FMRT

4Bit Coding for Make and Model in ADS-B

Presentation to the RTCA-SC 186, AdHoc Group

Dr. Jens Schiefele

Stefan Kranz

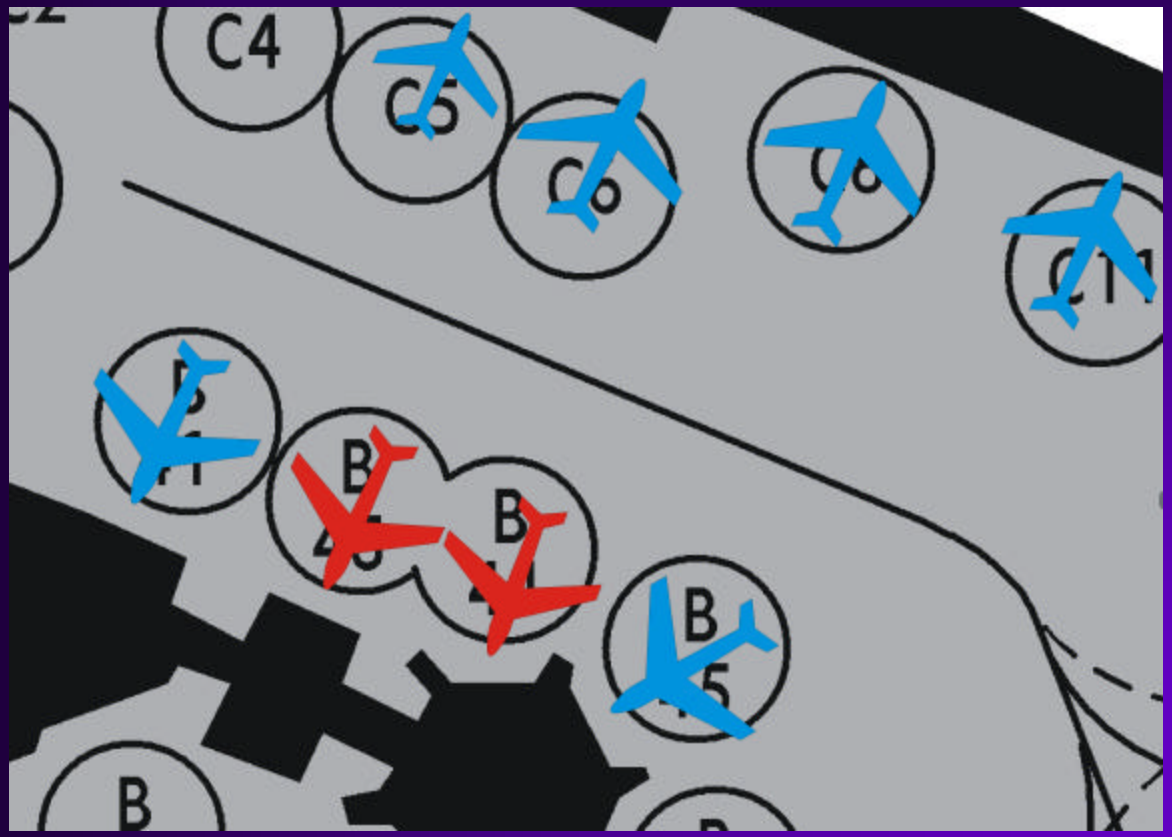
Marc Launer

Patrick Wipplinger

this work is funded under a research grant by the German Ministry of Economics
TU-Darmstadt is scientific consultant to Diehl-Avionik Systeme.

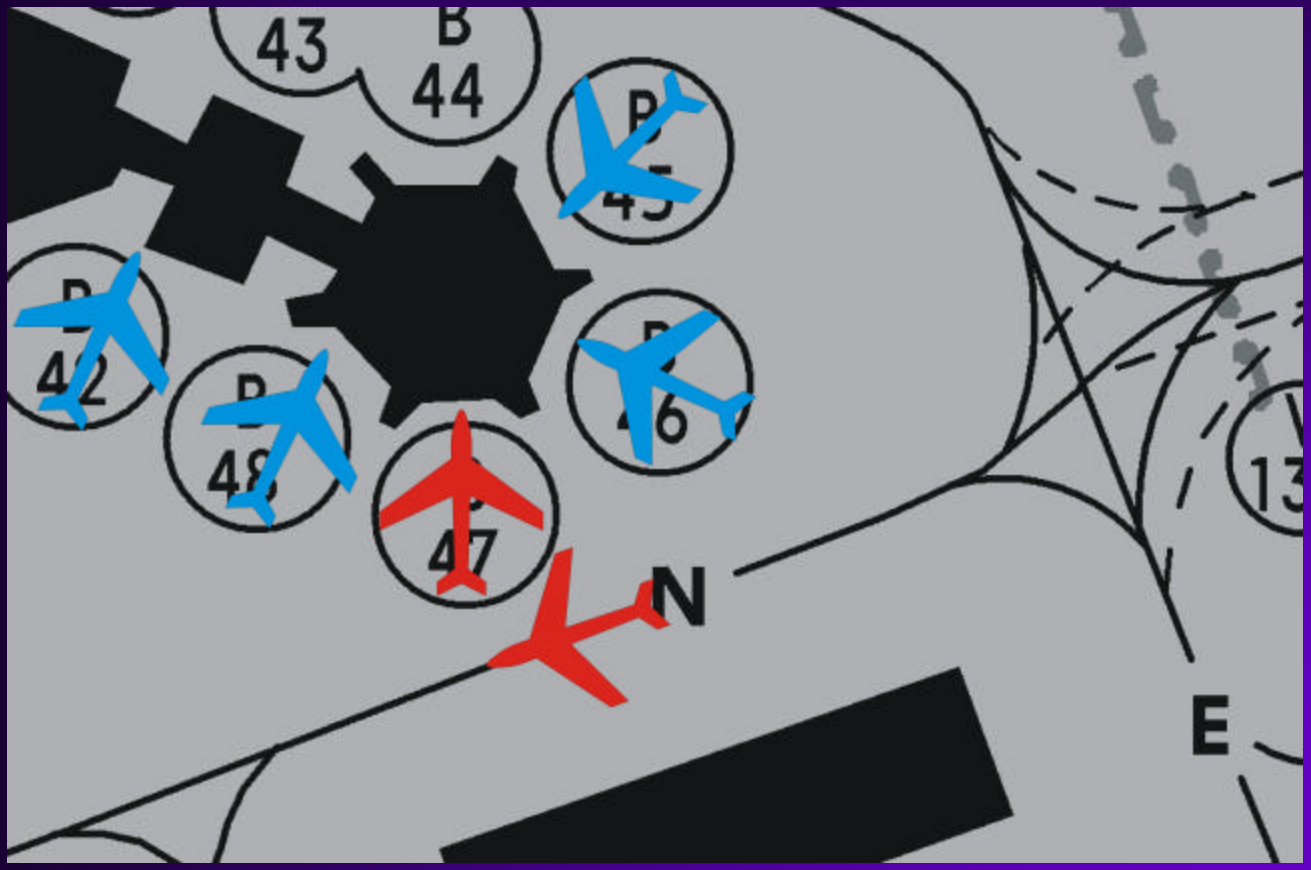
Potential Collision Risk (taxiing)

- Operation: Parallel Parking



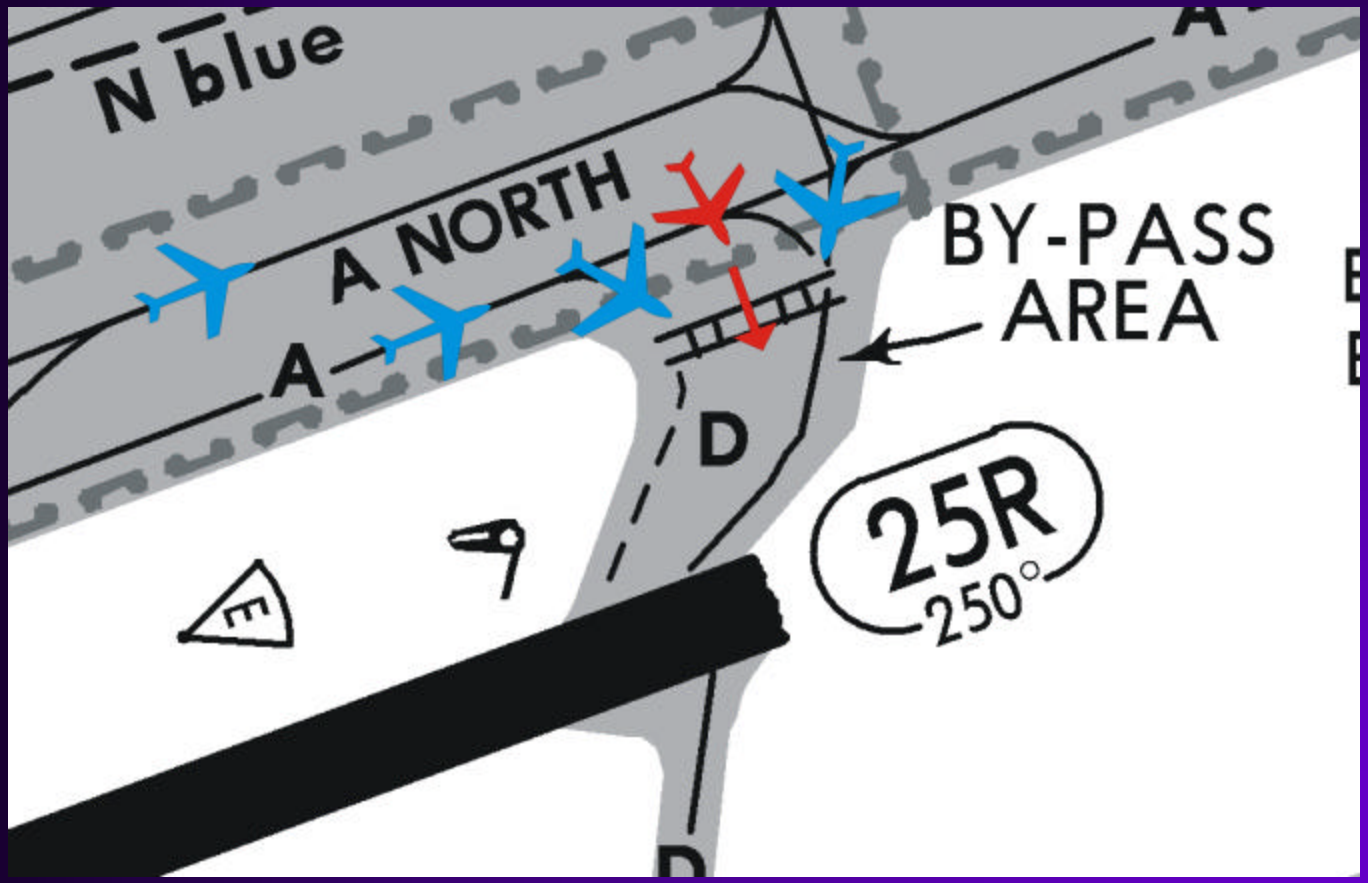
Potential Collision Risk (taxiing)

- Operation: Passing Parked Aircraft



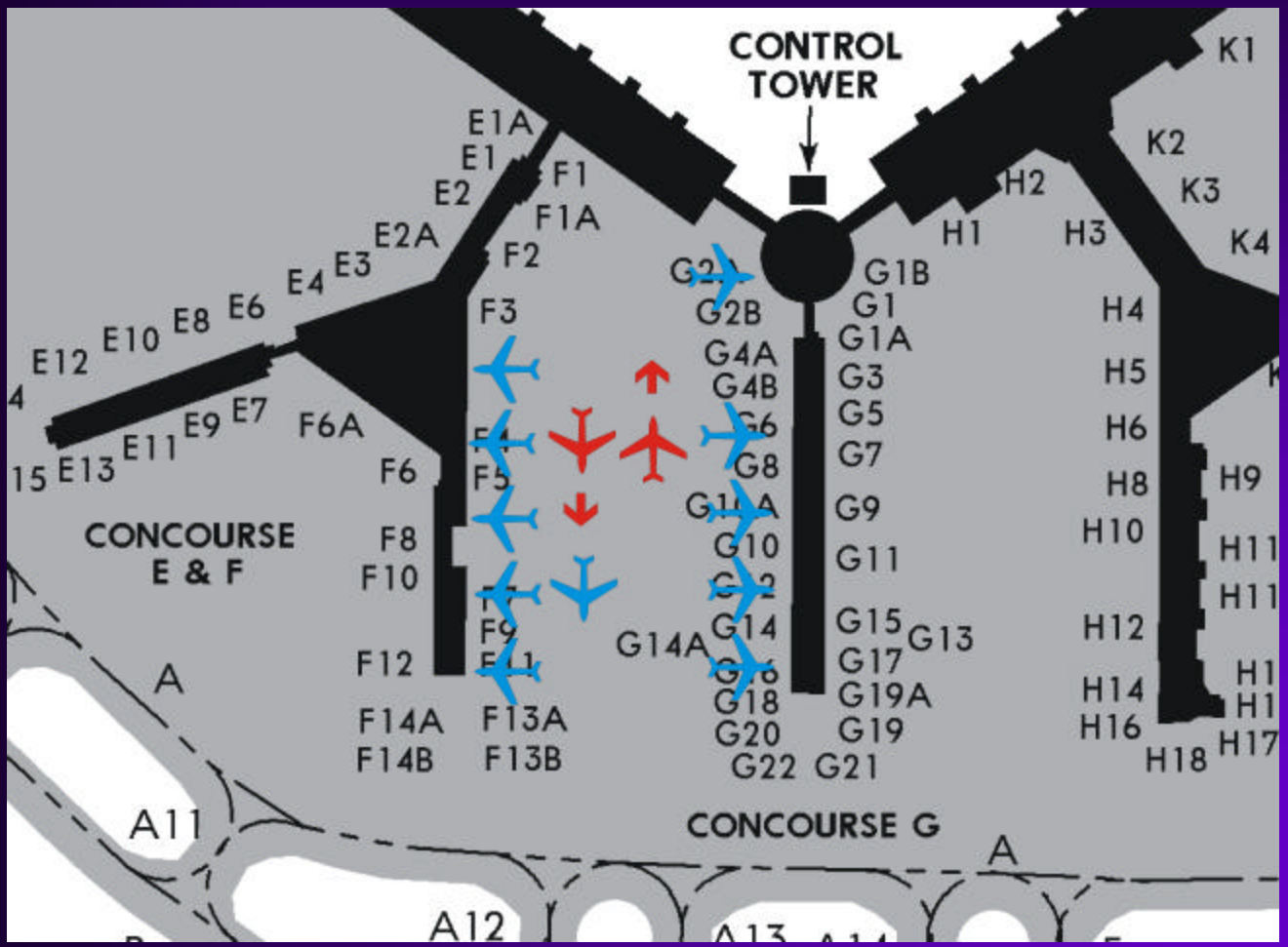
Potential Collision Risk (taxiing)

- Operation: Runway Line-Up



Potential Collision Risk (taxiing)

- Operation: Passing Other Aircraft



Solution: Synthetic Vision Systems

Depict other aircraft in shape and size

Depict own aircraft in shape and size

We need ADS-B to transmit make and model

Possible Coding

- Full name Coding (Make and Model)
  - ICAO aircraft list (Doc. 8643/27) e.g. B744,A340
  - Requires four characters (32Bit)

➢ Only four bits are available

- Coding by Identification
  - ICAO International identification e.g. D-AIBA
  - Requires a complete database of all aircraft and all nations on board (at least 40Bit)

➢ Only four bits are available

➢ Database cannot be generated

Approach to develop 4Bit Code

- Identify Parameters for Operational Concept
  - parallel Parking
  - passing Parked Aircraft
  - runway Line-Up
  - passing Other Aircraft
- Analyse Aircraft Types for Critical Parameters
- Build Data Classes for Parameters
  - evenly distribute error
  - minimize error
  - maintain significant aircraft size „jumps“
- Define Code

Identified Critical Parameters

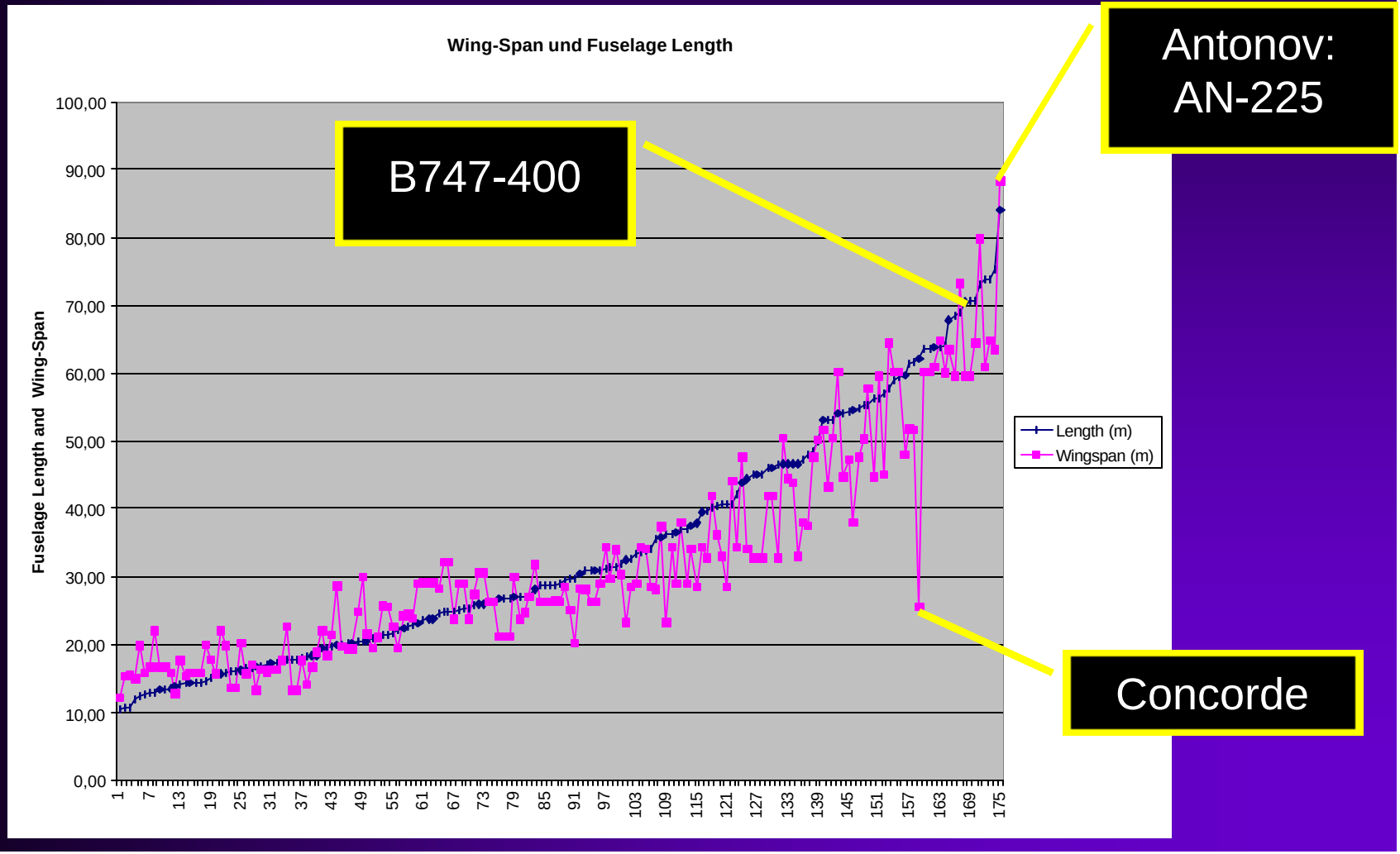
- Fuselage Length
  - passing parked aircraft
- Wing-Span
  - parallel parking
  - parallel runway line-up
  - passing other aircraft
- Maximal Thrust
  - maintain taxiing separation

Problem analysis

- Problem:
  No possibility to encode fuselage length, wingspan and max. thrust through 4 bits as seperate values
- Approach:
  Possible correlation between parameters to substitute two parameters with one

Data Analysis

- Analyzed 176 Aircraft Types



Data analysis

- High variaton fuselage / winspan ratio

Example:

Airbus A318	Airbus A321
fuselage length 31,44 m	fuselage length 44,51 m
wingspan **34,09** m	wingspan **34,09** m
➢ fuselage/wingspan = 1.04	➢ fuselage/wingspan = 1.3

Presentation error of fuselage length and wingspan not acceptable

Design of Dataclasses

- Approach:
  Design data classes in respect to aircraft sizes
- Survey of 175 aircraft types revealed a reasonable partition into eight fuselage classes
- Wingspan of respected fuselage classes are divided into two classes:
  - class smaller than the average wingspan
  - class larger than the average wingspan

Design of Dataclasses

fuselage			wingspan			
class	length range	average	span range	average	class 1	class 2
1	0 < l < 30 m	15 m	0 < b < 33 m	16.5 m	0 – 16.5	16.5 – 33
2	30 < l < 3[illegible]	[illegible]	[illegible]3 m	30.5 m	23 - 30.5	30.5 - 38
3	38 < l < 4[illegible]	[illegible]	[illegible]3 m	38 m	28 - 38	38 - 48
4	46 < l < 54 m	50 m	32 < b < 52 m	42 m	32 – 42	42 - 52
5	54 < l < 62 m	58 m	38 < b < 65 m	51.5 m	38 – 51.5	51.5 - 65
6	62 < l < 70 m	66 m	59 < b < 74 m	66.5 m	59 – 66.5	66.5 - 74
7	70 < l < 78 m	74 m	59 < b < 80 m	69.5 m	59 – 69.5	69.5 - 80
8	78 m < l		b = 84 m	0 m		

eight fuselage classes

Design of Dataclasses

fuselage			wingspan			
class	length range	average	span range	average	class 1	class 2
1	0 < l < 30 m	15 m	0 < b < 33 m	16.5 m	0 – 16.5	16.5 – 33
2	30 < l < 38 m	34 m	23 < b < 38 m	30.5 m	23 - 30.5	30.5 - 38
3	38 < l < 46 m	42 m	[illegible]	[illegible]	[illegible]	38 - 48
4	46 < l < 54 m	50 m	[illegible]	[illegible]	[illegible]	42 - 52
5	54 < l < 62 m	58 m	[illegible]	[illegible]	[illegible]	51.5 - 65
6	62 < l < 70 m	66 m	59 < b < 74 m	66.5 m	59 – 66.5	66.5 - 74
7	70 < l < 78 m	74 m	59 < b < 80 m	69.5 m	59 – 69.5	69.5 - 80
8	78 m < l		b = 84 m	0 m		

Each fuselage class categorized into fuselage length range

Design of Dataclasses

fuselage			wingspan			
class	length range	average	span range	average	class 1	class 2
1	0 < l < 30 m	15 m	0 < b < 33 m	16.5 m	0 – 16.5	16.5 – 33
2	30 < l < 38 m	34 m	23 < b < 38 m	30.5 m	23 - 30.5	30.5 - 38
3	38 < l < 46 m	42 m	28 < b < 48 m	38 m	28 - 38	38 - 48
4	46 < l < 54 m	50 m	32 < b <			
5	54 < l < 62 m	58 m	38 < b <			
6	62 < l < 70 m	66 m	59 < b < 74 m	66.5 m	59 – 66.5	66.5 - 74
7	70 < l < 78 m	74 m	59 < b < 80 m	69.5 m	59 – 69.5	69.5 - 80
8	78 m < l		b = 84 m	0 m		

Average fuselage length of each class

Design of Dataclasses

fuselage			wingspan			
class	length range	average	span range	average	class 1	class 2
1	0 < l < 30 m	15 m	0 < b < 33 m	16.5 m	0 – 16.5	16.5 – 33
2	30 < l < 38 m	34 m	23 < b < 38 m			
3	38 < l < 46 m	42 m	28 < b < 48 m			
4	46 < l < 54 m	50 m	32 < b < 52 m			
5	54 < l < 62 m	58 m	38 < b < 65 m			
6	62 < l < 70 m	66 m	59 < b < 74 m			
7	70 < l < 78 m	74 m	59 < b < 80 m			
8	78 m < l		b = 84 m	0 m		

Wingspan range corresponding to the fuselage class, which was determined through the survey

Design of Dataclasses

fuselage			wingspan			
class	length range	average	span range	average	class 1	class 2
1	0 < l < 30 m	15 m	0 < b < 33 m	16.5 m	0 – 16.5	16.5 – 33
2	30 < l < 38 m	34 m	23 < b < 38 m	30.5 m	23 - 30.5	30.5 - 38
3	3		m	38 m	28 - 38	38 - 48
4	4		m	42 m	32 – 42	42 - 52
5	5		m	51.5 m	38 – 51.5	51.5 - 65
6	62 < l < 70 m	66 m	59 < b < 74 m	66.5 m	59 – 66.5	66.5 - 74
7	70 < l < 78 m	74 m	59 < b < 80 m	69.5 m	59 – 69.5	69.5 - 80
8	78 m < l		b = 84 m	84 m		

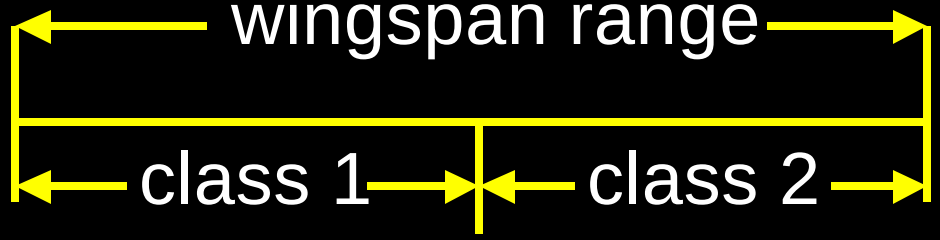
Average wingspan corresponding to each fuselage class

Design of Dataclasses

fuselage			wingspan			
					class 1	class 2
					0 – 16.5	16.5 – 33
					23 - 30.5	30.5 - 38
3					28 - 38	38 - 48
4					32 – 42	42 - 52
5				h	38 – 51.5	51.5 - 65
6				h	59 – 66.5	66.5 - 74
7				h	59 – 69.5	69.5 - 80
8	78 m < l		b = 84 m	84 m		

Class 1: wingspan < average

Class 2: wingspan > average



Design of Dataclasses

fuselage			wingspan			
class	length range	average	span range	average	class 1	class 2
1	0 < l < 30 m	15 m	0 < b < 33 m	16.5 m	0 – 16.5	16.5 – 33
					23 - 30.5	30.5 - 38
					28 - 38	38 - 48
					32 – 42	42 - 52
5	54 < l < 62 m	58 m	38 < b < 65 m	51.5 m	38 – 51.5	51.5 - 65
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8	78 m < l		b = 84 m	84 m		

For aircraft depictions the average value of either wingspan class will be used

Design of Dataclasses

wingspan					
span range	average	class 1	class 2	average class 1	average class 2
0 < b < 33 m	16.5 m	0 – 16.5	16.5 – 33	8.25 m	24.75 m
2				26.75 m	34.25 m
2				33 m	43 m
3				37 m	47 m
3				44.75 m	58.25 m
5				62.75 m	70.25 m
5				64.25 m	74.75 m
b = 84 m	84 m				

wingspan range

average class 1

average class 2

average wingspan

Design of Dataclasses

This procedure leads to the following displayed error:

fuselage class	max. wingspan error
1	8.25 m
2	3.75 m
3	5 m
4	5 m
5	6.75 m
6	3.75 m
7	5.25 m
8	0 m

Design of Dataclasses

- Max. thrust can be determined by the size of aircraft displayed

Design of Dataclasses

Example:

aircraft length: 46 m

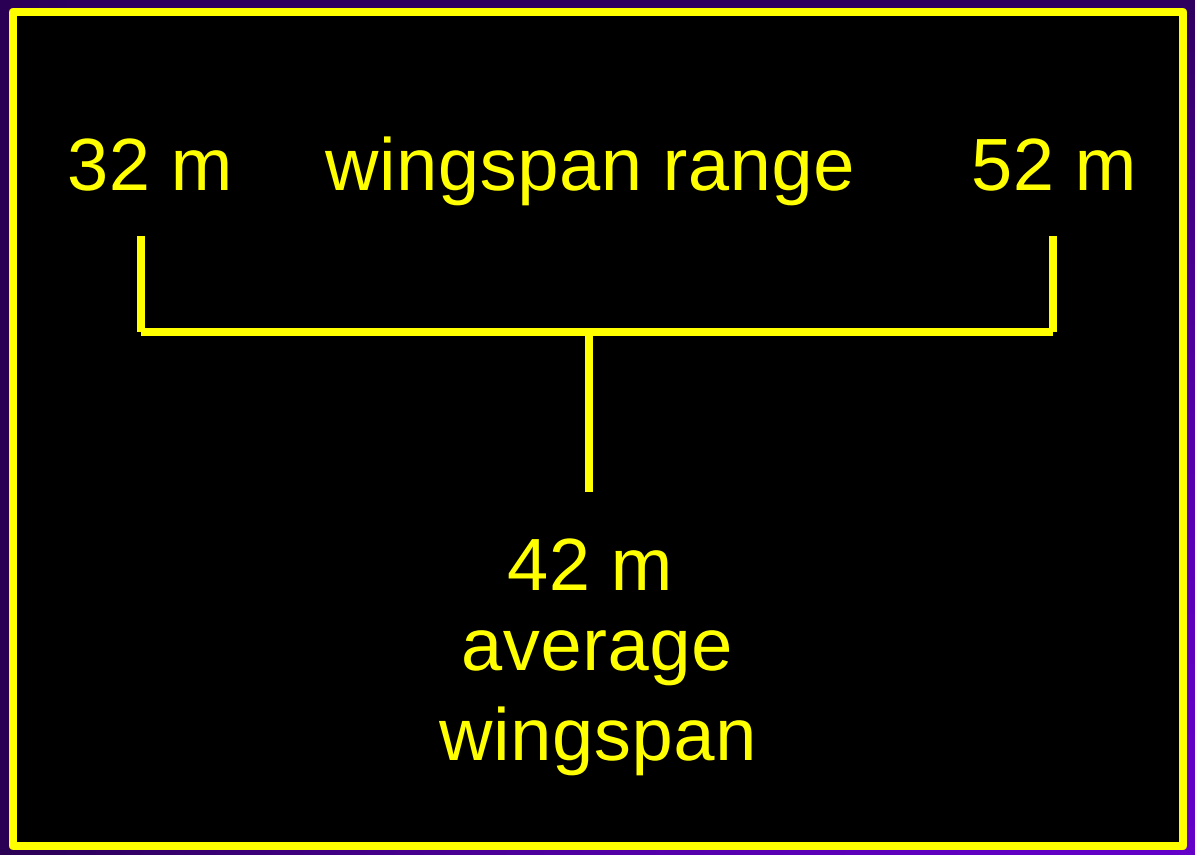
wingspan 32 m

- Fuselage class 4

  wingspan range $32 < b < 52$ m

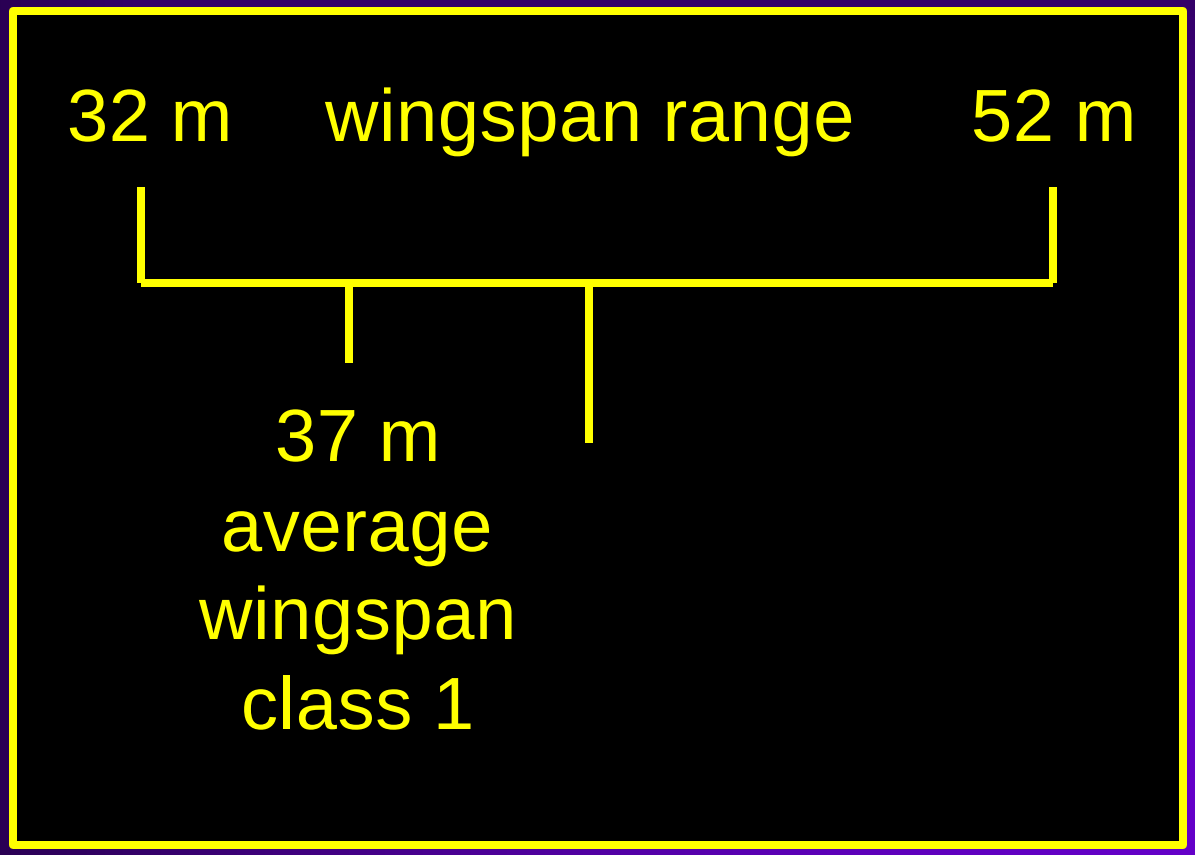
Design of Dataclasses

Wingspan class depicted as:



Design of Dataclasses

Actual aircraft wingspan (32 m) falls in average wingspann class 1:



Design of Dataclasses

- Displayed wingspan :37 m
  Actual wingspan: 32 m

  - Displayed wingspan error 5 m

Design of Dataclasses

- Bit can have the value either „0“ or „1“
- Three bits required for description of eight fuselage classes and one bit for wingspan average class

bits			
1	2	3	4
Three bits occupied for eight fuselage classes			One bit occupied for wingspan average class

Code Definition

One bit for average wingspan class

fuselage classes	3 bits		
1 (0 < l < 30 m)	0	0	0
2 (30 < l < 38 m)	0	0	1
3 (38 < l < 46 m)	0	1	0
4 (46 < l < 54 m)	0	1	1
5 (54 < l < 62 m)	1	0	0
6 (62 < l < 70 m)	1	0	1
7 (70 < l < 78 m)	1	1	0
8 (78 m < l)	1	1	1

+

class 1
0 (0<b<16.5 m)
0 (23<b<30.5 m)
0 (28<b<38 m)
0 (32<b<42 m)
0 (38<b<51.5 m)
0 (59<b<66.5 m)
0 (59<b<69.5 m)
0 (b < 84 m)

or

class 2
1 (16.5≤b<33 m)
1 (30.5≤b<38 m)
1 (38≤b<48 m)
1 (42≤b<52 m)
1 (51.5≤b<65 m)
1 (66.5≤b<74 m)
1 (69.5≤b<80 m)
1 (b ≤ 84m)