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THE ACR-PCR METHOD

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2. Main features

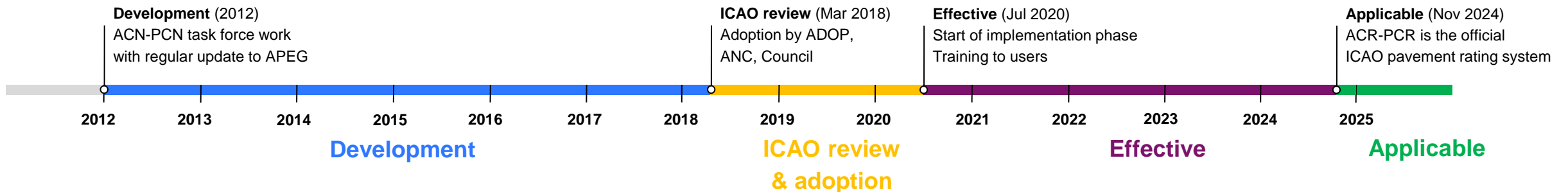
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- e) Overload Ops.

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Development process of ACR-PCR method

- The ACR-PCR method was finalized by the APEG beginning of 2018, followed by the full ICAO review & adoption process:
 - Aerodrome Design and Operations Panel (ADOP) adoption in March 2018
 - Air Navigation Commission (ANC) preliminary adoption in November 2018, final adoption (after consultation with States) in June 2019
 - ICAO Council adoption (amendment 15 to Annex 14) in March 2020
- The ACR-PCR method has been **effective** since July 2020:
 - Aircraft manufacturers start publishing their ACR
 - Trainings for users (CAAs, airports, aircraft manufacturers) can be initiated
 - CAAs should implement the new ICAO standard into the national regulations
 - Airports can start implementing the new protocol
- The method will be fully **applicable** in November 2024:
 - Airports should have published their PCR



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Key changes

- What **DOES NOT** change is the comparison of ACR and PCR as the core principle of the method:

If $ACR \leq PCR$, the aircraft can operate on the pavement without restriction

If $ACR > PCR$, the aircraft may be excluded, or may be allowed to operate subject to weight and/or frequency limitations

- What **DO** change are the procedures / model for determining the ACR and PCR:
 - Now based on rational models allowing the calculation of pavement mechanical response (surface deflections, internal stresses, strains within the pavement) induced by surface traffic loads from Layered Elastic Analysis (LEA)
 - Pavement **damage** is then quantified based on on a specific damage model, using as an input these responses (especially strains for flexible pavements and stresses for rigid pavements)

Key changes

- In **practical terms**, the ACR-PCR method will lead to:
 - New ACR values (calculated and published by aircraft manufacturers)
 - Still computed based on the combined result of aircraft wheel loads, tire pressures and landing gear geometry
 - New PCR values (calculated and published by airports)
 - Reporting format (one number and a series of four letters) is unchanged
 - A generic procedure for PCR determination is provided by ICAO (addressing the lack of ICAO guidance for PCN evaluation). **The generic procedure is general enough to accommodate most national or local (e.g. the generic procedure does not specify a particular subgrade failure model)**
 - The PCR is computed based on the accumulated pavement damage produced by entire traffic mix (**CDF Concept**)
 - Subgrade are now characterized by the elastic modulus E for both flexible and rigid pavements (unified characterization)
 - **Unchanged general approach** (comparison of ACR and PCR)
 - A new approach for overload operations (i.e. when $ACR > PCR$)
 - “ICAO allowance” is increased to 10% of the PCR for both flexible and rigid pavements
 - Overloads in excess of 10% may be allowed if justified through a technical analysis of the impact on pavement damage, consistent with the PCR philosophy



Both ACR and PCR numerical values are approximately one order of magnitude (10x) higher than the ACN and PCN numbers
However, **there is no ability to convert between ACN and ACR, nor between PCN and PCR**

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CUMULATIVE DAMAGE FACTOR (CDF) - DEFINITION

- The cumulative damage factor (CDF) is the amount of the structural fatigue life of a pavement which has been used up. It is expressed as the ratio of applied load repetitions to allowable load repetitions to failure, or, for one airplane and constant annual departures:
- $$CDF = \frac{\textit{Applied coverages}}{\textit{Coverages to failure}}$$
- where a coverage is one application of the maximum strain or stress due to load on a given point in the pavement structure.
- When $CDF = 1$, the pavement subgrade will have used all of its fatigue life;
- When $CDF < 1$, the pavement subgrade will have some remaining life and the value of CDF will give the fraction of the life used;
- When $CDF > 1$, all of the fatigue life will have been used and the pavement subgrade will have failed.
- For multiple aircraft (Miner's Rule):
- $CDF = CDF_1 + CDF_2 + \dots + CDF_N$ (Where CDF_i is the CDF for each airplane in the traffic mix and N is the number of airplanes in the mix.)

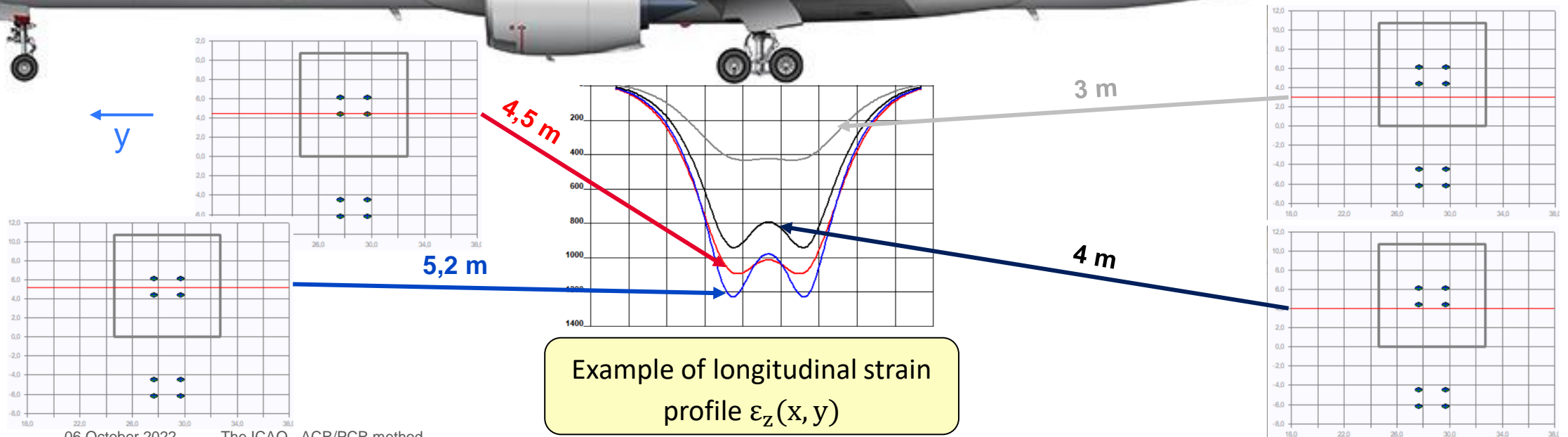
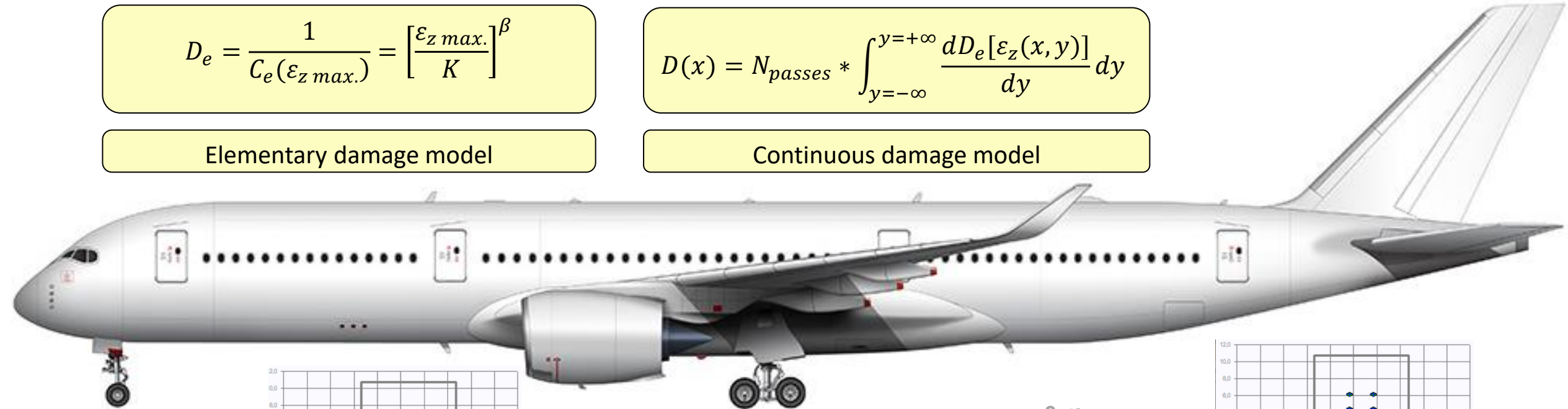
DAMAGE MODEL (EXAMPLE: WÖHLER / Subgrade criteria)

$$D_e = \frac{1}{C_e(\varepsilon_{z \max.})} = \left[\frac{\varepsilon_{z \max.}}{K} \right]^\beta$$

Elementary damage model

$$D(x) = N_{passes} * \int_{y=-\infty}^{y=+\infty} \frac{dD_e[\varepsilon_z(x, y)]}{dy} dy$$

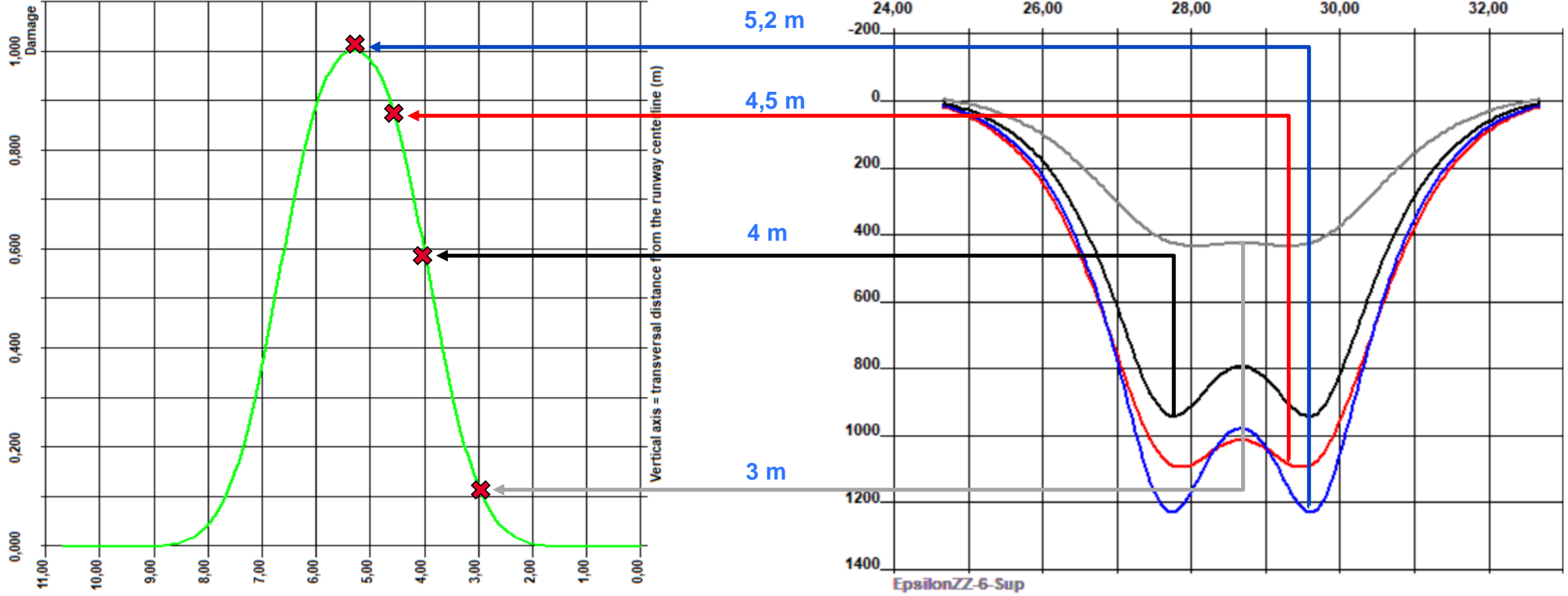
Continuous damage model



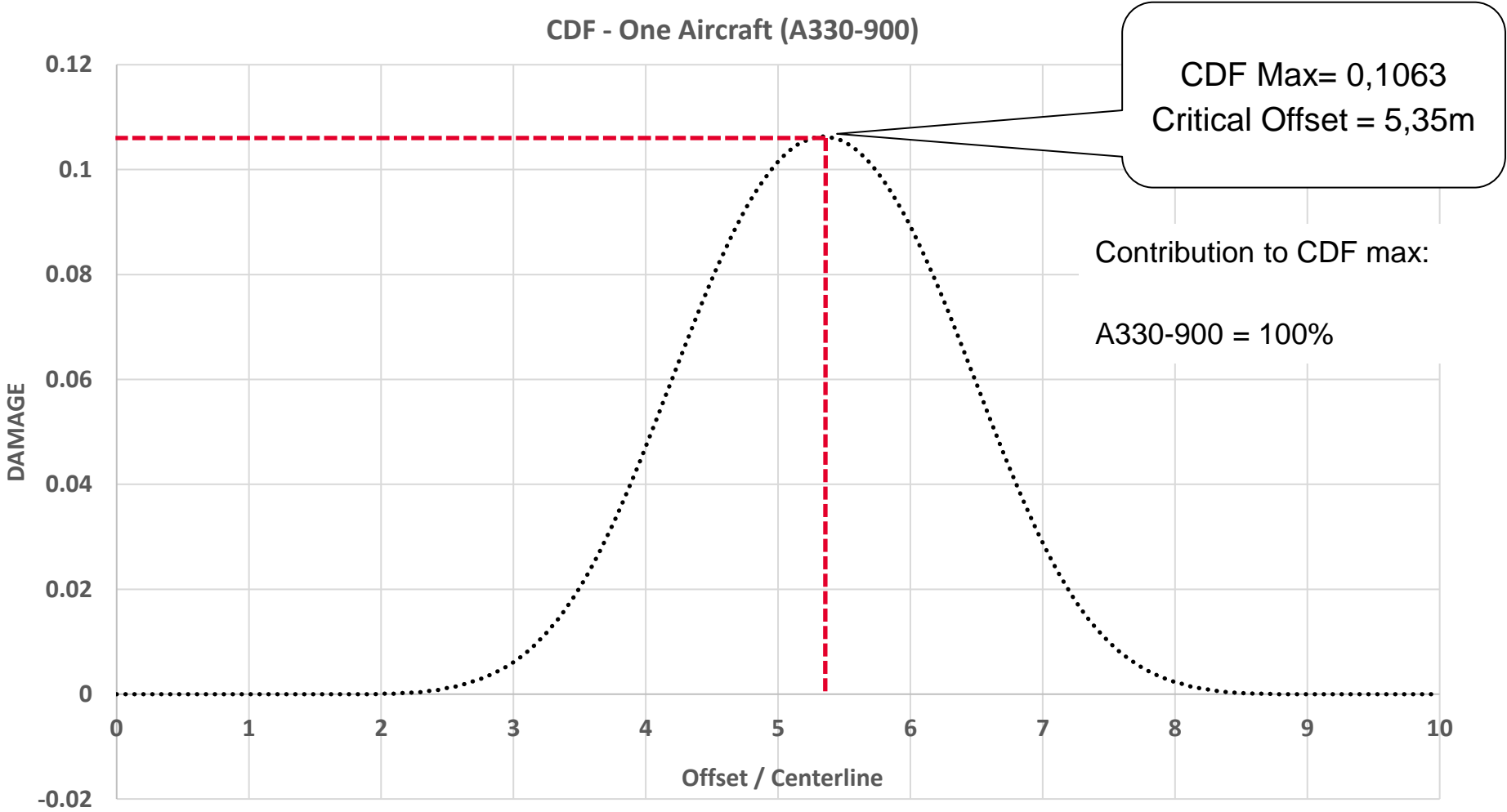
HOW IS CDF CURVE CALCULATED?



$$D(y, z_k) = \frac{\beta}{K\beta} \int_{-\infty}^{+\infty} \langle \varepsilon(x, y, z_k) \rangle^{\beta-1} \langle \frac{d\varepsilon}{dx}(x, y, z_k) \rangle dx$$

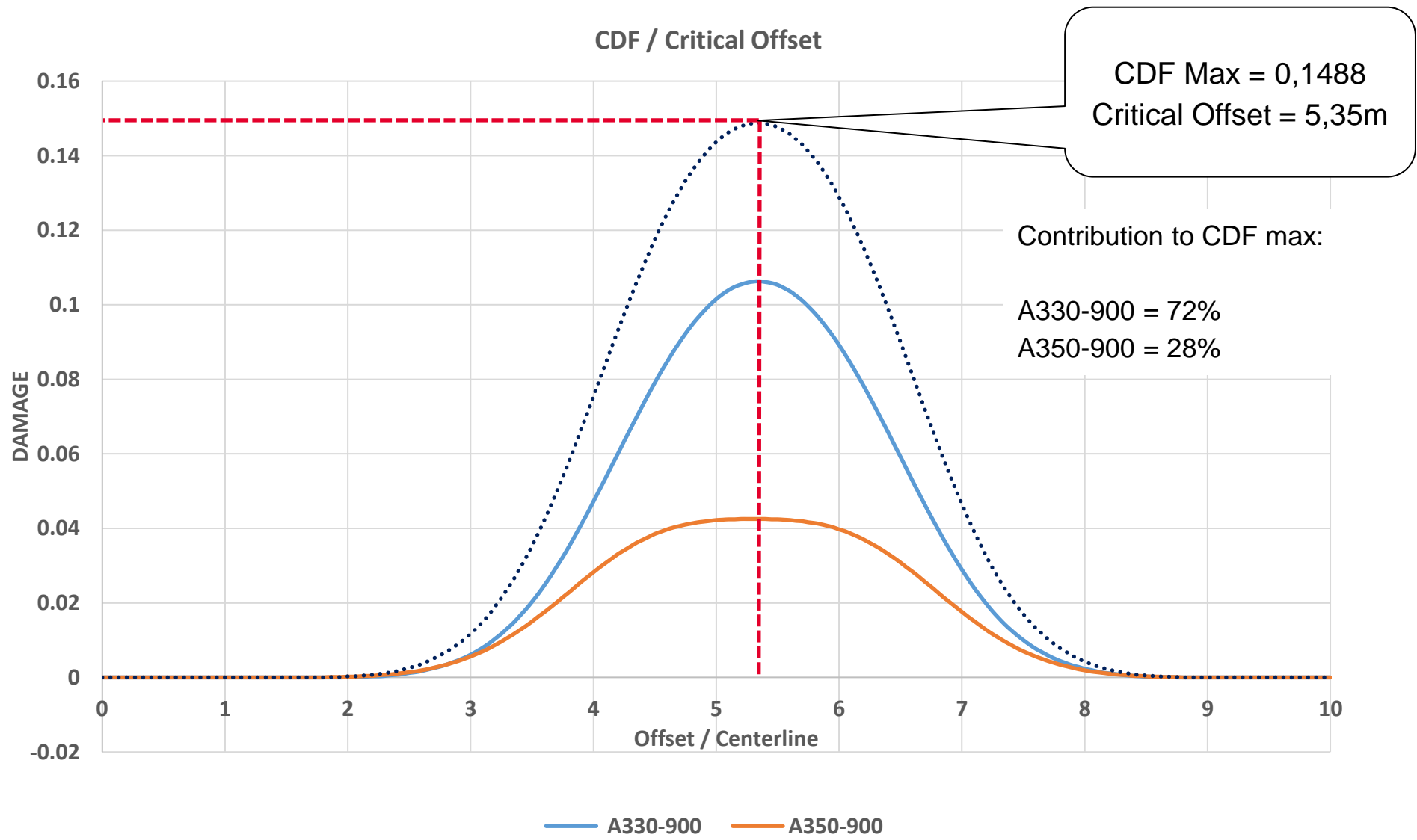


CDF – 1 (A330-900)



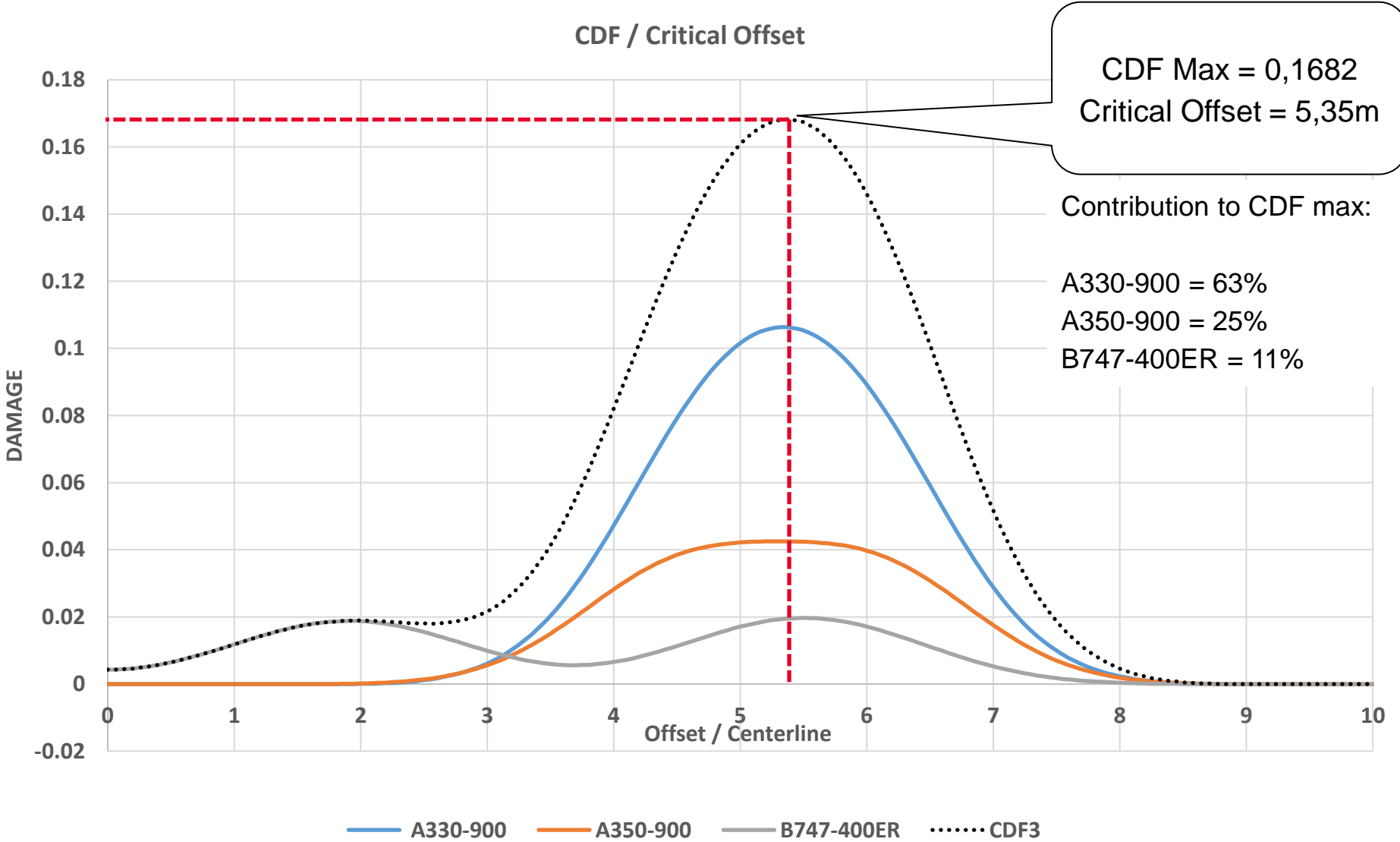
$CDF_{mix} = CDF_{A330-900}$

CDF – 2 (A330-900, A350-900)



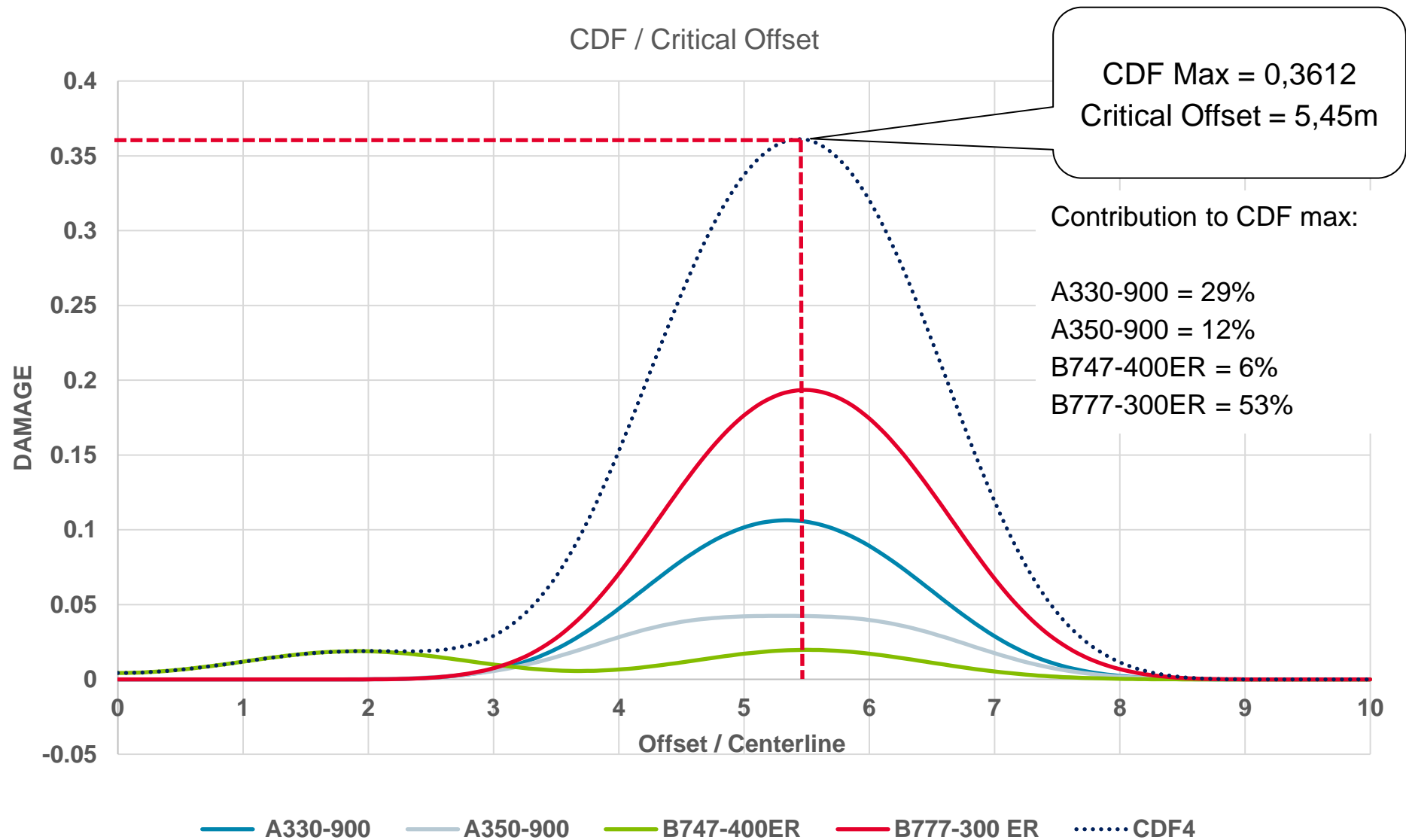
$CDF_{mix} = CDF_{A330-900} + CDF_{A350-900}$

CDF – 3 (A330-900, A350-900, B747-400ER)



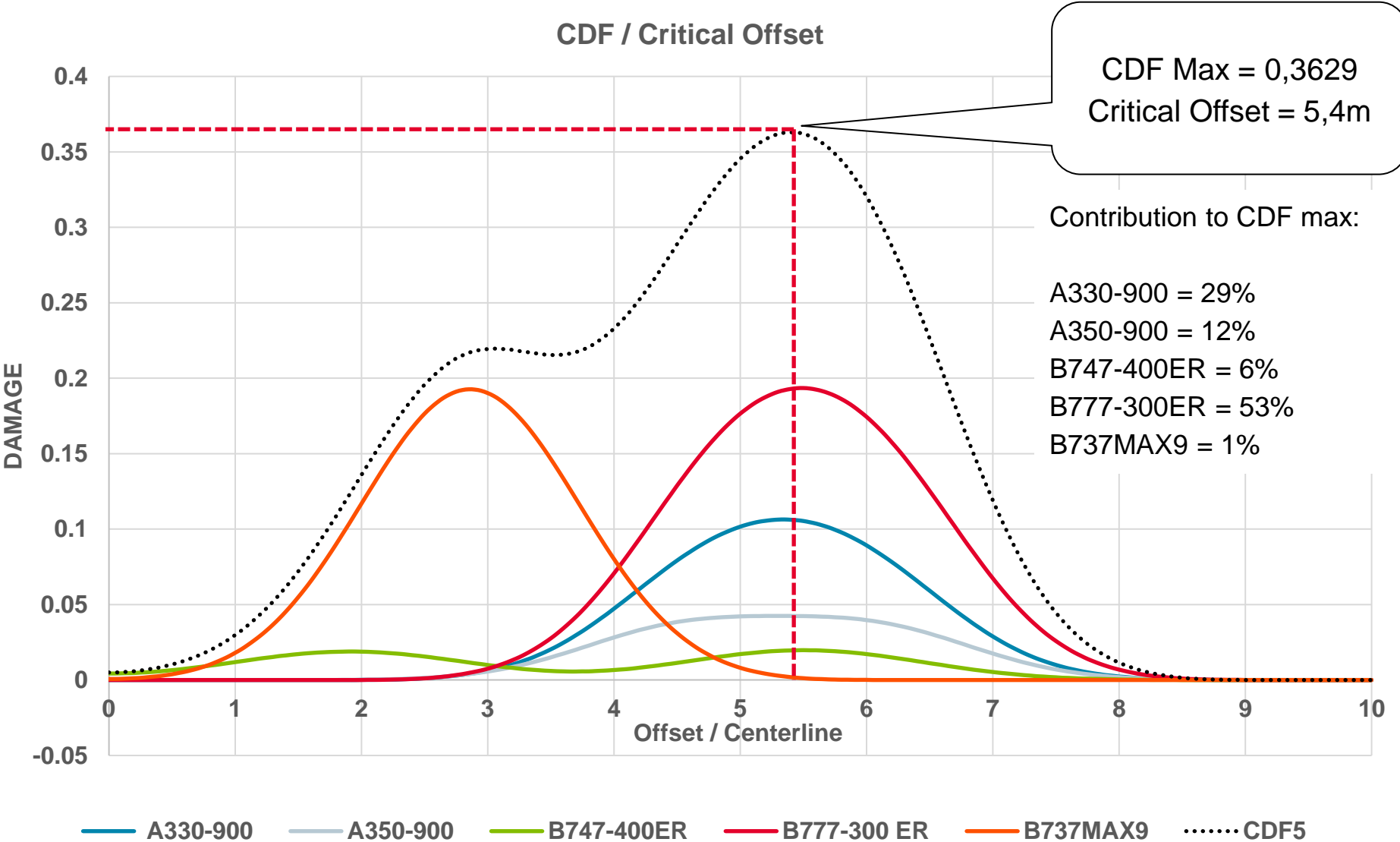
$CDF_{mix} = CDF_{A330-900} + CDF_{A350-900} + CDF_{B747-400ER}$

CDF – 4 (A330-900, A350-900, B747-400ER, B777-300ER)



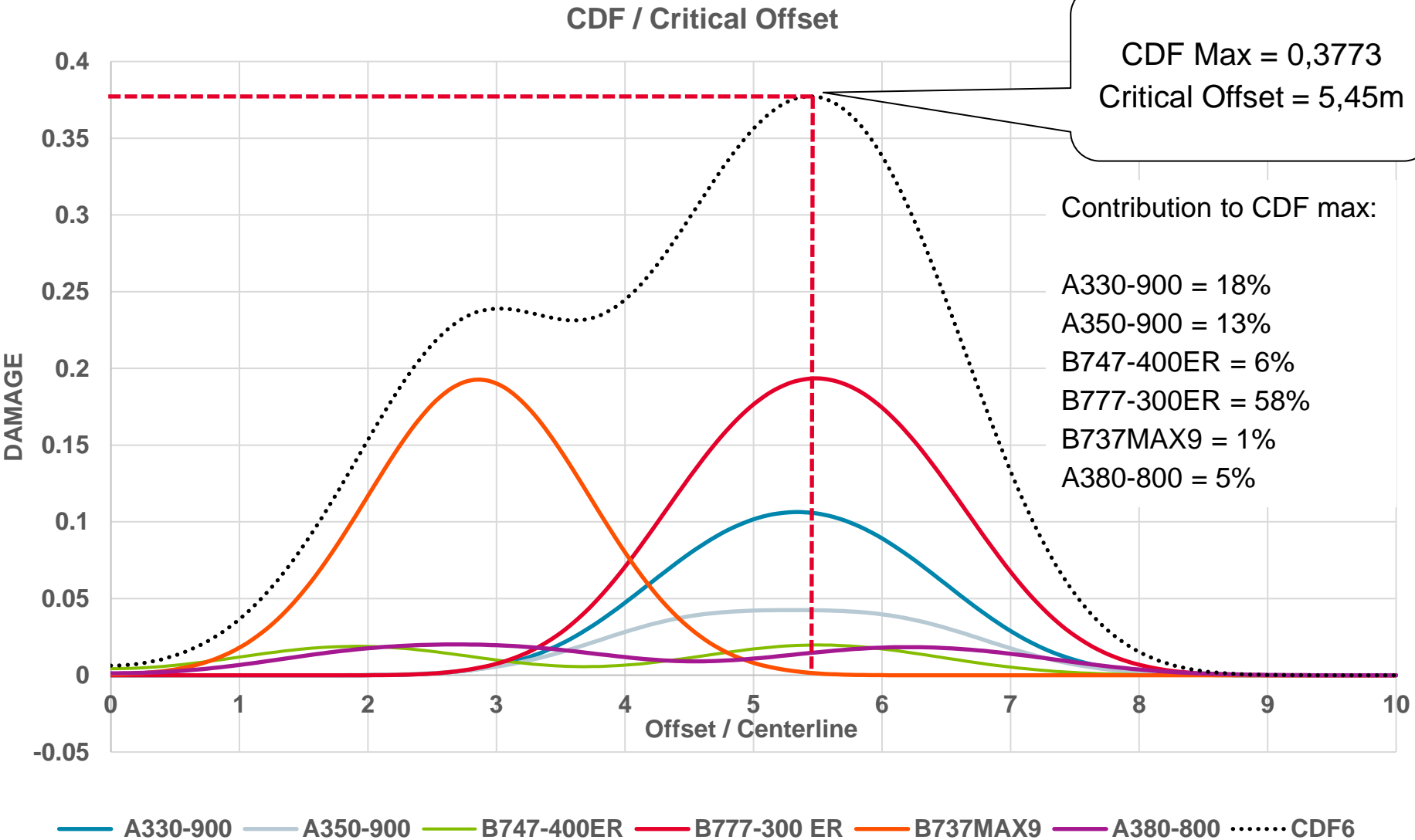
$$\text{CDF}_{\text{mix}} = \text{CDF}_{\text{A330-900}} + \text{CDF}_{\text{A350-900}} + \text{CDF}_{\text{B747-400ER}} + \text{CDF}_{\text{B777-300ER}}$$

CDF – 5 (A330-900, A350-900, B747-400ER, B777-300ER, B737MAX9)



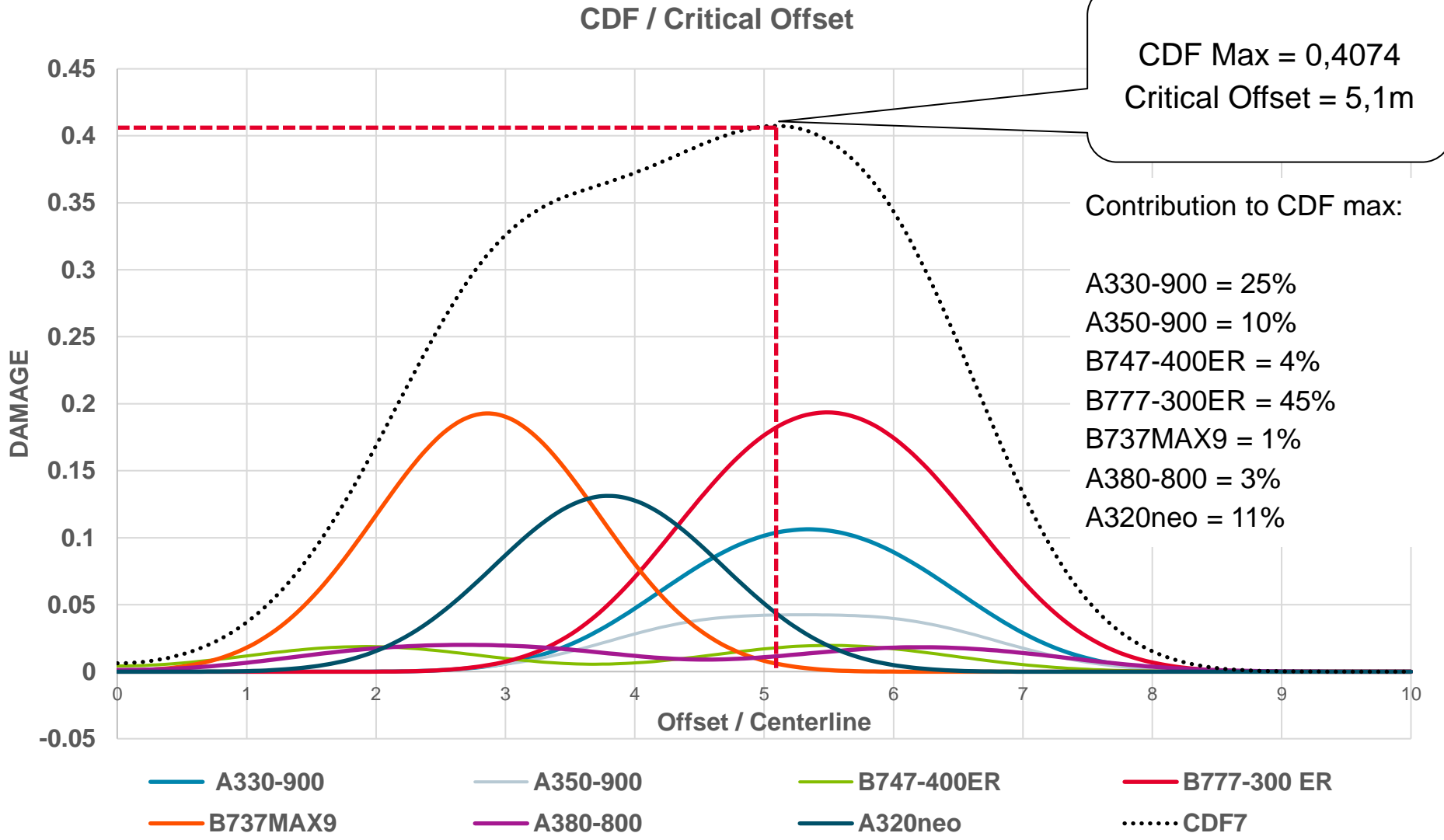
$CDF_{mix} = CDF_{A330-900} + CDF_{A350-900} + CDF_{B747-400ER} + CDF_{B777-300ER} + CDF_{B737MAX9}$

CDF – 6 (A330-900, A350-900, B747-400ER, B777-300ER, B737MAX9, A380-800)



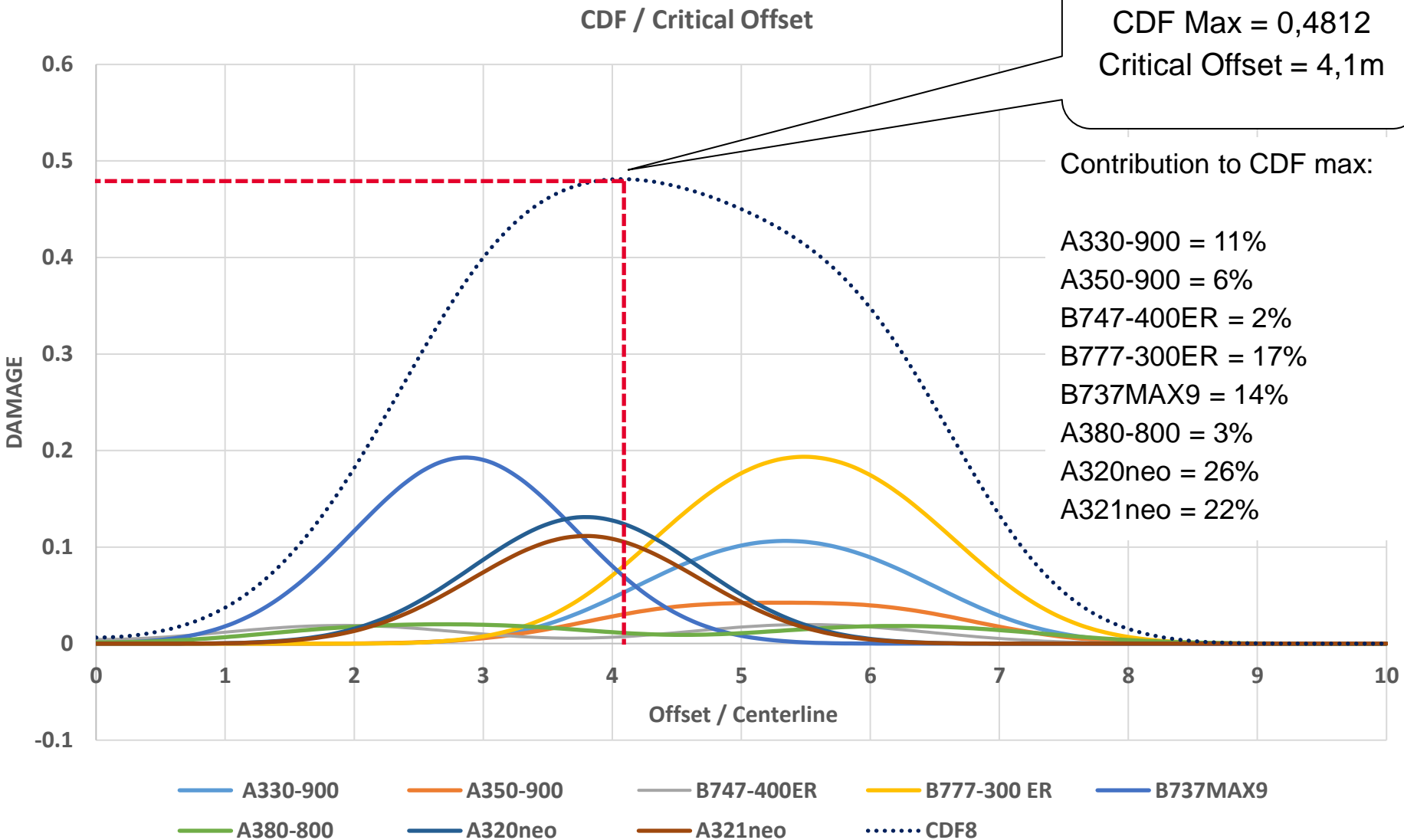
$$CDF_{mix} = CDF_{A330-900} + CDF_{A350-900} + CDF_{B747-400ER} + CDF_{B777-300ER} + CDF_{B737MAX9} + CDF_{A380-800}$$

CDF – 7 (A330-900, A350-900, B747-400ER, B777-300ER, B737MAX9, A380-800, A320neo)



$$CDF_{mix} = CDF_{A330-900} + CDF_{A350-900} + CDF_{B747-400ER} + CDF_{B777-300ER} + CDF_{B737MAX9} + CDF_{A380-800} + CDF_{A320neo}$$

CDF – 8 A330-900, A350-900, B747-400ER, B777-300ER, B737MAX9, A380-800, A320neo, A321neo)



$$CDF_{mix} = CDF_{A330-900} + CDF_{A350-900} + CDF_{B747-400ER} + CDF_{B777-300ER} + CDF_{B737MAX9} + CDF_{A380-800} + CDF_{A320neo} + CDF_{A321neo}$$

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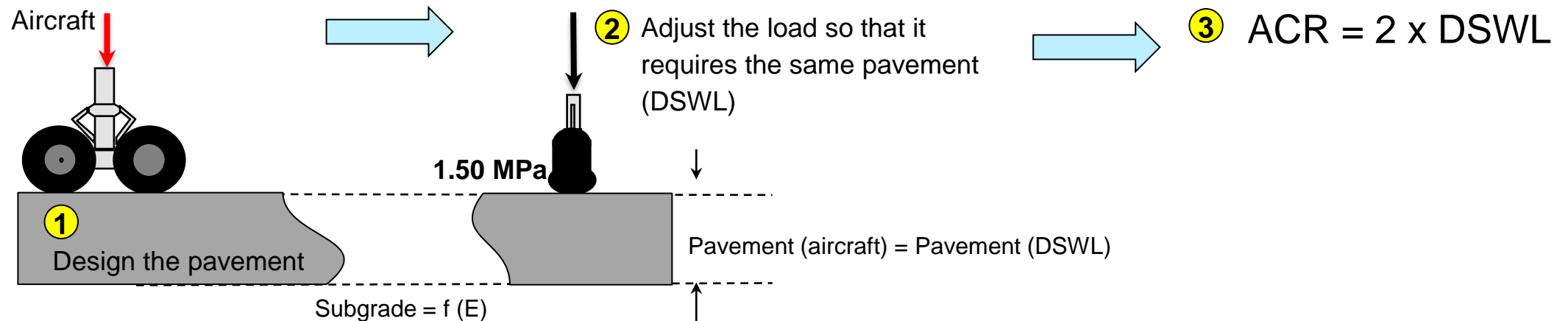
Definition

Aircraft Classification Rating(ACR)

”A number expressing the relative effect of an aircraft on a pavement for a specified standard subgrade strength.”

ACR concept

- Similarly to the ACN, the ACR is computed as twice the **Derived Single Wheel Load (DSWL)**, which is the load on a single, isolated wheel (with fixed tire pressure) requiring the same pavement thickness than the considered aircraft



- The changes vs. ACN are:
 - 1** The pavement is designed according to a rational pavement design procedure (vs. CBR or Westergaard procedures): **this is the major change vs. ACN and the key part of ACR computation**
 - 2** The DSWL is computed for a tire pressure of 1.50 MPa (vs. 1.25 MPa)
 - 3** The ACR is expressed in hundreds of kilograms (vs. tons)

ACR concept

- As for the ACN, the ACR is computed for 4 standard subgrade strength categories ranging from “high” (A) to “ultra-low” (D)
- The subgrade strength is now characterized by its elastic modulus (Young’s modulus) for both flexible and rigid pavements
- There is now a **unified subgrade strength characterization** for both pavement types

	CAT A High	CAT B Medium	CAT C Low	CAT D Ultra-low
ACR (flexible & rigid)	E = 200 MPa	E = 120 MPa	E = 80 MPa	E = 50 MPa
ACN (flexible)	CBR 15	CBR 10	CBR 6	CBR 3
ACN (rigid)	K = 150 MN/m ³	K = 80 MN/m ³	K = 40 MN/m ³	K = 20 MN/m ³

- The Young’s modulus E may be obtained by the following means:
 - In-situ tests (plate load test)
 - Laboratory tests
 - Approximate conversion from CBR or K value

Flexible ACR

Calculation procedure 1/2

- 1 Design the pavement (P-209 crushed aggregate layer) for 36500 passes of the considered aircraft
Target: CDF = 1 for the aforementioned damage model

	P-401/P-403 Hot Mix Asphalt	$E = 1379 \text{ MPa}$	$\nu = 0.35$	$t = 3 \text{ in (7.6 cm)}^*$ $t = 5 \text{ in (12.7 cm)}^{**}$	
Design layer	P-209 Crushed aggregate	$E = f(t)$	$\nu = 0.35$	t	
	Subgrade	$E = f(A, B, C, D)$	$\nu = 0.35$	$t = \infty$	ϵ_z

Reference pavement structure for the ACR

Sensitivity analysis showed that the ACR is relatively insensitive to the choice of the reference pavement structure (thicknesses and material types)

* For aircraft with Main Landing Gear ≤ 2 wheels

** For aircraft with Main Landing Gear > 2 wheels

$$t_{min} = 1 \text{ in (2.54 cm)}$$

- 2 Determine the single isolated wheel load, inflated at 1.50 MPa, that produces the same damage (i.e. CDF = 1) on the pavement structure (DSWL)
- 3 ACR = 2 x DSWL (in hundreds of kilograms)

Rigid ACR

Calculation procedure 1/2

- 1 Design the pavement (cement concrete layer) for the considered aircraft

Target: Maximum horizontal stress at the base of the cement concrete layer $\sigma_{h \max} = \sigma_{h \text{ target}} = 2.75 \text{ MPa}$

Design layer

PCC Cement Concrete	$E = 27579 \text{ MPa}$	$\nu = 0.15$	t
Base layer	$E = 500 \text{ MPa}$	$\nu = 0.35$	$t = 7.9 \text{ in (20.0 cm)}$
Subgrade	$E = f(A, B, C, D)$	$\nu = 0.40$	$t = \infty$

$\sigma_{h \max}$

Reference pavement structure for the ACR

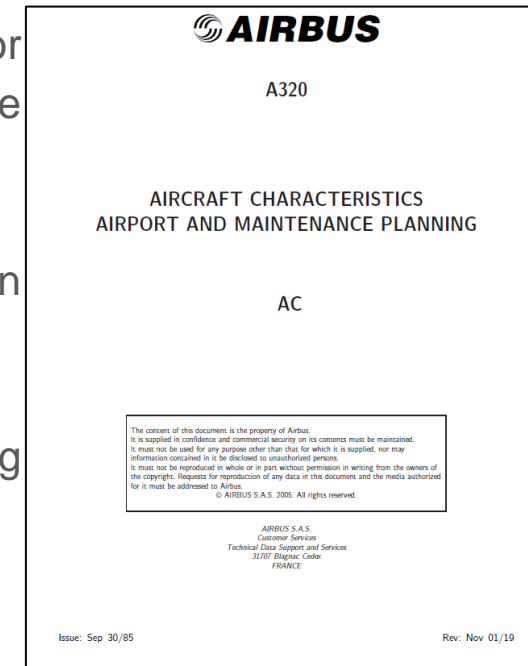
Sensitivity analysis showed that the ACR is relatively insensitive to the choice of the reference pavement structure (thicknesses and material types)

$$t_{\min} = 2 \text{ in (5.1 cm)}$$

- 2 Determine the single isolated wheel load, inflated at 1.50 MPa, that produces the same maximum horizontal stress (i.e. $\sigma_{h \text{ target}} = 2.75 \text{ MPa}$) at the bottom of the cement concrete layer (DSWL)
- 3 ACR = 2 x DSWL (in hundreds of kilograms)

How to get ACR?

- Aircraft manufacturers will publish their product's ACR in their *Aircraft Characteristics* manuals for the critical weight and center of gravity configuration (usually Maximum Ramp Weight and the corresponding maximum aft CG position)
- The ACR may be also provided for a lower weight in order to allow interpolation to get an approximate ACR for any operating weight
- A dedicated software ICAO-ACR (similar to the current ICAO-ACN) is available with the following features:
 - Built-in airplane library
 - Possibility to define customized aircraft configurations
 - Computation of flexible and rigid ACR for the desired weight / percentage of load on the main landing gear / tire pressure
- Available at:
<https://www.airporttech.tc.faa.gov/Products/Airport-Safety-Papers-Publications/Airport-Safety-Detail/icao-acr-13>



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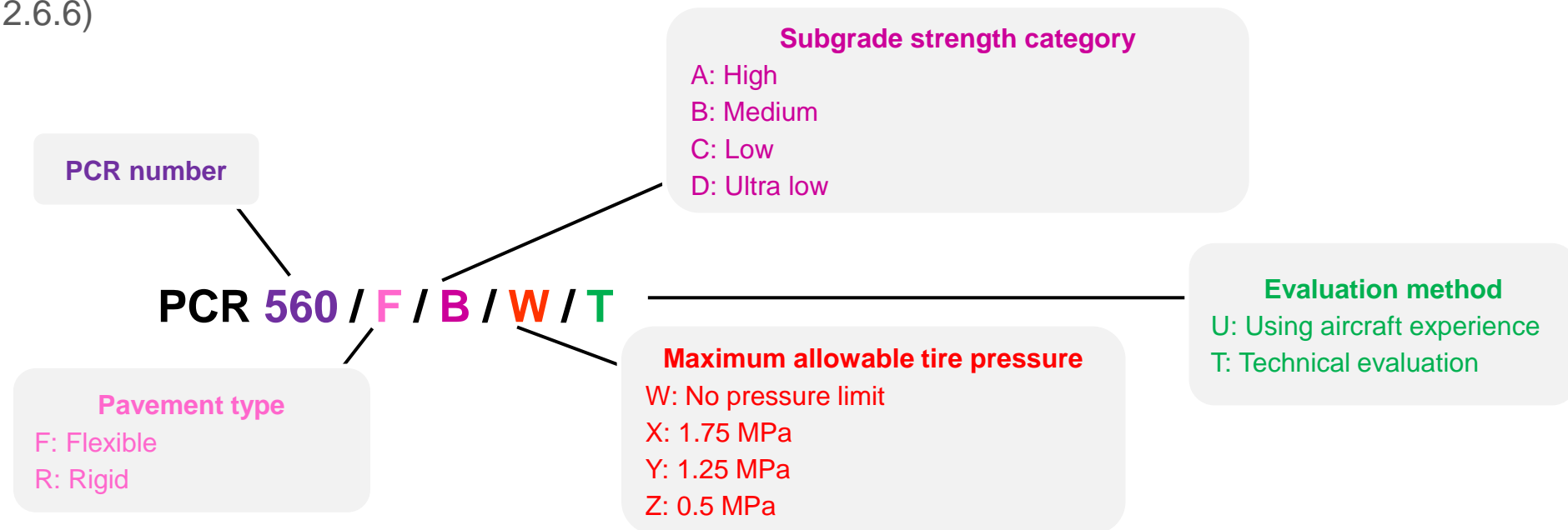
Definition

Pavement Classification Rating(PCR)

” A number expressing the bearing strength of a pavement for unrestricted operations.”

PCR concept / Reporting format

- Similarly to the PCN, the PCR represents the pavement bearing strength (on the ACR scale) for unrestricted operations
- A PCR should be determined by the airport operator for all the pavements intended for aircraft of mass greater than 5.7 tons
- The PCR should be published in the Aeronautical Information Publication (AIP) according to the format defined in ICAO Annex 14 (§ 2.6.6)



General principles

Determination of subgrade strength category (A/B/C/D)

- The subgrade strength is now characterized by its elastic modulus (Young's modulus) for both flexible and rigid pavements
- There is now a **unified subgrade strength characterization** for both pavement types

	CAT A High	CAT B Medium	CAT C Low	CAT D Ultra-low
PCR (flexible-F and rigid-R)	$E \geq 150 \text{ MPa}$	$100 \leq E < 150 \text{ MPa}$	$60 \leq E < 100 \text{ MPa}$	$E < 60 \text{ MPa}$
PCN (flexible)	$\text{CBR} > 13$	$8 < \text{CBR} \leq 13$	$4 < \text{CBR} \leq 8$	$\text{CBR} \leq 4$
PCN (rigid)	$K > 120 \text{ MN/m}^3$	$60 < K \leq 120 \text{ MN/m}^3$	$25 < K \leq 60 \text{ MN/m}^3$	$K \leq 25 \text{ MN/m}^3$

- The Young's modulus E may be obtained by the following means:
 - In-situ tests (plate load test)
 - Laboratory tests
 - Conversion from CBR or K value

Example of conversions:

$$E = 10 \text{ CBR (E in MPa)}$$

$$E = 20.15 K^{1.284} \text{ (E in psi, K in pci)}$$

General principles

Determination of tire pressure category (W/X/Y/Z)

- The tire pressure categories remain unchanged compared to the PCN

	Code W Unlimited	Code X High	Code Y Medium	Code Z Low
PCR (and PCN)	No pressure limit	$P \leq 1.75 \text{ MPa}$	$P \leq 1.25 \text{ MPa}$	$P \leq 0.50 \text{ MPa}$

- The results of pavement research and reevaluation of old test results reaffirm that except for unusual pavement construction (i.e. flexible pavements with a thin asphaltic concrete cover or weak upper layers), tire pressure effects are secondary to wheel load and wheel spacing
- **Rigid pavements** generally do not require tire pressure restrictions (except cases of spalling joints or unusual surface defects)
- For **flexible pavements** (or rigid pavements with flexible overlays), it is usually acceptable to establish category limits only when experience with high tire pressures indicates pavement distress

PCR determination – Technical evaluation (T)

Overview of generic procedure

- The ACR/PCR method does permit States to use the design/evaluation procedure of their choice when determining the PCR rating for their pavements, provided it remains consistent with the overall parameters of the ACR-PCR method
- Unlike the PCN, the ICAO developed a *generic procedure* for the PCR technical evaluation in order to fill the gap for states or Airport that may lack the expertise in the area
- The PCR determination should be based on the concept of Cumulated Damage Factor (CDF) implementing Miner's rule:
$$CDF = CDF_1 + CDF_2 \dots + CDF_N \quad \text{where } i = 1..N \text{ denotes the different aircraft in the mix}$$
- A valid PCR procedure must ensure that:
 - If the pavement CDF is lower than or equal to 1.0 (well or over-designed), no weight restriction should occur for aircraft in the evaluated traffic
 - If the pavement CDF is higher than 1.0 (under-designed), at least one aircraft from the evaluated traffic will be weight-restricted
- As the PCR is related to the *structural* pavement life, the CDF for flexible pavements should be based on the subgrade failure mode

PCR determination – Technical evaluation (T)

Damage model selection

- Although a full damage model is prescribed for the ACR calculation, the **generic PCR procedure does not dictate the use of a preferred damage model**
- The following elements can therefore be adjusted to obtain the best PCR accuracy:
 - Elementary (subgrade damage) law
 - Consideration of multi-axle loads (tandem wheels)
 - Handling of aircraft lateral wander (two methods) and standard deviation
- **Using the same damage model as for pavement design** will ensure consistency between what the actual pavement is able to withstand and the PCR assignment

Inconsistency between the damage models used for pavement design and PCR determination may result in:

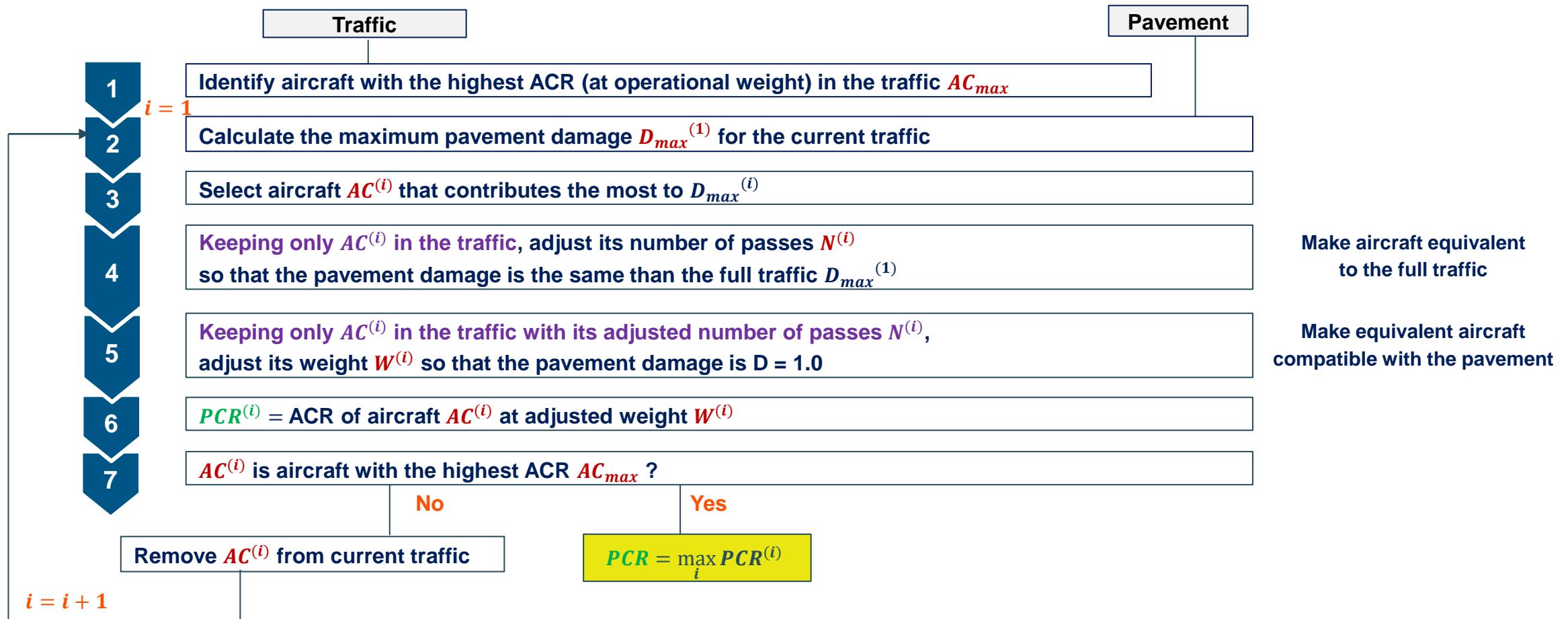


- PCR underestimation (hence unoptimized use of pavement, potential denial of aircraft operations, loss of revenue)
- PCR overestimation (hence accelerated pavement deterioration, reduced pavement life and premature pavement repairs / rehabilitation)

- Understanding and selecting the appropriate damage model and associated parameters for PCR calculation is of **paramount importance**

PCR determination – Technical evaluation (T)

Procedure flowchart



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Examples of PCR technical evaluation

Flexible pavement – Under-designed (CDF > 1.0)

- An existing flexible taxiway had been designed according to the US FAA design procedure.
- The subgrade modulus is estimated as: $E = 59 \text{ MPa}$ \Rightarrow subgrade category D
- There is no evidence of pavement distress attributable to excessive tire pressure \Rightarrow tire pressure category W
- The damage model for the PCR evaluation is the same than used for pavement design (FAA damage model for flexible pavements)

Pavement input data

P401 HMA Wearing course	$E = 1378 \text{ MPa}$	$\nu = 0.35$	$t = 12.7 \text{ cm (5 in)}$
P403 HMA Base course	$E = 2757 \text{ MPa}$	$\nu = 0.35$	$t = 13.97 \text{ cm (5.5 in)}$
P209 Crushed agg. Sub-base	$E = 358.3 \text{ MPa}$	$\nu = 0.35$	$t = 17.78 \text{ cm (7 in)}$
P209 Crushed agg. Sub-base	$E = 233.5 \text{ MPa}$	$\nu = 0.35$	$t = 25.4 \text{ cm (10 in)}$
Subgrade	$E = 59 \text{ MPa}$	$\nu = 0.35$	$t = \infty$

Examples of PCR technical evaluation

Flexible pavement – Under-designed (CDF > 1.0)

- Traffic forecasted over the expected remaining pavement life

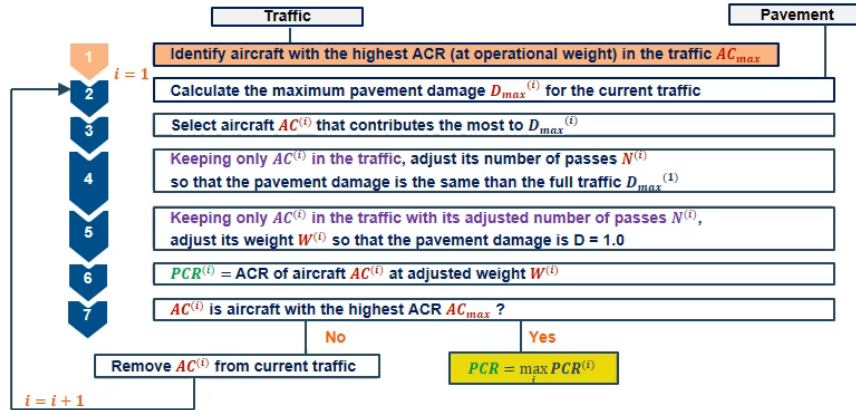
Aircraft	Operating weight (t)	Passes
ATR 42	18.8	172 042
ATR 72	22.7	151 032
E195	49.0	132 042
A319neo	75.9	32 043
A320neo	79.4	35 674
737-700	70.3	40 059
737-800	79.2	30 784
737-900ER	85.4	20 842

Traffic input data

- Aircraft wander is considered as per the FAA Pass-to-Coverage method (Standard deviation, $\sigma = 30.54$ in = 77.57 cm)

Examples of PCR technical evaluation

Flexible pavement – Under-designed (CDF > 1.0)



Examples of PCR technical evaluation

Flexible pavement – Under-designed (CDF > 1.0)

- The PCR should be reported as **550 F/D/W/T**
- The ACR of the 737-900ER (563 F/D) exceeds the PCR and would therefore be weight-limited (consistently with the pavement being under-designed for the traffic, CDF > 1.0)



- The PCR would be computed as 620 F/D/W/T if the French damage model is used
- The PCR would therefore be overestimated and no limitation would apply to the aircraft within the traffic, leading to reduced pavement life vs. expectations (as per design)
- This highlights the importance of the **damage model selection for PCR calculation**

Examples of PCR technical evaluation

Flexible pavement – Over-designed (CDF < 1.0)

- A new constructed flexible taxiway had been designed according to the French design procedure.
- The subgrade modulus is estimated as: $E = 80 \text{ MPa}$ \Rightarrow subgrade category C
- There is no evidence of pavement distress attributable to excessive tire pressure \Rightarrow tire pressure category W
- The damage model for the PCR evaluation is the same than used for pavement design (French damage model for flexible pavements)
- Design life = 20 yrs,
- HMA E-Modulus (15°C/3Hz)

Surface – BBSG 1	$E = 4512 \text{ MPa}$	$\nu = 0.35$	$t = 6 \text{ cm}$
Base – GB3	$E = 7383 \text{ MPa}$	$\nu = 0.35$	$t = 12 \text{ cm}$
Sub-base (top)	$E = 600 \text{ MPa}$	$\nu = 0.35$	$t = 16 \text{ cm}$
Sub-base (bottom)	$E = 240 \text{ MPa}$	$\nu = 0.35$	$t = 25 \text{ cm}$
Subgrade	$E = 80 \text{ MPa}$	$\nu = 0.35$	$t = \infty$

Pavement input data

Examples of PCR technical evaluation

Flexible pavement – Over-designed (CDF < 1.0)

- Traffic forecasted over the pavement design life

Aircraft	Operating weight (t)	Passes
ATR 72	20,02	24 000
A320-100	68,4	40 000
A320-200	77,4	50 000
A320neo	79,4	30 000
A321-100	89,4	20 000
B737-900	79,2	50 000
B737-800	79,2	30 000
B757-300	122,9	10 000
A330-200	233,9	10 000

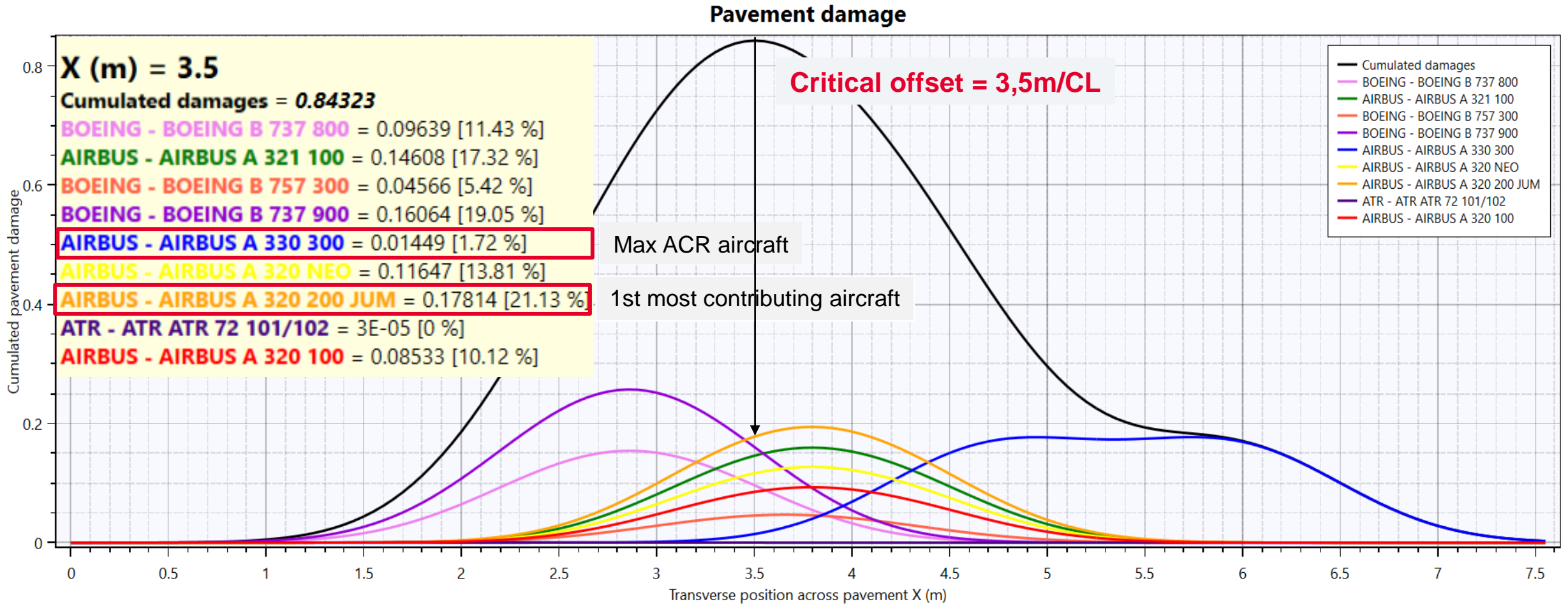
Traffic input data

- Aircraft wander is considered as per the French method / Normal distribution on all damage profiles (Standard deviation, $\sigma = 0,5\text{m}$ for taxiway)

Examples of PCR technical evaluation

Flexible pavement – Over-designed (CDF < 1.0)

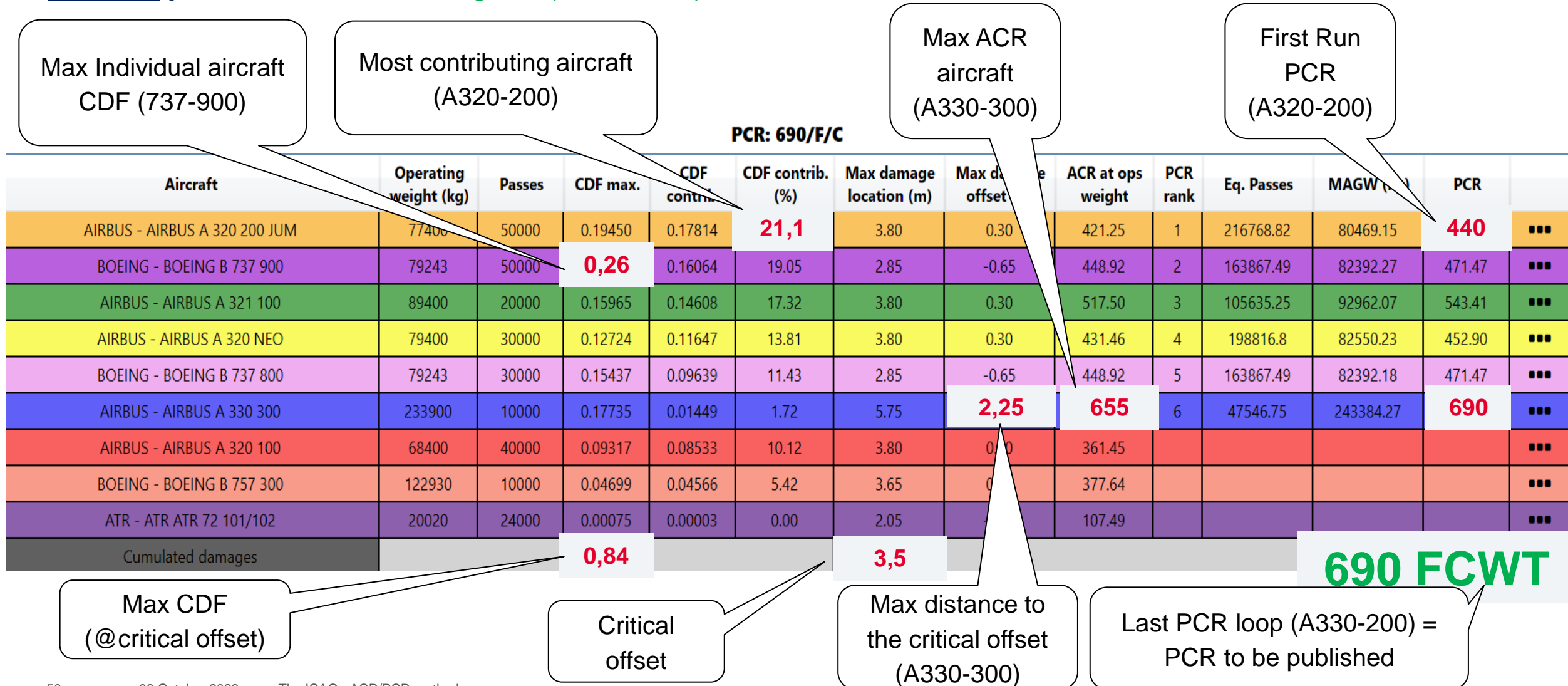
CDF



Examples of PCR technical evaluation

Flexible pavement – Over-designed (CDF < 1.0)

ANALYSIS



Examples of PCR technical evaluation

Flexible pavement – Over-designed (CDF < 1.0)

Inconsistent parameters for PCR calculation - examples

Design Parameters	CDF	PCR (F/C/W/T)	Delta (%)	Structural life (Years)
Consistent with pavement design*	0,84	690	Ref.	23,8
Wandering with P-to-C ratio (1)	1,02	650	-5,8	19,6
FAA subgrade failure model (2)	0,43	710	2,9	46,5
(1)+(2)=(3)	1,17	650	-5,8	17,1
T°(Corrected E) = 30°C (4)	2,41	500	-27,5	8,3
Frequency (speed) = 10Hz (100km/h) (5)	0,7	730	+5,8	28,6
(4)+(5)=(6)	1,91	540	-21,7	10,5
(3)+(6)=7	16,9	470	-31,9	1,2

*HMA@15°C/3Hz

Lateral wandering, standard deviation and subgrade failure model as per French practice

Examples of PCR technical evaluation

Rigid pavement (Concrete flexural strength = 5,17 MPa) / CDF = 1,05 (Slightly under-designed)

Aircraft	Operating weight (t)	Passes	ACR (RB)
COMAC C919	72,5	1 600	460
EMB-195	48,95	24 000	280
A320neo	70,4	30 000	430
A321-200	89,4	40 000	605
B737-900ER	85,4	20 000	590
B737-9MAX	88,5	18 000	600

R	P-501 PCC Surface	$E = 27\,579\text{ MPa}$	$\nu = 0.15$	$t = 36\text{ cm}$
	P-306 Lean Concrete	$E = 4826\text{ MPa}$	$\nu = 0.20$	$t = 13\text{ cm}$
	P209 Crushed agg. Sub-base	$E = 278\text{ MPa}$	$\nu = 0.35$	$t = 15\text{ cm}$
	Subgrade	$E = 100\text{ MPa}$	$\nu = 0.35$	$t = \infty$

B

New Apron construction → No tire limitation / Code **W**

RESULTING PCR = 600 **RBWT**

Consequences of PCR inaccuracies

A. Over-estimated PCR (underestimated CDF):

- More traffic acceptance (weight/volume) than what the pavement is able to withstand over its design life
- Premature pavement damage, increase of maintenance / repairs **COSTS**

B. Under-estimated PCR (overestimated CDF):

- Aircraft weight / annual departure restriction/limitation, loss of airport revenues, pavement under use

C. Optimized PCR (CDF consistent with the initial pavement design parameters):

Maximize the use of pavement, reduced maintenance needs and cost, increase airport revenues through airport charges (Landing charges, parking charges etc...)

→ All of that contributes to GHG* emissions reduction through a well mastered pavement life cycle (from raw material to end-life...)

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Overload operations

- Overloading of pavements can result from:
 - Loads larger than the design or evaluation load
 - A substantially increased application rate of existing traffic
- With the exception of massive overloading, pavements in their structural behavior are not subject to a particular limiting load above which they suddenly fail
- ICAO provides general pavement overload evaluation guidance for minor overloading, sometimes referred to as “ICAO allowance”
- Larger overloads may be assessed thanks to a detailed technical analysis, consistent with the PCR technical evaluation philosophy
- Specific state practices for overload operations may be developed (as for the ACN-PCN method)

Overload operations

ICAO and EASA allowance

- For those operations in which magnitude of overload and/or the frequency of use do not justify a detailed analysis the following criteria are suggested:
 - For flexible **and** rigid pavements, occasional movements by aircraft with ACR not exceeding **10 per cent above the reported PCR** should not adversely affect the pavement
 - The annual number of overload movements should not exceed approximately **5 per cent of the total annual movements excluding light aircraft.**

Note: ICAO allowance was previously 10 % of PCN for flexible pavements and 5 % of PCN for rigid pavements.

- Overloads should not be permitted:
 - On pavements exhibiting signs of distress
 - During periods of thaw following frost penetration
 - When the strength of the pavement (or subgrade) could be weakened by water
- The pavement condition should be regularly monitored when overload operations are conducted
- Excessive overloads may significantly reduce the pavement life

Overload operations

Technical analysis

- Overloads in excess of 10% can be considered on a case by case basis if supported by a technical analysis
- The ACR, even if exceeding the reported PCR, cannot predict accurately how the overload will affect the pavement damage (hence pavement life) since it is strongly dependant on its offset to the location of the maximum pavement damage
- The technical analysis should therefore determine how the overload operations **contribute to the maximum pavement damage** (maximum *CDF*) when mixed with the other traffic
- The inputs required to perform such analysis are the same than for the PCR technical evaluation:
 - Pavement structure
 - Aircraft traffic (including overload operations)
 - Damage model (consistent with the PCR calculation and pavement design)
- The decision to allow overload operations falls to the airport operator, depending on the impact of such operations on pavement life and its pavement management policy
- A cost-benefit analysis (loss of pavement life vs. additional revenues) can support such decision-making

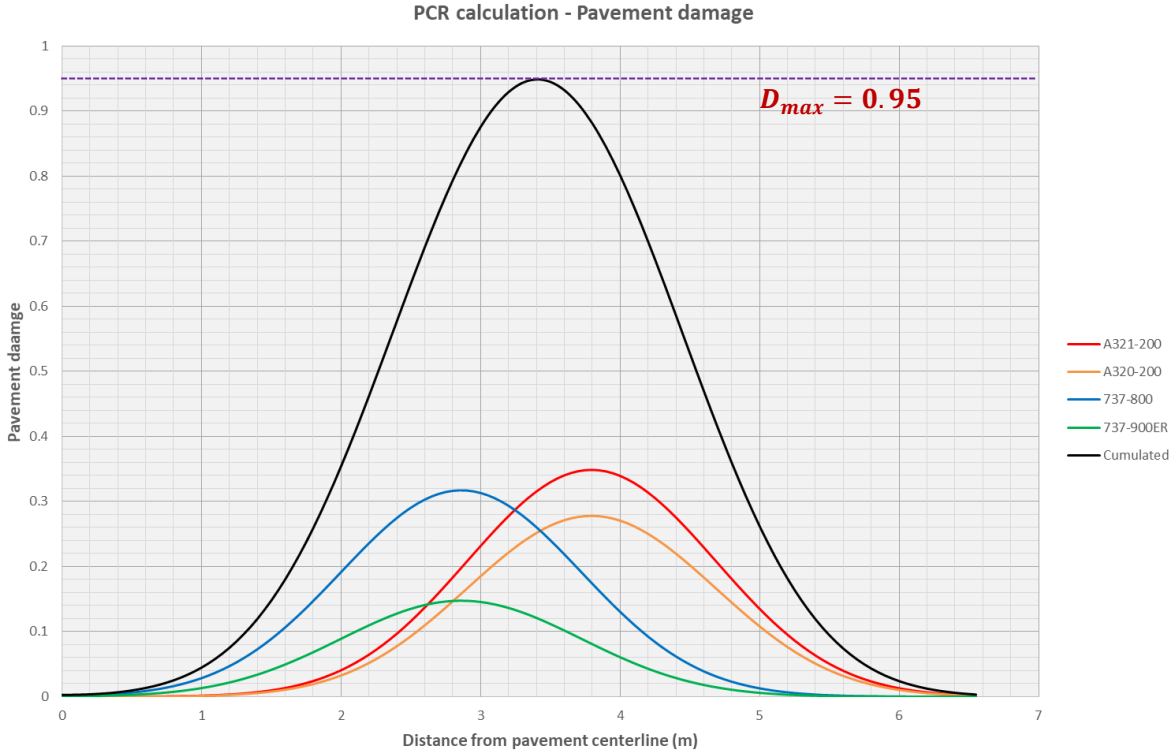
Overload operations

Example

- A flexible pavement runway has been designed (using the French rational design method) to accommodate a pure single-aisle/medium-range aircraft traffic (~ 25 daily departures over 10 years)

Aircraft	Operating weight (t)	Passes	ACR @ operating weight
A320-200	77.4	34 500	450 F/C
A321-200	93.9	17 000	550 F/C
737-800	79.2	30 000	420 F/C
737-900ER	85.4	14 500	440 F/C

- The designed pavement structure has a maximum CDF = 0.95
- The PCR is calculated and published as **PCR 560 F/C/W/T**



Overload operations

Example

- A new airline is willing to operate one daily departure to a long-haul destination with a fully loaded A321neo LR
- The ACR of the A321neo LR at Maximum Ramp Weight (97.4 t) is **580 F/C** and therefore exceeds the PCR (560 F/C)
- The ACR exceeds the PCR by less than 10 %

And

- The number of overload movements (1/day) would not exceed 5 % of the total movements (25/day)

⇒ **Overload operations can be granted as per the “ICAO and EASA allowance”**

Overload operations

Example

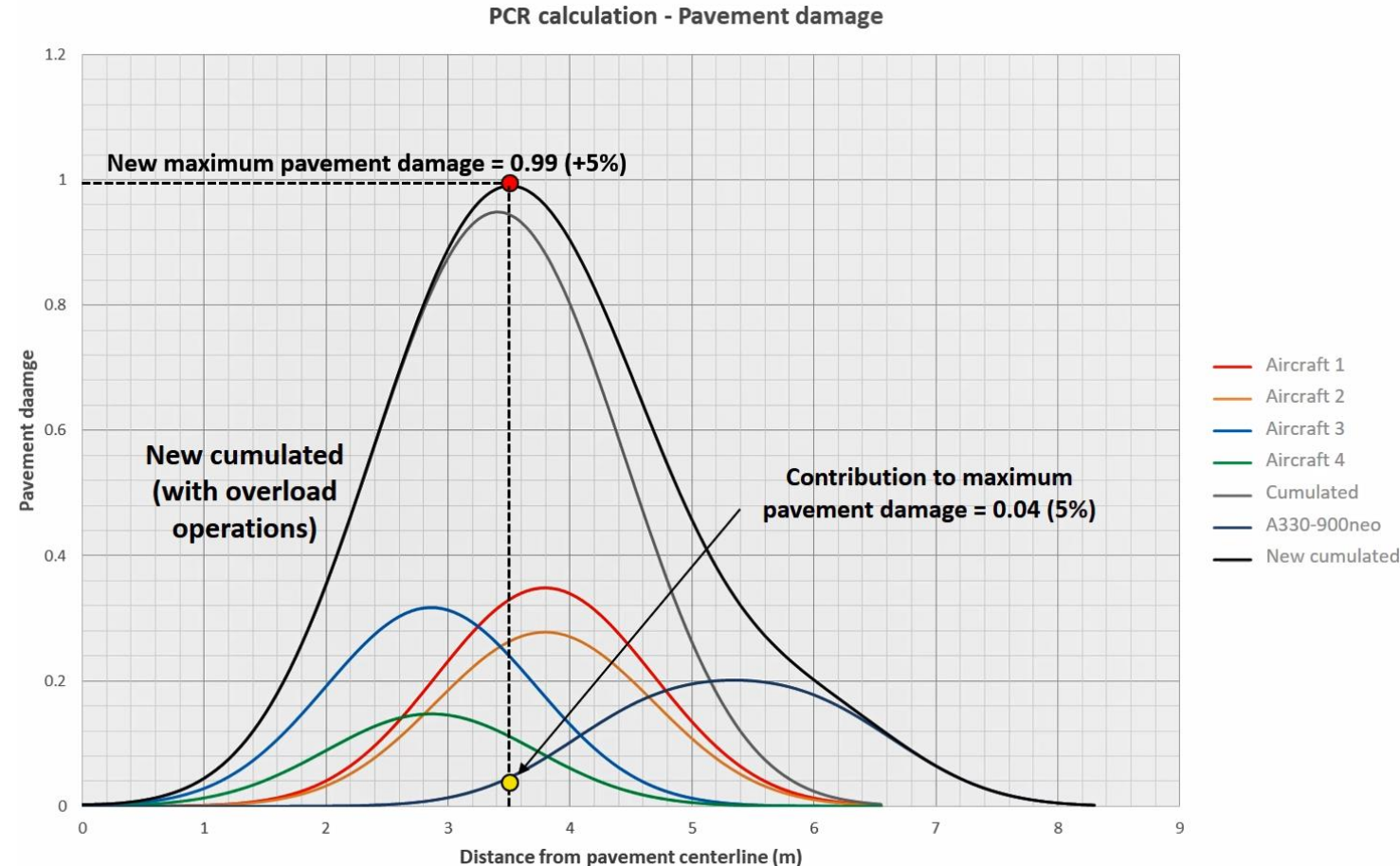
- The airline now contemplates the introduction of one daily departure of A330-900neo

- The ACR of the A330-900neo at Maximum Ramp Weight (251.9 t) is **710 F/C** and therefore exceeds the PCR (560 F/C) by more than 25 %

- The technical analysis shows that the actual impact is limited to an increase of pavement damage by 5 %

⇒ **Based on its cost-benefit analysis, the airport may allow these overload operations**

- If overload operations are allowed, the pavement condition should be regularly be inspected



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Benefits

- The ACR-PCR system overcomes the deficiencies of the ACN-PCN system and allows consistency between pavement design and pavement rating systems
- The new system enables an optimized usage (in terms of allowable aircraft weights and frequencies) of existing and future pavements, without excessive conservatism
- For **aircraft operators**, it should lead to fewer pavement-induced weight restrictions. (Local exceptions are possible.)
- For **airport operators**, it provides a consistent damage-based approach:
 - optimize the use of their pavements;
 - assess the impact of overload operations; and
 - improve pavement life predictions.
- For **aircraft manufacturers**, it will allow them to optimize landing gear geometry (both leg geometry and overall geometry) of their future products

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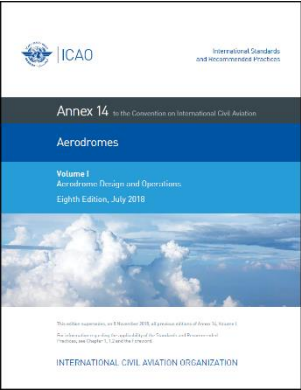
- a) CDF
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Reference documents

- The ACR-PCR method is fully documented in ICAO documents:
 - Annex 14 including Amendment 15 (method overview, definitions and PCR reporting format)



<https://store.icao.int/en/aerodrome-design-manual-part-3-pavements-doc-9157-part-3>

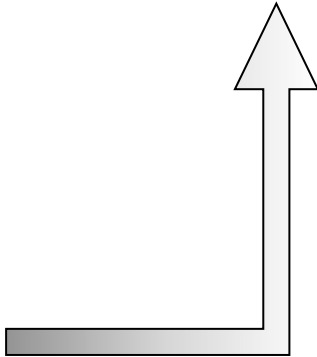
- Aerodrome design manual doc 9157 part 3, 3rd edition (implementation details)



2nd Edition
(1983)



3rd Edition
(2022)



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