ARINC 424 NDB

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Discussion/Proposal

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REMOVE XA LEGS TO 400 FT ON MISSED APPROACH

V1.0

Julien FOUGNION, SII for AIRBUS
Julien ROBIN, AIRBUS

SUMMARY
As a follow up of Airbus and Garmin Working Paper presented during Renton Meeting in July 2019 on a proposal to fix the operational impacts of the rule for xA coding as the first leg of the missed approach, Airbus has been working on the consolidation of an Airbus position, which is presented in this present paper.

1.0 INTRODUCTION/ BACK GROUND

During the 2017 meeting in Cocoa Beach, Airbus raised awareness on the operational impacts of the rule for xA coding as the first leg of the missed approach (ARINC Specification 424 - Requirement 9.3.1.5). This discussion originated from an observation raised during an Airbus flight test at LFKF VOR05 approach, which is not aligned with the runway.

During the flight test, it was noticed that upon initiating a go-around manoeuvre at low height above the runway and after the MAPt, due to the CA leg coded in the final approach segment axis (027°), the aircraft Flight Director commanded an immediate left turn (instead of the missed approach's right turn to 097° expected by the crew), as shown in figure below:
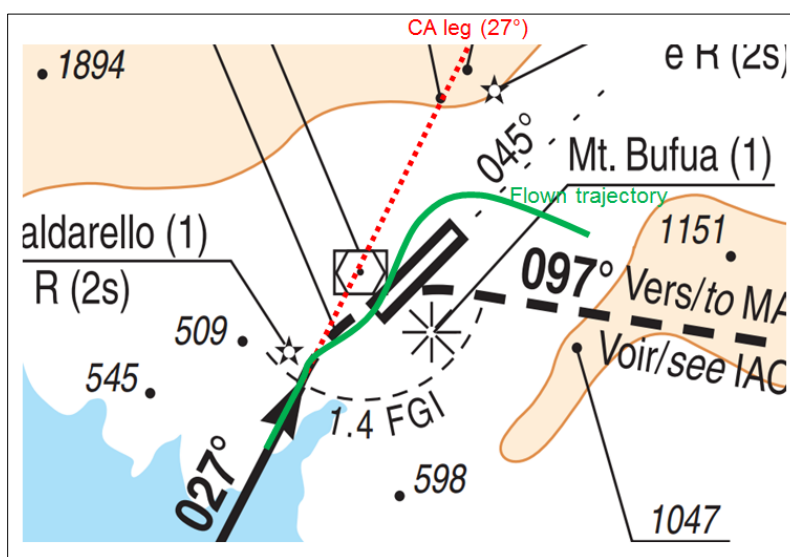

Figure 1: Flown trajectory (in green) during an arrival on VOR05 at LFKF

This scenario has been detailed in Attachment 2 of the Working Paper Circulation of the NDB Subcommittee held on March 7-9, 2017 in Cocoa Beach, Florida (ref. 17-021/NDT-170 lth February 15, 2017).

It has to be noted that following complaints from Airbus and airlines operating at LFKF, some Data Service Providers confirmed they have removed this CA leg from the VOR05 approach at LFKF for all their customers (i.e. not compliant with ARINC 424 req. 9.3.1.5 anymore). No negative feedbacks have been received so far after this modification as far as Airbus knows.

During several meetings, solutions have been proposed to the committee but none of them has been considered as fully satisfactory without further analysis.

Figure 2: Timeline of meetings and proposals on the xA leg to 400ft with immediate turn subject

For Renton Meeting of 2019, five solutions were presented and three remaining solutions have been identified as follows:

a) <u>New xA leg flag</u>

Keep the coding rules as they currently are, but add a flag in A424 source to identify whether such xA leg has been added directly based on the published source data (e.g. turn at a specified altitude) or added by the Data Service Providers after application of rule 9.3.1.5. This proposal was an alternative

2

idea to the new Path & Termination leg one (keep current track to an altitude). This solution was proposed in a meeting between Airbus, Garmin and FMS vendors in July 2019 and the idea convinced the participating actors.

➔ This flag would allow the detection of the problematic legs and allow the NDB Providers to filter these legs through the NDB packing tool according to the DQR of the A/C manufacturers/FMS Suppliers. This gives flexibility to each A/C manufacturer/FMS Suppliers to determine or apply customized rules to keep/delete such added xA legs.

➔ If this solution is the retained one, **a wording proposal shall be discussed during the current meeting to clearly explain the use of this flag and its definition (including ASCII vs XML choice).**

b) <u>Airbus first proposal</u>

The proposal made by Airbus in Phoenix (rewording of requirement 9.3.1.5 without the additional req. 9.3.1.7) could be a good solution but it also leaves out some significant cases such as the turns at low altitude that have previously been mentioned in Phoenix meeting.

➔ This solution would give flexibility to the Data Services Providers to code or not such CA leg for non-aligned approaches (e.g. based on customer feedback), and decide if the CA leg has to be coded and whether along final approach course or runway centerline depending on the procedure geometry. **In this case Data Providers and other OEMs point of view would be appreciated.**

c) <u>A new proposal for requirement 9.3.1.5</u>

This proposal was to have the Data Services Providers, FMS vendors and Aircraft manufacturers work on this requirement to propose a solution or rewording. To do so, some tests on their side was required (tests procedures to be flown - *Feedback form for vendors*). Afterwards, **a congruence of the entire proposal has to be made into a final wording covering every use case.**

The previous wordings proposed, as well as the initial requirements, are listed in this document in **APPENDIX**.

2.0 DISCUSSION and or ACTION

For Virtual Meeting of October 2021, AIRBUS Flight Test pilots and engineers flown the following test procedures. Tests were performed on AIRBUS A320 simulator with AIRBUS' Navigation database (AIRAC cycles 1913 and 2001). Except otherwise mentioned, it has been proposed to pilots to perform a Go Around manoeuvre below 400ft AGL (usually at around 50-100ft AGL) and to use guidance automatisms as much as possible (LNAV mode with AP/FD on).

Note: on most of Airbus aircrafts, upon a go-around, FD automatically engages and maintains current A/C track at low altitude then LNAV automatically engages to follow FMS' flight plan if defined.

- **Scenario #1** – VOR05 on LFKF **with** CA leg – Final Approach Course not aligned with Runway and MAPt before Runway threshold:
  - CF to MAPt then CA-CF legs combination for AIRAC cycle 1913.
  - CA leg course aligned with Final Approach Course (30°) up to 520ft MSL.
  - Final Approach Course (30°) not aligned with Runway (45°).
  - Right turn > 15° required for Missed Approach (97°).

  Before MAPt sequencing with AP/FD on in LNAV mode, pilots disconnected AP and visually aligned A/C with runway centreline. Upon MAPt sequencing, crew disengaged FD and continued in visual flight for landing.

  Go Around manoeuvre was initiated while below 100ft AGL near runway threshold. Consecutively with Go Around manoeuvre initiation, FD automatically engaged and maintained current A/C track with automatic LNAV rearming.

  After passing 100ft AGL, LNAV automatically engaged and crew immediately re-engaged AP, leading A/C to start turning left towards Final Approach Course 30° (so opposite to published missed approach path) with a low dynamic and for approximately 1NM. The left turn was considered very problematic by the pilots since not in accordance with the chart asking for an immediate right turn.

  CA leg was sequenced crossing 520ft MSL then a right turn towards continuation of Missed Approach procedure was initiated by the A/C automatisms.

- **Scenario #2** – VOR05 on LFKF **without** CA leg – Final Approach Course not aligned with Runway and MAPt before Runway threshold:
  - CF to MAPt then CF leg combination for AIRAC cycle 2001 (CA leg has been removed by DSP).
  - Final Approach Course (30°) not aligned with Runway (45°).
  - Right turn > 15° required for Missed Approach (97°).

  Before MAPt sequencing with AP/FD on in LNAV mode, pilots disconnected AP and visually aligned A/C with runway centreline. Upon MAPt sequencing, crew disengaged FD and continued in visual flight for landing.

  Go Around manoeuvre was initiated while below 100ft AGL near runway threshold. Consecutively with Go Around manoeuvre initiation, FD automatically engaged and maintained current A/C track with automatic LNAV rearming.

  After passing 100ft AGL, LNAV automatically engaged and crew immediately re-engaged AP, leading A/C to start turning right towards continuation of Missed Approach procedure with a maximum bank angle of 22 degrees while A/C V/S was around +2500ft/min. The right turn was deemed safe and in accordance with the published missed approach path by the crew.

- **Scenario #3** – VOR05 on LFKF **without** CA leg – Final Approach Course not aligned with Runway and MAPt before Runway threshold:

- o CF to MAPt then CF leg combination for AIRAC cycle 2001 (CA leg has been removed by DSP).
- o Final Approach Course (30°) not aligned with Runway (45°).
- o Right turn > 15° required for Missed Approach (97°).

While flying Final Approach Course in LNAV mode and about 3NM before MAPt sequencing with AP/FD on, a Go Around manoeuvre was initiated at around MDH (930ft AGL). Consecutively with Go Around manoeuvre initiation, AP maintained current A/C track (Final Approach Course) until MAPt sequencing then a right turn towards continuation of Missed Approach procedure was commanded. The missed approach was deemed safe and in accordance with the published missed approach path by the crew.

- **Scenario #4** – RNP05 on LFKF **without** CA leg – Final Approach Course not aligned with Runway and MAP before Runway threshold:
  - o TF to MAPt then DF leg combination for AIRAC cycle 2001 (CA leg has been removed by DSP).
  - o Final Approach Course (30°) not aligned with Runway (45°).
  - o Right turn > 15° required for Missed Approach (Direct To MASAL).

Upon MAPt sequencing, pilots visually aligned A/C with Runway centreline with AP/FD off and Go Around manoeuvre was initiated while below 100ft AGL. Consecutively with Go Around manoeuvre initiation, FD automatically re-engaged and LNAV automatically rearmed. AP was immediately re-engaged by the crew and followed current A/C track.

LNAV automatically engaged after crossing 100ft AGL and a right turn was commanded towards continuation of the Missed Approach procedure. The right turn was deemed acceptable by the crew and felt as a continuation of their manoeuvre. A slight overshoot of lateral trajectory (MAX Crosstrack around 0.5NM) was observed due to inertia and pilots observed that lateral guidance may have even turned quicker.

- **Scenario #5** – ILS34L on LIRF **with** CA leg - Final Approach Course aligned with Runway and MAP at Runway threshold – Go Around performed below 100ft AGL:
  - o CF to MAPt then CA-CF legs combination for AIRAC cycle 2001.
  - o CA leg course aligned with Final Approach Course (341°) up to 400ft MSL.
  - o Final Approach Course (341°) not aligned with Runway (341°).
  - o Left turn > 15° required for Missed Approach (291°).

A/C was stabilized on Approach path in LOC/GS modes with AP/FD on. Slightly before MAPt sequencing (Runway threshold), Go Around manoeuvre was initiated while below 100ft AGL. Consecutively with Go Around manoeuvre initiation, AP/FD maintained current A/C track and LNAV rearmed automatically.

LNAV automatically engaged after crossing 100ft AGL and lateral guidance maintained current track up to around 400ft MSL (when CA leg is sequenced). Then a left turn toward continuation of Missed Approach procedure was commanded.

Pilot noted that the chart required an immediate turn at Missed Approach initiation whereas A/C maintained the runway heading for few seconds due to the CA leg. However, this was deemed acceptable by the crew.

- **Scenario #6** – ILS34L on LIRF without CA leg - Final Approach Course aligned with Runway and MAP at Runway threshold:
  - o CF to MAPt then TF leg combination for (CA leg manually removed by pilots).
  - o Final Approach Course (341°) not aligned with Runway (341°).
  - o Left turn > 15° required for Missed Approach (291°).

CA leg was manually removed and corresponding lateral flight plan discontinuity was manually cleared. Consecutively, aircraft systems drew a straight line from Runway threshold to next point of the Missed Approach (D5 OST). This also led to a course of 302° towards next waypoint of the Missed Approach (D5 OST) for 6NM instead of 291° as expected by the chart and procedure. This limitation was specifically emphasized to the crew and collectively considered as having very low impact on the conclusions of the test.

During the test, A/C was stabilized on approach path in LOC/GS modes with AP/FD on. Slightly before MAPt sequencing (Runway threshold), Go Around manoeuvre was initiated while below 100ft AGL. Consecutively with Go Around manoeuvre initiation, AP/FD maintained current A/C track and LNAV armed automatically.

LNAV automatically engaged after crossing 100ft AGL and AP/FD immediately started to order a left turn toward continuation of Missed Approach procedure (max roll angle was 22°). The trajectory flown by the A/C was considered by the crew as safe and appropriate with respect to the published missed approach.

The here-above results are synthesized in following table based on format recommended by Joshua Fenwick from GARMIN:

#	Airport	Procedure	MAPt	Alignment	Path Term Combo	Test Condition	Arpt Elev	Potential Turns below 400'?	Should xA be added?	What course for xA?	AIP
1	LFKF	VOR RWY 05	MD05	Not aligned (15° Delta)	CF-CA-CF	With CA leg (AIRAC Cycle 1913)	85	NO	N/A	No unique solution for this approach depending on when Go Around manoeuvre is initiated	
2	LFKF	VOR RWY 05	MD05	Not aligned (15° Delta)	CF-CF	Without CA leg (AIRAC Cycle 2001)	85	YES	NO	N/A	AD_2_LFKF_IAC_RWY05_VOR.pdf
3	LFKF	VOR RWY 05	MD05	Not aligned (15° Delta)	CF-CF	Without CA leg (AIRAC Cycle 2001)	85	YES	NO	N/A	
4	LFKF	RNP 05	MKF05	Not aligned (15° Delta)	TF-DF	Without CA leg (AIRAC Cycle 2001)	85	YES	NO	N/A	AD_2_LFKF_IAC_RWY05_RNP.pdf
5	LIRF	ILS 34L	RW34L	Precision Straight-In	CF-CA-CF	With CA leg (AIRAC Cycle 2001)	14	NO	N/A	Not problematic as Final Approach Course = Runway Bearing	LIRFCharts201805.pdf
6	LIRF	ILS 34L	RW34L	Precision Straight-In	CF-TF	Without CA leg (AIRAC Cycle 2001)	14	YES	NO	N/A	

CONCLUSIONS

For each of the performed scenarios it has been proposed to pilots to perform Go Around manoeuvres below 400ft AGL (at around 50-100ft AGL) and to use guidance automatisms as much as possible (LNAV with AP/FD on). At these altitudes, pilots were always aligned with runway centreline except for one LFKF scenario for which pilots decided to perform the Go Around at MDA. Only LFKF VOR 05 scenario with the CA leg coded was considered as particularly problematic by the pilots.

With CA leg coded as the first point of the Missed Approach, turns were indeed initiated at higher elevations compared to the same procedures flown without CA leg. Without CA leg, considering high vertical dynamic of A/C in case of a Go Around manoeuvre and inertia of LNAV engagement and A/C to initiate a turn, no turn was detected by the crew at an elevation lower than 200ft AGL and those turns were performed with reasonable bank angles (no more than 22° of bank angle during the tests). Thus the roll rate and bank angle remained within the known capacities of the aircraft and should not surprise crews or passengers on AIRBUS aircrafts. Therefore, it has been deemed that the CA leg removal is much preferable to incorrect FD orders.

Based on those elements, AIRBUS considers that xA legs to 400ft AGL as first leg of missed Approach procedures that are followed by immediate turns should not be coded when the Final Approach Course is not aligned with Runway centreline or when the MAPt is not ending at the runway threshold.

In the opposite case, even if the presence of the leg does not cause adverse effect, it is not particularly required for AIRBUS aircrafts since automatisms prevents the A/C from aggresse or unexpected turns at very low altitude during a go-around.

3.0 Changes as depicted (Track Changes is Helpful)

As such, AIRBUS suggests to the committee either to:

- Merely delete requirement 9.3.1.5 (solution a. presented in Renton Meeting of July 2019)

- Only keep xA leg coding requirement when Final Approach course is aligned with Runway centreline and MAPt is at the runway threshold (solution d. presented in Renton Meeting of July 2019 and recalled in §4.2 here-below)

4.0 APPENDIX

During previous meetings, some different propositions have been made to handle this requirement. Here after the different evolutions proposed until now.

4.1 Initial requirement (A424-22)

9.3.1.5

When an immediate turn is specified in an ILS, MLS, or GLS missed approach, or if the source describes a turn greater than 15 degrees from the final approach course, without an altitude specified before the turn, as the first leg of a missed approach, a course from or heading to an altitude (CA, FA, VA) leg must be coded as the first leg of the missed approach and must include a command to climb before the turning leg, using the final approach course for the leg heading or course. The altitude will be coded as a minimum altitude, at least 400 feet above the airport elevation and the leg will terminate at that altitude.

4.2 First proposal (Airbus)

9.3.1.5

If the missed approach point is at the runway threshold and the final approach course is aligned with runway centerline, ~~W~~when an immediate turn is specified ~~in an ILS, MLS, or GLS missed approach,~~ or if the source describes a turn greater than 15 degrees from the final approach course, without an altitude specified before the turn, ~~as the first leg of a missed approach,~~ a course from or heading to an altitude (CA, FA, VA) leg must be coded as the first leg of the missed approach and must include a command to climb before the turning leg, using the final approach course for the leg heading or course. The altitude will be coded as a minimum altitude, at least 400 feet above the airport elevation and the leg will terminate at that altitude.

A new requirement was also proposed for clarification but not approved by the committee:

~~9.3.1.7~~

~~*If the missed approach point is not at the runway threshold or the final approach course is not aligned with runway centerline, the necessity to code such an altitude leg and the leg heading or course value (if coded) shall be assessed by the data provider with respect to the published missed approach path, taking into account the go-around may be initiated either before or after the published missed approach point.*~~

4.3 Second proposal (Garmin)

9.3.1.5

When an immediate turn is specified in an ~~ILS, MLS, or GLS missed~~ approach that (1) meets straight-in alignment criteria, (2)~~, or if~~ the source describes a turn greater than 15 degrees from the final approach course, (3) the first path on the missed approach is not intended to be a track (TF) between the MAP and the first missed approach fix, and (4) ~~without~~ there is not a climb to an altitude leg (xA) specified before the turn~~, as the first leg of a missed approach~~, a course from or heading to an altitude (CA,FA, VA) leg must be coded as the first leg of the missed approach and must include a command to climb before the turning leg, using the ~~final approach course~~ runway bearing/heading for the leg~~'s heading or~~ course. The altitude will be coded as a minimum (At/Above) altitude~~, at least~~ of 400 feet above the airport elevation (AFE), or the lowest DA/MDA, and will terminate at that altitude.

4.4 Garmin tests

For Gdansk meeting, Garmin made some flight tests in simulator and presented them in the following working paper (see §4):

PDF 29_Removal_of_xA_L
egs_Rev3.pdf

These tests showed that the deletion of the xA leg could lead to turns at low altitude.

4.5 Feedback form for vendors

To collect various feedbacks from vendors, Garmin provided them a form to complete. This form is based on the feedback Garmin made in the working paper for Gdansk meeting:

W xA_Legs_Feedback_F
orm.docx