aibn Accident Investigation Board Norway

Issued December 2014

REPORT SL 2014/13

REPORT ON SERIOUS AVIATION INCIDENT SOUTH OF SANDEFJORD AIRPORT TORP (ENTO) 22 MAY 2014, AIRPROX BETWEEN SOCATA TBM850 (N97RN) AND DIAMOND DA 42 NG (LN-FTL)

Accident Investigation Board Norway • P.O. Box 213, N-2001 Lillestrøm, Norway • Phone: + 47 63 89 63 00 • Fax: + 47 63 89 63 01
www.aibn.no • post@aibn.no

This report has been translated into English and published by the AIBN to facilitate access by international readers.
As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photos: AIBN and Trond Isaksen/OSL

REPORT

Accident Investigation Board Norway
Postboks 213
2001 Lillestrøm
Norway
Phone: + 47 63 89 63 00
Fax: + 47 63 89 63 01
http://www.aibn.no
E-mail: post@aibn.no

Date: 17.12.2014
SL Report: 2014/13

This report has been translated into English and published by the AIBN to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.
This investigation is limited in its extent. For this reason, the AIBN has chosen to use a simplified report format. The report format indicated in the ICAO Annex 13 is only used when the scope of the investigation makes it necessary.

All times given in this report are local time (UTC + 2 hours), unless otherwise stated.

Aircraft information:		
- Type and reg.:	Socata TBM850, N97RN	Diamond DA 42 NG, LN-FTL
- Operator:	Anodyne Air Ltd. (Great Britain)	Pilot Flyskole AS (Pilot Flight School, Norway)
Type of flight:	Private	Commercial, Pilot training
Flight plan:	IFR	IFR
No. of persons onboard:	2 (Commander and one passenger)	3 (Commander/Instructor and two students)
Date and time:	Thursday 22 May 2014 at time 1620	
Location:	South of Sandefjord Airport Torp (ENTO) at 5 000 ft	
ATS airspace:	Farris TMA, class C controlled airspace	
Type of occurrence:	Serious aviation incident, airprox	
Weather conditions:	METAR ENTO at time 1620: 18014KT CAVOK 21/13 Q1011 Onboard wind reading at 5 000 ft: 180 degrees 35 kt	
Light conditions:	Daylight	
Flight conditions:	VMC	
Injuries to persons:	None	
Damage to aircraft:	None	
N97RN Commander:		
- Age:	49 years	
- Licence:	PPL (A) IR	
- Flying experience:	Total flying time approx. 1,600 hours, of which approx. 600 hours in this aircraft type	
LN-FTL Commander/Instructor:		
- Age:	28 years	

- Licence:	CPL (A)
- Flying experience:	Total flying time 1,550 hours. 142 hours last 90 days, of which 28 hours in this aircraft type
Student in left seat; LN-FTL:	
- Age:	23 years
- Licence:	None
- Flying experience:	Total flying time 180 hours. 30 hours last 90 days, of which 1 hour in this aircraft type
Information sources:	"NF-2007 Accident/Incident/Occurrence reporting in civil aviation" from Commander LN-FTL and Avinor, report from Commander N97RN, and AIBN's own investigations

1. FACTUAL INFORMATION

1.1 Background Information

1.1.1 N97RN

The Commander flew N97RN from Liverpool John Lennon Airport (EGGP) the day before, and arrived at Sandefjord Airport Torp in the afternoon. The purpose of the flight was a business trip, with planned return flight the following day. The Commander had not flown to Norway before, but had flown regularly around Europe in recent years.

1.1.2 LN-FTL

LN-FTL was used as a pilot training aircraft at the Pilot Flight School, which is based at Sandefjord Airport Torp. Onboard the aircraft were the Commander, who was the instructor, seated in the right seat; and two students. The students took turns piloting, and the one not piloting sat in the back seat observing. The two students had both come quite far in their "multi engine" training program. The day's program consisted of four training flights, of which the flight in question was the third.

1.2 Sequence of Events

LN-FTL was on its way back to Torp after training instrument approaches at Skien Airport Geiteryggen (ENSN). They had checked in at Farris Approach (APP). On their way to Torp the crew received clearance for the approach procedure VOR RWY 18 and were informed that they should maintain 5 000 ft. The altitude restriction was given because the entry procedure to this specific VOR approach, when arriving from the west, includes the waiting pattern south of Torp, while the southbound Standard Instrument Departure (SID) procedure goes up to 4 000 ft.

As LN-FTL was on its way to Torp, the Commander of N97RN prepared for departure. He received and read back clearances from Torp GND (at time 1608) and Torp TWR (at 1617), respectively:

Torp GND: *N97RN Torp GND You are cleared to Liverpool via LUTOT 1 G departure squawk 6212*

Torp TWR: *N97RN wind 180 degrees 14 knots RWY 18 cleared for takeoff, so-long*

N97RN took off at time 1618 and climbed due south. At this time, LN-FTL had passed over Torp VOR (TOR) and was also flying due south, approximately 1 NM east of the departure path that N97RN was following. LN-FTL remained at cleared altitude, 5 000 ft, the whole time.

The Farris APP air traffic controller has explained that he followed the two flights on his radar screen to make certain the required separation between them was maintained[1]. He noticed that N97RN was not climbing as quickly as he expected based on the speed registered in the flight plan (295 kt). It was maintaining a ground speed of 100-110 kt, and the Farris APP controller anticipated that he would probably have to hold N97RN at 4 000 ft until it had reached further south than LN-FTL. The Farris APP controller therefore called up Torp TWR at time 1619 and asked them to give the next departure an altitude restriction of 3 000 ft.

The Farris APP controller waited for N97RN to check in on his frequency, but this did not happen. Approximately at time 1620, when LN-FTL commenced its turn back to TOR VOR, the controller observed that N97RN climbed above the altitude restriction of 4 000 ft. He called up N97RN, but received no answer. The Commander of N97RN had not changed radio frequency from Torp TWR to Farris APP, and therefore did not hear the call. During three subsequent radar data updates, the controller saw altitude indications of 4,100 ft, 4,200 ft and 4 500 ft respectively. He called up LN-FTL and gave the crew essential traffic information (at time 16:20:15):

> *Lima Tango Lima essential traffic at your one o'clock passing through your altitude shortly, is 4 500 ft*

The Commander of LN-FTL immediately responded to the call and reported that they had seen the other aircraft. LN-FTL had been warned of conflicting traffic by the aircraft's Traffic Advisory System (TAS), and had already initiated an evasive manoeuvre. The Farris APP controller once again called up N97RN, without getting an answer.

The Farris APP controller phoned the tower controller at Torp (at time 16:20:39) and reported that N97RN had not checked in on the Farris APP frequency. Next he called up LN-FTL and requested confirmation that they were clear of other traffic. The Commander of LN-FTL gave an affirmative answer and added that they had caught sight of it just in time. At the same time the tower controller called up N97RN on the tower frequency. The Commander of N97RN answered back:

> *We are turning direct LUTOT N97RN*

The tower controller informed him that they should have contacted Farris APP. He went on to say that they had violated the SID altitude restriction of 4 000 ft, and that they had been involved in an airprox with another aircraft at 5 000 ft. The N97RN Commander apologized and added:

> *[…] didn't get that instruction N97RN*

The radar playback showed that the minimum distance between the aircraft, immediately before they passed each other, was approximately 400 ft vertically and 0.2 NM (370 m) horizontally (see figure 1). The playback also showed that the trainer aircraft climbed from 5 000 ft to 5 250 ft in few seconds, simultaneously increasing its turn rate. N97RN made a minor heading adjustment before the airprox, and continued to climb while maintaining a steady ground speed of 100-110 kt.

N97RN was at 6,700 ft, at a net distance of approx. 6 NM from Torp VOR (TOR), when the Commander contacted Farris APP for the first time:

> *Farris approach, N97RN, we are direct LUTOT, apologies I understand my error at this point.*

[1] Vertical separation between LN-FTL and N97RN was maintained as long as N97RN did not climb higher than 4 000 ft (the altitude restriction given in SID LUTOT 1G), and LN-FTL complied with the altitude restriction of 5 000 ft, which they had been given. See chapter 1.4.

Both LN-FTL and N97RN conducted the rest of their flights as planned, landing at Torp and Liverpool, respectively.

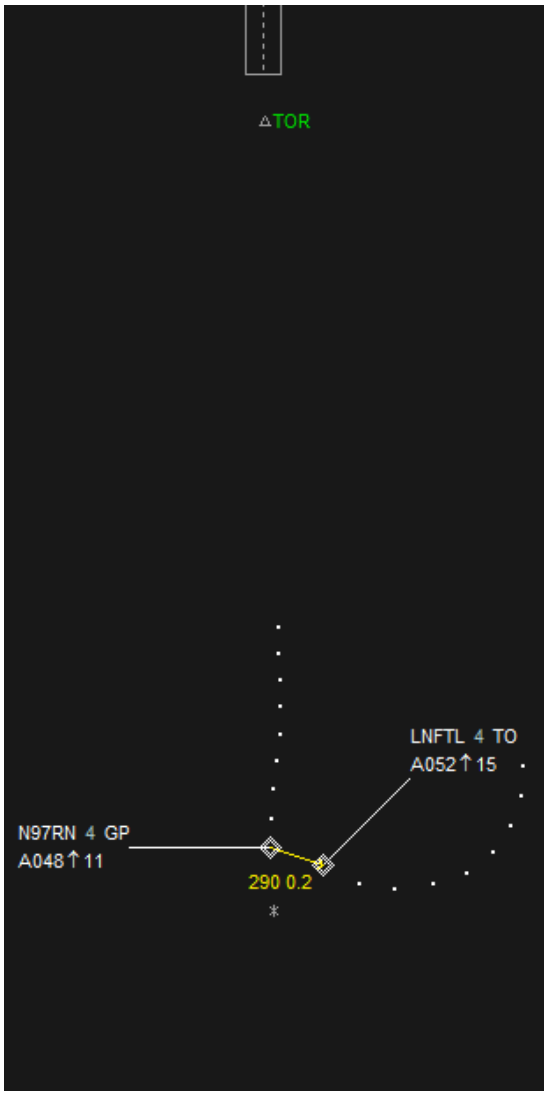

Figure 1: At time 16:20:34. Radar playback from Mode-C information with accuracy of up to 100 ft, shows that N97RN was at 4,800 ft, climbing, southbound with a ground speed of 110 kt. LN-FTL was at 5,200 ft, climbing, northwest bound, with a ground speed of 150 kt. The distance between the two aircraft was approximately 400 ft vertically and 0.2 NM (370 m) horizontally. The image also shows the location of Torp VOR (TOR). Source: AVINOR

1.2.1 Additional Information - LN-FTL

It was the aircraft's Traffic Advisory System (TAS, see figures 4 and 5) which first drew the trainer aircraft crew's attention to the fact that they were in a conflict situation and made them aware of the whereabouts of the other aircraft relative to their own position. The student, who was sitting in the left seat, was piloting the aircraft manually. Both he and the instructor saw and heard the alert that was activated immediately after they had initiated a right turn in towards Torp VOR. The Commander of LN-FTL has stated that everything happened very quickly. On his traffic screen he saw that another aircraft, represented by a yellow circle, was very close to them to their right. At the same time they heard a voice alert, which the Commander afterwards recalled as saying: "*Traffic 12 o'clock, less than one mile, same altitude".* Based on what he observed on the traffic screen, the Commander looked out through his window, down to his right. He then immediately caught sight of the other aircraft, which was climbing straight ahead. At that moment he thought that they were

close to colliding. Both the student and the instructor held their hands on the controls and pulled up steeply while at the same time turning more sharply to the right. The Commander has stated that the evasive manoeuvre was initiated instinctively and very quickly. Immediately after they had initiated the evasive manoeuvre, they heard that Farris APP gave traffic information. They didn't quite catch what was said, but the Commander reported *"Traffic in sight".*

The Commander has stated that he thinks the outcome of the incident might have been a different one if they hadn't carried out the evasive manoeuvre.

When all was clear, they completed the approach procedure as planned. The student continued piloting the aircraft, and they landed 14 minutes later. The flight was debriefed, and after some hours on the ground, the fourth training flight was carried out with the other student at the controls.

1.2.2 Additional Information – Air Traffic Control

1.2.2.1 *Farris APP*

Standard Instrument Departure (SID) LUTOT 1G specifies that the air crew shall contact Farris APP *"when airborne"*(see figures 2 and 3). The Farris APP air traffic controller stated that there were instances when a flight would not change radio frequency until they levelled out at 4 000 ft at Torp. On the day of the incident he saw that N979RN climbed to 3 000 ft without having changed to his frequency yet. The Farris APP controller called up N97RN, without getting an answer[2]. He didn't recognize the aircraft's call sign, and thought that it might be a pilot who was unfamiliar with the local area. He stated that in such situations, involving a potential conflict with other traffic if the altitude restrictions are violated, he would usually provide extra information, such as e.g. *"maintain 4 000 ft, traffic 1 000 ft above".*

The air traffic controller also stated that he had thought about what he should do if N97RN didn't stop at 4 000 ft, and decided that in such a case, he would turn LN-FTL east to increase the distance to the departing aircraft. When he, after receiving calls from other flights, looked at N97RN once more and observed that the aircraft continued climbing higher than 4 000 ft, he already had the microphone in his hand ready to turn LN-FTL towards the east. He first called up N97RN, without getting an answer. He saw that LN-FTL had started the right turn towards Torp VOR, and that they consequently were headed towards N97RN. He gave traffic information to LN-FTL, and received an immediate response. On his radar screen he could see that the two flights' tracks practically touched, before continuing in different directions. The next time he communicated with LN-FTL, he received confirmation that it had gone well.

The Farris APP controller informed the supervisor at the Air Traffic Control Center about the incident. He was replaced in his position a few minutes later, and offered colleague support. The Norway Control supervisor alerted AIBN about the incident the same evening.

The Farris APP controller has stated that after this incident he is going to call tower control on the phone to have them pass on to him any flights that haven't checked in by the time they are 1 000 ft from the altitude restriction, if a possible violation of the altitude restriction threatens to lead to conflict with another aircraft.

[2] Noise in the radio communication playback didn't give a clear answer to whether there had been any calls at this time.

1.2.2.2 *Tower*

The tower controller informed AIBN that he had not noticed anything particular about the departure of N97RN. The Commander sounded secure and professional during radio communication with the tower. In cases when the tower controller had the impression that a pilot was insecure, he tended to add "*after take-off contact Farris"* as a reminder, even though this results in additional radio communication. The tower controller concluded his communication with the words *"so long"*, as an indication that their communication was finished.

When the tower controller saw that N97RN climbed through 4,300 ft, while at the same time LN-FTL was maintaining 5 000 ft in the holding area south of Torp, he tuned in to the Farris APP frequency. Thus he heard the Farris APP controller giving essential traffic information to LN-FTL. When he received a phone call from the Farris APP controller, the two aircraft had passed each other.

All Standard Instrument Departures (SIDs) have altitude restrictions, and at Torp they are all set at the same altitude, 4 000 ft. It has happened before that flights have violated this altitude restriction. The tower controller said that he had also experienced flights that climbed to 4 000 ft and then requested further climb on the tower frequency. This means that the pilot has missed out on the fact that they were supposed to switch their frequency to Farris Approach. The tower controller, who had been working at this unit for many years, had, however, never before experienced a combination of both these circumstances: a flight both violating the altitude restriction and failing to change to the required frequency.

1.2.3 Additional Information - N97RN

Following the incident, the N97RN Commander has made several reflections on his perception of what happened and has offered explanations as to how the airprox could happen.

The N97RN Commander has stated that two to three days prior to his departure for Norway he had conducted pre-flight planning, including a run-through of the approach and departure procedures at Torp. On the day of their return flight back to Liverpool, the Commander arrived at Torp together with his passenger two hours before the estimated time of departure. It took him approximately 45 minutes to get through the passport control, security control and to transit to the aircraft. While he waited for the aircraft to be refuelled, he checked the flight plan and possible departure procedures on his iPad. Runway 18 was in use, and since LUTOT was the first waypoint on his flight plan, he assumed that he would be given RNAV SID LUTOT 1G by air traffic control at departure. He has written in his report that his iPad was set in "*screen mode locked*", and that he viewed the departure procedure in "*landscape mode*". He says that he therefore didn't see the entire procedure; only from the top and down to where it says "NOT TO SCALE" on the right side (see figure 3).

It proved that refuelling could not be carried out on apron, and that the Commander therefore had to taxi to the refuelling facility. Playback of the radio communication shows that the Commander contacted Torp GND at time 1534 for taxi clearance to the fuel station. At the same time he asked:

N97RN*:* *Do you have our IFR in for I believe is 1400 local?*
[Torp GND confirmed that they had the flight plan]
N97RN*:* *Sorry, could I get the waypoints of that flight plan real quick [illegible] .....downloading them*
[Torp GND gives the waypoints LUTOT and OSVAL]
N79RN: *I got LUTOT, and second point was what?*

[Torp GND repeats and spells out]
N97RN: *Affirm, copied, thank you for your help, N79RN*

The Commander had to wait for the pump to become available at the refuelling facility, and for his passenger to be brought out to the aircraft. In his statement he writes that he felt frustrated and concerned about the passing of time, and that he thought that he might have to submit a new flight plan. They were ready at time 1608 (8 minutes after the estimated time of departure).

The Commander states that he made a similar scale fault as he had done on his iPad before, when he checked the LUTOT 1G procedure on the Garmin G1000 Multi Function Display (MFD) on board the aircraft. Again he couldn't view the entire procedure on the screen. He has explained that he only viewed the part down to where it says "If unable to comply inform ATC" (see figure 3). He had set the Garmin G1000 in a mode which allowed him to view charts by their independent sections, which he found useful during approaches, but SIDs are thus displayed piecewise.

In his report he goes on to state that he had expected to find altitude/flight level on the LUTOT 1 G chart, and he explained that the reason for this was that many charts do have "target altitude" indications in the profile section. The SID he looked at didn't. In his report he describes that he assumed that he should continue climbing to FL100 (10 000 ft), as indicated in the text *"SPEED: MAX 250 KT BELOW FL100 UNLESS OTHERWISE INSTRUCTED"*. The Commander then goes on to explain:

> *I recognize this altitude is to provide speed limitations but I thought it logical that the flight profile area in this SID was controlled by ATC so nothing would be in my way below FL100. […] I was expecting an onward frequency on departure and believed further clarifications would be forthcoming during line up and departure clearance.*

The Commander states that he had selected Farris APP, 134.05 MHz, as his standby frequency, but that he didn't change frequency after take-off because he wasn't given any further instructions to do so. He had missed out on the fact that in point 3 at the top of the SID procedure it said "*Contact FARRIS Approach when airborne"*(see figure 3).

A while after take-off he viewed in the traffic advisory part of the G1000 display (see figures 4 and 5), that another aircraft was moving towards the west, and that the aircraft's heading would intersect with his departure path. The Commander writes that several thoughts went through his mind at that point. His flight was IFR, and consequently he must follow the procedure. He wondered if the other aircraft was a VFR flight and wondered how it might be that he hadn't been informed about this. He also wondered about why he hadn't heard anything from radar/ATCC, and he considered whether he might not have the right "target altitude".

The N97RN Commander has explained that he monitored the traffic display and expected the other aircraft to change its heading, which it did not. After a while the symbol for the other aircraft turned yellow, and in addition he heard a voice alert. At this time the Commander had visual contact with the other aircraft. He didn't call anyone up on the radio. He says that he adjusted his heading slightly towards the right and seems to remember that he levelled out at approx. 6 000 ft. After the conversation with the tower controller the Commander pulled the SID up again on the Garmin G1000 display, and then became aware that he hadn't seen the entire procedure. He flipped to the bottom part of the procedure and saw that it said: "*Initial climb clearance 4000', expect further climb by FARRIS Approach"*.

1.3 SID LUTOT 1G

The source for approach and departure charts is Aeronautical Information Publication (AIP), and in AIP Norway it is described that the departure procedure LUTOT 1G has an altitude restriction of 4 000 ft. The following description states that radio frequency should be changed to Farris APP 134.050 MHz *"when airborne".* This information is presented somewhat differently to pilots depending on which chart presentation they use. The AIP has the chart on one page, while information on such parameters as altitude restriction and the instruction on how and when to change to the next radio frequency are in a table on the next page (see figure 2).

LUTOT 1G **(LUTOT ONE GOLF DEPARTURE)**	Climb on course 178° to TO909, to LUTOT	Max speed 220 KIAS during first turn. A MNM climb gradient of 6.6% i.e. 401 FT/NM is required until 4000 FT. If unable to comply inform ATC.	4000 FT Expect further climb from Farris APP	When airborne contact Farris APP 134.050 MHZ
Recommended coding:	(LUTO1G): TO909[M178; K220-]-LUTOT			

Figure 2: AIP/Norway AD 2 ENTO 4–4 STANDARD DEPARTURE CHART INSTRUMENT (SID) – LUTOT 1G

Jeppesen charts present this same information on one single page (see figure 3). In point 3, at the top of the Jeppensen chart, it says *"Contact FARRIS approach when airborne*". At the bottom it says *"Initial climb clearance 4000', expect further climb by FARRIS Approach"*.

AIBN has checked SID departure charts from several European airports and has found that information is not always presented in the same manner. Some departure procedures have extra information on the chart page, in addition to what is standard. One instance is SID DESIG 1V from the N97RN Commander's home base at Liverpool EGGP/LPL. This departure procedure has a box drawn in directly under the speed reduction "Speed max 250 kt [...]" In this box it says: *"WARNING Do not climb above 4000' until cleared by ATC".*

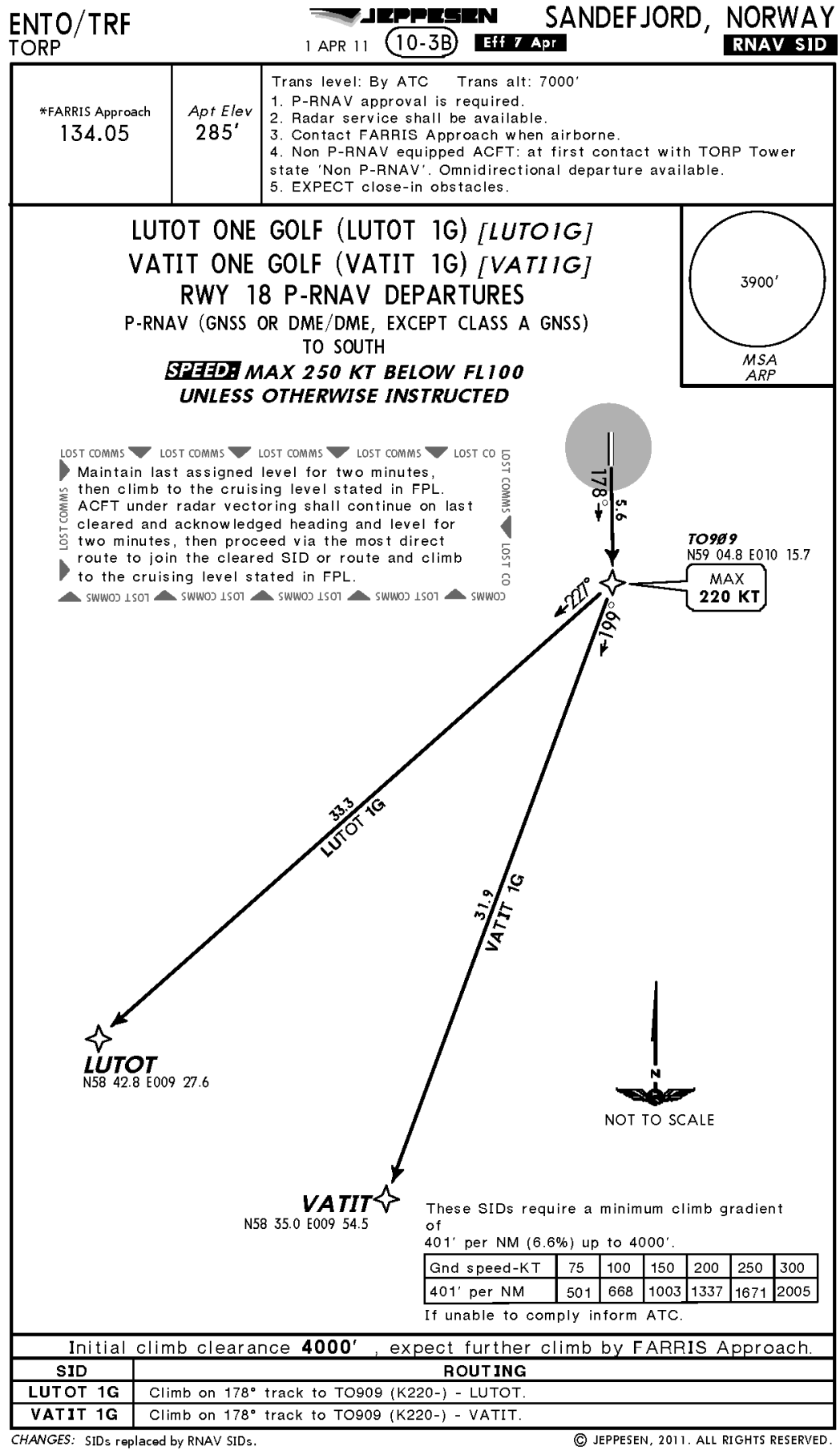

Figure 3: Jeppesen STANDARD DEPARTURE CHART INSTRUMENT (SID) – LUTOT 1G ENTO

1.4 Relevant Provisions on Air Traffic Control

AIP Norway ENR 1.4 describes requirements for separation in ATS Class C airspace as follows:

> *IFR and VFR flights are allowed, all flights are subject to air traffic control. IFR flights are separated from other IFR flights and from VFR flights.[…].*

The minimum distance between two IFR flights in Farris TMA is 5 NM horizontally or 1 000 ft vertically.

1.5 Traffic Advisory System - TAS

Both aircraft had Garmin G1000 Integrated Flight Deck System[3] glass cockpits. Both aircraft also had the additional Traffic Advisory System (TAS) function installed (see figures 4 and 5).

Figure 4: LN-FTL cockpit with Garmin G1000 Integrated Flight Deck System. The image related to the Traffic Advisory System (TAS) is in the lower righ hand corner of the right hand screen (MFD). See close-up image in figure 5. Photo: LN-FTL Commander

[3] G1000 manuals for different aircraft types, including Diamond DA42NG and Socata TBM8, are available on the Garmin web site: https://support.garmin.com/support/manuals/searchManuals.faces

Figure 5: Detail from figure 4 displaying the traffic situation (TAS). The aircraft was not in a conflict situation when this photo was taken. The image shows own aircraft in the middle, and another aircraft climbing 1 000 ft below. If it had been a conflict, the other aircraft would have been represented by a filled yellow circle. Photo: LN-FTL Commander.

The Traffic Advisory System (TAS) establishes an "air-to-air traffic data link" using onboard interrogator-processor and Mode S transponder. TAS has a Traffic Advisory (TA) function, but no Resolution Advisory (RA) function. Thus TAS can help the pilot locate other traffic visually, but does not provide a recommended evasive manoeuvre to solve the conflict, as the more advanced Traffic Alert and Collision Avoidance System (TCAS) can. TAS displays other traffic using TCAS symbology:

- "Non-Threat Traffic", white diamond frame filled with black: represents traffic 1200 ft or more below or above own position or more than 5 NM away. Represents no danger.
- "Proximity Advisory (PA)", filled white diamond: represents traffic within the values given above. Represents no danger.
- "Traffic Advisory (TA)", filled yellow circle: represents traffic in conflict with own aircraft.

Simultaneously with the symbol changing shape and colour to become a filled yellow circle, a TA will also generate a voice alert consisting of the word *"Traffic"* followed by the other aircraft's clock position and relative altitude compared to own position and distance to own aircraft.

Garmin G1000 has recording facilities that store the most recent flight. The chip on which the data is stored, was not taken out after the flight in question, neither for LN-FTL nor N97RN. AIBN therefore has not had access to this information source, which could have provided detailed information about altitude choices, TAS alerts, power settings, control settings, etc.

1.6 STCA

The radar display in use at Norway Control has the alert function Short Term Conflict Alert (STCA), which alerts the air traffic controller if violation of separation minima is about to occur. The STCA alert has two components: Predicted Conflict (PC) and Conflict Alert (CA). Within Farris TMA airspace, STCA PC alert is given 20 seconds before separation minima of 5 NM horizontally or 1 000 ft vertically are violated. STCA CA is activated for all of Farris TMA, but only actuates if at least one of the aircraft in the conflict is above 5 500 ft. This restriction has been set to minimize the number of false alarms. STCA PC did not actuate when the traffic went directly from the filtered area to a conflict situation. STCA CA actuated at time 16:20:59, after the conflict was over, exactly when N97RN passed 5 500 ft.

1.7 Change of Frequency

Most Norwegian controlled aerodromes use approximately the same procedure to transfer communication from Tower to Approach control after takeoff. The procedure calls for the departing aircraft to change from Tower frequency to radar frequency after takeoff. In connection with the present investigation, AIBN has asked pilots and air traffic controllers what the phrase "*Contact Farris approach when airborne"* means to them, and how this is carried out in practice.

The answers give an unclear picture. Some were of the opinion that "*when airborne*" means as soon as the aircraft has been configured for climb, and never later than at 1 500 ft. Others understood it to mean right after takeoff, as soon as it is no longer conceivable to turn back, and that the pilot shall change frequency as soon as he is ready to do so. It was also mentioned that many flights contacted Farris Approach at around 1 000 ft, others at 2 000 – 2 500 ft. And there were occasionally flights that checked in as late as at an altitude of 3 000 – 4 000 ft.

1.8 SID and Level Bust

An SID is defined in ICAO doc 4444, PANS-ATM[4]:

> *Standard Instrument Departure (SID): A designated instrument flight rule (IFR) departure route linking the aerodrome or a specified runway of the aerodrome with a specified significant point, normally on a designated ATS route, at which the en-route phase of flight commences.*

"Amendment No. 5 to ICAO PANS-ATM, doc 4444, point 1.3" says the following about altitude restrictions:

> *Flight crews operating on a SID or STAR which includes level restrictions published in association with specific waypoints, must always comply with the level restrictions as published unless such restrictions are explicitly cancelled by ATC.*

In the European Action Plan for the Prevention of Level Bust, Eurocontrol has given the following description of "level bust":

> *Any unauthorized vertical deviation of more than 300 ft from an ATC flight clearance (200 ft in RSVM airspace). A Level Bust or Altitude Deviation occurs when an aircraft fails to fly at the level to which it has been cleared, regardless of whether actual loss of separation from other aircraft or the ground results.*

[4] PANS-ATM is the acronym for Procedures for Air Navigation Services – Air Traffic Management

In aviation for many years there has been a focus on measures to reduce the number of "level busts". The reason is that this phenomenon can lead to loss of vertical and/or horizontal separation between two aircraft or an aircraft and the terrain, which in turn can lead to a collision if conditions are conducive to it. Under the SKYbrary Level Bust Products menu, there are a number of links to articles, reports, action plans and auxiliary tools related to this issue. The material describes factors contributing to the occurrence of "level bust", and what the different actors can do to prevent this. One of the links under "Solutions": "*The A to E of avoiding level bust for pilots*", i.a. states:

> *B is for Briefing: altitude constraints such as on SIDs and STARS should be thoroughly briefed between crew members. Then you can ensure the correct settings are made on the autoflight system.*
>
> *C is for Clearances: Set the clearance received, not the clearance expected. If in any doubt, confirm with ATC.*

2. COMMENTS FROM THE AIBN

As AIBN sees it, several circumstances indicate that the Commander of N97RN was not well enough prepared for the flight he was about to execute. He was not familiar enough with how his electronic aids functioned, and selected options in such a way that he could see only parts of the procedure. Despite having planned the trip beforehand, as he claims, he missed out on the standard altitude restriction and procedures for frequency change at Torp, and he had to request waypoints for the SID (cf. 1.2.3). If unforeseen practical problems arise before departure, which jeopardize safety-critical preparations, then one has to accept undesirable delays as a consequence.

AIBN finds that the airprox in Farris TMA happened as a consequence of the N97RN Commander not having acquainted himself sufficiently well with the departure procedure he was cleared for, and that en route he did not confer with air traffic control when he could see the other aircraft steadily moving closer to them.

- The incident was initiated by a "level bust", when the Commander of N97RN climbed above the SID altitude restriction of 4 000 ft.
- The incident resulted in "violation of separation minima", because LN-FTL at the same time was up above, at 5 000 ft.
- The severity escalated to airprox, because the aircraft were closing in on each other.
- The risk of a collision was averted because LN-FTL did an evasive manoeuvre.

2.1 Level Bust

Human Factors Analysis and Classification System (HFACS)[5] can be used to classify and assess the background for erroneous human acts. As AIBN sees it; if the N97RN Commander studied the departure procedure twice without making certain that he had taken in such vital information as altitude restriction and change of radio frequency, then this can be characterized as "*unsafe act* -

[5] Human Factors Analysis and Classification System (HFACS): Shappel, S.A. and Wiegmann, D.A. (2000). The Human Factors Analysis and Classification System – HFACS. Final Report. DOT/FAA/AM-00/7 Office of Aviation Medicine, Washington, DC 20591.

skill based error"[6]. Because he did not make certain that he had obtained all available information concerning the procedure, he had actually - without being aware of it – missed out on crucial information necessary to act correctly. If the 4 000 ft altitude restriction had been set correctly in the G1000 system, the alert from the system could have prevented level bust from happening as a result of inattention on the part of the Commander. All departure procedures for Sandefjord Airport Torp have an altitude restriction of 4 000 ft, a fact that was stated in the standard location in both the AIP and Jeppesen chart representations. AIBN cannot see that the chart representation for SID LUTOT 1G is such that it needs to be altered.

Based on the stated level of experience, AIBN considers it likely that the Commander was well acquainted with SID procedures, and that he knew that altitude restrictions are commonly found in SIDs. One of several reasons why standardized departure procedures were introduced, was to reduce radio communication. Consequently an IFR pilot cannot expect a tower controller to convey essential information which is written in the procedure, such as altitude restriction and change of frequency. AIBN, like the tower controller, perceives the Commander as secure and experienced in his radio communication, and consequently finds it understandable that he was not given additional information about change of frequency.

The N97RN Commander has conveyed that he became frustrated and concerned when refuelling took much more time than he had made provisions for. As AIBN sees it, playback of the Commander's communication with the Torp Ground controller substantiates that he was stressed. AIBN considers it likely that his increasing frustration and stress may have been detrimental to his work performance and contributed to him missing out on essential information from the departure procedure. In an HFACS analysis, AIBN would place this background under "*Preconditions for unsafe acts - Adverse Mental States"*[7].

2.2 Violation of Separation Minima

The Commander of N97RN writes that several thoughts went through his mind when, not long after takeoff - while climbing out, he could see on the traffic advisory part of his G1000 display (see figures 4 and 5) another aircraft moving westerly, and that this aircraft's course would cross his departure path. The fact that he sees the other aircraft, has thoughts and makes assumptions, but does not take any active steps to clarify and secure safe distance, AIBN views as an "*unsafe act - decision error"*[8], cf. HFACS.

AIBN is of the view that the N97RN Commander could have contributed to preventing the incident from developing into an airprox if he had called up ATC to inquire about the other aircraft. He could also have reduced his rate of climb, levelled out, or adjusted his heading.

[6] HFACS level 1: Unsafe Acts- Errors-Skill-based errors: *"Errors which occur in the operator's execution of a routine, highly practiced task relating to procedure, training of proficiency and result in an unsafe situation (e.g. fail to prioritize attention. Checklist error, negative habit)*".

[7] HFACS level 2: Preconditions for unsafe acts - Condition of Operators - Adverse Mental State: *"Refers to factors that include those mental conditions that affect performance (e.g. stress, mental fatigue, motivation)"*

[8] HFACS level 1: Unsafe Acts - Errors - Decision errors: "*Errors which occur when the behaviors or actions of the operators proceed as intended yet the chosen plan proves inadequate to achieve the desired end-state and result in an unsafe situation (e.g. exceeded ability, rule-based error, inappropriate procedure)"*.

2.2.1 Airprox, Evasive Manoeuvres and Safety Barriers when Clearance is Violated

The N97RN Commander hadn't read that he should contact Farris Approach *"when airborne*". Established safety barriers were taken to the test when he, on top of that, violated the altitude restriction.

The investigation of this incident showed that in actual practice flights changed their radio frequency from Tower frequency to Approach frequency at very different altitudes (cf. chapter 1.7). Consequently the air traffic controller could not know what was the latest point at which he could expect the flight to check in on his frequency. In controlled airspace, Air Traffic Control shall see to it that IFR flights are separated from other traffic (cf. chapter 1.4). With required separation of 1 000 ft, the time available to discover deviations and initiate measures is limited. The Farris APP controller monitored the two flights, N97RN and LN-FTL on his radar screen, but due to coinciding unfortunate circumstances, the controller's intervention was somewhat belated. As AIBN sees it, he could have prevented a continued climb beyond the altitude restriction if he had managed to establish contact with N97RN earlier, and the accident board supports his thoughts concerning when one should act to establish communication in a potential conflict situation (cf. chapter 1.2.2.1). The AIBN has considered whether an attempt to call N97RN on frequency 121,5 could have contributed to solve the conflict at an earlier stage. The AIBN believes that from the moment the situation was assessed to be critical to the time the actual airprox took place, there was too little time available. With that in mind, the use of 121,5 would not have made any difference in this matter.

Alert from the radar system's Short Term Conflict Alert (STCA) was not actuated until after the conflict was over, due to the fact that STCA is filtered below 5 500 ft (cf. chapter 1.6). In this incident the Farris Approach controller was already aware of the conflict and was monitoring the flights. STCA therefore could not have served a practical purpose in this incident.

The instructor and the student in LN-FTL hadn't taken specific note of the other aircraft, which was on departure, since it was more than 1 000 ft below them. It was not in their minds that the departing aircraft would end up flying through the altitude restriction, which they knew was 4 000 ft. If the traffic information from Farris APP about N97RN had come earlier, AIBN considers it likely that LN-FTL would have adjusted its course and thus avoided having to perform a quick evasive manoeuvre.

Both aircraft had systems onboard that displayed close traffic and thus contributed to improve the pilots' perception of the current situation. It was TAS that first made the LN-FTL crew aware that they were in conflict with another flight, and which caused them to initiate an evasive manoeuvre. Such systems are not compulsory for this category of light aircraft, but in this case they proved their value as an extra safety net when the established safety barriers failed.

The fact that the student in the left seat was hand flying when the TAS alert concerning the other aircraft actuated, meant that the instructor and the student could react quickly and make the aircraft climb. They won valuable time compared to if they had been on autopilot. AIBN agrees with the LN-FTL Commander, that the situation might have become more critical if they hadn't performed the evasive manoeuvre, and wishes to commend the LN-FTL crew for the resolute manner in which they acted as soon as they became aware of the dangerous situation.

2.3 Closing Remarks

Both Commanders had visual contact shortly before the airprox. The crew on LN-FTL made a quick evasive manoeuver whilst the Commander on N97RN only made a minor heading adjustment. In theory the Commander on N97RN had the possibility to make a larger correction. Therefore AIBN believes there still was one remaining latent safety barrier. Whether this would or could have been used is unknown. With that in mind, the AIBNs assessment is that this was a serious incident where the margin for further escalation of the conflict was narrow.

Accident Investigation Board Norway

Lillestrøm, 17 December 2014