COMFAA 3.0

An FAA Computer Program to Compute Pavement Classification Numbers (PCN)

Presented to: SWIFT 2010 Conference

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Acknowledgements

- Rodney Joel and Jeffrey Rapol, FAA AAS-100.
- Ken DeBord and Mike Roginski, Boeing Commercial Airplane Co.
- Gary Mitchell, ACPA, and Roy McQueen.

Download AC 150/5335-5A at www.faa.gov/airports/resources/advisory_circulars

Contact Jeffrey Rapol for a copy of Draft AC 150/5335-5B at jeffrey.rapol@faa.gov

Download COMFAA 3.0 Beta at www.airporttech.tc.faa.gov/naptf/download/index1.asp

ACN-PCN – Technical Evaluation

Basic Steps to Determine PCN in AC 150/5335-5A

1) Identify the features and properties of the pavement.
2) Determine the traffic mix.
3) Compute the design thickness for each aircraft alone.
4) The largest design thickness identifies the "critical" aircraft.
5) Convert traffic to equivalent traffic of the critical aircraft.
6) Determine the maximum allowable operating weight of the critical airplane.
7) Determine the ACN of the critical airplane at its maximum allowable operating weight.
8) Report PCN as the ACN from step 7.

The ACN-PCN System

- **Aircraft Classification Number (ACN) is precisely specified as a standard by ICAO in Annex 14 to the Convention on International Civil Aviation. Aircraft manufacturers are required to publish properly computed ACN values for all of their aircraft.**

The ACN-PCN System

- **Procedures for determining Pavement Classification Number (PCN) are given in the ICAO Aerodrome Design Manual, Part 3, Pavements.**
- **The PCN procedures in the manual are for guidance only and a great deal of latitude is provided.**
- **Airport operators are responsible for determining and publishing PCN values for runways.**

Annex 14 to the Convention on International Civil Aviation

INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERODROMES

ANNEX 14

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I
AERODROME DESIGN AND OPERATIONS

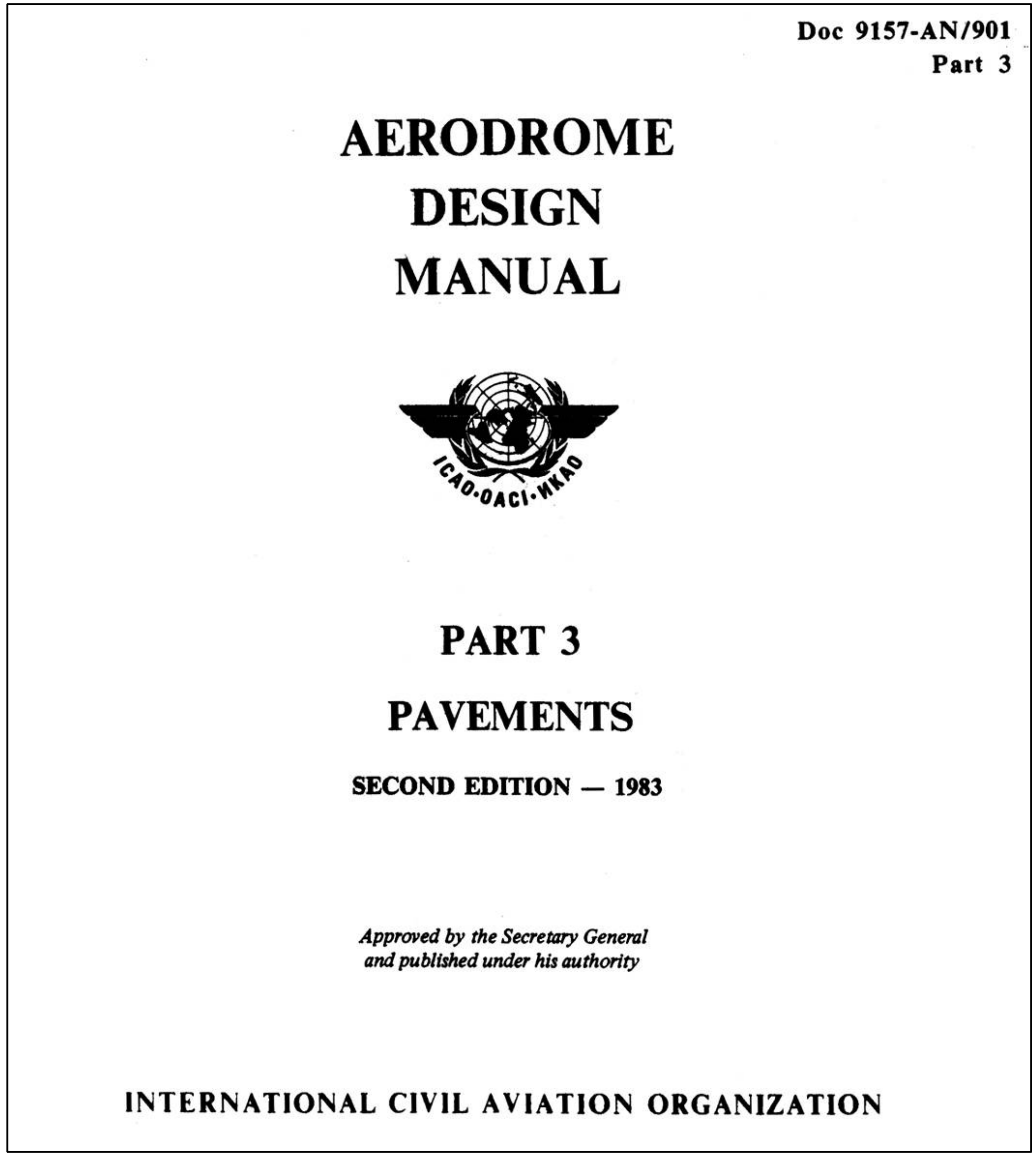
THIRD EDITION — JULY 1999

This edition incorporates all amendments to Annex 14, Volume I, adopted by the Council prior to 6 March 1999 and supersedes on 4 November 1999 all previous editions of Annex 14, Volume I.

For information regarding the applicability of the Standards and Recommended Practices, *see* Chapter 1, 1.2 and Foreword.

INTERNATIONAL CIVIL AVIATION ORGANIZATION

ICAO Aerodrome Design Manual Part 3 – Pavements


Doc 9157-AN/901
Part 3

AERODROME DESIGN MANUAL

ICAO·OACI·ИКАО

PART 3

PAVEMENTS

SECOND EDITION — 1983

Approved by the Secretary General and published under his authority

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Definitions in Annex 14

- **ACN – A number expressing the <u>relative</u> effect of an aircraft on a pavement for a specified standard subgrade strength.**
- **PCN - A number expressing the bearing strength of a pavement for <u>unrestricted</u> operations.**

Therefore:

- **If a particular aircraft at a given weight has an ACN less than, or equal to, the PCN of a particular pavement (ACN <= PCN), then no restrictions need to be placed on operation of that aircraft on that pavement.**
- **Overload evaluation is a separate topic and will not be discussed.**

PCN Reporting Information

- **Pavement Type: Flexible or Rigid.**
- **Subgrade Strength: High, Medium, Low, or Ultra Low.**
- **Maximum Allowable Tire Pressure (flexible only): High, Medium, Low, Very Low.**
- **Pavement Evaluation Method: Using or Technical.**

ACN-PCN SYSTEM – PCN Values

- **PCN values are reported in a coded format using 5 parts separated by "/"**

  Sample   39/F/B/X/T

- **Information includes**
  - Numerical PCN Value = 39
  - Pavement Type = Flexible
  - Subgrade Category = 10 CBR
  - Allowable Tire pressure <= 1.5 MPa = 218 psi
  - Method used to determine the PCN value = Using or Technical

Proposed Change in Tire Pressure Limits

Tire Pressure Category	Current ICAO designations and limits	Proposed ICAO designations and limits
W	High: no pressure limit	Unlimited
X	Medium: pressure limited to 1.50 MPa	High : pressure limited to 1.75 MPa
Y	Low: pressure limited to 1.00 MPa	Medium: pressure limited to 1.25 MPa
Z	Very low: pressure limited to 0.50 MPa	Low: pressure limited to 0.50 MPa

ACN Computation

- **Ratio of a computed single-wheel load to a reference single-wheel load with a tire pressure of 1.25 MPa (181 psi).**
- **Flexible: Based on the USACOE ESWL CBR method of design using alpha factors adopted by ICAO October 2007. Thickness is computed for 10,000 coverages.**
- **Rigid: PCA Westergaard interior stress method of design. Thickness is computed for 10,000 coverages at a concrete strength of 4.217 MPa (620 psi) (working stress of 2.75 MPa (400 psi)).**
- **<u>These are fixed standard procedures. Other design procedures or traffic levels cannot be substituted</u>.**

Subgrade Strength for ACN Computation

- **Flexible: The CBR of the subgrade soil.**
- **Rigid: The k value at the top of the support, including all subbase layers. It is not the same as the k value of the subgrade soil.**

Using Aircraft Method for PCN

- **Find the ACN of all of the aircraft regularly using the pavement and pick the largest ACN to be the PCN of the pavement.**
- **But see page 3-27 of the ICAO manual: "Support of a particularly heavy load, but only rarely, does not necessarily establish a capability to support equivalent loads on a regular repetitive basis." Where is the line between regular and overload operation?**

Technical Method for PCN

- **The ICAO manual covers in detail a very broad range of methods, including:**
  - Any rational design procedure developed specifically for airport pavements but applied in reverse for pavement evaluation.
  - Pavement surface deflection measured under the load from a representative aircraft.
  - Non-destructive test results with backcalculation.
  - Allows for design and evaluation procedures not in use when the manual was written.

Excerpt from the ICAO Manual - 1

- **In 3.3.3 "Since the effectiveness of aircraft undercarriages using multiple wheels is greater on pavements founded on strong subgrades compared to those on weak subgrades, the problem of reporting bearing strength is complicated."**
- **Hence four <u>representative</u> subgrade strengths.**

Excerpt from the ICAO Manual - 2

- In 3.4.2 “Thus fairly large variations can exist in the loading-repetitions relation without serious differences in evaluation resulting.”
- The statement is supported by the fact that the relationship between load and repetitions is logarithmic rather than direct.

Excerpt from the ICAO Manual - 2

- **This assumption is probably the justification for ACN being computed at 10,000 coverages for all aircraft, independent of the use levels.**
- **This basic assumption in the ACN-PCN method appears to break down at large hub airports with a <u>very large number of small aircraft</u> departures and a <u>relatively small number of very large aircraft</u> departures.**

Excerpt from the ICAO Manual - 3

- In 3.6.3.1 "From the chosen design method and established quantities for the design elements, limiting load or mass can be established for any aircraft expected to use the pavement."
- Establishes the maximum allowable load for any aircraft used in the evaluation.

Excerpt from the ICAO Manual - 4

e) Reported PCN. The PCN to be reported can be determined from the aircraft loads (masses) which the evaluation has established as maximum allowable for the pavement. By using the evaluation load for one of the heaviest type aircraft using the pavement and information shown in Appendix 5, and interpolating as necessary, the PCN can be found. This can be done for a selected representative aircraft or for several aircraft for which evaluation of allowable load has been made. All such determinations should yield the same PCN value, or very nearly so. If there are large differences it would be well to recheck both the translation from the evaluation load and the evaluation. If differences are small an average or lower range value should be selected for reporting. If needed information is not

- **The second highlighted statement is not supported by case studies on some large hub airports.**

FAA Guidance on PCN Calculation

- **The FAA is responsible for certifying all commercial airports in the U.S. and is the organization generally responsible for complying with international agreements on aviation.**
- **Well defined procedures are therefore required for determining and publishing PCN values for runways at all commercial airports in the U.S.**

FAA Airport Master Record Data (Form 5010 Database)

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

AIRPORT MASTER RECORD

PRINT DATE: 10/05/2009
AFD EFF 08/27/2009
Form Approved OMB 2120-0015

> 1 ASSOC CITY: BALTIMORE 4 STATE: MD LOC ID: BWI FAA SITE NR: 08456.*A
> 2 AIRPORT NAME: BALTIMORE/WASHINGTON INTL THURGOOD MARSHAL 5 COUNTY: ANNE ARUNDEL MD
3 CBD TO AIRPORT (NM): 09 S 6 REGION/ADO: AEA/DCA 7 SECT AERO CHT: WASHINGTON

RUNWAY DATA

		04/22	10/28	15L/33R	15R/33L
> 30 RUNWAY IDENT:		04/22	10/28	15L/33R	15R/33L
> 31 LENGTH:		6,000	10,502		
> 32 WIDTH:		150	200		
> 33 SURF TYPE-COND:		ASPH-F			
> 34 SURF TREATMENT:		GRVD	GRVD	GRVD	GRVD
35 GROSS WT:	SW	100.0	100.0	30.0	100.0
36 (IN THSDS)	DW	220.0	220.0	60.0	220.0
37	DTW	500.0	500.0		500.0
38	DDTW	728.0	790.0		790.0
> 39 PCN:		65 /F/A/W/T	110/F/A/W/T	26 /F/A/W/T	100/F/A/W/T

Gross Weight data will transition

PCN data request now part of all airport inspections

- **The Master Record is required to be updated periodically. PCN is now mandatory and Gross Weight data will possibly be phased out with time.**

FAA Guidance on PCN Calculation

- **2005 – The PCN field was re-activated in the Form 5010 Database.**
- **September, 2006 - AC 150/5335-5A "Standardized Method of Reporting Airport Pavement Strength – PCN" was released to standardize the procedures for computing and reporting PCN values for inclusion in the 5010 database. (Complete re-write of AC 150/5335-5.)**

FAA Guidance on PCN Calculation

- **AC 150/5335-5A is based in large part on the procedures described in Boeing Report D6-82203 "Precise Methods for Estimating Pavement Classification Number," 1998.**
- **D6-82203 is, in turn, based in large part on recommendations contained in the ICAO Aerodrome Design Manual.**

ACN-PCN – Technical Evaluation

Basic Steps to Determine PCN in AC 150/5335-5A

1) Identify the features and properties of the pavement.
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Draft AC 150/5335-5B

- **AC 150/5335-5A was rewritten based on the work of an industry working group in which about ten case studies were evaluated (Case 1 was one).**
- **The new AC (-5B) is still a draft and is in the final stages of public review and comment.**
- **-5B is accompanied by:**
  - a completely automated version of COMFAA, version 3.0.
  - and a support spreadsheet to help in deriving pavement design thickness and sorting the results.

Draft AC 150/5335-5B

U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: STANDARDIZED METHOD OF REPORTING AIRPORT PAVEMENT STRENGTH - PCN	**Date:** DRAFT **Initiated by:** AAS-100	**AC No:** 150/5335-5B **Change:**

1. PURPOSE OF THIS ADVISORY CIRCULAR.

a. This advisory circular (AC) provides guidance for using the standardized International Civil Aviation Organization (ICAO) method to report airport pavement strength. ICAO requires member countries to report pavement strength information for a variety of purposes. The standardized method, known as the Aircraft Classification Number – Pavement Classification Number (ACN-PCN) method, has been developed and adopted as an international standard and has facilitated the exchange of pavement strength rating information.

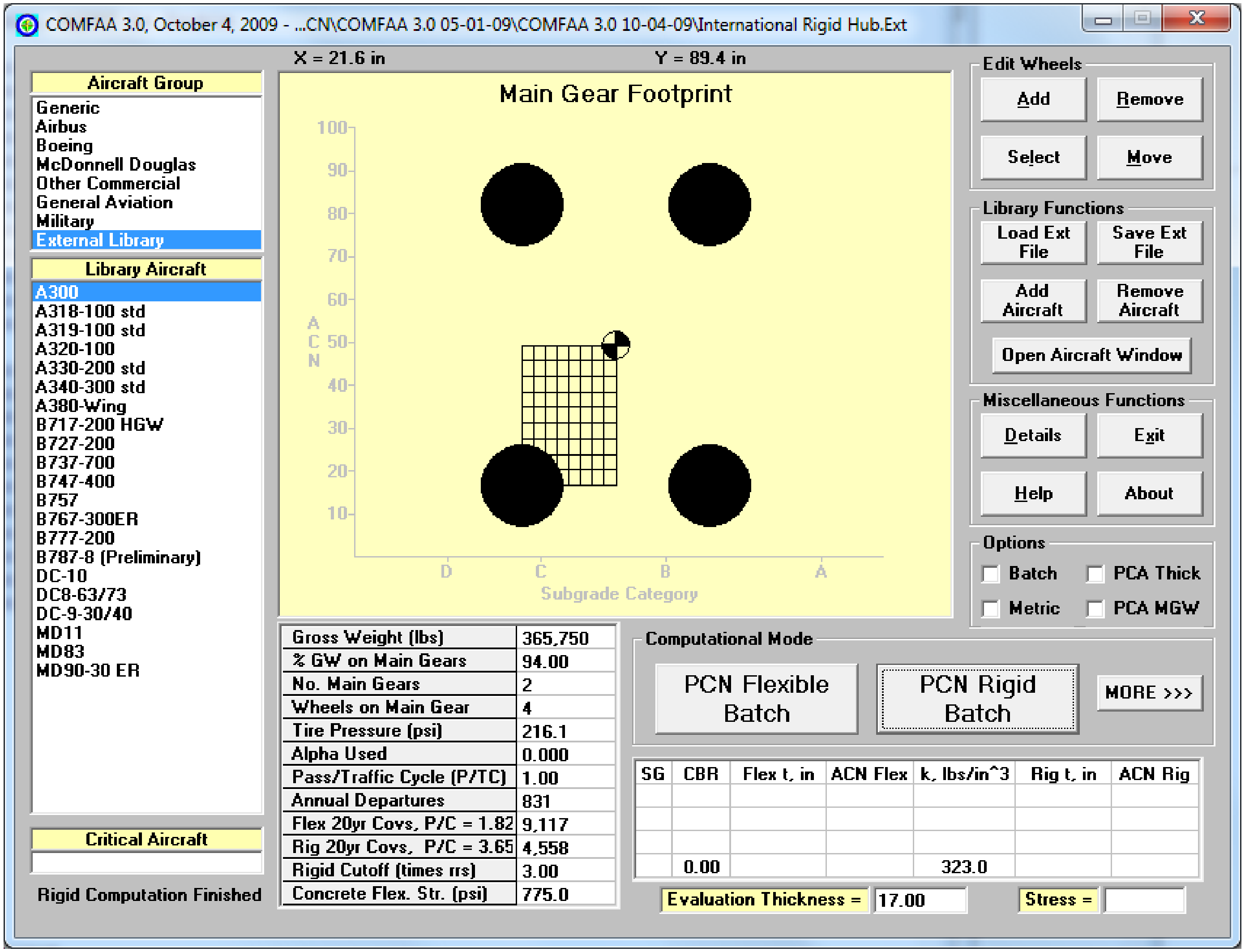
b. The AC provides guidance for reporting changes to airport data that is generally published on Federal Aviation Administration Form 5010, Airport Master Record. The data elements associated with Gross Weight (Data Elements 35 through 38) and Pavement Classification Number (Data Element 39) are affected.

2. EFFECTIVE DATE. Effective three years after the issue date of this AC, all public-use paved runways serving aircraft with gross weights equal to or greater than 25,000 pounds at NPIAS airports must be assigned gross weight and PCN data using the guidance provided in this AC. At the issue date of this AC, about 1,850 runways met this requirement.

Draft AC 150/5335-5B

- **The design procedures recommended in the new AC are:**
  - CBR ESWL with the new alpha factors for flexible pavements.
  - Edge stress Westergaard as implemented in AC 150/5320-6C and -6D.
  - The PCA center stress method can also be selected in COMFAA 3.0.
- **These were selected for backward compatibility with established methods and compatibility with the ACN computation procedure.**

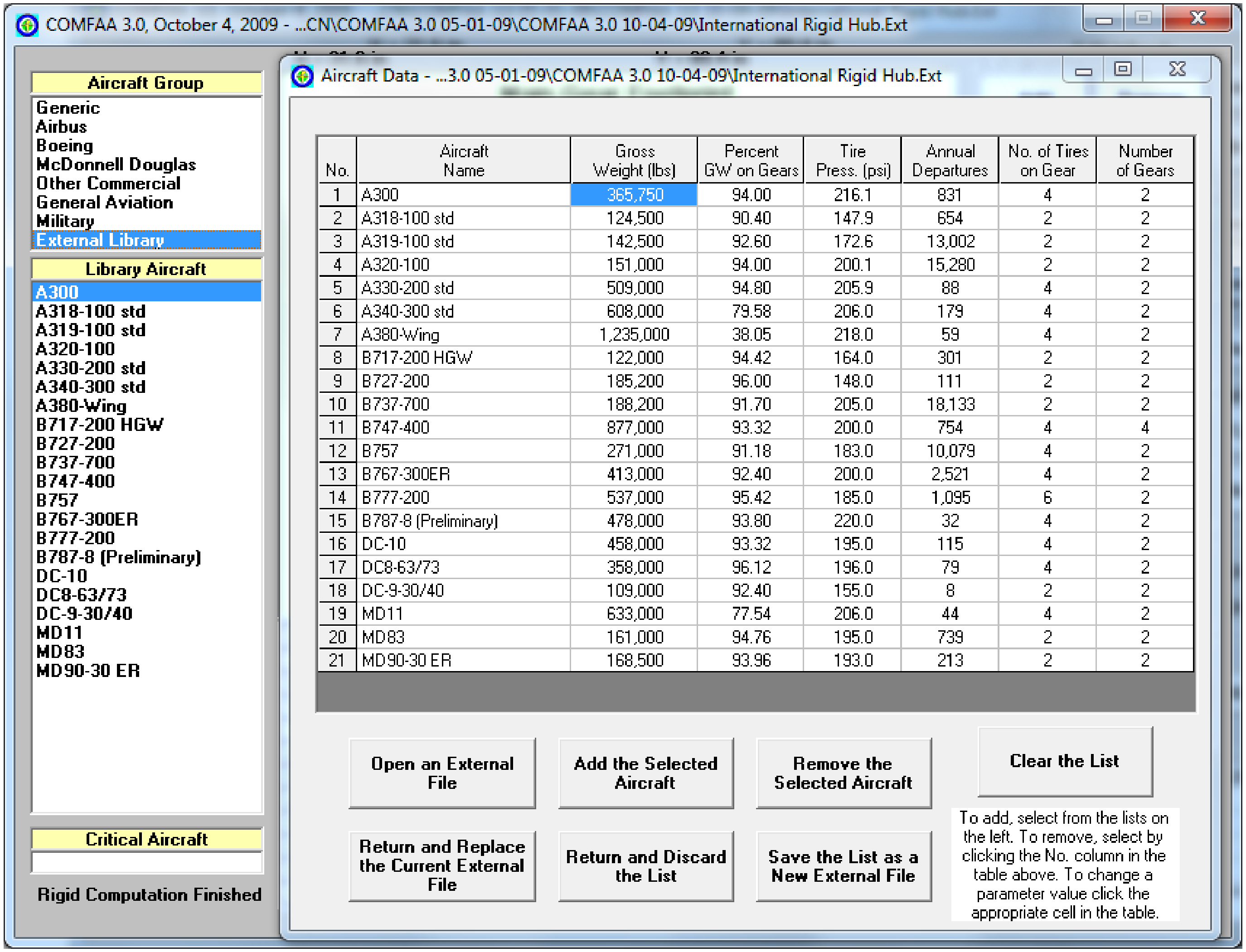
COMFAA 3.0 – Base Screen



The PCN Methodology

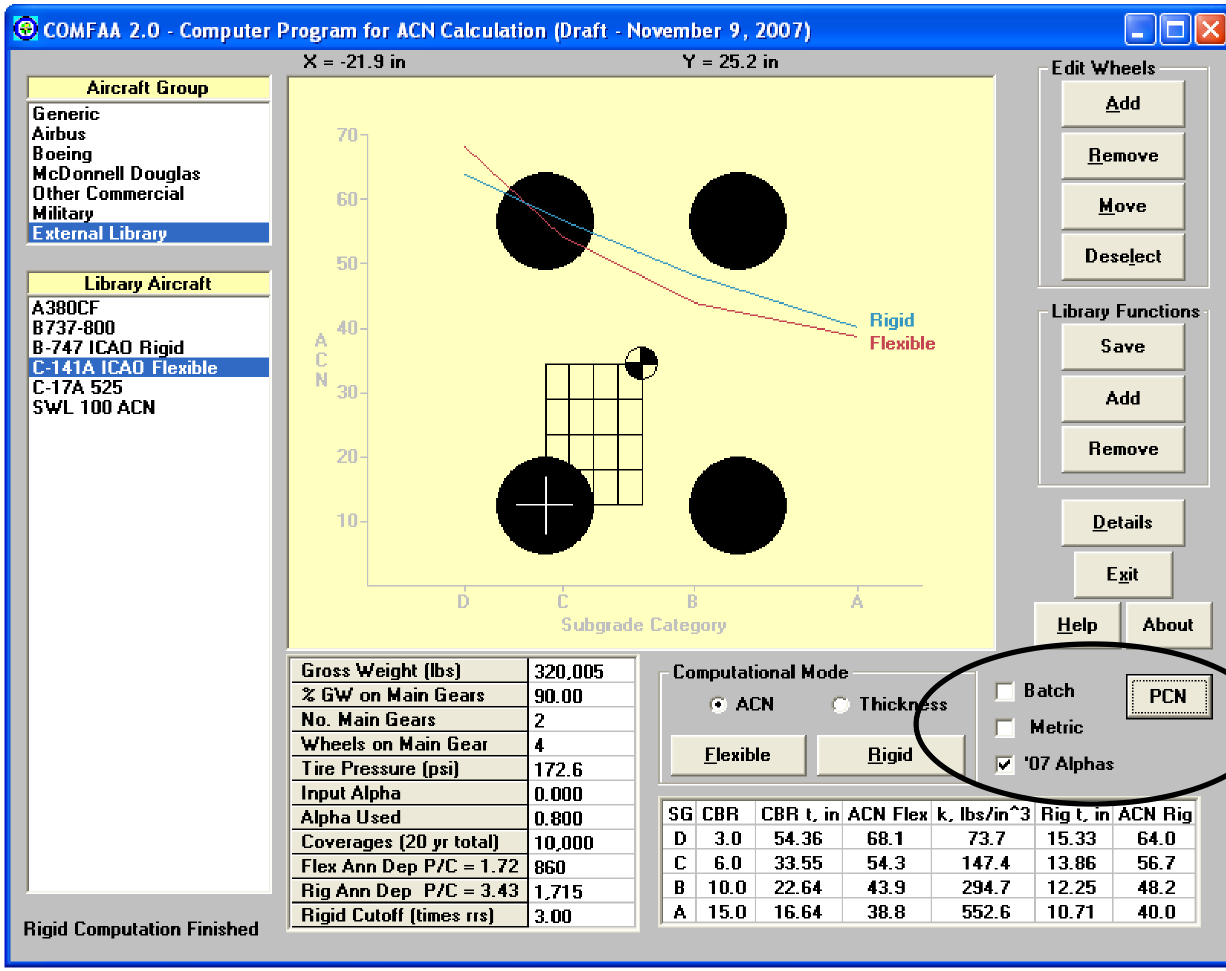
- The current methodology (-5A) finds the critical aircraft and then finds the ACN of that aircraft at the maximum allowable gross weight. That ACN is then the PCN.
- The new methodology is the same except that the ACN at maximum allowable gross weight is calculated for all of the aircraft in the mix.
- The largest ACN value is then selected as the PCN.
- There is a need for a way to eliminate "occasional or overload" aircraft from the mix.

COMFAA 3.0 – Aircraft Window

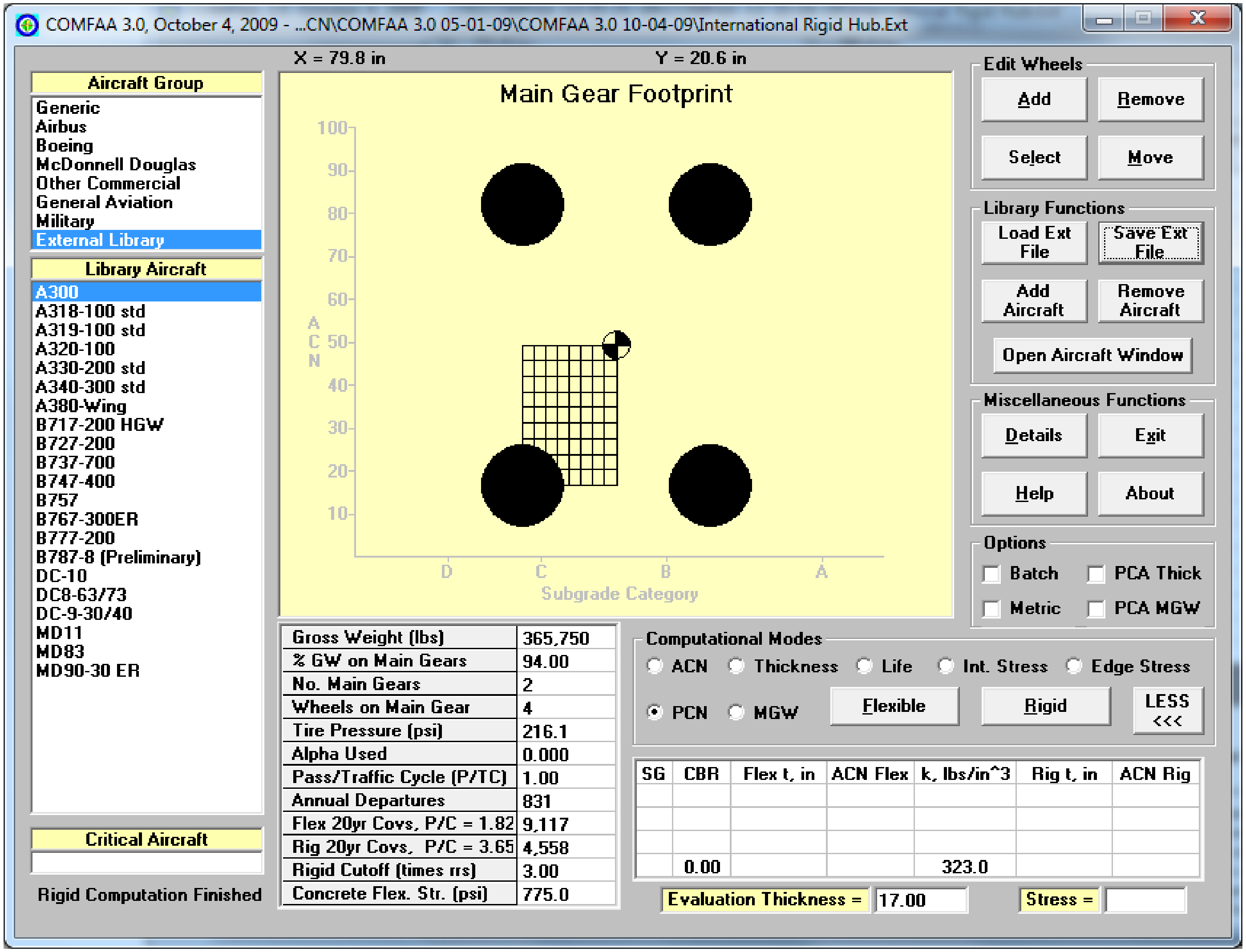


No.	Aircraft Name	Gross Weight (lbs)	Percent GW on Gears	Tire Press. (psi)	Annual Departures	No. of Tires on Gear	Number of Gears
1	A300	365,750	94.00	216.1	831	4	2
2	A318-100 std	124,500	90.40	147.9	654	2	2
3	A319-100 std	142,500	92.60	172.6	13,002	2	2
4	A320-100	151,000	94.00	200.1	15,280	2	2
5	A330-200 std	509,000	94.80	205.9	88	4	2
6	A340-300 std	608,000	79.58	206.0	179	4	2
7	A380-Wing	1,235,000	38.05	218.0	59	4	2
8	B717-200 HGW	122,000	94.42	164.0	301	2	2
9	B727-200	185,200	96.00	148.0	111	2	2
10	B737-700	188,200	91.70	205.0	18,133	2	2
11	B747-400	877,000	93.32	200.0	754	4	4
12	B757	271,000	91.18	183.0	10,079	4	2
13	B767-300ER	413,000	92.40	200.0	2,521	4	2
14	B777-200	537,000	95.42	185.0	1,095	6	2
15	B787-8 (Preliminary)	478,000	93.80	220.0	32	4	2
16	DC-10	458,000	93.32	195.0	115	4	2
17	DC8-63/73	358,000	96.12	196.0	79	4	2
18	DC-9-30/40	109,000	92.40	155.0	8	2	2
19	MD11	633,000	77.54	206.0	44	4	2
20	MD83	161,000	94.76	195.0	739	2	2
21	MD90-30 ER	168,500	93.96	193.0	213	2	2

COMFAA 2.0 Will Continue to be Supported – Simpler and Old Alphas



COMFAA 3.0 – Options



COMFAA 3.0 – Sample Results

ICAO ACN Computation, Detailed Output

Unit Conversions | Show Alpha | Show Ext File | Single Aircraft ACN: Flexible, Rigid (selected) | Other Calculation Modes: PCN (selected), ACN Batch, Thickness, Life | Back

19	MD11	633,000	77.54	206.0	44	239	10.62
20	MD83	161,000	94.76	195.0	739	4,321	11.66
21	MD90-30 ER	168,500	93.96	193.0	213	1,275	11.42

No.	Aircraft Name	Critical Aircraft Total Equiv. Covs.	Thickness for Total Equiv. Covs.	Maximum Allowable Gross Weight	PCN at Indicated Code A(552)	B(295)	C(147)	D(74)
1	A300	1,997,313	15.10	445,810	64.4	76.1	88.0	98.4
2	A318-100 std	>5,000,000	15.39	151,296	34.5	37.2	39.7	41.9
3	A319-100 std	>5,000,000	15.20	176,541	45.0	48.0	50.7	53.0
4	A320-100	1,533,532	15.08	191,198	52.8	55.8	58.5	60.7
5	A330-200 std	496,735	14.98	657,683	73.3	86.6	103.6	120.2
6	A340-300 std	482,102	14.98	785,764	73.6	87.0	104.1	120.7
7	A380-Wing	358,352	14.95	1,558,981	76.6	91.2	108.1	123.8
8	B717-200 HGW	>5,000,000	15.24	150,549	44.8	47.0	49.0	50.5
9	B727-200	321,940	14.94	237,374	66.9	71.1	74.9	77.9
10	B737-700	117,290	14.84	244,772	72.2	75.5	78.4	80.8
11	B747-400	934,194	15.03	1,076,982	70.4	84.6	99.5	112.5
12	B757	>5,000,000	15.41	314,766	41.2	49.3	57.7	64.9
13	B767-300ER	2,265,827	15.11	501,589	63.1	75.8	89.4	101.5
14	B777-200	>5,000,000	15.43	646,541	49.0	63.7	83.8	103.2
15	B787-8 (Preliminary)	288,854	14.93	590,004	77.4	92.2	108.3	122.6
16	DC-10	2,241,344	15.11	568,580	63.6	76.2	91.3	105.6
17	DC8-63/73	1,348,041	15.07	422,819	64.5	76.3	88.0	97.9
18	DC-9-30/40	>5,000,000	15.36	132,915	37.7	39.7	41.4	42.9
19	MD11	287,118	14.93	792,982	79.7	95.8	113.9	130.3
20	MD83	287,599	14.93	205,211	65.9	68.5	70.8	72.6
21	MD90-30 ER	196,488	14.89	215,817	69.2	71.9	74.2	76.0

Rigid ACN at Indicated Gross Weight and Strength

No.	Aircraft Name	Gross Weight	% GW on Main Gear	Tire Pressure	A(552)	B(295)	C(147)	D(74)
1	A300	365,750	94.00	216.1	48.5	57.3	66.9	75.5
2	A318-100 std	124,500	90.40	147.9	27.4	29.5	31.6	33.4

Acknowledgements

- Rodney Joel and Jeffrey Rapol, FAA AAS-100.
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- Gary Mitchell, ACPA, and Roy McQueen.

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