Pratt & Whitney Canada
A United Technologies Company

ENGINE RELIABILITY DEMONSTRATION IN SUPPORT OF EUROPEAN SET IMC APPROVAL

Cologne July 4th, 2017

Yvan Nadeau

DEPENDABLE

ENGINES | SUPPORT | INNOVATION | PEOPLE

EXPORT CLASSIFICATION

Check this box if presentation contains "**no technical data**" [X] OR summarize the export classifications of all slides in this presentation as instructed below:

Instructions: Box 1 and one (1) of boxes 2-5 must always be completed	
	Classification:
1. Canadian ECL(s):	NLR
2. ECCN(s) (EAR):	
3. P-ECCN(s) :	
4. USML (ITAR):	
5. P-USML:	

AGENDA

P&WC In Service

P&WC Reliability Process

Reliability Demonstration

Communication

Conclusion

PWC IN-SERVICE EXPERIENCE

P&WC PRODUCT MANDATE
Over 100,000 Engines Produced

General Aviation
500–2,000 shp

PT6A Small

PT6A Medium

PT6A Large

Regional Turboprop
1,800–6,500 shp

PW100

PW150

Auxiliary power units

PW900

APS

Helicopter
600–2,200 shp

PW200

PW210

PT6T/B

PT6C

Business Aviation
900–20,000 lbf

PW600

JT15D

PW500

PW300

PurePower® PW800

Export Classification: **[No Technical Data]**

P&WC KEY BUSINESS SEGMENTS

Business Aviation

Embraer Phenom 300

Dassault F7X/F8X

APU

Boeing 787

Airbus A380

General Aviation

Beechcraft King Air 350

Cessna Grand Caravan EX

Regional

ATR 72

Bombardier Q400

Civil Helicopters

Leonardo AW169

Bell 429

Military

Beechcraft T-6C

Pilatus PC-21

Aftermarket

Customer First Centre

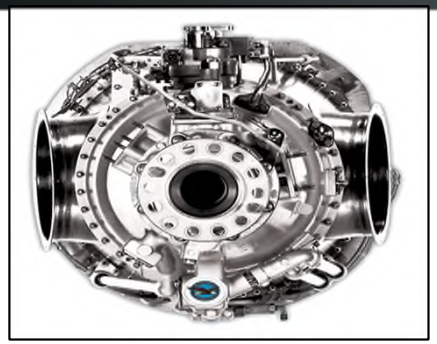
Maintenance, Repair & Overhaul

GLOBAL ACTIVITY

Operators	+14,500
Airlines	+1,300
Aircraft in service	+37,000
Engines in service	+60,000
Countries and territories	+200
Operating hours	+800,000,000

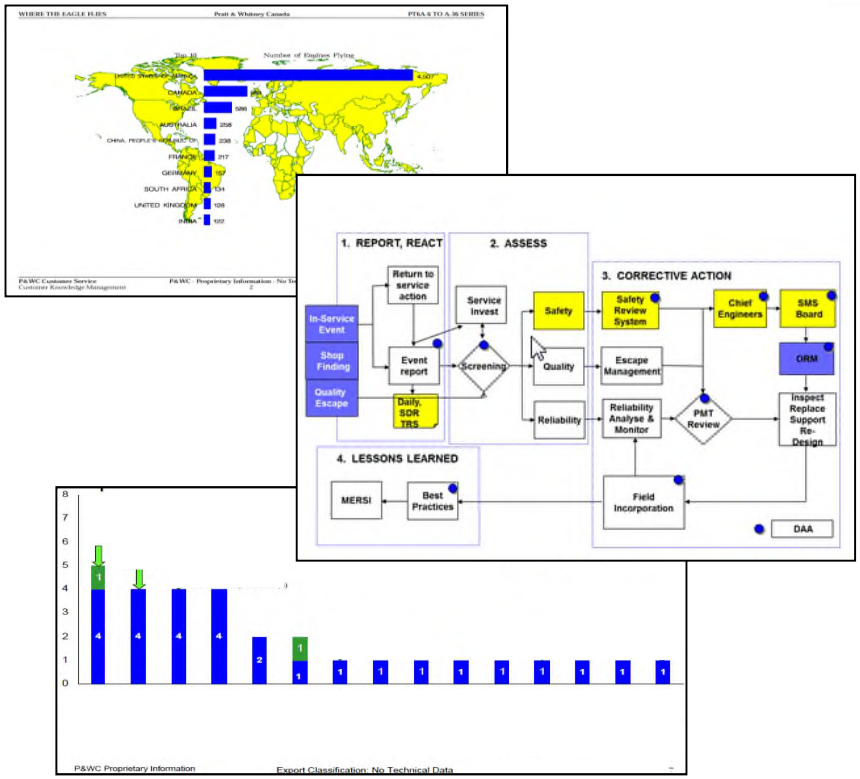
PWC RELIABILITY PROCESS

PT6A ENGINE RELIABILITY



	PT6A Models	P&WC Engines (APU excluded)
Fleet Hours	382,390,000	705,744,000
Flying Engines	23,470	54,482
Annual hours	11,569,200	27,602,000
Fleet BIFSD Rate	3 per Million	4 per Million
Fleet TIFSD Rate	6 per Million	8 per Million

RELIABILITY PROCESS



Key Ingredients

High fidelity database

Rapid analysis of event drivers

- Report, React, Assess
- Corrective Action
- Lessons Learned

RELIABILITY DEMONSTRATION & MONITORING IN SUPPORT OF EUROPEAN APPROVAL OF SET IMC

RELIABILITY REQUIREMENTS DEFINITION

AMC1 SPA.SET-IMC.105(a) SET-IMC operations approval

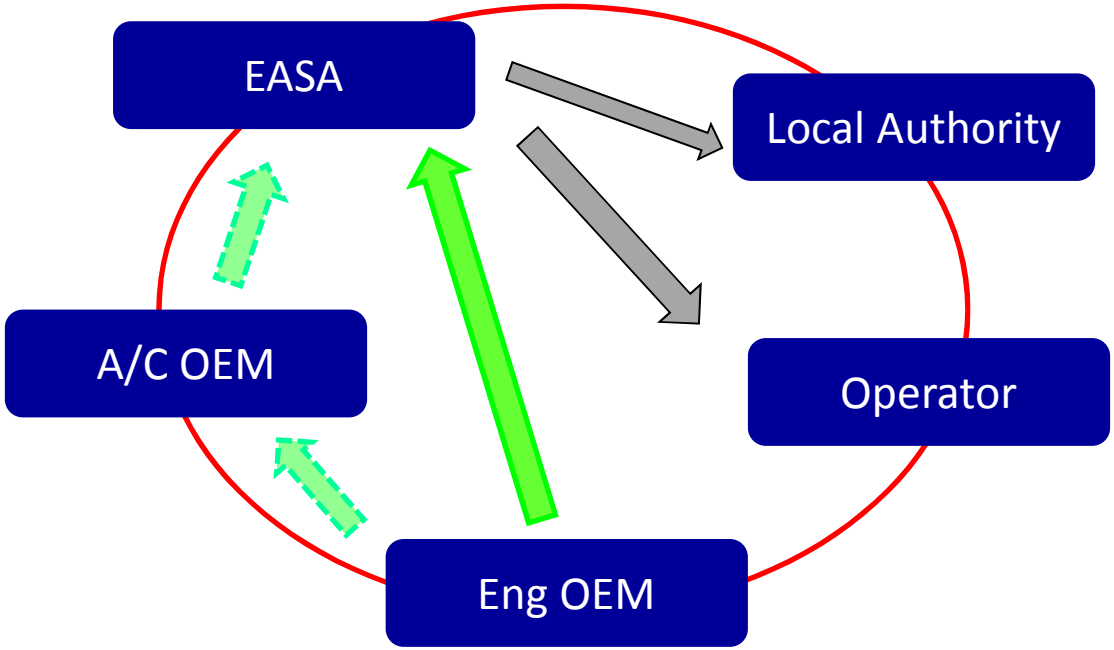
TURBINE ENGINE RELIABILITY

(a) The operator should obtain the power plant reliability data from the type certificate (TC) holder and/or supplemental type certificate (STC) holder.

(b) The data for the engine-airframe combination should have demonstrated, or be likely to demonstrate, a power loss rate of less than 10 per million flight hours. Power loss in this context is defined as any loss of power, including in-flight shutdown, the cause of which may be traced to faulty engine or engine component design or installation, including design or installation of the fuel ancillary or engine control systems.

(c) The in-service experience with the intended engine-airframe combination should be at least 100 000 h, demonstrating the required level of reliability. If this experience has not been accumulated, then, based on analysis or test, in-service experience with a similar or related type of airframe and turbine engine might be considered by the TC/STC holder to develop an equivalent safety argument in order to demonstrate that the reliability criteria are achievable.

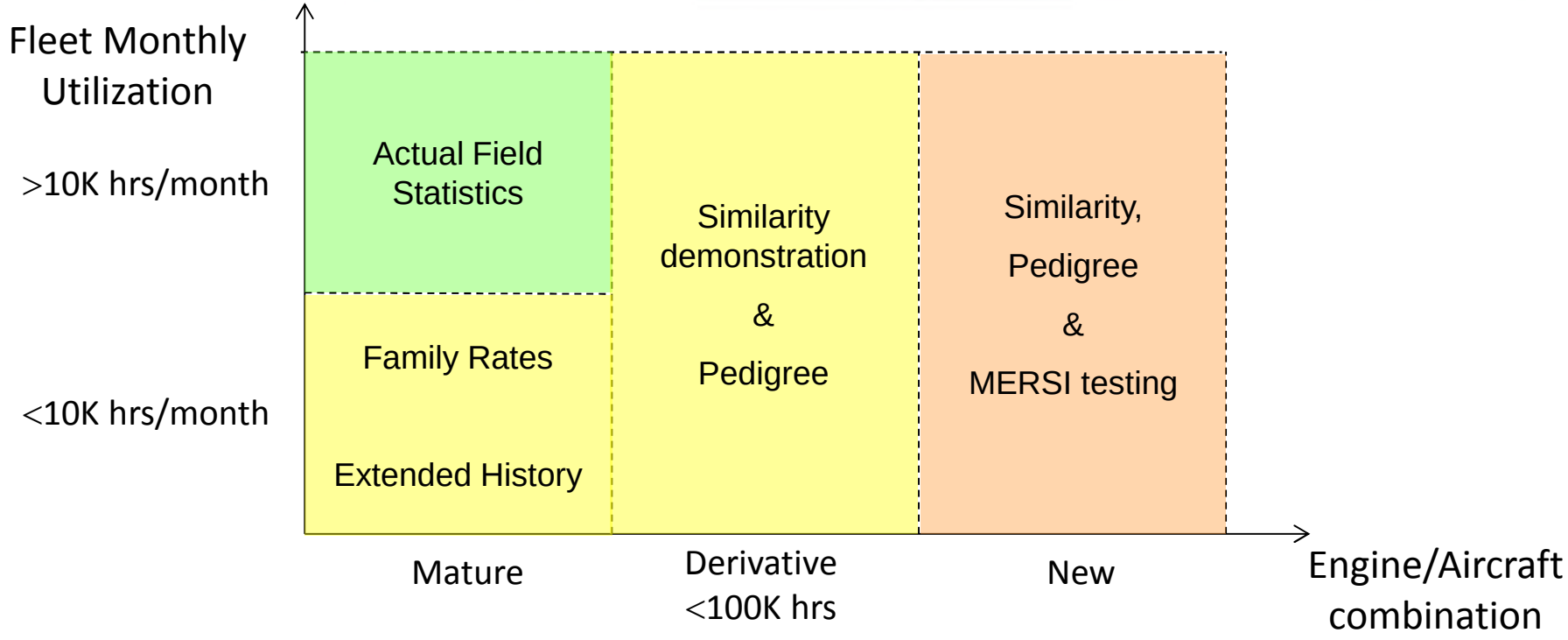
ECOSYSTEM – SET IMC RELIABILITY



Step 1:
Engine OEM presents reliability data to EASA

Step 2:
EASA reviews and accepts data and make determination available to operator and OEM

POSSIBLE MEANS of compliance



All events need to be properly charaterized

CHARACTERIZING FIELD EVENTS

Elements to consider

- New issue never seen before?
- Design, Quality, Maintenance, Operation related?
- Physics based explanation?
- OEM parts and recommendations?
- Weibull analysis to determine wear-out or infant mortality
- Risk assessment to predict future rate of event

Past Rate is not necessarily indicative of future risk

NEW ENGINE OR DERIVATIVE

Elements to consider:

- Degree of Commonality or similarity to prior designs
- Field experience of prior designs
- Difference in power levels, mission, environment, usage
- Sourcing and manufacturing process
- Validation process and experience

Leverage engine certification/validation process to present data to EASA

MANAGING 10 per MILLION HOURS RATE USING FIELD DATA

Rate is TOTAL IFSD (all causes), with a 12 month rolling average .

Per ETOPS norms

Basic (engine design only) IFSD rates also tracked

The TIFSD rate will be highly erratic until a significant number of hours are accumulated on a monthly basis.

At 1,000 fleet hours per month, 1 event will create a TIFSD rate of 83/M

At 10,000 fleet hours per month, 1 event will create a TIFSD of 8.3/M

It is recommended that 10,000 fleet hours per month be the boundary for using statistical rates to show compliance

Per AC 120.42B (ETOPS)

The certificate holder must investigate any indication of a high IFSD rate; however, it should consider that in the case of the smaller fleet, the high IFSD rate may be because of the limited number of engine operating hours used as the denominator for the rate calculation. This can cause an IFSD jump well above the standard rate because of a single IFSD event.

UNDER 10/M – SMALL FLEETS

For Engine/Airframe Combinations with **less than 10,000 hrs MRT**

If engine issue is clearly independent of potential installation or operational effects, use current family rates – provided that engine issue is not unique and is not occurring more frequently than general family.

eg –

1) One RGB distress experienced in installation having less power demand than general family – use family rate
2) First stage compressor distress in an installation having higher power and mass flow than general family, and is occurring more frequently than in general family – do NOT use family rates. Address on basis of a corrective continued airworthiness plan as agreed with TCCA and EASA.

OVER 10/M - LARGE FLEETS

For Engine/Airframe Combinations with **more than 10,000 hrs AMU**

Characterize all IFSD event to assess future risk

Corrective Plan to be provided to TCCA/EASA within 30 days of 10/M being exceeded, or risk of exceeding is identified

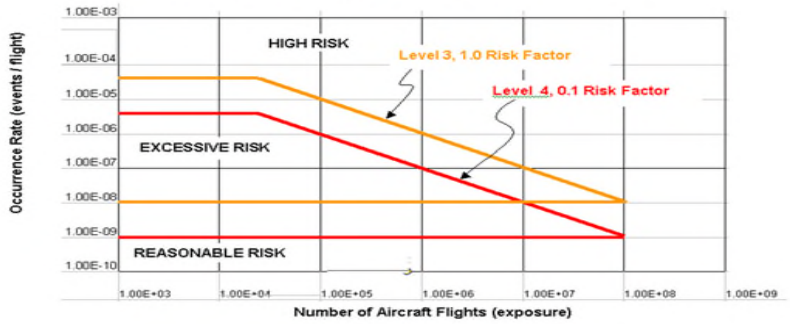
Plan to be based on AC39-8 methodology - or EASA GM21.A.3B(d)(4)

- Consider all IFSD drivers
- Establish future projections
- Specify actions to bring rate to <10/M (if rate will not self-correct)
- Ensure <0.5 incremental Cat 3 event and <0.1 incr. Cat 4-5

RATIONALE

The proposal is based on the logic of AC-39-8 , wherein a higher rate can be tolerated for a limited period of time, with a committed action plan that restores the rate to the target rate within a time period that does not result in a unreasonable increase in operational risk.

	Level 3 Guidelines		Level 4 Guidelines	
	Risk factor	Per flight	Risk factor	Per flight
Long-term acceptable risk	-	$1x10^{-8}$	-	$1x10^{-9}$
Short-term acceptable risk	1.0	$4x10^{-5}$	0.1	$4x10^{-6}$



COMMUNICATION

PROPOSED RELIABILITY COMMUNICATION

MONTHLY –

1. Summary of stats goes to TCCA and EASA for commercial singles

QUARTERLY –

1. EASA standing invite to TCCA/P&WC meetings
2. P&WC states which engine/airframe combinations meet 10/M total criteria
3. Minutes of meeting record TCCA and EASA concurrence

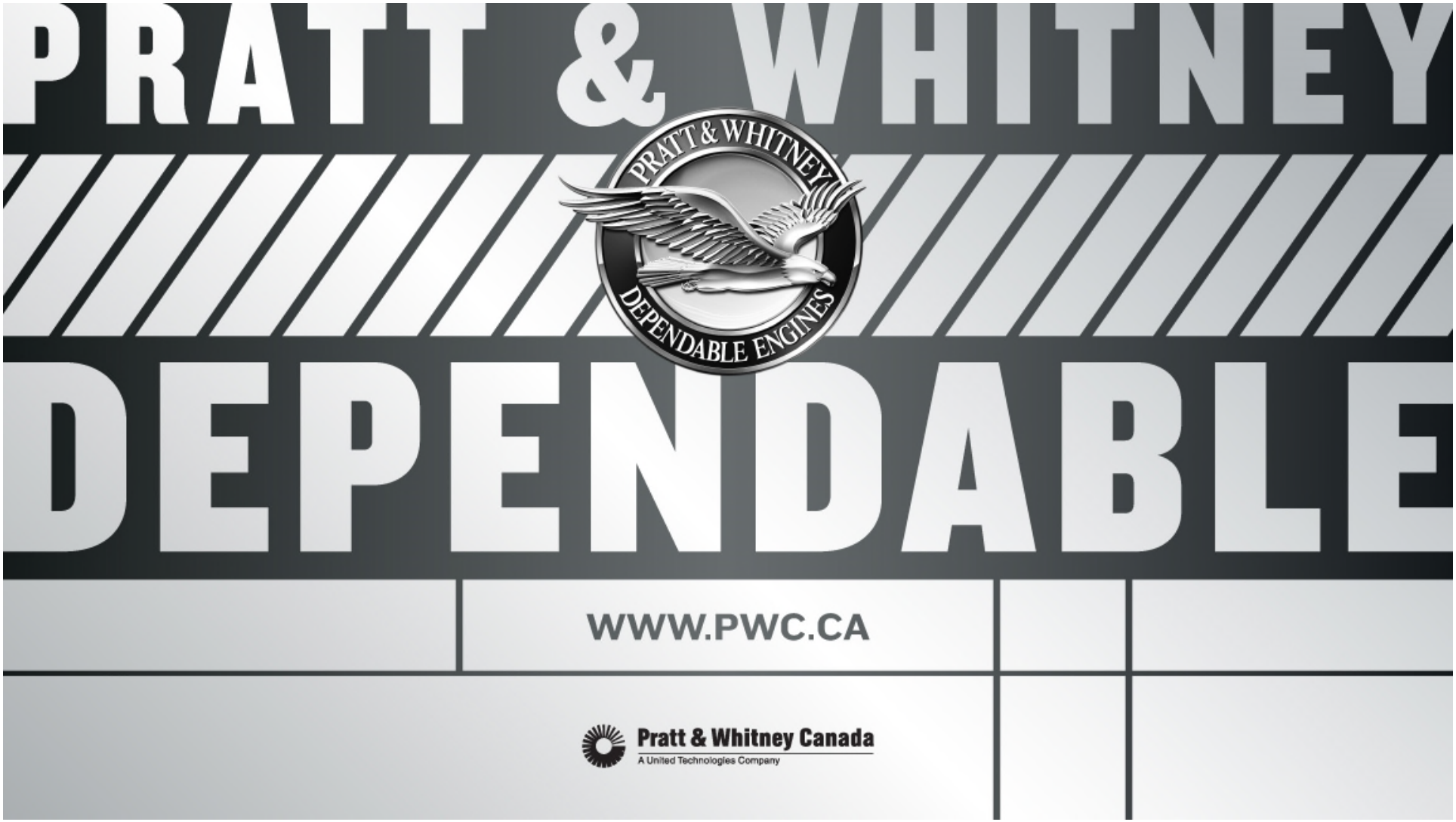
CONCLUSION

Reliability demonstration in support of SET IMC must rely on continuous event monitoring and characterization in order to understand reliability trends

Proposed means of compliance are based on proven, well established methods:

- SDR process to Certifying Authorities
- ETOPS (AC 120-42B)
- Risk Assessment per AC 39-8 or GM21.A.3B(d)(4)
- Corrective Action Plan

Care must be taken to establish reliability of small fleet with low utilization


PRATT & WHITNEY
PRATT & WHITNEY
DEPENDABLE ENGINES
DEPENDABLE
WWW.PWC.CA
Pratt & Whitney Canada
A United Technologies Company