

SURVEILLANCE AND CONFLICT RESOLUTION SYSTEMS PANEL (SCRSP)

SURVEILLANCE SYSTEMS

WG/B

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Review of register 4,0

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SUMMARY

This paper is a review of register 4,0 following a clear understanding by all States involved in the development of enhanced surveillance of their respective requirements regarding the so-called "selected" altitude parameter.

# 1 Introduction

A meeting involving NATS, DFS, STNA, British Airways and Aérospatiale/Matra was held in Toulouse on the 2<sup>nd</sup> of March 2001. Following a presentation by each State of their operational needs, a revised format for register 4,0 has been worked out. This revised format takes into consideration current and planned future aircraft avionics ability to provide information that will improve the ground ATM systems performance and reduce controller pilot workload.

## 2 Operational requirement summary

### 2.1 NATS

When a valid selected altitude is downlinked from the aircraft, it should be displayed to the controller for comparison with the ATC cleared altitude. This will assist NATS in reducing the number of level busts (which are currently increasing). Ultimately, the selected altitude would be automatically compared with the cleared altitude and an alert given to the controller if there is a discrepancy. This requirement can be satisfied with existing airborne avionics functionality for the vast majority of commercial aircraft in Europe.

### 2.2 DFS

Selected Altitude / FL shall be the short-term intent value, to which the aircraft is flying to at the end of its vertical manoeuvre (in respect of the given ATC clearance). It is foreseen that this will reduce the number of STCA false alerts during the vertical manoeuvring of the involved aircraft (level-off scenarios) by about 90%.

### 2.3 STNA

Value which will be reached and maintained by the aircraft if it is flying to this altitude in the next two minutes in order to reduce the number of STCA false alerts during the vertical manoeuvring of the involved aircraft.

## 3 Analysis

The DFS and STNA operational requirements are very similar. The NATS need is quite different. The altitude information to be down-linked for the NATS need will be referred to as "Selected altitude from the altitude control panel" and for DFS/STNA it will be referred to as "Target altitude". The latter can either be the "selected altitude from the altitude control panel" or the "FMS selected altitude" or even the aircraft current altitude, it all depends on which equipment is actively controlling the vertical profile of the aircraft (see section 5 of this document).

The selected altitude from the altitude control panel is available on today's airborne architectures.

The determination of the target altitude will require an airborne logic that will gather information to determine the equipment managing the vertical profile.

It is also clear that there is no identified current operational requirement for other intent parameters of current register 4,0.

It was therefore decided to review register 4,0 limiting its content to the current identified DFS, NATS and STNA operational need:

- Include the "selected altitude from the altitude control panel" and associated mode bits in order to meet the NATS need
- Include the "Target altitude" with associated source bits to indicate which equipment is providing the it, to meet the DFS/STNA need.

## **4 Associated SARPS change**

It is proposed to replace current Table 2-64 of Appendix 1 to Chapter 5 of Annexe 10 Volume III with the one included in the next page. The remaining data items identified in the old definition of register 4,0 will be moved to the Manual of Mode S Specific Services (Doc. 9688) and another register label assigned. This will enable visibility of the development of these data items in the future. Additional changes to Appendix C have been identified as a consequence of this change and are included.

**Table 2-64 BDS 4,0 - Selected Vertical Intention**

**MB FIELD**

1	STATUS
2	MSB = 32 768 ft
3	
4	SELECTED ALTITUDE
5	FROM ALTITUDE
6	CONTROL PANEL
7	
8	Range = 0 to 65 520 ft
9	
10	
11	
12	
13	LSB = 16 ft
14	STATUS
15	MSB = 32 768 ft
16	
17	TARGET
18	ALTITUDE
19	
20	
21	Range = 0 to 65 520 ft
22	
23	
24	
25	
26	LSB = 16 ft
27	
28	
29	
30	
31	
32	
33	
34	
35	
36	RESERVED
37	
38	
40	
41	
42	
43	
44	
45	
46	
47	
48	STATUS OF ALTITUDE CONTROL PANEL MODE BITS
49	MANAGED VERTICAL MODE
50	ALT HOLD MODE
51	APPROACH MODE

52	UNASSIGNED
53	UNASSIGNED
54	STATUS OF TARGET ALT SOURCE BITS
55	TARGET ALTITUDE SOURCE
56	

**PURPOSE:** To provide ready access to information about the pilot's current vertical intentions, in order to improve the effectiveness of conflict probes and to provide additional tactical information to controllers.

- 1) The data entered into bits 1 to 13 shall be derived from the Altitude Control Panel (Mode Control Panel/Flight Control Unit or equivalent equipment). Alerting devices may be used to provide data if it is not available from 'control' equipment.
- 2) The data entered into bits 14 to 26 shall be the Target Altitude.
- 3) Bits 48 to 56 shall define the status of the values provided in bits 1 to 26 as follows:

Bit 48 shall indicate whether the Mode Bits (49,50 & 51) are actively being populated.

- 0 = No mode information provided
- 1 = Mode information deliberately provided

Bits 49, 50 and 51:

- 0 = Not active
- 1 = Active

#### A-2.1 Transponder register table

Delete

“40<sub>16</sub> Aircraft intention 1.0s”

Insert

“40<sub>16</sub> Selected vertical intention 1.0s”

“TBD<sub>16</sub> Reserved for Aircraft intention 1.0s”

(TBD to be agreed during the meeting)

Modify the first page of the Tables for Chapter 2 of Appendix 1 to assign an un-assigned register for Aircraft Intention

Bits 52 & 53 currently unassigned.

Bit 54 shall indicate whether the Target Altitude Source Bits (55 & 56) are actively being populated.

- 0 = No source information provided
- 1 = Source information deliberately provided

Bits 55 and 56 shall indicate that target altitude is:

- 00 = Unknown
- 01 = Aircraft Altitude
- 10 = FCU/MCP Selected Altitude
- 11 = FMS Selected Altitude

- 4) Target Altitude shall be the short-term vertical intent value, at which the aircraft will level-off (or has levelled-off) at the completion of the current manoeuvre. This information which represents the real “aircraft intent”, when available, represented by the Altitude Control Panel Selected Altitude, the Flight Management System Selected Altitude, or the current aircraft altitude, according to the aircraft's mode of flight. (Note that the intent may not be available at all when the pilot is flying the aircraft manually.)

## **5 Associated Doc 9688 changes**

Insert the new Aircraft Intention register definition detailed on the following page.

**Table TBD BDS Code TBD - Aircraft Intention**

MB FIELD	
1	Reserved
2	
3	
4	
5	
6	
7	Reserved
8	
9	
10	
11	
12	
13	
14	STATUS
15	SIGN
16	MSB = 8 192 ft/min
17	SELECTED
18	ALTITUDE RATE
19	ARINC 429 Label 104
20	
21	Range = ± 16 352 ft/min
22	
23	
24	Resolution = 32 ft/min
25	SWITCH (See 2)
26	STATUS
27	SIGN
28	MSB = 90 degrees
29	
30	SELECTED
31	TRACK/HEADING
32	
33	
34	Range = ± 180 degrees
35	Resolution = 360/512 degrees
36	SWITCH (See 2)
37	STATUS
38	MSB = 256 Kt/Mach 2.048
40	SELECTED
41	AIRSPEED/MACH
42	
43	
44	Range = 0 to 512 / 4.096
45	
46	
47	LSB = 0.5 Kt/Mach 0.004
48	Reserved
49	Reserved
50	
51	MODE

52	SELECTED ALTITUDE RATE
53	MODE
54	SELECTED TRACK/HEADING
55	MODE
56	SELECTED AIRSPEED/MACH

**PURPOSE:** To provide ready access to information about an aircraft's short-term intentions, in order to improve the effectiveness of conflict probes and to provide additional tactical information to controllers.

*Notes:*

- 1) *The data entered into this register should be derived from the sources that are controlling the aircraft, however when a valid parameter is available and there is insufficient information to ensure that it is being delivered from the system that is flying the aircraft the Mode field for that parameter shall be set to the value = 00. (See Note 3)*
- 2) *Selected track/heading and selected airspeed/mach are switchable with an extra switch bit included to indicate which parameter is in use. It is defined as follows:*

SWITCH bit	0	1
Track/heading	Track	Heading
Airspeed/Mach	Airspeed	Mach

- 3) *6 mode bits have been allocated to provide a limited and standardised set of modes derived from the more extensive ARINC 429 FCC status words. This is sufficient to indicate the validity of each parameter to the ground systems which do not need to understand the full complexities of operation of FCCs.*

*The mode is defined with 2 bits per parameter as follows:*

- 00 = Not active*
- 01 = Acquiring*
- 10 = Maintaining (or capture)*
- 11 = Holding actual rather than selected value*

- 4) *For all parameters the value used is to be the 'target' rather than the 'control' as the latter may fluctuate continuously under the control of the FMS or other system. For example, selected heading is not suitable when flying a track.*

Replace the existing chapter 3 material in doc 9688 with the text below.

## Chapter 2

### 2.1.4 GUIDANCE MATERIAL FOR REGISTER FORMATING

#### 2.1.4.1. EXAMPLE OF HOW THE TARGET ALTITUDE IS DERIVED ON AIRBUS AIRCRAFT

##### Introduction

In order to clarify how target altitude information is reported in register 4,0, a mapping has been prepared to illustrate, for a number of conditions:

- how the target altitude data is derived that is loaded into bits 14 to 26 of register 4,0; and
- how the corresponding source bits are set; and
- How the Selected altitude from the Altitude Control Panel status and mode bits are set.

##### 2.1.4.1.1 A 330/A340 family

Autopilot or Flight Director status	Autopilot or Flight Director Vertical Mode	Conditions : Vertical Status / Altitude (FCU, FMS or Aircraft)	Target Altitude Used	Bit 55	Bit 56
(AP on and FD on/off) or (AP off and FD on )	Vertical speed (V/S)	V/S>(<)0 with FCU ALT >(<) A/C ALT	FCU ALT	1	0
		V/S>(<)0 with FCU ALT <(>) A/C ALT	/	0	0
		V/S = 0	A/C ALT	0	1
	Flight Path Angle (FPA)	FPA>(<)0 with FCU ALT >(<) A/C ALT	FCU ALT	1	0
		FPA>(<)0 with FCU ALT <(>) A/C ALT	/	0	0
		FPA = 0	A/C ALT	0	1
	Altitude Acquire (ALT CAPT)	Aircraft operating with FCU altitude	FCU ALT	1	0
	Altitude Acquire (ALT CAPT)	Aircraft capturing a constrained altitude imposed by the FMS	FMS ALT	1	1
	Altitude Hold (ALT)		A/C ALT	0	1
	Descent (DES)	FCU ALT > NEXT FMS ALT	FCU ALT	1	0
		FCU ALT ≥ NEXT FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
Open Descent (OPEN DES)	Mode used to descend directly to the FCU ALT disregarding the computed descent path and FMS constraints	FCU ALT	1	0	

Autopilot or Flight Director status	Autopilot or Flight Director Vertical Mode	Conditions : Vertical Status / Altitude (FCU, FMS or Aircraft)	Target Altitude Used	Bit 55	Bit 56
	Climb (CLB)	FCU ALT < NEXT FMS ALT	FCU ALT	1	0
		FCU ALT ≥ NEXT FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Open Climb (OPEN CLB)	Mode used to climb directly to the FCU ALT disregarding the computed ascent path and FMS constraints	FCU ALT	1	0
	Take Off (TO)	FCU ALT < NEXT FMS ALT	FCU ALT	1	0
		FCU ALT ≥ NEXT FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Go Around (GA)	FCU ALT > A/C ALT and FCU ALT < next FMS ALT	FCU ALT	1	0
		FCU ALT > A/C ALT and FCU ALT ≥ next FMS ALT	FMS ALT	1	1
		FCU ALT > A/C ALT and no next FMS ALT	FCU ALT	1	0
		FCU ALT ≤ A/C ALT	/	0	0
	Other vertical modes (final approach, land, glide slope)		/	0	0
	AP off and FD off		/	0	0

#### 2.1.4.1.2 A320 family

The A320 has two additional modes compared to the A330/340:

- The Expedite Mode: it climbs or descends at respectively “green dot” speed or Vmax speed.
- The Immediate Mode: it climbs or descends immediately while respecting the FMS constraints.

Autopilot or Flight Director status	Autopilot or Flight Director Vertical Mode	Conditions : Vertical Status / Altitude (FCU, FMS or Aircraft)	Target Altitude Used	Bit 55	Bit 56
(AP on and FD on/off) or (AP off and FD on )	Vertical speed (V/S)	V/S > (<) 0 with FCU ALT > (<) A/C ALT	FCU ALT	1	0
		V/S > (<) 0 with FCU ALT < (>) A/C ALT	/	0	0
		V/S = 0	A/C ALT	0	1
	Flight Path Angle (FPA)	FPA > (<) 0 with FCU ALT > (<) A/C ALT	FCU ALT	1	0

Autopilot or Flight Director status	Autopilot or Flight Director Vertical Mode	Conditions : Vertical Status / Altitude (FCU, FMS or Aircraft)	Target Altitude Used	Bit 55	Bit 56
		FPA>( < )0 with FCU ALT <( > ) A/C ALT	/	0	0
		FPA = 0	A/C ALT	0	1
	Altitude Acquire (ALT CAPT)	Aircraft operating with FCU altitude	FCU ALT	1	0
	Altitude Acquire (ALT CAPT)	Aircraft capturing a constrained altitude imposed by the FMS	FMS ALT	1	1
	Altitude Hold (ALT)		A/C ALT	0	1
	Descent (DES) or Immediate Descent (IM DES)	FCU ALT > NEXT FMS ALT	FCU ALT	1	0
		FCU ALT ≥ NEXT FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Open Descent (OPEN DES) or Expedite (EXP)	Mode used to descend directly to the FCU ALT disregarding the computed descent path and FMS constraints	FCU ALT	1	0
	Climb (CLB) or Immediate Climb (IM CLB)	FCU ALT < NEXT FMS ALT	FCU ALT	1	0
		FCU ALT ≥ NEXT FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Open Climb (OPEN CLB) or Expedite (EXP)	Mode used to climb directly to the FCU ALT disregarding the computed ascent path and FMS constraints	FCU ALT	1	0
	Take Off (TO)	FCU ALT < NEXT FMS ALT	FCU ALT	1	0
		FCU ALT ≥ NEXT FMS ALT	FMS ALT	1	1
		No next FMS ALT	FCU ALT	1	0
	Go Around (GA)	FCU ALT > A/C ALT and FCU ALT < next FMS ALT	FCU ALT	1	0
		FCU ALT > A/C ALT and FCU ALT ≥ next FMS ALT	FMS ALT	1	1
		FCU ALT > A/C ALT and no next FMS ALT	FCU ALT	1	0
		FCU ALT ≤ A/C ALT	/	0	0
	Other vertical modes (final approach, land, glide slope)		/	0	0
	AP off and FD off		/	0	0

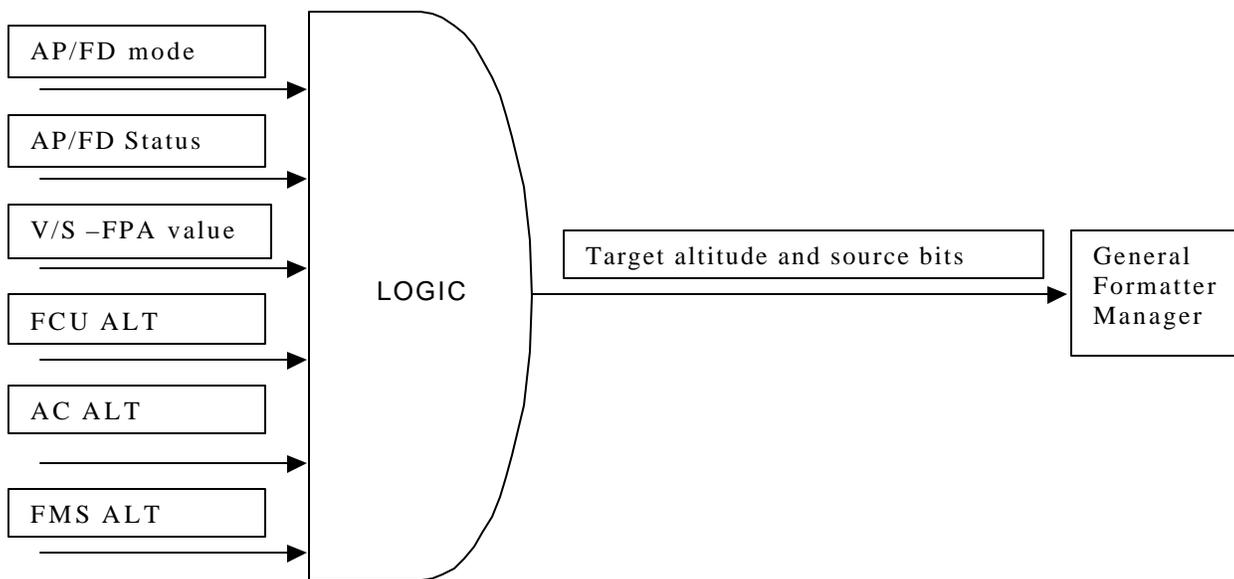
### 2.1.4.1.3 Synthesis

These tables show the following:

- a) Depending on the AP/FD vertical modes and some conditions, the desired target altitude might differ. Therefore a logical software combination should be developed in order to load the appropriate parameter in register 4,0 with its associated source bit value and status.
- b) A large number of parameter values are required to implement the logic: the V/S, the FCU ALT, the A/C ALT, the FPA, the FMS and the AP/FD status and vertical modes. The following labels might provide the necessary information to satisfy this requirement:

- 1) V/S : label 212 (Vertical Rate) from ADC;
- 2) FCU ALT : label 102 (Selected Altitude) from FCC;
- 3) A/C ALT : label 361 (Inertial Altitude) from IRS/ADIRS;
- 4) FPA : label 322 (Flight Path Angle) from FMC;
- 5) FMS ALT : label 102 (Selected Altitude) form FMC; and
- 6) AP/FD: labels 272 (Auto-throttle Modes), 273 (ARM modes) and 274 (Pitch modes).

The appropriate Target altitude should, whatever its nature (A/C, FMS, or FCU), be included in label TBD, which would be received by the GM that will then include it in register 4,0. A dedicated label (such as 271) could then contain the information on source bits for target altitude.



Bit 54 may be derived from the logic process to positively indicate that bits 55 and 56 are actively being loaded where '1' indicates active and '0' indicates inactive.

When selected altitude is provided in bits 1 to 13, the status and mode bits (48 – 51) may be provided from the following sources:

	A320	A340	
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Status of altitude control Panel mode bits (bit 48)	SSM labels 273/274	SSM labels 274/275
Managed Vertical Mode (bit 49)	Label 274 bit 11 (climb) Label 274 bit 12 (descent) Bus FMGC A	Label 275 bit 11 (climb) Label 275 bit 15 (descent) Bus FMGEC G GE-1
Altitude Hold Mode (bit 50)	Label 274 bit 19 (Alt mode) Bus FMGC A	Label 275 bit 20 (Alt hold) Bus FMGEC G GE-1
Approach Mode (bit 51)	Label 273 bit 23 Bus AFS FCU	Label 273 bit 15 Bus AFS FCU

#### 2.2.1.4.3 EXAMPLE OF HOW THE SELECTED ALTITUDE IS DERIVED ON BOING 747-400, 757 AND 767 AIRCRAFT

##### Introduction

In order to clarify how selected altitude information from the Altitude Control panel is reported in register 4,0, a mapping has been prepared to illustrate how the status and mode bits can be derived.

Register bit	Description	Label
48	Status of mode bits	SSM of 272 and 273
49	Managed Vertical Mode	272 bit 13
50	Altitude Hold Mode	272 bit 9
51	Approach Mode	233 bit 19
54	Status of Target Altitude source bits	SSM of new label (TBD)
55 56	Target altitude source bits	New label (TBD)

The Selected Altitude from the Mode Control Panel may be obtained from label 102 (source ID 0A1). The status bit may be derived from the SSM of label 102.