APPENDIX P

4 Bit Coding for Make and Model in ADS-B

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P.1 OVERVIEW

This Appendix summarizes the rationale for Table 2.1.2.5, which specifies coding for aircraft size category. The requirement supports a number of current Safe Flight 21 Surface Operations Applications as described in the Safe Flight 21 Master Plan, published in April 2000.

Examples of the types of surface operations applications that would require reporting of aircraft size categories are

- Passing Parked Aircraft on the Airport surface.
- Runway line up.
- Passing aircraft taxiing.
- Surface use of emerging "synthetic vision" systems.

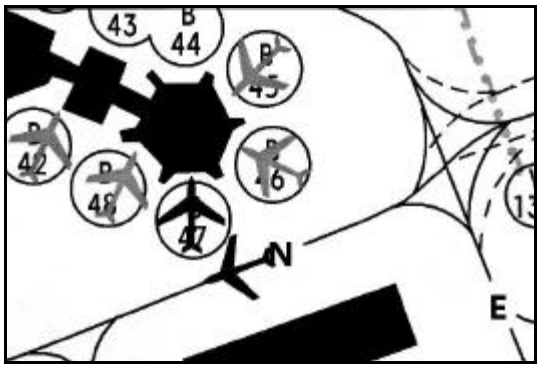

Figure P-1 **Passing Parked Aircraft**

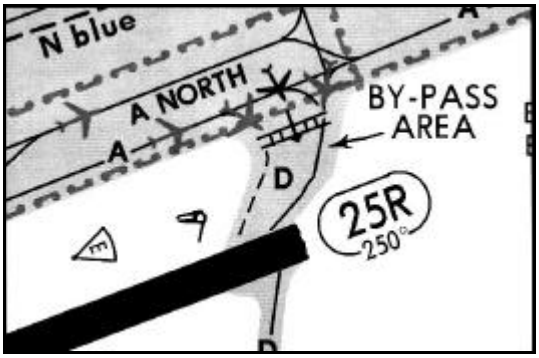

Figure P-2 **Runway Line-up**

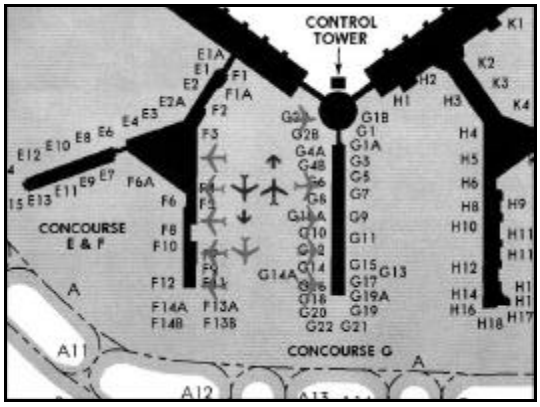

Figure P-3 **Passing Taxiing Aircraft**

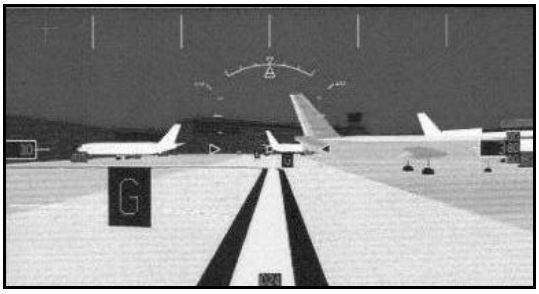

Figure P-4 **Sample synthetic Vision View**

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P.2 REVIEW OF EXISTING DATA AND ASSUMPTIONS

Ideally, full coding of aircraft "make and model' would provide the maximum resolution of aircraft size. However, it is assumed that regardless of ADS-B RF link used, available bandwidth will be limited. An analysis of the most common aircraft data report formats reflected a considerable "overhead" in coding bit requirements.

For example:

- Full name coding from the ICAO Aircraft List (Doc. 8643/27) e.g. B-747, A-320, requires four characters (32 bits).
- Coding by ICAO international identification, e.g. D-AIBA, requires a complete database of all aircraft of all nations (40 bits).

The operational capabilities and their subsequent "bit encoding" requirements described in this MASPS reflect a compromise to accommodate the capabilities of current ADS-B RF link technology and the requirements of the near-term SF-21 applications. Subsequently, in order to support certain applications in a multi-link environment, it was assumed that aircraft size depictions would need to be limited to no more than four bits in the ADS-B Message/Report encoding process.

P.3 APPROACH TO DEVELOP 4 BIT CODE

A. Identifying the basic parameters for the described operational applications.

- Passing Parked Aircraft on the Airport surface.
- Runway line up.
- Passing aircraft taxiing.
- Synthetic vision systems.

B. Analyzing the ICAO listed aircraft types and operational needs in relation to the minimum parameters (Table P-4).

- Fuselage length
- Wingspan
- Overall width
- Ratio to length

Analysis of the variations in aircraft size within type and even model series, made it clear that there was a large variation in fuselage to wingspan ratios, making it difficult to encode fuselage length, wingspan and thrust values according to make and model, independently through four bits.

Therefore, the parameters were correlated in order to combine and reduce encoding requirements, where possible, through substitution of a single value in lieu of two. Survey of the aircraft listed in Table P-4 revealed a reasonable partition into eight fuselage length classes. Further review of the listed aircraft allowed for the wingspans of the respective aircraft to be divided into two classes, i.e. wingspans smaller than the average or, wingspans larger than the average.

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C. Building data classes for Parameters

- Evenly distribute errors
- Minimize errors
- Describe significant aircraft size differentials

D. Defining the Code

Using the four bit limitation as a guide, the analysis focused on developing a methodology whereby the amount of space that an aircraft occupies could be described by the smallest length and width dimensions. Tables P1 through P4 represent the recommended solution to the aircraft size coding issue.

The left side of Table P-1 describes the distribution of the eight fuselage length classes (0 through 7) in relationship to lengths ranging between "x" meters (at the shortest) and "y" meters (at the longest) The right side of the table divides wingspan into two width classifications, one above and, one below the average size of the wingspan ranges for the associated fuselage class.

For example, the Airbus 318 has a fuselage length of 31.44 meters with a wingspan of 34.09 meters. Correspondingly the Airbus 321 has a fuselage length of 44.51 meters with the same wingspan as the 318. Using the figures in Table P-1, the Airbus 318 would be classified as fitting into the "Class 1" (fuselage length) category and the "Class 2"(wingspan) category since, the 34.09 meter wingspan is wider than the 30.5 meter average span for that fuselage length category. However, the Airbus 321, with the same wingspan, would fit into the "Class 2" length category and the "Class 1" wingspan category. Reasonably, for safety reasons an aircraft would be placed in a class wherein the largest size (length or width) could be contained.

Using Table P-2 (Size Code Bit Allocation) as a guide, Table P-3 (Code Definition) describes how the 318 and 321 would be defined in an ADS-B Message/Report.

- Airbus 318 = 0011
- Airbus 321 = 0100

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Table P-1: Design of Data Classes

FUSELAGE			WINGSPAN			
Class	Length Range	Average	Span Range	Average	Class 1	Class 2
0	0 < L < 30m	15m	0 < W = 33m	16.5m	0-16.5	16.5-33
1	30 = L < 38m	34m	23 < W = 38m	30.5m	23-30.5	30.5-38
2	38 = L < 46m	42m	28 < W = 48m	38m	28-38	38-48
3	46 = L < 54m	50m	32 < W = 52m	42m	32-42	42-52
4	54 = L < 62m	58m	38 < W = 65m	51.5m	38-51.5	51.5-65
5	62 = L < 70m	66m	59 < W = 74m	66.5m	59-66.5	66.5-74
6	70 = L < 78m	74m	59 < W = 80m	69.5m	59-69.5	69.5-80
7	78m = L		80m < W			

Table P-2: Size Code Bit Allocation

Encoding Bits			
1	**2**	**3**	**4**
Three bits required for eight fuselage classes			One bit required for average wingspan class

Table P-3: Code Definition

Fuselage Classes (Length Code)					Wingspan Classes (Width Code)			
	Length	3 Bits			LSB	Wingspan	LSB	Wingspan
0	0 < L < 30m	0	0	0	0	0 < W < 16.5m	1	16.5 = W < 33m
1	30 = L < 38m	0	0	1	0	23 < W < 30.5m	1	30.5 = W < 38m
2	38 = L < 46m	0	1	0	0	28 < W < 38m	1	38 = W < 48m
3	46 = L < 54m	0	1	1	0	32 < W < 42m	1	42 = W < 52m
4	54 = L < 62m	1	0	0	0	38 < W < 51.5m	1	51.4 = W < 65m
5	62 = L < 70m	1	0	1	0	59 < W < 66.5m	1	66.5 = W < 74m
6	70 = L < 78m	1	1	0	0	59 < W < 69.5m	1	69.5 = W < 80m
7	78m = L	1	1	1	0	W < 84	1	W = 84m

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Table P-4: Makes and Modes Considered

Aircraft Make and Model			
Brand	Type	Length (m)	Wingspan (m)
Aerpspatiale	TBM 700	10.43	12.16
Beechcraft	C 90 King Air	10.82	15.32
Beechcraft	Queen Air 65 / 70	10.82	15.47
Cessna	441 Conquest	11.89	15.04
Shorts	SC 7	12.21	19.79
Cessna	Caravan	12.67	15.88
Fairchild-Swearingen	Merlin 3 / 300	12.85	16.60
Antonov	An-28	12.98	22.06
Beechcraft	200 Super King Air	13.34	16.61
Beechcraft	300 Super King Air	13.36	16.61
Gulfstream Aerospace	Turbo Commander 690	13.52	15.89
Aerpspatiale	SN601/602 Corvette	13.83	12.87
Beechcraft	350 Super King Air	14.22	17.65
Embraer	EMB 110	14.23	15.32
British Areospace	Jetstream 32EP	14.36	15.85
British Areospace	Jetstream 31	14.37	15.85
Cessna	550 / 551 Citation	14.39	15.90
Let Kunovice	Turbolet 410	14.42	19.98
Beechcraft	Starship	15.20	17.80
British Areospace	HS 125	15.60	15.66
Antonov	An-38-100	15.67	22.06
De Havilland	DHC 6 Twin Otter	15.77	19.81
Israel Aircraft Industrie	IAI 1123	15.93	13.65
Israel Aircraft Industrie	IAI 1124	15.93	13.65
Casa	Casa 212/200	16.15	20.28
British Areospace	Hawker 1000	16.42	15.66
Dornier	228 - 100/200	16.55	16.97
Gates Learjet	Learjet 55	16.79	13.34
Cessna	650 Citation	16.90	16.31

Aircraft Make and Model			
Brand	Type	Length (m)	Wingspan (m)
Israel Aircraft Industrie	IAI 1125	16.94	16.05
Dassault Brequet	Mystere / Falcon 20	17.15	16.30
Dassault Brequet	Mystere / Falcon 200	17.15	16.30
Beechcraft	1900D Airliner	17.63	17.67
Shorts	Shorts 330	17.69	22.76
Gates Learjet	Learjet 60	17.88	13.34
Gates Learjet	Learjet 45	17.89	13.35
Embraer	CBA 123	18.09	17.72
Fairchild-Swearingen	Merlin 4	18.10	14.10
Lookheed	L 1329 Jetstar	18.42	16.60
Dassault Brequet	Mystere / Falcon 50	18.43	18.86
Aerpspatiale	N262 Fregate	19.28	21.99
British Areospace	Jetstream 41	19.33	18.42
Saab	SB 340	19.73	21.44
Canadair	CL-415	19.82	28.61
Embraer	EMB 120	20.00	19.78
Dassault Brequet	Mystere / Falcon 900B	20.21	19.33
Dassault Brequet	Mystere / Falcon 2000	20.23	19.33
Yakovlev	YAK 40	20.36	25.00
British Areospace	HS 748	20.42	30.02
VFW Fokker	VFW 614 (ATTAS)	20.60	21.50
Canadair	CL-601/604	20.85	19.61
Dornier	DO 328	21.22	20.98
Casa	CN 235	21.35	25.81
Let Kunovice	Let 610	21.42	25.60
Shorts	Shorts 360	21.58	22.80
Cessan	750 Citation	22.00	19.51
Antonov	An-140	22.43	24.25
Aerpspatiale	ATR 42	22.67	24.57
Grumman	G159 Gulfstream 1	22.96	23.92

Table P-4: Makes and Modes Considered (continued)

Aircraft Make and Model			
Brand	Type	Length (m)	Wingspan (m)
British Areospace	HPR-7	23.01	28.88
Antonov	An-24	23.53	29.20
Antonov	An-32	23.68	29.20
Antonov	An-26	23.80	29.20
De Havilland	DHC 7 / Dash 7	24.58	28.35
Convair	Convair 600/640	24.84	32.11
Convair	Convair 580	24.84	32.12
Grumman	G159 Gulfstream 2	24.97	23.72
Fokker	Fokker 27	25.06	29.00
Fokker	Fokker 50	25.24	29.00
Grumman	G1159 Gulfstream 3	25.32	23.72
De Havilland	Dash 8 - 300/400	25.68	27.43
British Areospace	Jetstream 61	26.01	30.63
British Areospace	ATP	26.01	30.65
Avro	RJ70	26.19	26.34
Avro	RJX-70	26.19	26.34
Canadair	CRJ100	26.77	21.21
Canadair	CRJ200	26.77	21.21
Canadair	Regionaljet	26.77	21.21
Ilyushin	IL-114	26.87	30.00
Gulfstream Aerospace	G1159 Gulfstream4	26.92	23.72
Saab	Saab 2000	27.03	24.76
Aerpspatiale	ATR 72-210	27.16	27.05
Antonov	An-72/74	28.07	31.89
Avro	RJ85	28.55	26.34
Avro	RJX-85	28.55	26.34
British Areospace	BAC 146	28.55	26.34
Boeing	737-100	28.60	26.50
British Areospace	Avro RJ/RJX	29.00	26.34
Gulfstream Aerospace	Gulfstream 5	29.40	28.50
Fokker	Fokker 28	29.61	25.07

Aircraft Make and Model			
Brand	Type	Length (m)	Wingspan (m)
Embraer	EMB 145	29.76	20.16
Boeing	737-200Adv	30.53	28.35
Fokker	Fokker 70	30.91	28.08
Avro	RJ100	31.00	26.34
Avro	RJX-100	31.00	26.34
Boeing	737-500	31.01	28.88
Boeing	737-600	31.20	34.31
Tupolev	Tu-334	31.26	29.77
Airbus	A318-100	31.44	34.09
Lookheed	L 188 Electra	31.81	30.37
Canadair	CRJ700	32.51	23.24
British Areospace	1-11-500	32.61	28.50
Boeing	737-300	33.40	28.88
Boeing	737-700	33.60	34.31
Airbus	A319-100	33.84	34.10
Boeing	717-100X	33.94	28.45
Fokker	Foker 100	35.51	28.08
Ilyushin	IL-18	35.90	37.40
Canadair	CRJ900	36.19	23.24
Aerpspatiale	SE S210 Caravelle	36.24	34.40
Boeing	737-400	36.45	28.88
Antonov	An-12	37.00	38.00
Tupolev	Tu-134	37.05	29.01
Airbus	A321-200	44.51	34.10
Boeing	717-200	37.80	28.40
Boeing	737-800	39.50	34.31
Boeing	MD-87	39.75	32.80
Tupolev	Tu-204-300	40.20	42.00
Yakovlev	YAK-42	40.38	36.25
Boeing	727-100QF	40.59	32.92
Boeing	DC 9	40.70	28.50

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Table P-4: Makes and Modes Considered (continued)

Aircraft Make and Model			
Brand	Type	Length (m)	Wingspan (m)
Antonov	An-70 T	40.73	44.06
Boeing	737-900	42.10	34.31
Aerpspatiale	Super Guppy 201	43.84	47.62
Airbus	A321-200	44.51	34.10
Boeing	MD-81	45.10	32.80
Boeing	MD-82	45.10	32.80
Boeing	MD-83/88	45.10	32.80
Tupolev	Tu-204-100	46.10	42.00
Tupolev	Tu-214	46.10	42.00
Boeing	MD-90	46.50	32.86
Ilyushin	IL-76 T	46.60	50.50
Boeing	707-320C	46.61	44.42
Airbus	A310-300	46.66	43.90
Boeing	727-200Adv	46.69	32.92
Boeing	757-200	47.32	38.05
Tupolev	Tu-154M	47.90	37.50
Boeing	767-200	48.51	47.57
Lookheed	Tristar L1011-500	50.04	50.09
Boeing	BC-17X	53.04	51.74
Ilyushin	IL-62 MK 2	53.12	43.20
Ilyushin	IL-76 MF	53.19	50.50
Airbus	A330-500	54.00	60.30
Airbus	A300 - 600R / B4	54.10	44.84
Lookheed	Tristar L1011	54.33	47.35
Boeing	757-300	54.50	38.05
Boeing	767-300	54.94	47.57
Boeing	DC 10	55.30	50.40
Ilyushin	IL-96-300	55.35	57.66

Aircraft Make and Model			
Brand	Type	Length (m)	Wingspan (m)
Airbus	A300-600STBeluga	56.16	44.84
Boeing	747 SP	56.30	59.60
Boeing	DC 8	57.10	45.20
Antonov	An-22	57.80	64.40
Airbus	A330-200	59.00	60.30
Airbus	A340-200	59.40	60.30
Ilyushin	IL-86	59.54	48.06
Boeing	767-400	61.37	51.92
Boeing	MD-11	61.60	51.70
Aerpspatiale	Concorde	62.10	25.56
Airbus	A330-300	63.70	60.30
Airbus	A340-300	63.70	60.30
Boeing	777-200ER	63.73	60.90
Boeing	777-200LR	63.73	64.80
Ilyushin	IL-96T	63.94	60.11
Airbus	A340-500	67.90	63.45
Boeing	747-200	68.60	59.64
Antonov	An-124 Ruslan	69.10	73.30
Boeing	747-100	70.60	59.60
Boeing	747-300	70.70	59.64
Boeing	747-400	70.70	64.40
Airbus	A380	73.00	79.80
Boeing	777-300	73.86	60.90
Boeing	777-300ER	73.90	64.80
Airbus	A340-600	75.30	63.45
Antonov	An-225 Mriya	84.00	88.40