Fixed Radius Transition (FRT) Flight Data Collection Report

Prepared by the EUROCONTROL Navigation and CNS Research Unit

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Summary

EUROCONTROL completed a data analysis investigating the functionality, performance and operational use of the Fixed Radius Transition (FRT). This function allows the definition of a repeatable path during turns in en route airways and provides steering guidance for the aircraft to remain on this path. The function is available on modern Airbus and Boeing B737 aircraft.

In cooperation with Lufthansa, the FRT function was enabled in their Airbus A320 and Boeing B737 fleet by programming a 22.5NM radius turn in the database at a waypoint, "LIMGO", located in Belgian / Maastricht airspace along the UN858 airway. Track data was collected between 7th of February and 30th of June 2013, for all the Lufthansa flights operating between Paris CDG and Frankfurt and between Paris CDG and Berlin TXL, with flight plans via LIMGO along the UN858. Controllers were asked, whenever possible, to keep the flights on their route between the waypoint before and after LIMGO. Pilots were briefed and were asked not to modify the route in their FMS between the points preceding and succeeding LIMGO.

Track data was collected for a total of 1203 flights. A majority of flights were still radar vectored and therefore did not fly the planned route over LIMGO. Those were excluded from the sample. Out of the remaining sample, the following results were obtained:

- 212 flights started the FRT correctly of which 144 flights completed the FRT correctly
- 191 flights went direct to LIMGO and did not perform an FRT
- 15 flights went direct to LIMGO and still performed an FRT
- 64 flights were on the planned route to LIMGO but did not perform an FRT

Lateral navigation accuracy was analysed for the 144 flights that performed a correct FRT between the start and end of the turn. It was found that lateral deviations were extremely low and thus tracking accuracy was very high, with an average lateral deviation of 0.006NM and a 95% (2σ) tolerance interval of +/- 0.052NM.

The remaining flights that appeared to be on the planned route but did not perform an FRT, as well as the flights that were cleared direct to LIMGO and performed or did not perform an FRT, were further investigated. In addition, flight simulations were performed using an A320 flight crew training simulator of Lufthansa Flight Training and a certified GE B737 FMS desktop simulator, to further investigate the behaviour of the FRT function in the presence of tactical interventions.

It was found that tactical interventions, as well as common ATC instructions causing modifications by the pilot to the FMS flight plan, can lead to the cancellation of the FRT and its replacement in the FMS by a traditional fly-by transition. More in particular, it was found that the FRT is not flown in the following cases:

- ATC tactical interventions (radar vectors)
- Aircraft cleared direct to the FRT point and clearance inserted in the FMS flight plan for Airbus (even if not deviating from the original plan)
- Typical ATC instruction "Proceed <FRT point> thereafter <next point>" when inserted by the pilot in the FMS flight plan for Airbus and Boeing (even if not deviating from the original plan)
- Changes in the FMS (i.e. directs) to other points that violate the required turn geometry (start and end points) of the FRT

Furthermore, analysis of ATC voice recordings by Belgocontrol indicated that the instruction "Proceed LIMGO then BITBU" was very commonly issued after first contact with the air crew and entry into Belgian airspace which, according to the third bullet point above, lead to the replacement of the FRT by a fly-by transition in the FMS flight plan after insertion by the pilot.

The FRT data collection and analysis indicated that the tracking of the FRT in modern aircraft is impressively accurate. Route design aspects as well as pilot and controller awareness and procedures would have to be taken into consideration for the handling of the FRT functionality, taking into account its sensitivity to tactical interventions, if FRT were to be used today in an existing operational environment.

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1. BACKGROUND

The Fixed Radius Transition, abbreviated as FRT, is a function of an aircraft Flight Management System (FMS), allowing the aircraft to fly a defined and repeatable curved path, when transiting from one airway segment to another. It was defined in the RTCA / EUROCAE Minimum Aviation System Performance Standard (MASPS), Required Navigation Performance for Area Navigation DO-236B / ED-75B in 2003. This standard required the system to be able to define a transition using a fixed turn radius of either 22.5NM, for high altitudes, or 15NM, for low altitudes. The standard also explained that this type of turn is intended to define transitions along airways in the case where separation between parallel routes is also needed in the transition and the "fly-by transition" is not compatible with the separation criteria.

In 2013, the MASPS was updated and DO-236C / ED-75C version was released. This new release contains an update of the FRT specification. In DO-236C / ED-75C it is specified that the system shall use the navigation database specified radius associated with each waypoint along an airway, and if there is a blank entry in the database field for a particular waypoint no fixed-radius transition is required. Furthermore it is noted in this edition that in order to respect bank angle limitations used in current systems under all foreseeable conditions, the standard turn radius at FL 200 and above should be defined as 22.5 NM and at FL 190 and below as 15 NM.

Arinc Specification 424, "Navigation System Database" allows the coding of a turn radius at each fix ident along an enroute airway, by means of a 3 digit numerical value representing the radius of the turn to 1 decimal place in NM, entered in fields 99-101.

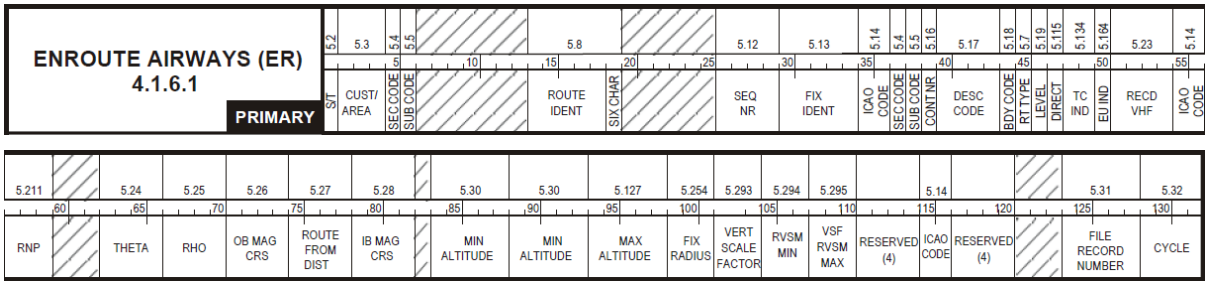

Figure 1: Arinc 424 enroute airway record with FRT in fields 99-101

FRT is implemented today in Airbus aircraft using a Thales-GE Release 1/A or Honeywell Pegasus Release 1/A Flight Management System and in Boeing B737 aircraft using a GE Flight Management System with software version 10.

The FRT function was designed originally for potential use in European airspaces, however implementations have been lacking. Therefore a project was started in under SESAR WP 4.7.3, "Use of Performance Based Navigation (PBN) for En Route Separation Purposes" with the objective to collect real flight data of aircraft using the FRT function and to evaluate the performance and operation of this function.

2. INTENDED USE OF FRT

The Fixed Radius Transition allows closely spaced parallel route design in restricted airspaces. Figure 2 illustrates two parallel routes with a route spacing of 7NM. If the Fixed Radius Transition is used, the route spacing at the bisector of the turn becomes slightly greater. i.e. 7.6NM which is due to the geometry of the two circles segments with a displayed turn centre and a constant radius. When a traditional fly-by transition would be used, the lateral spacing between two aircraft in the turn is undefined and depends on the location of the actual turn path of the aircraft within the fly-by transition area. The fly-by turn path depends on the aircraft's groundspeed and the bank angles applied by the aircraft's Flight Management System (FMS). The boundaries of the two fly-by transition areas depicted in Figure 2 have a minimal spacing of 3.8NM (indicated as 4NM in the figure) at the bisector of the turn, compared to a 7NM route spacing along the straight segments. These values represent a particular example of a configuration with a 45 degree track change.

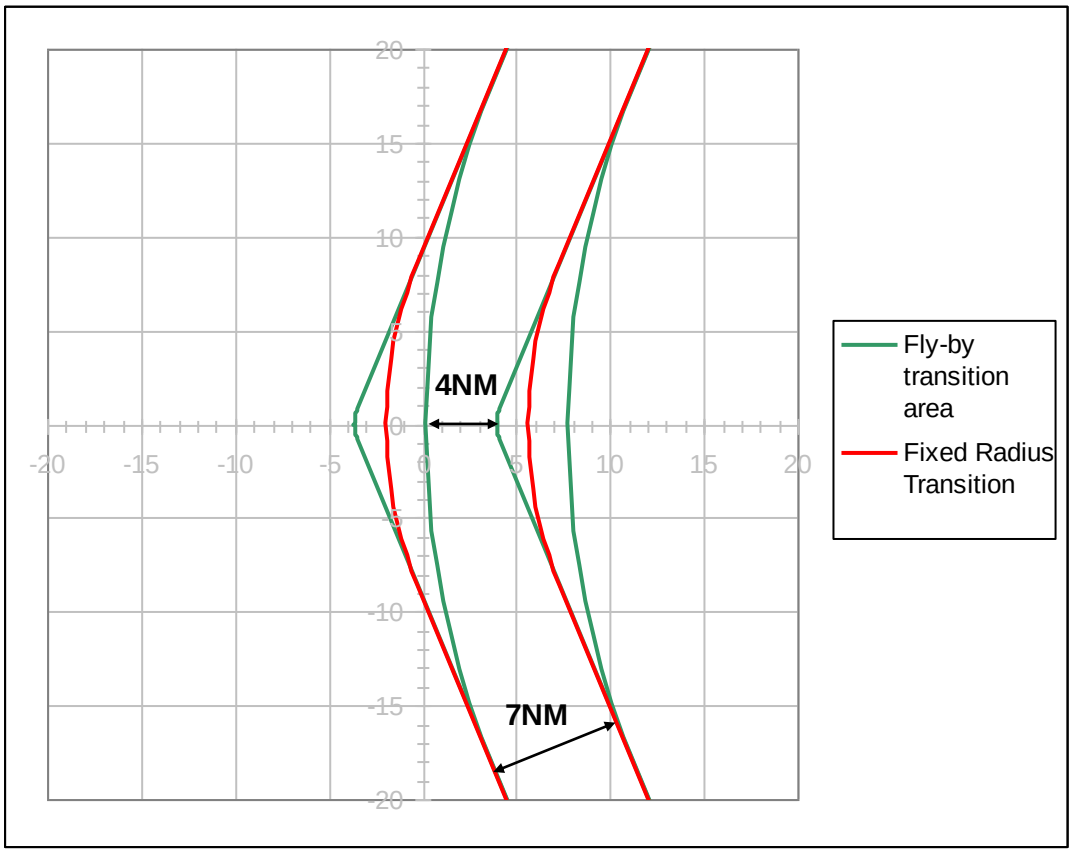

Figure 2: Comparing FRT (red) with conventional fly-by transition boundaries (green) along two parallel routes with initial route spacing of 7NM and track change of 45 degrees.

3. FRT DATA COLLECTION SETUP

Within SESAR WP 4.7.3, “Use of Performance Based Navigation (PBN) for En Route Separation Purposes”, a data collection was organised with the objective to collect real flight data of aircraft using the FRT function and to evaluate the performance and operation of this function.

To facilitate this data collection, a collaboration was setup between the following partners with their respective roles:

- EUROCONTROL: organisation, data analysis and reporting
- Lufthansa: coding of the FRT, briefing of pilots and operation of aircraft equipped with FRT
- MUAC: provision of ATC tracking data, notice to controllers concerning FRT data collection in their airspace
- Belgocontrol: notice to controllers concerning FRT data collection in their airspace
- DSNA: notice to controllers concerning FRT data collection in adjacent airspace
- DFS: notice to controllers concerning FRT data collection in adjacent airspace

A route segment had to be identified that contained a turn with sufficient track angle change, which was situated in one of the airspaces of the partners and which was flown by the Lufthansa aircraft equipped with FRT. Airway UN858 located in Belgian / MUAC airspace, from waypoint LIPNI towards BETEX via turn waypoint LIMGO, situated almost overhead Luxembourg airport, was identified as suitable. Figures 3 and 4 provide an illustration of the location of this airway with the identified turn waypoint LIMGO. The track angle change between the segments LIPNI - LIMGO and LIMGO - BETEX is 42 degrees.

As UN858 is an airway in upper airspace above FL195, a turn radius of 22.5NM was coded at waypoint LIMGO, in the UN858 airway record of the Lufthansa databases, in the following aircraft with indicated equipment of the Lufthansa fleet:

- Airbus A32F (A319/A320/A321) with Thales-GE Release 1/A S6 FMGC
- Boeing B737-300 and B737-500 with GE 10.7 FMS

Furthermore two city-pairs were identified between which Lufthansa operated their A32F and B737 aircraft and which contained the UN858 airway section from LIPNI via LIMGO to BETEX in the flight plan. Those city pairs were:

- Paris Charles De Gaulle (LFPG) – Frankfurt (EDDF)
- Paris Charles De Gaulle (LFPG) – Berlin Tegel (EDDT)

Flights between Paris and Frankfurt were operated at FL230 and flew over LIMGO within Belgian airspace, at typical True Airspeeds around 400kts. Flights between Paris and Berlin were operated at cruising levels between FL310 and FL390 within MUAC airspace, at typical True Airspeeds around 450kts.

Approximately 8 aircraft per day were operated by Lufthansa between Paris and Frankfurt and 2 flights per day went from Paris to Berlin. The applicable call signs of these flights were identified and provided to MUAC. ATC track data, provided by MUAC for those call signs on a daily basis, was used to analyse the turn performance at waypoint LIMGO.

To increase the likelihood that the FRT was performed correctly, a notice explaining the FRT function and the objective of the data collection was issued to the Lufthansa pilots. A notice about the FRT data collection, with the request not to vector Lufthansa aircraft inbound Frankfurt or Berlin after LIPNI waypoint (whenever possible and safety permitting), was provided by Belgocontrol, MUAC and DSNA to their controllers. Similarly, a notice was

provided by DFS to their controllers with the request to keep the aircraft on the flight plan until at least BETEX waypoint.

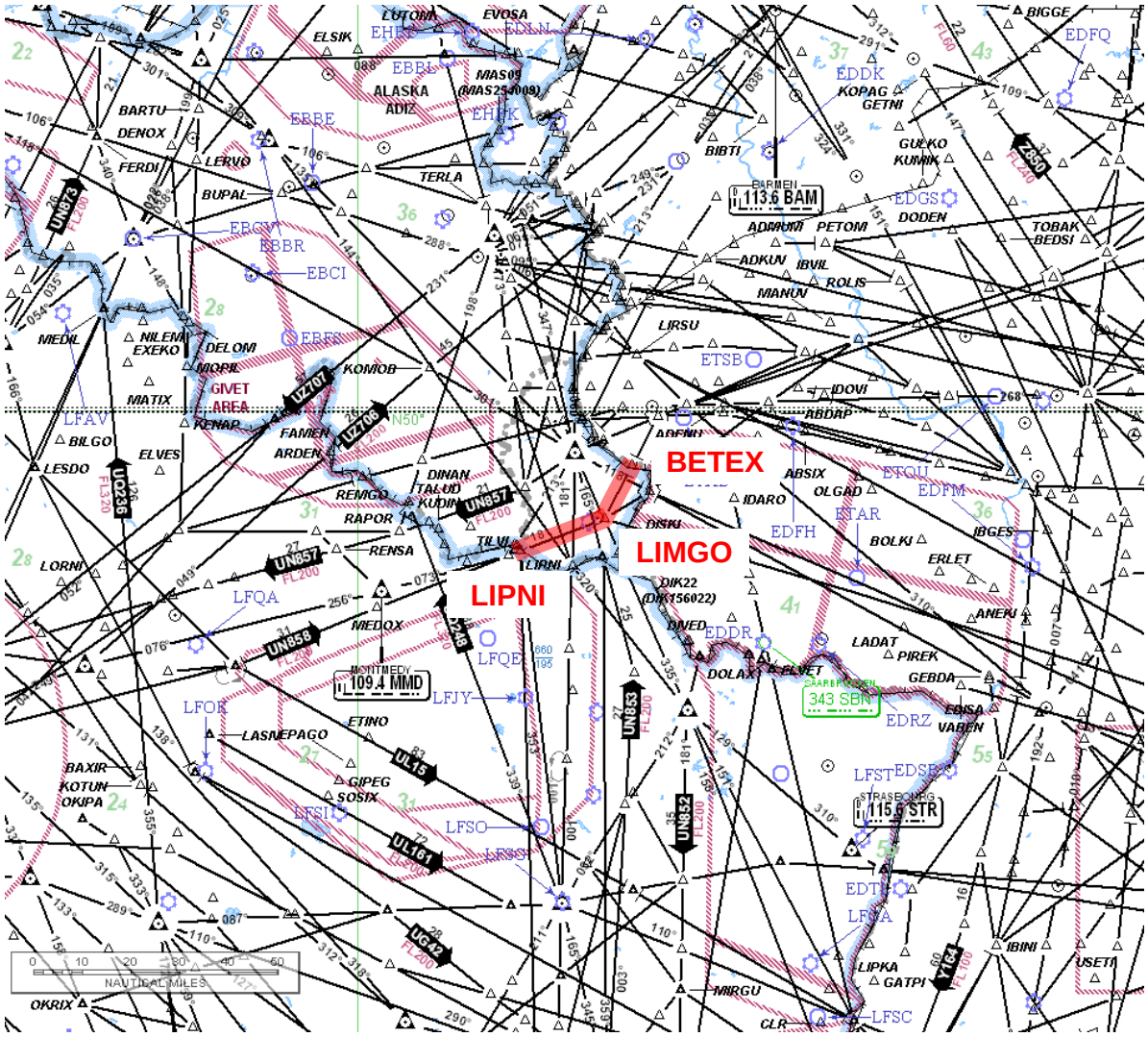

Figure 3: Location of turn waypoint LIMGO along UN858 airway

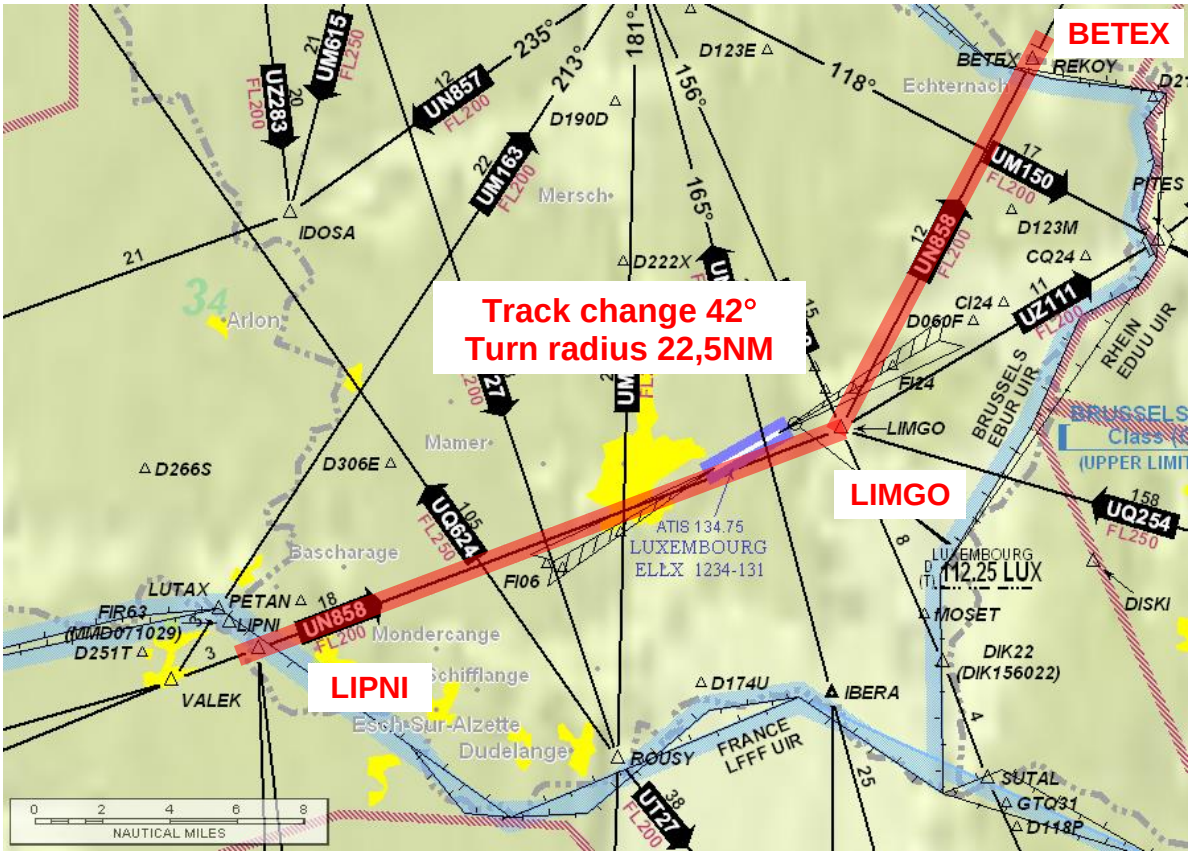

Figure 4: Location of turn waypoint LIMGO along UN858 airway (detail)

4. DATA ANALYSIS

4.1 Turn performance analysis

Aircraft track data of a total number of 1203 flights was recorded during a period of almost 5 months, between 7th February and 30th June 2013. This dataset contained the Lufthansa Airbus A32F and Boeing B737 aircraft which had originally planned their flights from Paris to Frankfurt or from Paris to Berlin via the UN858, passing via LIMGO waypoint. The tracks were converted to a stereographic projection with LIMGO as the center point so that turn angles were plotted realistically.

A first observation made from the plotted data is that a lot of the flights did not proceed via the turn waypoint LIMGO or the next waypoint BETEX, as they were radar vectored by ATC. Those flights were excluded from the dataset. From the remaining data set, which contained all the flights that passed by LIMGO and BETEX, the following 4 groups of flights were distinguished:

- Group 1: containing 144 flights which performed a correct FRT from the start until the end point of the turn (out of a total of 212 flights which started the FRT correctly)
- Group 2: containing 191 flights which went direct to LIMGO and did not perform an FRT
- Group 3: containing 15 flights which went direct to LIMGO and still performed an FRT
- Group 4: containing 64 flights which were on the planned route to LIMGO but did not perform an FRT

Figure 5 presents an overview of the 144 flights that flew the FRT correctly from the start to the end point. The blue circle segment in the figure represents FRT and it can be seen that although a lot of tactical interventions occurred before LIPNI and after BETEX, all the 144 flights tracked the FRT very well. On the right hand side of the figure, the arrivals into Frankfurt can be observed, as well as the flights that continue to Berlin.

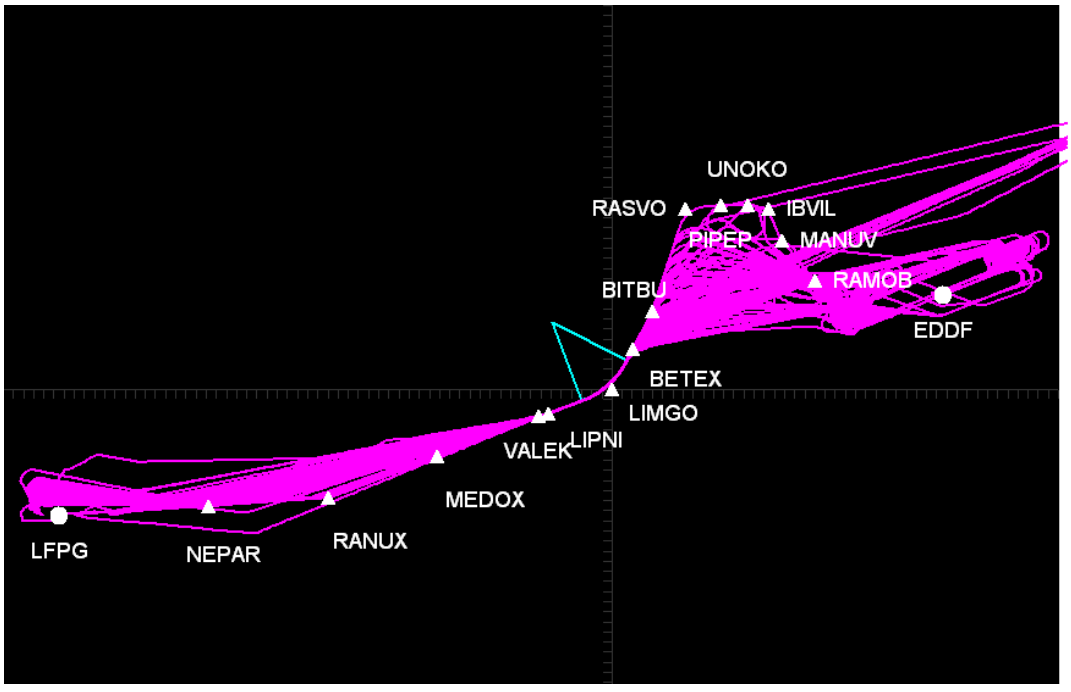

Figure 5: Track data of 144 flights performing an FRT at LIMGO

Figure 6 provides a detailed view of the tracks between LIPNI and BETEX for the 4 groups of flights as defined above. Track data of respectively Group 1, 2, 3 and 4 is indicated from left to right and from top to bottom.

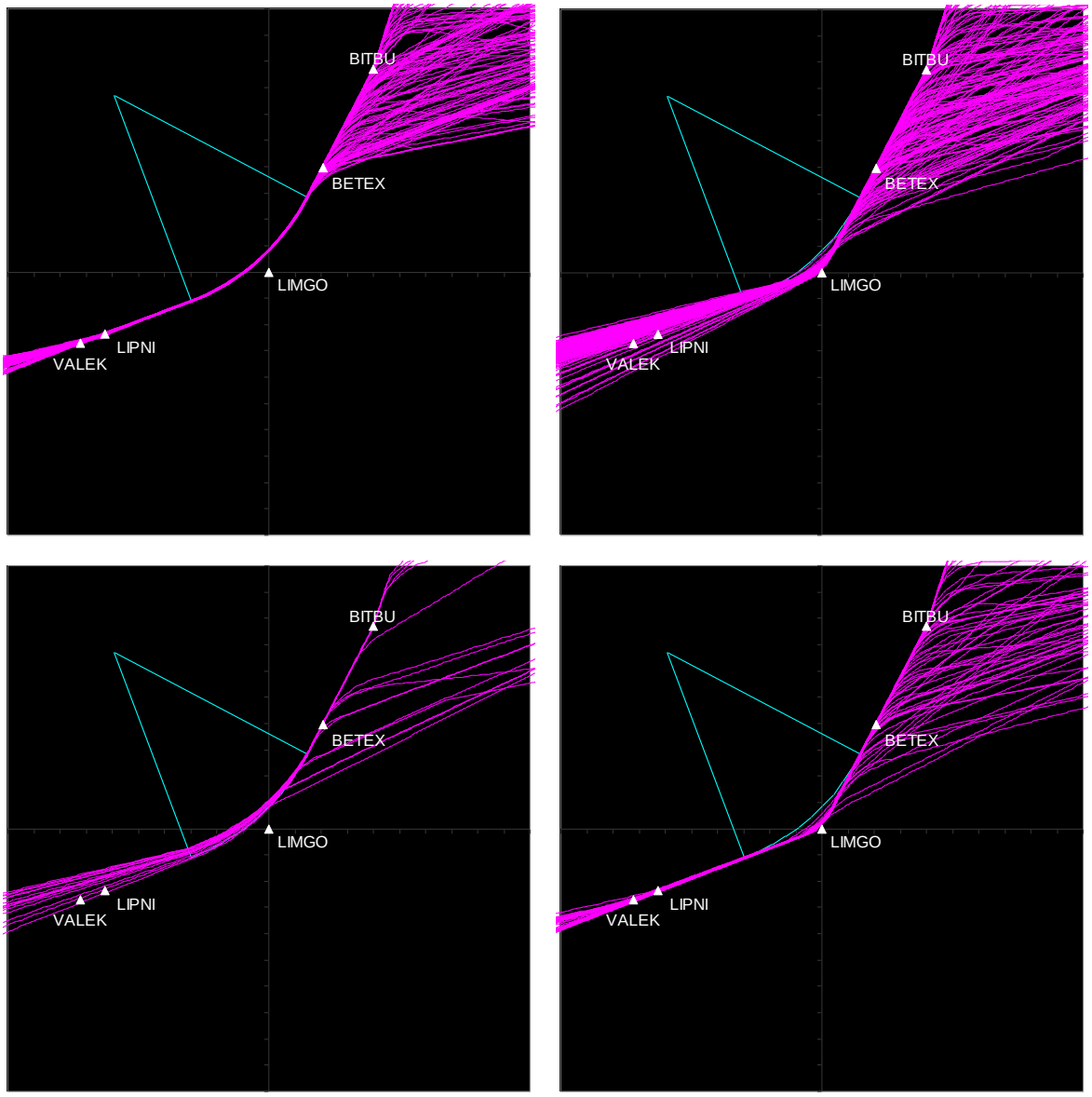

Figure 6: From left to right and top to bottom, track data of Group 1 (144 flights that performed an FRT), Group 2 (191 flights that went direct to LIMGO and did not perform an FRT), Group 3 (15 flights that went direct to LIMGO and still performed an FRT) and Group 4 (64 flights that flew planned route after LIPNI but did not perform an FRT)

A first observation is obviously that the trajectories of the flights that performed an FRT are much more consistent in the turn than the trajectories of the other flights. The flights that did not perform an FRT abeam LIMGO performed a fly-by transition, resulting in non-repeatable paths due to mainly differences in ground speed. Note that, as the flights were operated using A32F and B737 aircraft equipped with a Thales-GE or GE navigation system and most of the flights were operated at FL230 between Paris and Frankfurt, variations in bank angles applied during the fly-by transitions were most probably limited. It can be expected that if data from a broader range of aircraft types were collected, the spread of tracks resulting from the fly-by transitions would even be greater.

A second observation is that in most cases, when the aircraft was cleared direct to LIMGO, it did not perform an FRT but a fly-by transition instead as indicated by the trajectories of Group 2. Still, Group 3 displayed in the bottom-left graph, presents 15 flights that flew direct to LIMGO and performed an FRT with a 22.5NM radius. Note that in this group, the aircraft flew a more easterly course to LIMGO than the original course in the flight plan, which as a result increased the track angle change of the turn and therefore shifted the turn initiation point upstream. This is why the turn paths are initially not aligned but converge towards the end of the turns when the aircraft is back on course to BETEX. An interesting observation is that those tracks are all located on the inside of the defined turn path, which means that no aircraft in this group would have infringed any potentially protected airspace on the outside of the turn or would have caused a reduction in spacing with another aircraft flying along a parallel route.

Further analysis showed that the 15 aircraft in Group 3, which retained the FRT when flying direct to LIMGO, were all Boeing B737 types. However the aircraft in Group 2, aircraft that performed a fly-by transition when flying direct to LIMGO, were both Airbus A32F and Boeing B737 types. The fact that this group also contained B737 types caused a discrepancy with the earlier observations from the B737 flight tracks in Group 3. This required further investigation.

Furthermore, Group 4 presented aircraft that appeared to be well on the flight plan route from LIPNI to LIMGO but did not perform an FRT, which caused another discrepancy. Therefore, in order to fully explain the observations presented above, a number of flight simulations were undertaken which will be further discussed in paragraph 5. In addition, ATC voice recordings were analysed for a few specific flights, in order to better understand the operating conditions that most likely affected the turn performance. This is explained further in paragraph 6.

4.2 Lateral deviation during turn

For the 144 flights that performed the FRT correctly, the lateral deviations from the route centreline between LIPNI and BETEX, including the turn path abeam LIMGO, were calculated and plotted in Figure 7 in function of the along track position. Waypoint LIPNI as well as the start and end points of the FRT, the position abeam turn waypoint LIMGO and waypoint BETEX are indicated. Below these points, the along track distance starting from LIPNI is indicated. It can be seen that the lateral deviations were very small and well below 0.15NM. At the start of the turn, deviations were slightly to the right of the turn, meaning that the aircraft initially did a very slight overshoot of the turn. Towards the end, deviations were slightly left of track so on the inner side of the turn. After the end point of the turn, many aircraft received direct routings, which can be observed in Figure 7 by the increasing lateral deviations.

Figure 8 displays the distribution of the lateral deviations between the start and the end point of the turn. The distribution is based on a sample 4382 measurement points, from the 144 flights that performed the FRT correctly. The distribution is nearly Gaussian, with a mean value of 0.006NM and a standard deviation of 0.026NM. 95% of the positions were within 2*0.026 = 0.052NM (96 metres) from the route centreline and 99.7% of the points were within 3*0.026 = 0.078NM (144 metres) from the route centreline in the turn. As a result it can be concluded that the tracking of the FRT by the aircraft, as well as lateral position determination by the navigation system, was extremely accurate.

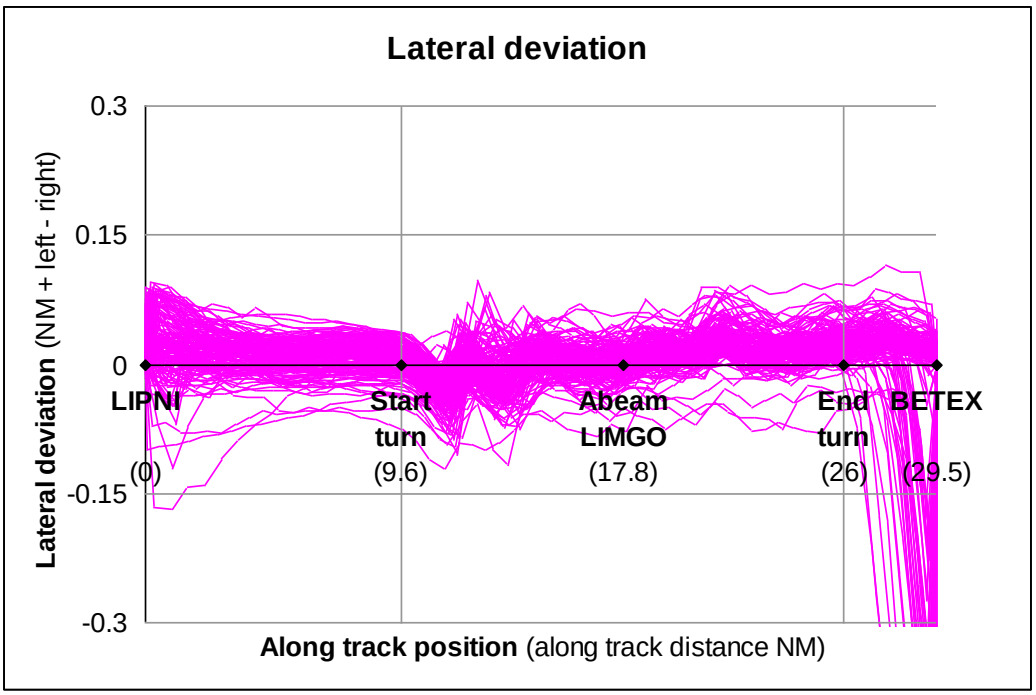

Figure 7: Lateral deviation versus along track position and along track distance for flights in Group 1 (144 flights that performed an FRT)

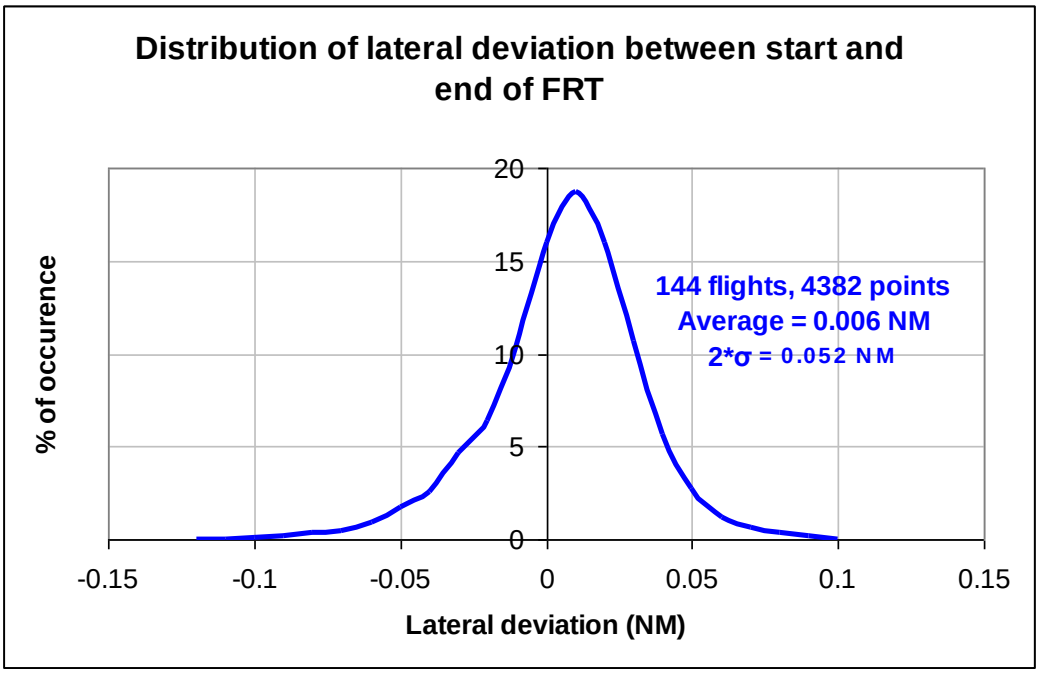

Figure 8: Distribution of lateral deviations for flights in Group 1 (144 flights that performed an FRT)

5. FLIGHT SIMULATION

5.1 Impact of "direct" to FRT waypoint (Airbus)

To get a better understanding of the behaviour of the FRT function in case of tactical interventions by ATC and to get a better understanding of the observations made in the turn performance analysis described in paragraph 4.1, a series of simulations were undertaken.

Figure 9 presents 4 pictures taken during a simulation on an Airbus A320 flight simulator of Lufthansa Flight Training in which the database containing the FRT at LIMGO waypoint was loaded. On the left side, the Navigation Display is presented, while on the right side the MCDU is presented. The two pictures on top represent the situation in which the aircraft was kept on the flight plan route with the FRT at LIMGO in the flight plan. Note that on the MCDU, before and after LIMGO, the airway identifier UN858 is indicated, which indicates to the crew that the aircraft is on the UN858 to LIMGO and thereafter will continue the UN858 to BETEX. Besides the airway identifier, there is no specific indication that the aircraft will fly an FRT at LIMGO. Therefore, a special route designator could be used to indicate that this airway contains Fixed Radius Transitions, provided that this is defined in Appendix 1 to ICAO Annex 11, "Principles governing the identification of navigation specifications and the identification of ATS routes other than standard departure and arrival routes", stipulating how ATS routes are to be designated. Note that according to Arinc Specification 424, "Navigation System Database", en route airway identifiers are limited to a maximum length of 5 characters in the navigation database.

The two pictures on the bottom of Figure 9 represent a second simulation during which the aircraft was send direct to LIMGO, while still on the same inbound course as defined by the airway. As a result, the airway identifier UN858 inbound LIMGO disappeared from the MCDU menu and the FRT was replaced with a fly-by transition which is indicated by the green line on the Navigation Display. The secondary flight plan contained a copy of the active flight plan before the direct was inserted and therefore still contained the FRT at LIMGO, which is displayed by the white line on the Navigation Display. Re-inserting the FRT at LIMGO would have been possible by activating the secondary flight plan or by performing a lateral revision at a waypoint before LIMGO and re-inserting the airway identifier UN858 to LIMGO in the active flight plan.

The simulation indicated that with the current implementation of FRT in an Airbus aircraft, a direct-to operation to a waypoint containing the FRT cancels the FRT and replaces the FRT with a fly-by transition.

Figure 9: Navigation Display and MCDU of an Airbus A320 showing an FRT (top) and a fly-by transition (bottom)

5.2 Impact of "direct" to FRT waypoint and to next waypoint (Boeing)

Another simulation was performed using a certified GE Boeing 737 Flight Management Workstation coupled to a PC. The GE FMS contained software version U10.7 and was loaded with a test-database containing an FRT at a waypoint called LTJ.

The two pictures on top of Figure 10 provide an overview of the Navigation Displays and MCDUs during a first simulation in which the aircraft was originally on the airway to LTJ but was then radar vectored and sent direct to LTJ. The two pictures of the Navigation Display, before and after the direct, are superimposed to illustrate the difference in tracks. Note that just before the direct, the aircraft was vectored in order to put it at an initial position exactly abeam the initial position of the aircraft in the first screenshot. The MCDU before the direct-to operation indicated an airway identifier inbound LTJ and another one from LTJ to the next waypoint. In the MCDU screenshot taken after the direct-to operation, the airway identifier inbound LTJ is replaced by the indication "DIRECT". However, this did not result in the loss of the FRT. As the initial position of the aircraft was slightly displaced, the inbound course to LTJ was slightly different and therefore the turn centre of the FRT was displaced as well. But in both cases, before and after the direct, the aircraft flew an FRT with a 22.5NM radius. This is exactly the behaviour observed in Group 3 of the collected data and as displayed in the lower left corner of Figure 6.

The two lower pictures in Figure 10 provide an overview of the result of a second simulation in which the aircraft, originally following the airway to LTJ, was cleared direct to LTJ and then cleared direct to a waypoint after LTJ. As a result, the airway identifiers before and after LTJ in the MCDU were replaced by "DIRECT" indications. In this simulation, the FRT was deleted from the flight plan and replaced with a fly-by transition. This explains why Boeing B737 aircraft were also present in Group 2 of the collected data presented in paragraph 4.1 and indicated in the top right corner of Figure 6, which contains aircraft that performed a fly-by transition after flying direct to LIMGO.

As a result, the simulations indicated that inserting a "direct-to" the FRT waypoint does not normally delete the FRT in the current implementation in a Boeing B737 aircraft. Inserting a direct to the FRT waypoint followed by a direct from the FRT waypoint to a next waypoint deletes the FRT and replaces it with a fly-by transition.

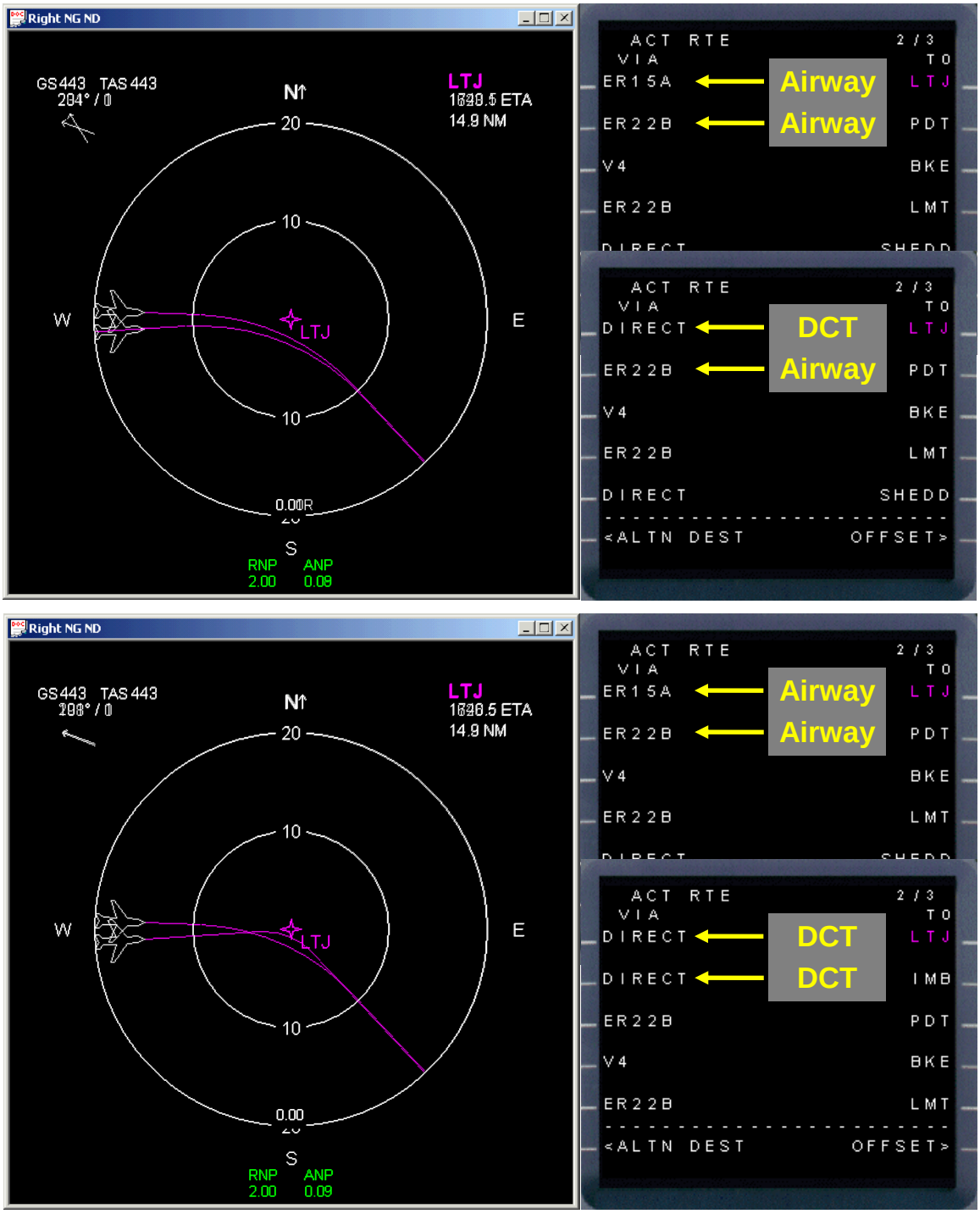

Figure 10: Navigation Display and MCDU of Boeing B737 showing an FRT (top) and a fly-by transition (bottom)

5.3 Impact of "direct" to waypoint before or after FRT waypoint

An additional simulation was performed using both the Airbus A320 and Boeing B737 simulators. In this simulation, a direct was performed to the waypoint previous to the FRT waypoint. This did not cause the FRT to be replaced by a fly-by transition except under one condition. If the direct to the previous waypoint created a fly-by transition at the previous waypoint which provided insufficient remaining distance to the next waypoint to construct the FRT, then the FRT was deleted. In other words when the end point of the fly-by transition at the previous waypoint falls beyond the required start point of the FRT at the next waypoint, then the FRT is replaced with a fly-by transition.

Figure 11: Navigation Display of an Airbus A320 (top) and Boeing B737 (bottom) whereby the FRT (left) is replaced by a fly-by (right) due to flying direct to the previous waypoint and due to insufficient distance between the two waypoints

Figure 12 provides an example of a similar situation in the collected flight data, described in paragraph 4.1, where this might have been an issue. In this example, a short-cut was created in the flight plan from BETEX to RAMOB, by-passing all the waypoints in between those two points. The remaining distance between the required end point of the FRT at LIMGO and the next waypoint BETEX was only 3.5NM. The creation of a fly-by transition at BETEX with a turn initiation distance greater than 3.5NM might have been the reason why a fly-by transition at LIMGO was flown instead of an FRT.

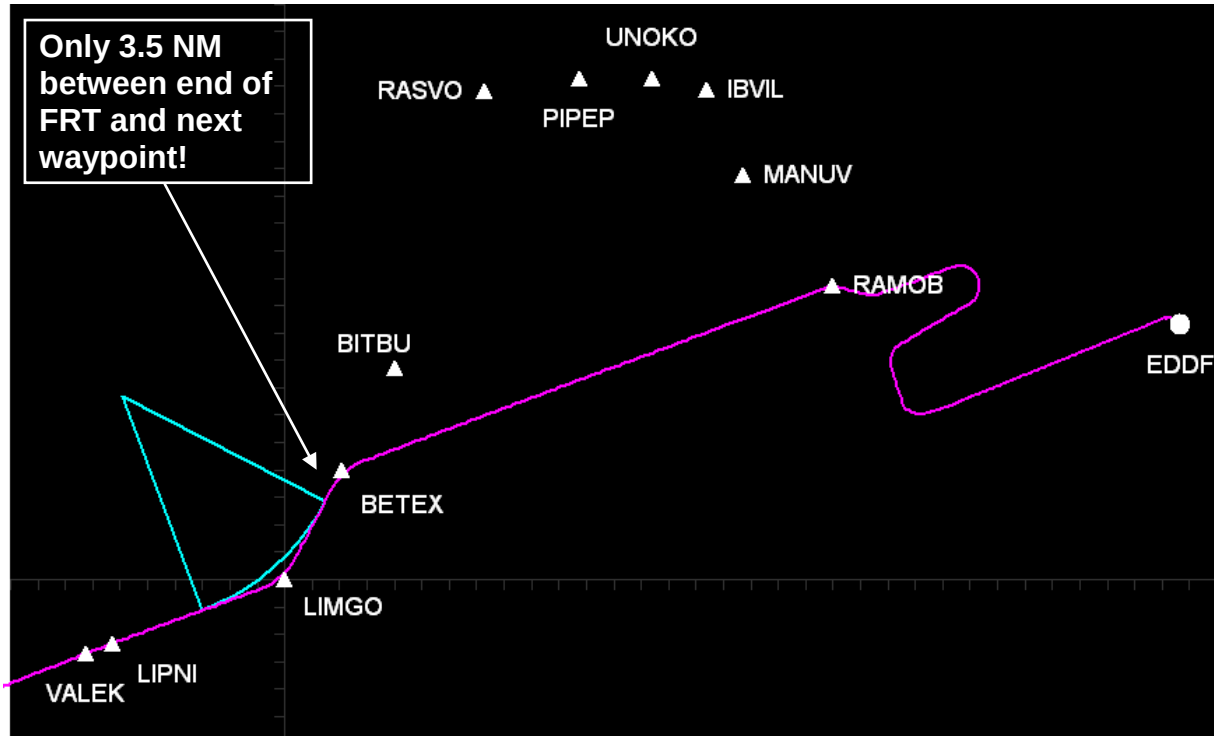

Figure 12: Track data of one flight, flying direct from BETEX to RAMOB and performing a fly-by transition at LIMGO instead of an FRT

6. ANALYSIS OF ATC VOICE RECORDINGS

The analysis of the collected data described in paragraph 4.1 identified a group of flights (Group 4) that appeared to be on the airway centreline before the FRT waypoint, but did not perform an FRT. For a selection of flights of this group, ATC voice recordings were analysed by Belgocontrol. It was found that an instruction “Proceed LIMGO then BITBU” was very commonly issued after first contact with the air crew and entry into Belgian airspace, even if the aircraft was following its flight planned route.

The simulations discussed in paragraph 5.1 and 5.2 have indicated that in this situation, when such an instruction is implemented in the FMS flight plan by creating a direct route to the FRT waypoint and thereafter a direct route to another waypoint, the FRT is replaced in the FMS with a fly-by transition. This explains why the flights in Group 4 of the collected flight data did not perform an FRT.

Figure 13, provided by Belgocontrol, illustrates the track of one of those flights. The aircraft call sign in white indicates the position of the aircraft at the moment when it became under Belgian radar control and when the instruction “Proceed LIMGO then BITBU” was given.

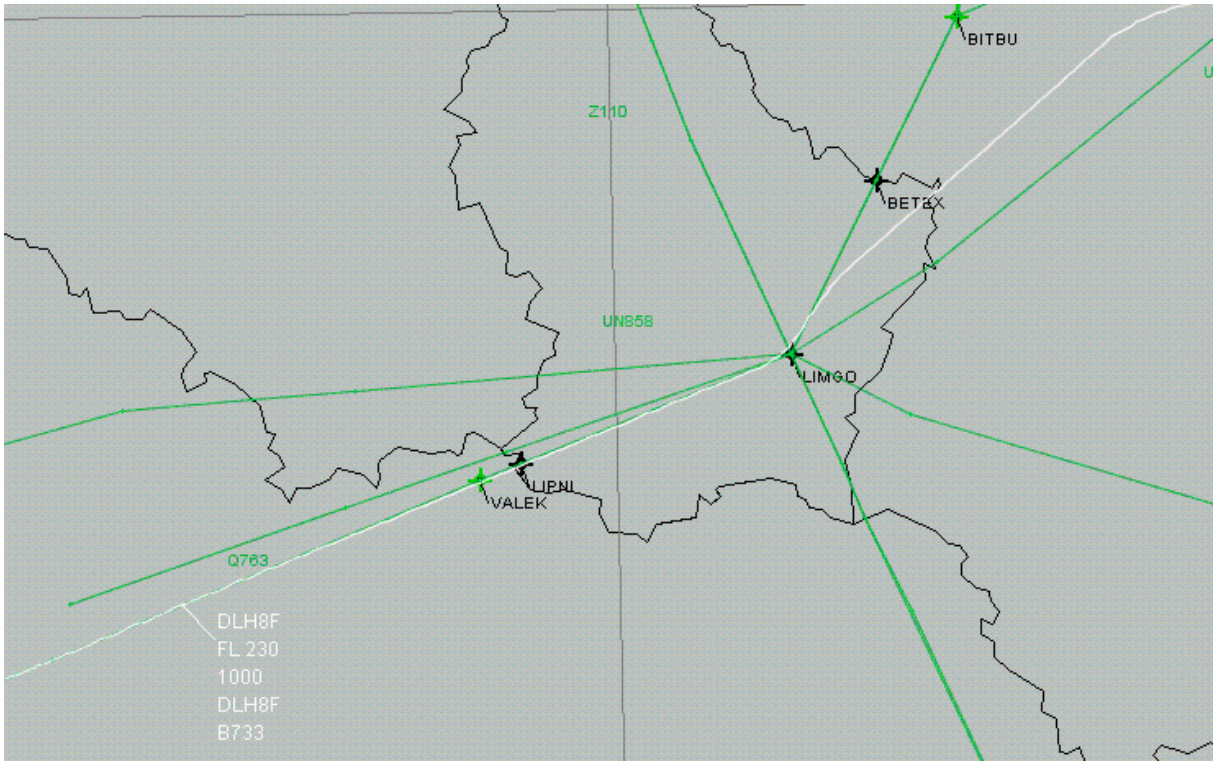

Figure 13: Indication of aircraft position when receiving ATC instruction “proceed LIMGO, then BITBU” (source: Belgocontrol)

7. CONCLUSIONS AND RECOMMENDATIONS

Track data was collected for a total of 1203 flights with a flight plan route via airway UN858 along which an FRT was coded at waypoint LIMGO. A majority of flights were still radar vectored and therefore did not fly the planned route over LIMGO. Those were excluded from the sample. Out of the remaining sample, the following results were obtained:

- 212 flights started the FRT correctly of which 144 flights completed the FRT correctly
- 191 flights went direct to LIMGO and did not perform an FRT
- 15 flights went direct to LIMGO and still performed an FRT
- 64 flights were on the planned route to LIMGO but did not perform an FRT

Lateral deviations between the start and the end of the turn for the 144 flights that performed a complete FRT were extremely low, with an average lateral deviation of 0.006NM and a 95% (2σ) tolerance interval of +/- 0.052NM.

The recorded data and additional subsequent flight simulations showed that tactical interventions, as well as common ATC instructions causing modifications by the pilot to the FMS flight plan, can lead to the cancellation of the FRT and its replacement in the FMS by a traditional fly-by transition. More in particular, it was found that the FRT is not flown in the following cases:

- ATC tactical interventions (radar vectors)
- Aircraft cleared direct to the FRT point and clearance inserted by the pilot in the FMS flight plan for Airbus (even if not deviating from the original plan)
- Typical ATC instruction “Proceed <FRT point> thereafter <next point>” when inserted by the pilot in the FMS flight plan for Airbus and Boeing (even if not deviating from the original plan)
- Changes in the FMS (i.e. directs) to other points that violate the required turn geometry (start and end points) of the FRT

Analysis of ATC voice recordings performed by Belgocontrol indicated that the instruction “Proceed <FRT point> thereafter <next point>” was issued frequently during the period of the data collection. This is the main reason why many of the tracks in the collected data appear to be perfectly on the airway centreline, but do not perform an FRT at the identified turn point, as the FRT is replaced with a fly-by after the pilot has inserted two subsequent direct routings in the FMS flight plan.

There is no specific indicator on the flight deck to enable the pilot to make a distinction between an FRT and a fly-by transition. As an FRT is always coded at a point being part of an airway, the airway identifier is the only way to make the pilot aware that this airway requires an FRT at one or more of its waypoints. It is therefore recommended that Appendix 1 to ICAO Annex 11 “Principles governing the identification of navigation specifications and the identification of ATS routes other than standard departure and arrival routes” defines a special designator that identifies routes containing one or more FRTs. Note that ARINC Specification 424-19, Section 5, “Navigation Data – Field Definitions”, paragraph 5.8, “Route Identifier (ROUTE IDENT)”, prescribes a length of maximum 5 characters for en route airway identifiers.

The FRT data collection and analysis indicated that the tracking of the FRT in modern aircraft is impressively accurate. Route design aspects as well as pilot and controller awareness and procedures would have to be taken into consideration for the handling of the FRT functionality, taking into account its sensitivity to tactical interventions, if FRT were to be used today in an existing operational environment.