to a specific condition in affected airplanes during the control program time”

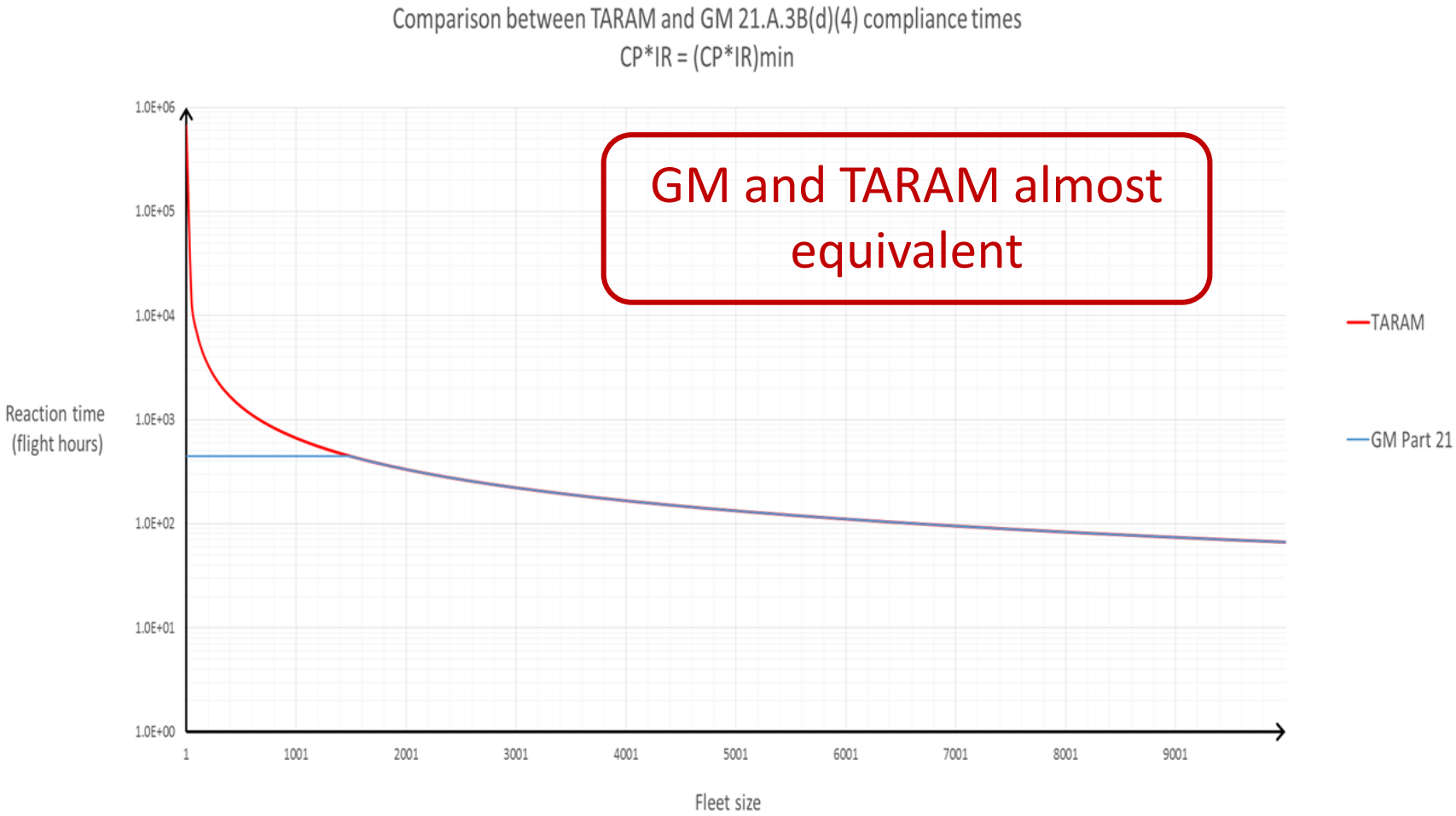
Example - Hypothesis

- A passenger A/C (TARAM guideline = 0.02)
- PO = 1,5*10-7 per flight hour
- Utilization U = 2.1 hours per day i.e. an Aircraft Design Life of 27 000 flight hours flying 35 years
- 10 campaigns
- A catastrophic failure condition
- CP*IR = 0.1 (Comparison 1)
- CP*IR = 0.2 (Comparison 2)
- CP*IR = 0.34 (Comparison 3)

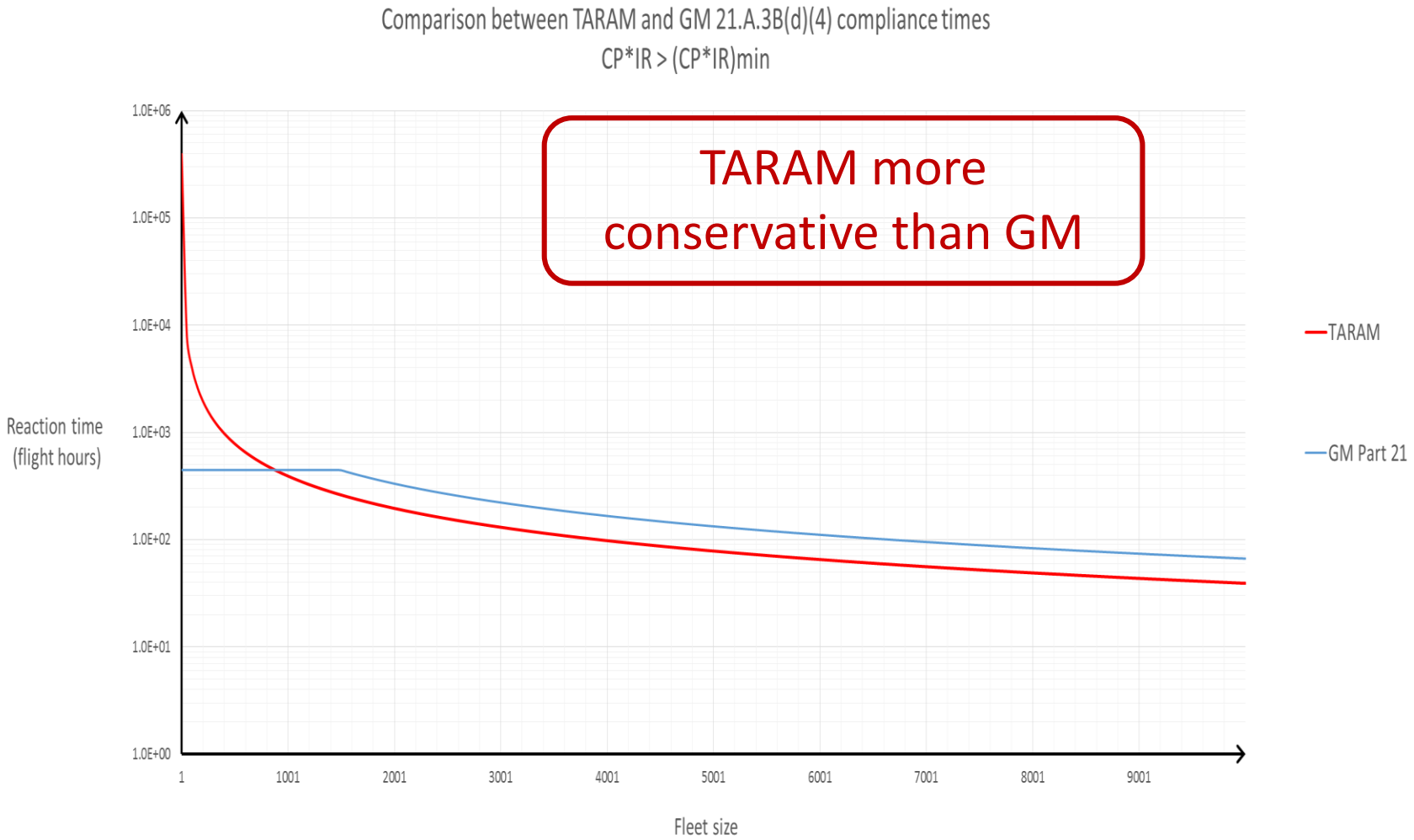
Comparison 1



Comparison 2



Comparison 3



Conclusions

- The Guidance is a starting point
- It does not represent the reality
  - A whole set of assumptions are behind them and each TC/STC holder must be aware of them
  - Is not a magic tool
  - Require extensive and specialised knowledge to be used
- Different assessment methodologies exist
  - Rather consistent
  - Complexity vs simplicity
- Engineering Judgement and Common Sense are a MUST for correct CAW assessment

Conclusions

- Determination of Unsafe Condition and Compliance Time is
  - Following a structured process
  - Following a structured decision making
  - Always focusing on Safety

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BUT Experience shows it provides adequate Level of Safety Up to now…

NO Compromise with Safety

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Thank You
Any Question?

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