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Swiss Accident Investigation Board SAIB

Aviation Division

Final Report No. 2205 by the Swiss Accident Investigation Board SAIB

concerning the accident involving the Embraer EMB-505 aircraft, CN-MBR

on 6 August 2012

St. Gallen-Altenrhein (LSZR) regional aerodrome, Thal/SG municipality

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Ursachen

Der Unfall ist darauf zurückzuführen, dass das Flugzeug nach einem unstabilisierten Endanflug spät und mit zu hoher Geschwindigkeit auf der Piste aufsetzte und diese in der Folge überrollte.

Zum Unfall beigetragen haben folgende Faktoren:

- Die mangelhafte Zusammenarbeit und die unzureichende Situationsanalyse durch die Besatzung.
- Die auf rund 10 Grad blockierten Landeklappen, was ungefähr der Klappenstellung 1 entsprach.
- Spätes Einleiten einer Vollbremsung nach der Landung.

General information on this report

This report contains the Swiss Accident Investigation Board's (SAIB) conclusions on the circumstances and causes of the accident, which is the subject of the investigation.

In accordance with Art 3.1 of the 10th edition, applicable from 18 November 2010, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944 and Article 24 of the Federal Air Navigation Act, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent accidents or serious incidents. The legal assessment of accident and serious incidents causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All times in this report, unless otherwise indicated, follow the coordinated universal time (UTC) format. At the time of the accident, Central European Summer Time (CEST) applied as local time (LT) in Switzerland. The relation between LT, CEST and UTC is:
LT = CEST = UTC + 2 hours.

Contents

Final Report

Synopsis

Owner	DALIA AIR, 30 Rue Normandie, Casablanca 20100, Morocco
Operator	DALIA AIR, 30 Rue Normandie, Casablanca 20100, Morocco
Manufacturer	Embraer, Sao José dos Campos, Brazil
Aircraft type	Embraer EMB-505 Phenom 300
Country of registration	Morocco
Registration	CN-MBR
Location	St. Gallen-Altenrhein (LSZR)
Date and time	6 August 2012, 13:40 UTC

Investigation

The accident occurred at 13:40 UTC. The notification was received at 14:01 UTC by the Swiss Accident Investigation Board, Aviation Division (SAIB-AV). The investigation was opened immediately on the same day in cooperation with the St. Gallen cantonal police. The SAIB-AV informed the following states of the reports about the accident: Morocco, Brazil, Canada and the United States of America (USA). All four states nominated each an authorised representative, who assisted with the investigation.

The final report is published by the SAIB-AV.

Summary

On 6 August 2012 the Embraer EMB-505 Phenom 300 aircraft, registration CN-MBR, took off at 12:59 UTC from Geneva (LSGG) on a commercial flight to St. Gallen-Altenrhein (LSZR). After the initial call to the aerodrome control centre St. Gallen tower, the crew quickly decided, after an enquiry from the air traffic controller, on a direct approach on the runway 10 instrument landing system (ILS). Shortly thereafter, the landing gear and flaps were extended. The flaps jammed at approximately 10 degrees and the FLAP FAIL warning message was displayed. The crew carried out a go-around shortly before landing. The landing gear subsequently remained extended. The flaps remained jammed for the remainder of the flight.

The crew decided immediately on a second ILS approach with jammed flaps, which according to the manufacturer's information required an increased approach speed. During the approach, the crew had difficulty in reducing the airspeed to this increased approach speed. At 13:40 UTC, the aircraft subsequently touched down on the wet runway at an indicated air speed of 136 kt, approximately 290 m after the runway threshold, and could not be brought to a standstill on the remaining length of runway. The aircraft then rolled over the end of runway 10, broke through the aerodrome perimeter fence and overrun the road named Rheinholzweg running perpendicular to the runway centreline, on which a public transport bus was travelling. The aircraft rolled very close behind the bus and came to a standstill in a maize field, approximately 30 m from the end of the runway.

The female passenger and the two pilots were not injured in the accident. The aircraft was badly damaged.

There was crop damage and damage to the aerodrome perimeter fence.

Causes

The accident is attributable to the fact that the aircraft touched down late and at an excessively high speed on the wet runway after an unstabilised final approach and consequently rolled over the end of the runway.

The following factors contributed to the accident:

- The insufficient teamwork and deficient situation analysis by the crew.
- The flaps remained jammed at approximately 10 degrees, a position that is almost consistent with the flaps 1 position.
- Late initiation of full brake application after landing.

Safety recommendations

In the context of the investigation, two safety recommendations were issued.

According to the provisions of Annex 13 of the ICAO, all safety recommendations listed in this report are intended for the supervisory authority of the competent state, which has to decide on the extent to which these recommendations are to be implemented. Nonetheless, any agency, establishment or individual is invited to strive to improve aviation safety in the spirit of the safety recommendations pronounced.

In the Ordinance on the Investigation of Aircraft Accidents and Serious Incidents (OIAASI), the Swiss legislation provides for the following regulation regarding implementation:

“Art. 32 Safety recommendations

1 DETEC, on the basis of the safety recommendations in the SAIB reports and in the foreign reports, addresses implementation orders or recommendations to the FOCA.

2 The FOCA informs DETEC periodically about the implementation of the orders or recommendations pronounced.

3 DETEC informs the SAIB at least twice a year on the state of implementation by the FOCA."

1 Factual information

1.1 Pre-history and history of the flight

1.1.1 General

For the following description of the pre-history and history of the flight, the recordings of the radio communication, the combined cockpit voice and data recorder (CVDR), radar data and the statements of the crew members, the air traffic control officer involved and the bus driver (as eye witness) were used.

For the entire flight the commander was pilot flying (PF) and the copilot was pilot not flying (PNF). The communication between the pilots during both approaches in St. Gallen-Altenrhein took place in Arabic and French. The conversation in Arabic were translated into French by a representative of the Moroccan investigation authority. The translation from French into English follows in each case in square brackets. Words or parts of conversation which were not comprehensible are marked with "xxx".

It was a commercial flight under instrument flight rules (IFR).

1.1.2 Pre-history

For the flight from Geneva (LSGG) to St. Gallen-Altenrhein (LSZR), the crew had a folder from the operator which, among other things, contained an operational flight plan (OFP) with the corresponding fuel calculations and information about the weather. The crew confirmed with their signature on this folder that they had examined the following documents: weather, NOTAM, journey log, ATC FPL, computerised FPL, loadsheet, passenger information list, fuel receipt.

The aircraft was refuelled at 12:10 UTC with 139 l of fuel. There was therefore 2020 kg of fuel on board on take-off, according to the flight plan. On the ATC flight plan, the crew had replaced the originally envisaged alternate aerodrome of Samedan (LSZS) with Geneva airport (LSGG). For the flight to St. Gallen-Altenrhein a trip fuel of approximately 300 kg was shown.

In the St. Gallen-Altenrhein aerodrome traffic control centre there were usually two air traffic control officers (ATCOs) in the control tower during the day. At the time of the accident, one air traffic control officer was on a break. The ATCO involved described the workload as low.

1.1.3 History of the flight

At 12:59 UTC on 6 August 2012, the Embraer EMB-505 Phenom 300, registration CN-MBR, radio callsign "Dalia two one one", flight number DLI 211, took off on runway 23 in Geneva (LSGG) on a commercial flight to St. Gallen-Altenrhein (LSZR). Two pilots and one female passenger were on board.

At 13:08:23 UTC, the crew reported to the Swiss Radar West air traffic control officer (ATCO). They then received clearance to take a direct course to waypoint ROLSA and a little later they received clearance to descend to flight level (FL) 130. At 13:11 UTC, the copilot monitored on the second VHF receiver the automatic terminal information system (ATIS) information INDIA for St. Gallen-Altenrhein (cf. chapter 1.7.6) and in the following minutes he informed the commander of this. The setting of the navigational aids for the approach on runway 10 instrument landing system (ILS) was discussed and reviewed on the cockpit screens. Also, circling on runway 28 was addressed. An approach briefing in which among others, essential altitudes, approach angle, approach speeds and missed approach procedure are addressed, did not take place (cf. chapter 1.17.1.1).

At 13:16:16 UTC, the ATCO instructed the crew to increase their rate of descent to 1500 feet per minute (ft/min) or more. The crew acknowledged this instruction and were then instructed to switch to the Zurich departure frequency.

At 13:17:39 UTC, the crew reported to the Zurich departure ATCO and then received clearance to fly after ROLSA direction SITOR (cf. Annex 1). At 13:20:39 UTC, the ATCO cleared the crew to descend to FL 80 and just two minutes later the crew were requested to switch to the Zurich arrival frequency.

At 13:22:42 UTC the Zurich arrival ATCO replied as follows to the greeting from the crew of the DLI 211: *"Dalia two one one, Zurich arrival, hello identified, continue inbound SITOR, radar vectors for the ILS approach runway one zero followed by visual right hand circuit runway two eight St. Gallen."* The crew confirmed this clearance and at 13:23:00 UTC the ATCO gave the following additional clearance: *"Dalia two one one uh descend to five thousand feet, QNH St. Gallen one zero one six."* The copilot acknowledged this clearance and the commander made the following remark to him: *"Donc, c'est une approche followed with ehh... un vent arrière pour la vingt-huit la procédure"* [so it's an approach followed with ehh... downwind leg onto 28, the procedure]. The commander was speaking of the circling procedure onto runway 28 (cf. Annex 11).

At 13:23:41 UTC, the ATCO instructed the crew to fly a heading of 040 degrees. At this time the aircraft was 13 NM north-east of waypoint ROLSA at a pressure altitude of 8060 ft and descending. The indicated airspeed was 218 knots (KIAS). The tailwind component amounted to just over 70 kt. The copilot acknowledged this instruction and the commander then said to the copilot: *"Je comprends pas ce monsieur ATC, regarde le radar comme il est xxx, il faut trouver la procédure, xxx"* [I don't understand the ATC guy, take a look at the radar xxx one has to find the procedure xxx]. The copilot commented: *"contact au sol... après la prochaine couche on aura contact"* [ground contact... after the next layer (cloud band) we will have contact]. The commander gave the following answer: *"ce qui m ' inquiète plutôt, c'est ce qu' on au-dessus de nous..."* [What worries me more is what we have above us]. To the subsequent exclamation "*ah*" from the copilot, the commander replied: *"on se fait tabasser."* [we will be shaken about].

At 13:24:57 UTC, the ATCO gave the crew the following instruction: *"Dalia two one one, turn right heading zero seven zero, cleared for ILS approach runway one zero followed by visual right-hand circuit runway two eight St. Gallen, report established."* During transmission of this instruction, a warning tone was audible in the cockpit. The copilot now confirmed the ATCO's instruction and the commander commented eleven seconds later: *"Okay, ah... Je t'affiche... Ah"* [Okay, ah... I get you... ah] and after seven seconds: *"okay, en interception"* [Okay, intercepting] and a further six seconds later: *"le localizer"* [the localizer]. Twelve seconds later, at 13:25:42 UTC, the commander asked the copilot for the aerodrome elevation and the copilot said at the same time: *"glide, localizer"*. The commander himself answered his question about aerodrome elevation: *"ah... mille trois cents, xxx, missed approach altitude please"*. [ah... one thousand three hundred, xxx, missed approach altitude please]. The copilot seemed not to have understood this and the commander again said: *"missed approach altitude please"*. The copilot then replied: *"mille huit cent"* [one thousand eight hundred], whereupon the commander responded that this was not the missed approach altitude. At the same time, a warning tone was again audible in the cockpit. The commander asked a third time for the missed approach altitude. The copilot could not answer the question and referred a little later to the circling relating to the landing, upon which the commander then asked about the circling altitude. He answered himself seven seconds later as follows: *"deux mille, mille deux cent* *soixante-dix."* [two thousand, two thousand one hundred and seventy] (cf. Annex 11).

At 13:26:34 UTC the ATCO instructed the crew to change to the St. Gallen tower frequency. The crew obeyed this instruction and after the change the St. Gallen ATCO responded as follows: *"Dalia two one one, St. Gallen tower good afternoon, actual surface wind two eight zero degrees niner knots, uh do you request straight in for one zero or a circling for runway two eight?"* According to the recordings, during this radio conversation, at 13:26:54 UTC, the landing gear was extended with the aircraft at an altitude of 3250 ft QNH and 222 KIAS. This action was not addressed verbally by the crew. At the same time, a warning tone was again audible in the cockpit. At 13:27:06 UTC, the copilot replied to the ATCO as follows: *"Uh in this case we make one zero, Dalia two one one."* This decision was not preceded by any verbal communication between the pilots. Immediately afterwards, at 13:27:11 UTC, the ATCO gave the following clearance: *"Dalia two one one that's copied, wind two niner zero degrees niner knots, runway one zero cleared to land."*

A few seconds later, at 13:27:18 UTC, the commander asked the copilot for the missed approach altitude. The latter promptly gave him the following reply: *"cinq milles, high-speed, doucement,..., gear, flaps."* [Five thousand, high speed, gently,..., gear, flaps]. The commander replied *"coming, coming"* and according to the recordings applied the speed brakes at 13:27:24 UTC to further reduce his speed (cf. chapter 1.6.3.2.3).

At 13:27:29 UTC, at a speed of 183 KIAS, the commander said: *"… one hundred and eighty, flaps one."* The copilot set the flap selector lever to position 1 and commented at 13:27:36 UTC: *"okay, we have the runway in sight"* at which point the commander ordered: *"Flaps two."* The copilot immediately reported *"coming to two."* At 13:27:40 UTC, the commander immediately ordered *"and full flaps"* which the copilot acknowledged without delay with *"and full down"*. According to the recordings, the flap selector lever was set to the FULL position at 13:27:41 UTC and two seconds later set to position 3. As a result of the extension of the flaps the speed brakes were system-related retracted, and this triggered the SPDBRK SW DISAG message in the cockpit (cf. chapter 1.6.3.2.3). This message was not addressed verbally in the cockpit.

Five seconds later, at 13:27:45 UTC, a warning tone, generated by the master warning system, sounded twice in the cockpit and at the same time the FLAP FAIL warning appeared; it continued to be displayed until the end of the CVDR recording. At 13:27:53 UTC the synthetic voice "MINIMUMS, MINIMUMS" and then "FIVE HUNDRED" sounded. At 13:27:56 UTC the speed brake switch was set to the CLOSE position and at the same time the synthetic voice reported "AUTOPILOT".

Whilst the copilot informed the commander as follows: *"okay, on n'a pas les flaps... presque"* [Okay, we have no flaps... almost], the aural altitude message "FOUR HUNDRED" sounded in the cockpit. In response to the commander's surprised cry of "*huh*!" the copilot said at 13:28:03 UTC: *"sortis mais arrêtés"* [extended but stopped]. At virtually the same time the altitude call out "THREE HUNDRED" sounded. At this time, the aircraft was flying at 154 KIAS with a rate of descent of over 1000 ft / min.

The commander commented at 13:28:06 UTC: *"je vois rien"* [I see nothing] to which the copilot replied: *"aller... descends, descends"* [go on... descend, descend]. At 13:28:08 UTC, the altitude call out "TWO HUNDRED" sounded in the cockpit and the commander again said: *"Je vois rien"* [I see nothing]. Immediately the copilot said: *"voilà la piste, voilà la piste"* [there's the runway, there's the runway]. Immediately before the altitude call out "ONE HUNDRED" sounded at 13:28:13 UTC, the commander said "*xxx, puisqu'on voit rien"* [xxx, here, one can't see anything] and after a few incomprehensible words it was quiet in the cockpit for a few seconds. Then, at 13:28:22 UTC the commander said: *"remise de gaz"* [power again] and initiated a go-around. The lowest radio altitude during the go-around was less than one foot (30.5 cm) above ground and the indicated airspeed was 147 kt.

The copilot reported to the ATCO at 13:28:24 UTC *"Go around, Dalia two one one"* and the commander immediately ordered *"Flaps one"*. There was no verbal reaction to this command from the copilot. The recordings show that the flap selector lever had already been set from position 2 to position 1 at 13:28:23 UTC. The ATCO replied at 13:28:28 UTC: *"Dalia two one one, uh, go around, I ... go around, follow the standard missed approach procedure uh climb to five thousand feet."* The copilot confirmed this instruction at 13:28:37 UTC and at the same time set the flap selector lever to position 0. Shortly afterwards, at 13:28:41 UTC, he reported to the commander *"flaps up"*. The gear was not mentioned by the crew during the go around and was left extended.

Just two seconds later, at 13:28:43 UTC, when the speed increased to above 180 KIAS (cf. Annex 3), the synthetic voice "HIGH SPEED" sounded in the cockpit; this was repeated until 13:29:32 UTC, prompting the copilot to ask: *"Why high speed?"*. At 13:28:54 UTC the aural warning "AUTOPILOT" also sounded in the cockpit; this was repeated alternately with the "HIGH SPEED" warning until 13:29:17 UTC. Three seconds later, the commander said: *"cet ILS ne marche pas"* and after a further four seconds: *"Même les flaps sont coincés "* [this ILS isn't working / even the flaps are stuck]. The copilot replied: *"mais pas les volets oui"* [but not the flaps, yes].

During the go-around, the ATCO instructed the crew at 13:29:11 UTC to change back to the Zurich arrival frequency. The crew confirmed this instruction and reported at 13:29:37 UTC to the Zurich arrival ATCO once again, with the following words: *"Arrival, Dalia two one one, going around by the left"*, upon which the ATCO immediately asked the following question: *"Dalia two one one, uh do you prefer a second approach?"* Without hesitation the commander said to the copilot *"yes, affirmative"*, upon which the latter then gave the ATCO the following answer at 13:29:48 UTC: *"affirmative, Dalia two one one"*. The ATCO then gave the following instruction: *"Dalia two one one fly heading two eight zero, new radar vectors for the line up runway one zero."* The commander got the copilot to confirm the heading of 280 degrees and at the same time asked for the altitude to fly. The ATCO replied as follows to the enquiry from the copilot "*Sorry, five thousand feet, QNH one-zero one six, for the line-up."*

At 13:30:19 UTC, the commander said to the copilot: *"les volets sont coincés, le high speed va persister"* [the flaps are stuck and the high speed will persist]. He further requested the copilot to ask the ATCO whether he could make a visual approach. The copilot answered: *"laisse le nous ramener au final, cela nous arrangera, cela nous permettra de prendre notre vitesse... parce que les flaps sont toujours restés en position un"* [let him get us back on final approach, that will suit us, it will allow us to reduce our speed, because the flaps are still in position one]. The commander answered at 13:30:40 UTC: *"les flaps ne veulent pas descendre, si on met sur en position deux, qu'est-ce que cela va donner?"* [the flaps won't extend, what will that mean?] and 21 seconds later: *"on va les laisser à deux, c'est mieux que rien..."* [We'll leave them in position two, which is better than nothing]. The copilot corrected this with the following words: "*non, ils sont coincés à un. là j'ai fait deux recyclés... parce que..."* [No they are stuck in position one, I have tried to move them twice... because...]. According to the recordings, after the appearance of the FLAP FAIL warning the copilot had unsuccessfully tried several times to retract and extend the flaps using the flap selector lever. These attempts continued until shortly before the landing, while the FLAP FAIL[1] warning remained constantly displayed. To the commander's question as to whether the flaps could be retracted, the copilot replied in the negative.

At 13:31:38 UTC the copilot reported to the commander that they would make the approach with the flaps in position 1. The commander remarked at 13:32:25 UTC that it would not be a problem to reduce speed. At 13:33:54 UTC the commander asked the copilot, what was in the checklist with reference to *"flaps up"*. The latter answered at 13:34:24 UTC as follows with interruptions: *"okay, Il va falloir augmenter le V-ref… no icing… de 17 V-ref 3 [ligne], plus 17 donc, on a V-ref den combien? ah, V-ref cent douze ça fait cent trente à peu près, permettra nous…."* [okay, we will the V_{REF} ...no icing... from 17, V_{REF} 3 plus 17, so we get V_{REF} of how much? Ah, V_{REF} one hundred and twelve, that makes about one hundred and thirty, that'll allow us...]. Then the commander ordered: *"mets cents trente"* [set one hundred and thirty]. The copilot did not understand this command and the commander repeated: *"mets cents trente"* [set one hundred and thirty]. The copilot did not reply and said 26 seconds later, in brief, that the maximum altitude was limited to 18 000 ft and they would have to avoid icing conditions: *"maximum altitude, dix huit mille pieds, donc is not … no equipment ah … xxx … anti ice … ice … if not possible avoid".*

At 13:35:33 UTC the ATCO gave the crew the following clearance: *"Dalia two one one turn left heading one three zero, cleared for the ILS approach runway one zero St. Gallen, report established."* The copilot confirmed this clearance and then said to the commander: *"donc checklist donne la V ref réalisé, donc c'est bon"* [so checklist gives the reference speed used, so that's good]. The commander asked back whether the copilot had set this reference speed. The latter in turn replied that he would do so immediately and asked the commander a few seconds later as follows: *"je te mets direct au final?"* [I'll set you directly on the final approach course]. The commander agreed and then asked: *"le terrain [la piste] c'est combien?"* [the terrain (the runway) is how much], to which the copilot replied nine seconds later: *"quatre mille pieds, longueur quatre mille ah quatre mille neuf cent"* [four thousand feet, the length, er, four thousand and nine hundred].

At 13:36:47 UTC the ATCO cleared the crew to descend to 4500 ft QNH. The copilot confirmed this clearance and the commander remarked immediately afterwards that they probably would capture the localizer and glide slope simultaneously. In addition, he noted that poor conditions would prevail with an approach speed of 130 kt and a wet runway. At 13:37:56 UTC the commander reported that he had captured the localizer and would now descend more quickly to join the glide slope as well. The copilot confirmed this and said that they would have to monitor the airspeed well in order not to be too fast. The commander then remarked: *"ah, surveille les quarante noeuds ah il nous a ramené haut ce coup-là"* [er, monitor the forty knots, er he has taken us high this time]. The copilot now advised the commander: *"prends mille deux cents, ah okay c'est bon"* [take one thousand two hundred, that's good] and at the same time informed the ATCO that they had captured the localizer.

The ATCO then instructed the crew at 13:38:25 UTC to change to the St. Gallen tower frequency, which the copilot acknowledged. The aircraft was at this time at an altitude of 4000 ft QNH and was flying at 160 KIAS. At 13:38:28 UTC, accord-

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[1] FLAP FAIL: defective flap system

ing to the recordings, the speed brake switch had been set back to the OPEN position causing the SPDBRK SW DISAG message to be triggered. This action, as well as the warning message, was not addressed verbally by the crew. At 13:38:40 UTC, at an altitude of 3530 ft QNH, the aircraft reached an airspeed of 172 KIAS. At 13:38:49 UTC the commander said that he could not understand anything any more, to which the copilot responded with *"laisse-les"*. At 13:38:53 UTC the commander remarked: *"les spoilers ne sortent pas... c'est pourquoi que la vitesse ne chute pas"* [the spoilers are not extending, that's why the airspeed is not decreasing]. Five seconds later, a warning tone sounded in the cockpit followed by the aural warning "AUTOPILOT", whereupon the commander commented: *"elle reste à cent quarante noeuds"* [it's staying at one hundred and forty knots]. The copilot answered: *"cent trente, c'est bien, descend(s) s'il te plaît"* [one hundred and thirty, that's good, descend, please].

At the same time, at 13:39:08 UTC, the ATCO gave the crew the following clearance: *"Dalia two one one, wind three zero zero degrees three knots, runway one zero cleared to land."* The copilot then advised the commander to increase the rate of descent slightly. The latter promptly replied: *"eeh mon ami, la vitesse, elle monte beaucoup, on n'a pas de speedbrake, on n'a rien…… on a un problème avec les speedbrakes, ils ne marchent pas"* [hey, my friend, the speed is increasing sharply, we have no speed brakes, we have nothing... we have a problem with the speed brakes, they're not working]. According to the recordings, at 13:39:24 UTC the speed brake switch was brought back in the CLOSE position, and this deactivated the SPDBRK SW DISAG advisory message. Neither was addressed verbally by the crew.

A little later the copilot broached the high airspeed and the commander answered at 13:39:31 UTC: *"problème, c'est un grand grand problème on peut t'essayer et puis on décolle"* [problem, this is a big problem, we can give it a try and then start]. The copilot answered: *"Voilà, c'est ce que je voulais te dire tout à l'heure, malheureusement…"* [Precisely, that's what I wanted to tell you earlier, unfortunately...]. The aircraft was at this time at an altitude of 2330 ft QNH and was flying at 162 KIAS, at a rate of descent of approximately 2000 ft/min. At virtually the same time the aural warning "TERRAIN" sounded in the cockpit and four seconds later, at 13:39:38 UTC, the warning "< whoop > < whoop > PULL UP" sounded and the copilot called out: *"diminue"* [reduce]. The Commander was commenting that they had a problem with this aircraft and at the same time, the "TERRAIN" warning sounded in the cockpit. The copilot advised the commander, to bring up the aircraft's nose slightly, in response to which the latter asked how he should do that. Immediately the copilot said: *"tu viens dans... vas-y, vas-y, tout se passe bien"* [you're coming in... come on, come on, everything comes good]. At 13:39:47 UTC, the synthetic voice announced "MINIMUMS, MINIMUMS" and the copilot again said: *"vas-y, tu vas être just just"* [go on, you're just right, right]. The aircraft was at this time at a height of approximately 550 ft above ground and was flying at 163 KIAS, at a decreasing rate of descent of approximately 900 ft/min. At 13:39:50 UTC, the altitude message "FIVE HUNDRED" sounded and the copilot again said: *"vas-y tu vas bien"* [go on, you're doing fine].

At 13:39:58 UTC the altitude call out "FOUR HUNDRED" sounded and at the same time, the commander said: *"vingt noeuds, stabilisé à la vitesse normal d'approche"* [twenty knots, stabilised at the normal approach speed]. At this moment the aircraft was flying at 153 KIAS at a rate of descent of approximately 1000 ft/min.

At 13:40:03 UTC the warning "TOO LOW TERRAIN" sounded in the cockpit, followed by the altitude call out "THREE HUNDRED". At 13:40:10 UTC, the altitude call out "TWO HUNDRED" sounded and the commander commented: *"c'est bon"*.

During the next five seconds the warning "TOO LOW-FLAPS / TOO LOW-FLAPS" sounded and two seconds later the altitude message "ONE HUNDRED" followed. In the next two seconds, the warnings "TOO LOW FLAPS" and "GLIDESLOPE" sounded. The aircraft was flying at a height of 70 ft above the ground. The speed at that moment was 143 KIAS and the rate of descent was 850 ft/min.

At 13:40:29 UTC, the aircraft touched down on runway 10 on its right main landing gear, with a slight tailwind, at 136 KIAS approximately 290 m after the runway threshold. Ground contact of the left main landing gear took place one second later, after a further 70 metres. At 13:40:31 UTC, at 135 KIAS and approximately 450 m after the runway threshold, all weight on wheel sensors reported that the aircraft was on the ground. Three seconds later the copilot said: *"pourvu qu'on s'en sort..."* [hopefully it will work] and the commander added: *"c 'est ce que je t' ai dit xxx m..."* [that's what I told you xxx (expletive)].

At 13:40:46 UTC the aircraft reached the ungrooved end of runway 10 with a speed of 60 KIAS (cf. chapter 1.10. 3). Two seconds later, it reached the stopway at the end of runway 10 and left the runway at 13:40:51 UTC with a speed of 44 KIAS. One second later, it broke through the aerodrome perimeter fence at 39 KIAS, rolled across the road named Rheinholzweg, which runs perpendicular to the end of the runway centreline at a distance of approximately 20 m from the runway, and came to a standstill in a maize field after a further 10 m (cf. chapter 1.12.1).

A few seconds previously, a Rheintal Bus AG (RTB) public service bus licensed for 90 persons had travelled along the Rheinholzweg from south to north. The bus driver later stated that he had glimpsed an aircraft on his left, approaching the end of the runway at high speed. He recognised this as a hazard and therefore applied the accelerator pedal.

The aircraft past just behind the bus. The crew and the female passenger were able to leave the aircraft unassisted. The aircraft was badly damaged.

1.1.4 Accident location

Accident location	St. Gallen-Altenrhein (LSZR) regional aerodrome
Date and time	6 August 2012, 13:40 UTC
Lighting conditions	Day
Coordinates	760 708 / 261 456 (Swiss grid 1903) N 47° 29’ 3.19’’ / E 009° 34’ 16.10’’ (WGS 84)
Elevation	399 m AMSL (1309 ft AMSL)
Final position of the wreckage	Eastern side of the road named Rheinholzweg running perpendicular to the runway, approximately 30 m beyond the end of runway 10
Map of Switzerland	Sheet no. 1076, St. Margrethen, scale 1:25,000

1.2 Injuries to persons

1.2.1 Injured persons

Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	0	0	0	0
Serious	0	0	0	0

Minor	0	0	0	0
None	2	1	3	Not applicable
Total	2	1	3	0

1.2.2 Nationality of the occupants of the aircraft

Both pilots were Moroccan citizens.

The female passenger was a French citizen.

1.3 Damage to aircraft

The aircraft was badly damaged. The two engines remained undamaged.

1.4 Other damage

There was damage to the terrain. Due to the fuel tank damage fuel spilled out. Around 60 m^3 of soil had to be removed, disposed of and replaced. The perimeter fence of the aerodrome was damaged.

1.5 Personnel information

1.5.1 Flight crew

1.5.1.1 Commander

1.5.1.1.1 General

Person	Moroccan citizen, born 1972
Licence	Commercial pilot licence II, issued by the Ministry of Equipment and Transport of the Kingdom of Morocco on 10 March 2012
Ratings	Type rating EMB-505
	Language proficiency: English Level 6
Instrument flying rating	Instrument rating (IR), valid till 31 March 2013
Crew resource management (CRM) course	19 December 2011
Last proficiency check	Operational proficiency check (OPC) on 10 March 2012
Medical certificate	Class 1, no conditions or restrictions, issued on 17 November 2011, valid till 17 November 2012
Last medical examination	17 November 2011

1.5.1.1.2 Flying experience

Total	7025:00 hours
on the accident type	75:00 hours
of which as commander	75:00 hours
during the last 90 days	58:35 hours
of which on the accident type	58:35 hours

1.5.1.1.3 Crew times

Start of duty in the 48 hours before the accident	4 August 2012: off duty 5 August 2012: off duty 6 August 2012: 11:00 UTC
End of duty in the 48 hours before the accident	4 August 2012: off duty 5 August 2012: off duty
Flight duty times in the 48 hours before the accident	off duty
Rest times in the 48 hours before the accident	over 24 hours
Flight duty time at the time of the accident	2:40 hours

1.5.1.1.4 Training

After a break in his flying activity of approximately 24 months, the commander completed his training on the EMB-505 aircraft type under FAA regulations between 15 February 2012 and 10 March 2012 with the CAE SimuFlite Inc. company in Dallas/Fort Worth in the USA. According to the training syllabus, the theoretical training required 43 hours.

The flight training on the simulator is certified on a detailed list by the company CAE SimuFlite Inc. and among other things it is evident that the commander, in all seven listed lessons passed the topic crew resource management with the identification letter P *(*proficient - meets PTS standard (if applicable)). The following points are listed under crew resource management: briefings, decision-making, crew coordination, leadership, workload management, situational awareness, communication management. In addition the commander stated that he had 1500 hours experience on multi-crew airplanes.

Under abnormal / emergency it is stipulated among other things that the commander was confronted during three exercises by the theme "Flight Controls / Autopilot". It is not clear whether approaches with a defective flap system (FLAP FAIL) were also carried out.

In the case of the line flights made in the simulator, several landings are documented at airports KJFK (New York), KPHL (Philadelphia), KRNO (Reno), KPNE (Northeast Philadelphia), KDCA (Washington), KSFO (San Francisco), and KHPN (Westchester). Since the runway used for these landings is not listed, nothing specific can be said about the training with regard to landings on short runways (short field operation).

The commander's flight training on the aircraft extended from 21 April 2012 to 27 May 2012 and included a line introduction. He made ten flights, of which three were to Cannes (LFMD) and one to Geneva (LSGG). The commander was consistently rated by the instructor on these flights as very well qualified. The available landing distances on runway 17/35 in Cannes were 1400 m, respectively 1260 m.

The commander himself said of his experience with regard to landings on short runways: *"Many times in Cannes, France."* He further stipulated that he never flew to St. Gallen-Altenrhein before.

In the airline company, in addition to his flying function, the commander was employed as deputy of the director of flight operations.

1.5.1.2 Copilot

1.5.1.2.1 General

Person	Moroccan citizen, born 1959
Licence	Commercial pilot licence II, issued by the Ministry of Equipment and Transport of the Kingdom of Morocco on 25 January 2012
Ratings	Type rating EMB-505 Language proficiency: English Level 4, valid till 15 April 2014
Instrument flying rating	Instrument rating (IR) valid till 31 January 2013
Last proficiency check	Line check on 25 January 2012
CRM course	19 December 2011
Medical certificate	Class 1, with the condition: corrective lenses, issued on 1 June 2012 for three months [2]
Last medical examination	1 June 2012

1.5.1.2.2 Flying experience

Total	5854:05 hours
on the accident type	465:25 hours
during the last 90 days	52:25 hours
of which on the accident type	52:25 hours

1.5.1.2.3 Crew times

Start of duty in the 48 hours before the accident	4 August 2012: off duty 5 August 2012: off duty 6 August 2012: 11:00 UTC
End of duty in the 48 hours before the accident	4 August 2012: off duty 5 August 2012: off duty
Flight duty times in the 48 hours before the accident	off duty
Rest times in the 48 hours before the accident	over 24 hours
Flight duty time at the time of the accident	2:40 hours

[2] The time restriction corresponds to TML (valid for … months); its medical background was not supplied to the SAIB, despite several requests.

1.5.1.2.4 Training

The copilot completed his training on the EMB-505 aircraft type, under JAA/EASA regulations, at CAE SimuFlite Inc. in Dallas/Fort Worth in the USA on 31 January 2012. The flight training on the simulator amounted to 14.1 hours.

In relation to theoretical teaching, re-training in the sections aircraft systems, FMS and limitations was required, and this was successfully completed.

During the flight training in the simulator the instructor certified that he worked well as a crew member with regard to checklist and normal/abnormal procedures.

In the "simulator detail six" performance sheet, on a flight from LSGG (Geneva) to LSZH (Zurich) it was certified under item 12 and 13 that the copilot had successfully completed practical training regarding "Flap Abnormal Operation" and "Landing without Flaps". In the assessment, the instructor noted that the copilot carried out a visual approach without flaps and after the landing, owing to failure of the hydraulic system, had to use emergency braking. Regarding qualification, the instructor stated, among other things, that: *"... demonstrated good leadership and control during the emergency situation."*

There is no mention of special training for landings on short runways in the detailed documentation relating to the copilot's training. The copilot himself said of his experience in short field operation: *"Yes in the army on the Hercules."*

The copilot stated that he carried out the flight training under a JAA/CRE approved captain. In the process, he flew from Rabat (GMME) to Fez (GMFF), there completing four take-offs and landings, before flying back to Ben Slimane (GMMB). Documented evidence of a line introduction is not available.

Within the airline company, in addition to his flying function, the copilot was employed as quality and flight safety manager. Prior to his employment with the operator, he was in the military as a commander on the C130-H aircraft type and at the RAM Academy as an instructor on single-engine piston-powered aircraft.

1.5.2 Air traffic control personnel

Person	Swiss citizen, born 1984
Start of duty on the the accident day	07:15 UTC
Licence	Safety-related task (SRT) licence, rating ADI, first issued by the Federal Office of Civil Aviation (FOCA) on 2 July 2009, valid till 10 July 2013 Language endorsements: English Level 4, valid till 29 September 2012
Medical fitness certificate	Class 3, issued on 17 August 2011, valid till 16 September 2012

1.6 Aircraft information

1.6.1 General information

Registration	CN-MBR
Aircraft type	EMB-505 PHENOM 300
Characteristics	Low-wing executive aircraft with twin jet engines and without thrust reversers. The aircraft is certified for single pilot

	operation.
Manufacturer	Embraer, Sao José dos Campos, Brazil
Year of manufacture	2011
Serial number	50500025
Owner	DALIA AIR, 30 Rue Normandie, Casablanca 20100, Morocco
Operator	DALIA AIR, 30 Rue Normandie, Casablanca 20100, Morocco
Engine	Two engines Pratt & Whitney Canada PW535E Left: serial number PCE-DG0043 Right: serial number PCE-DG0040
Operating hours	Airframe 510:38 hours Engines 624:07 hours
Max. permitted masses	Max. permitted take-off mass 8150 kg Max. permitted landing mass 7650 kg
Mass and centre of gravity	The mass of the aircraft at the time of departure was 7543 kg. The mass of the aircraft at the time of the accident was 7093 kg. Both the mass and centre of gravity were within the permitted limits according to the aircraft flight manual (AFM).
Maintenance	The last scheduled maintenance took place on 7 July 2012 after 480:45 hours.
Technical limitations	In the technical log book no defects were noted which would have had an effect on airworthiness. In the aircraft manufacturer’s pilot's operating handbook it was stated that the "FULL" flaps position is not available and that this position is mechanically blocked for the flap selector lever.
Permitted fuel grade	JET A1 kerosene
Fuel	According to the flight plan, take-off fuel was 2020 kg. Among other things, this included trip fuel of 279 kg. According to the flight plan, the minimum block fuel was 776 kg. The additional 1244 kg in the tanks would have been sufficient for approximately three hours flying time. According to the operational flight plan, the amount of fuel used for the flight was 450 kg.
Certificate of registration	No. 645, issued by the Ministry of Equipment and Transport of the Kingdom

	of Morocco on 14 February 2011
Certificate of airworthiness	No. 0269, issued by the Ministry of Equipment and Transport of the Kingdom of Morocco on 11 February 2011, valid only in combination with a valid airworthiness review certificate.
Airworthiness review certificate	No. 803/12, valid from 16 January 2012 to 9 January 2013
Certification	NORMAL *Transport public de passager 1*

1.6.2 Cockpit equipment

1.6.2.1 General

The aircraft was equipped with a *Garmin Embraer Prodigy Flight Deck 300* system. This system allows the flight crew to have access to all required information and flight guidance systems. The aircraft is being operated via the main- and side panels.

System malfunctions are primarily displayed to the flight crew on the crew alerting system (CAS). Synoptic displays make system monitoring easier for the flight crew.

1.6.2.2 Cockpit layout

The general cockpit layout is shown in Annex 7. The left and right screens are primary flight displays (PFD) for the commander and the copilot. The center screen is a multi-function display (MFD).

Figure 1: Overview of cockpit front panel with screen selection for normal operation: left and right primary flight display (PFD) and in the centre a multifunction display (MFD)

The pilots' PFD (cf. Annex 8) displays primarily the airspeed, altitude, heading and attitude. Various additional information such as communication, navigation, flight guidance and flight plan displays can also be represented. In addition, the PFD also serves as crew alerting system (CAS). Displays concerning system faults are shown on the right next to the altitude display.

The left side of the MFD (cf. Annex 9) is intended for a display of engine data and aircraft systems. The centre and right side of the MFD is used mainly for charts and flight plan displays. In addition a wide range of additional information can be displayed on the MFD, e.g. traffic displays, weather radar, terrain, approach charts and waypoint information.

1.6.3 Aircraft systems

1.6.3.1 General

The following sections describe only those aircraft systems which played a part at the time of the accident flight. A detailed description of the systems can be found in the manufacturer's pilot's operating handbook (POH), in chapter 6 *Systems description*.

1.6.3.2 The aircraft control system

1.6.3.2.1 General

The flight control system consists of a primary and a secondary flight control system and their associated components. The secondary flight control system consists of:

- flaps
- aileron and rudder trim tabs
- elevator tab and movable horizontal stabilizer surface
- ground spoilers
- speed brakes

Both flaps and trim systems are electrically commanded and driven by electro-mechanical actuators. The ground spoilers and speed brakes are electrically commanded and hydraulically actuated.

1.6.3.2.2 Flap system

The flap control system is an electromechanical system and is designed to actuate four flap surfaces, two per wing. Two flap actuators each drive the external flap surfaces, while one flap actuator drives the each internal flap surfaces only. The flap mechanical driveline is composed of six flexible shafts that transfer the PDU (power drive unit) output torque to six irreversible flap linear actuators (IFLA). Flap position monitoring and control consists of the following components:

- flap selector lever (FSL)
- flight control electronics (FCE)
- power drive unit (PDU)
- irreversible flap linear actuator (IFLA)
- flap position sensor unit (FPSU)
- flexible shafts

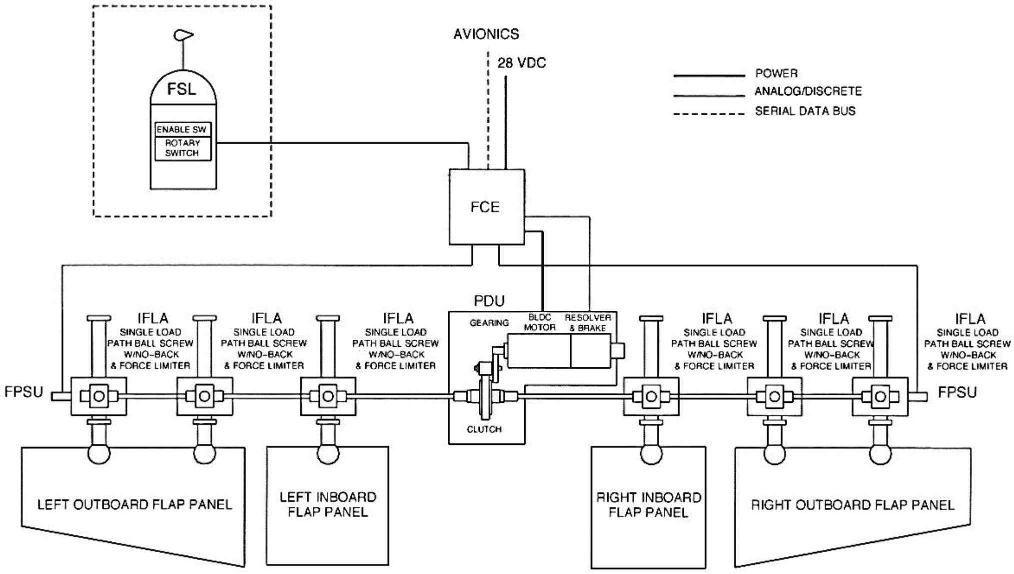
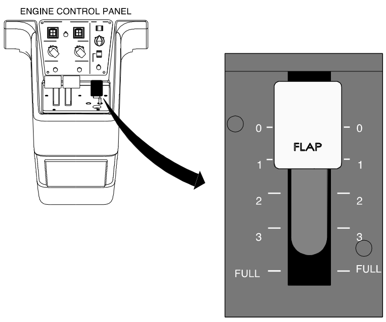


Figure 2: Flaps control schematic (POH 2908, 6-07-10)

The flap position is selected through the flap selector lever (FSL) in the cockpit. Selecting the flaps has to be done by lifting the lever to disengage it and moving it into the selected position. Intermediate positions are not valid and, if the lever is selected and kept in an intermediate position, a FLAP FAIL warning will be displayed on the CAS (crew alerting system). In this case, flaps panels will remain in the last valid position commanded.



Lever Position	Flaps Position	Detent/Gated
0	0°	Detent/Stop
1	8°	Detent
2	26°	Gated/Stop
3	26°	Detent
FULL	35°	Detent/Stop

NOTE: The flap FULL position is not available and is blocked by a mechanical stop added to the FSL.

Figure 3: Flap selector lever (POH2908, 6-07-05)

In addition, the flap position will be displayed to the pilot on the MFD (multi function display) as follows:

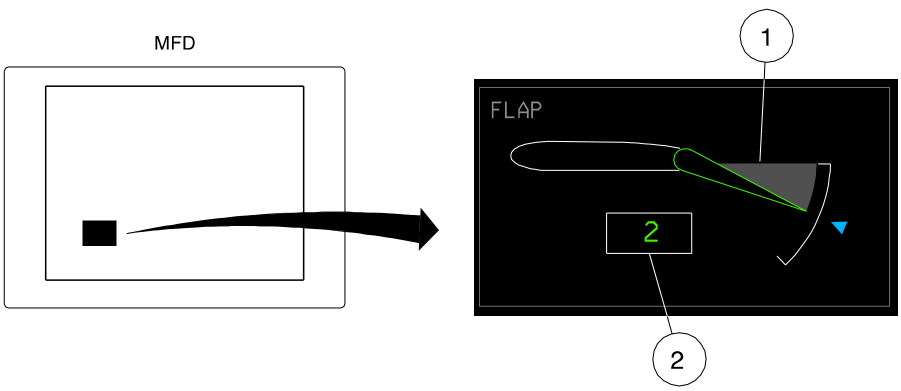


Figure 4: Flap indication (POH2908, 6-07-05)

① Displays the flap position in three different colors as follows:

GREEN: Normal system operation

YELLOW: The flap system is failed or FSL position is lost

RED: Before take off, flap is out of take off position

The pointer (cyan) shows the selected flap position (FSL position) along the scale and moves up the scale for decreasing values of flap angle. The flap scale has tic marks at each end, representing positions at 0 and FULL. If the information is lost or out of valid range, the indication will be removed.

② Displays the flap surface position numerically in three different colors as follows:

GREEN: Valid flap position

YELLOW: Flap system is inoperative but position information is available

RED: Before take off, flap is out of take off position

When the flaps are in transit, the readout is replaced with green dashes. If the flap position is invalid or unavailable, the readout is replaced with a red X.

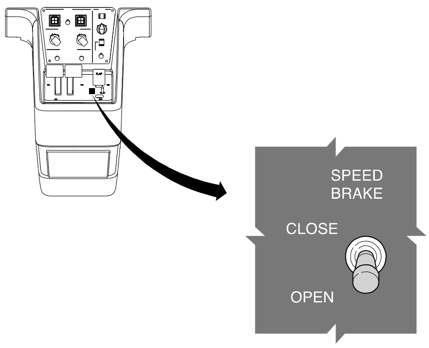
1.6.3.2.3 Spoiler

There are four spoiler panels, two in each wing. In each wing there is only one power control unit (PCU) that commands both panels. The spoiler control system performs three functions on the airplane:

- roll spoiler
- speed brakes
- ground spoiler

The roll spoiler adds more roll authority to the airplane summing to the aileron commands. On the roll spoiler function, the spoiler panels deploy asymmetrically to increase the roll capability of the airplane. This function is available with any flap position. The spoiler deflection depends on the control wheel angle and the commanded flap position.

The speed brake spoiler increases drag and dump lift, creating a steeper angle of descent, increasing the descent rate of the airplane. It is commanded by a switch located on the center console in the cockpit.



The speed brakes function is available only when the flaps are retracted. If the speed brakes are extended and if the flaps are simultaneously extended, the speed brakes retract automatically and the white message SPDBRK SW DISAG is displayed in the CAS.

Figure 5: speed brake control switch (POH 2908, 6-07-15)

The ground spoilers increase drag and dump lift on landing and rejected take off. It works without any specific pilot action, and there are three conditions to deploy the spoilers as ground spoilers:

- airplane on ground
- thrust levers in the idle position
- ground spoiler armed

The ground spoilers are considered armed when left wheel speed discrete or right wheel speed indicates wheel spinning and/or at least three of four WOW (weight on wheel) sensors indicate in air for more than ten seconds and airspeed is valid and greater than 60 KIAS (knots indicated airspeed).

1.6.3.3 Limitations

In the operator's operation manual OM B, Section 1 the following speed values are published under *1 Limitations*, among other things:

Limitations	*KIAS*
Maximum speed with flaps in position 1	*180*
Maximum speed with flaps in position 2	*170*
Maximum speed with flaps in position 3	*170*
Maximum speed with flaps in position FULL (not available)	
Flap manoeuvring speed:	
Gear up, flaps in position 0	*180*
Gear up, flaps in position 1	*150*
Gear down, flaps in position 2	*140*
Gear down, flaps in position 3	*140*
Landing gear operating speed:	
V_{LO}	*250*
V_{LE}	*250*

V_{LO} *max. speed at which the landing gear can safely be extended and retracted*
V_{LE} *max. speed at which the airplane can safely be flown with the gear extended*

1.6.3.4 Main brake system

The main brake consists of a brake-by-wire system controlled by either the commander or copilot via rudder pedals. The brake pedals of the two pilots are mechanically connected to each other. Rudder pedals actuate the pedal transducers that send the brake inputs to the brake control unit (BCU). Then, the BCU receives all brake interface signals and controls the shut off valve (SOV) and both brake control valves (BCV) for braking capability.

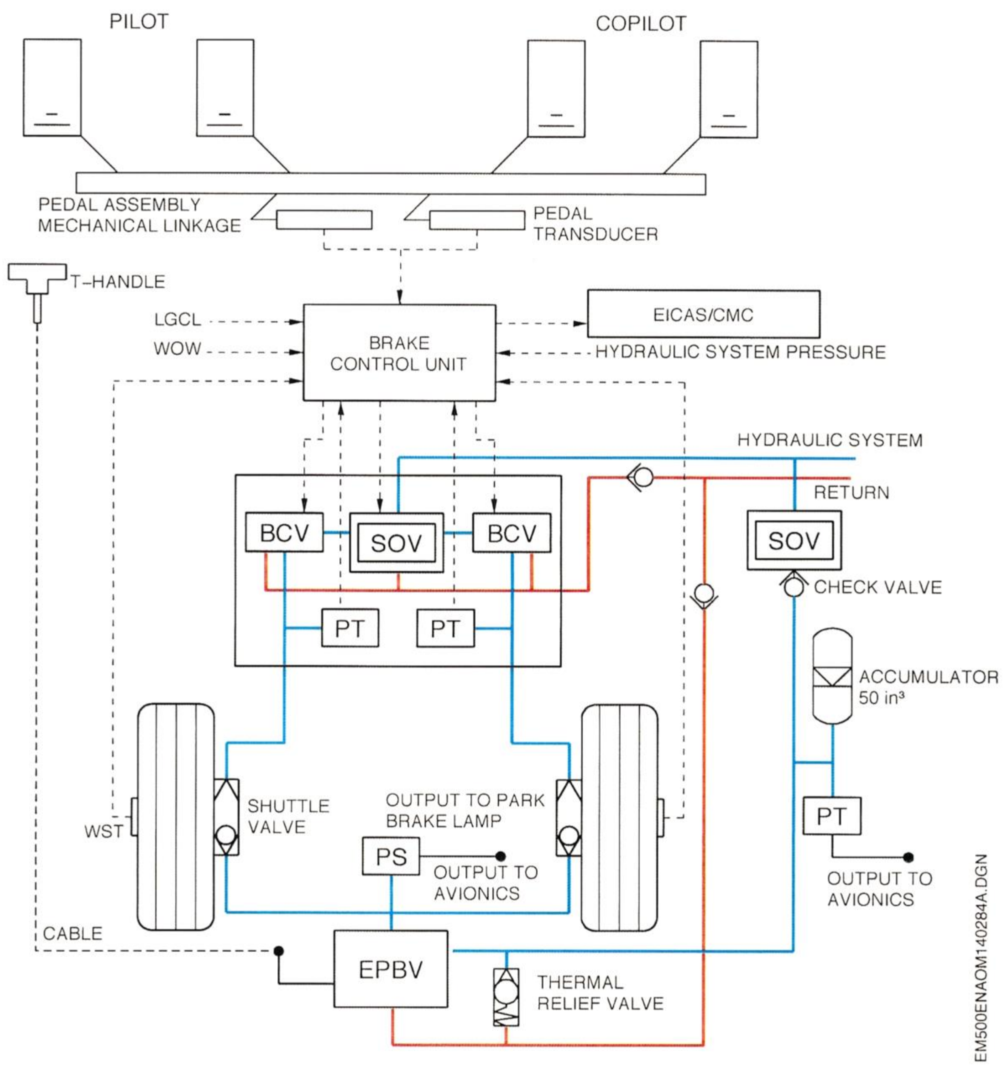


Figure 6: Brake system schematic (POH2908, 6-12-20)

The system provides differential brake capability for steering the airplane with gear free to castor from either commander or copilot brake pedals. However, basically will the airplane be steered via the nose landing gear, which is mechanically connected with the rudder pedals (left and right) to provide steering command of the airplane.

Antiskid protection prevents tire skidding and maximizes brake efficiency according the runway surface. The system provides antiskid protection when both wheel speed reference speeds are above 30 knots acceleration. For wheel speeds below 10 knots, antiskid protection is deactivated.

In addition, a so-called touchdown protection prevents brake application prior airplane on ground or spin up condition occurs. System functionality commands dump pressure when it is determined that the airplane is airborne, allowing the wheels to spin up at touchdown even if the pilot is pressing pedals in order to avoid tire blow out. Even before WOW (weight on wheel) indicate airplane "on ground", touchdown protection is cancelled when both wheel speeds exceed 60 kt. After WOW indicates airplane "on ground" the spin up threshold is reduced linearly from 60 to 30 knots in 3 seconds. Also, touchdown protection is cancelled 3 seconds after WOW indicate airplane "on ground" regardless of the wheel speed.

In case of hydraulic system failure, the emergency/parking brake is available and must be used carefully to stop the airplane. The emergency/parking brake has a pressure accumulator isolated from hydraulic system by a check valve. The emergency/parking brake is mechanically actuated and provides pressure to all brakes allowing the pilot to modulate brake pressure in emergency situations. The accumulator has sufficient pressure to provide six full-brake applications. If the emergency/parking brake is used, anti skid is not available.

1.6.3.5 Calculation of landing distance

The details on calculation of the landing distances as a function of landing mass and taking into consideration any limitations are given in Section 3 *Performance* and Section 3-45 *Approach and landing* of the aircraft manufacturer's POH.

The landing data are based on a landing technique described in Section 3-45-20 as follows:

- *"Steady three degree angle approach at V_{REF} in landing configuration;*
- *V_{REF} airspeed maintained at runway threshold;*
- *Idle thrust established at runway threshold;*
- *Attitude maintained until MLG* [main landing gear] *touchdown;*
- *Maximum brake applied immediately after MLG touchdown;*
- *Antiskid system operative*

If these performance techniques are not strictly used for a typical landing made during normal operations, the distance may be longer."

Regarding the factored landing distance, which is mentioned, for example, in the FLAP FAIL checklist (cf. Annex 13), the following is stated, among other things in Section 3-45-30:

"Factored landing distance is the actual distance to land the airplane from a point 50 ft above runway threshold to complete stop, factored according operational rules, using the landing technique described in the beginning of this section." [see above].

In this context it must be borne in mind that in this factored landing distance a reserve is included. According to JAR-OPS 1.515 this reserve is 40 %. This means that the effective landing distance (unfactored landing distance) is 60 % and must consequently be multiplied by 1.67 to obtain the factored landing distance, which corresponds to 100 %.

In the table LANDING DISTANCE CORRECTION, published by the aircraft manufacturer (QRH, PD35-1, Figure 9) it must be noticed that this reserve is not 40 % but 32.5 %.

Furthermore, concerning the use of the tables in Section 3-45-40 *Corrected landing distances - wet runways or abnormal landings* the following is also stated:

"In order to determine the landing distance on wet runways or abnormal landings, the LANDING DISTANCE CORRECTION table should be used.

Enter the factored landing distance for the selected configuration (weight/landing Flap/anti-ice setting/altitude and wind) found on the FACTORED LANDING DISTANCE tables in the FACTORED LANDING CORRECTION table.

NOTE: *Do not interpolate between distances. Use the next highest value of factored landing distance available (...)"*

For use in daily operation, pilots are provided with an adjusted selection of these tables in the checklist for emergency and abnormal cases (quick reference handbook – QRH) in the "green" register under *Landing, performance data.*

In the QRH, among other things, the following comments are made:

"NOTE:
- *The tables in the following pages provide the corrected distances for landings with different weights and runway conditions. The distances provided consider the worst case among the scenarios presented in the POH in terms of contaminent depths and landing flaps.*
- *These tables constitute a simplification and therefore do not represent the optimized landing performance for each condition. They are a source for an in-flight quick assessment of the actual landing condition if the runway becomes wet or contaminated. (...)"*

Assuming the landing data existing in the present case, i.e.:

- Landing mass 7093 kg
- V_{REF} 130 KIAS ($V_{REF\ 3}$ + 17 KIAS; QRH, EAP7-3)
- Correction factor 1.3 (QRH, EAP7-4, cf. Annex 13)

one obtains the following values from the corresponding tables, taking into account flaps in position 3, a wet runway and no wind condition (QRH, PD35-3): $V_{REF\ 3}$ 113 KIAS, factored landing distance wet 1438 m.

FACTORED LANDING DISTANCE (m) – ISA
ENGINE ICE PROTECTION OFF/ON – WINGSTAB OFF – ZERO SLOPE
NO WIND – FLAP 3

Alt. (ft)	Weight (kg)	V_{REF} (KIAS)	V_{AC} (KIAS)	V_{FS} (KIAS)	Dry (m)	Wet Unfact. (m)	Wet Fact. (m)	Std. Water (m)	Slush (m)	Wet Snow (m)
	5600	100	104	113	1009	887	1208	1497	1498	1568
	5800	102	105	115	1029					
2000	6600	109	112	123	1153	1014	1380	1827	1839	1865
	6800	110	114	125	1175					
	7000	112	115	126	1196					
	7200	114	117	128	1218	1056	1438	1937	1953	1978
	7400	115	118	130	1239					
	7600	117	120	132	1263					

Figure 7: QRH, PD35-3, FACTORED LANDING DISTANCE (NO WIND)

Taking into account a tailwind component of 10 kt (QRH; PD35-7) results in a factored landing distance of 1668 m.

FACTORED LANDING DISTANCE (m) – ISA
ENGINE ICE PROTECTION OFF/ON – WINGSTAB OFF – ZERO SLOPE
10 kt TAILWIND – FLAP 3

Alt. (ft)	Weight (kg)	V_{REF} (KIAS)	V_{AC} (KIAS)	V_{FS} (KIAS)	Dry (m)	Wet Unfact. (m)	Wet Fact. (m)	Std. Water (m)	Slush (m)	Wet Snow (m)
	5600	100	104	113	1200	1014	1380	1827	1839	1865
	5800	102	105	115	1222					
2000	6600	109	112	123	1353	1182	1610	2267	2295	2290
	6800	110	114	125	1377					
	7000	112	115	126	1404	1225	1668	2377	2409	2373
	7200	114	117	128	1432					
	7400	115	118	130	1459					

Figure 8: QRH, PD35-7, FACTORED LANDING DISTANCE (10 kt TAILWIND)

If one now applies these two values, as recommended in the checklist for FLAP FAIL, as the factored landing distance in the table LANDING DISTANCE CORRECTION (QRH; PD35-1 with rounding up to the next higher value), the result for a wet runway with the required correction factor of 1.3 is a minimum required runway length of 1142 metres without wind and 1318 m with a 10 kt tailwind.

LANDING DISTANCE CORRECTION
(FOR ABNORMAL LANDING USE ONLY)

MINIMUM REQUIRED RUNWAY LENGTH (m)								
FACTORED (V_{REF})		UNFACTORED (V_{REF})		ABNORMAL LANDING FACTORS				
Dry	Wet	Dry	Wet	1.10	1.20	1.30	1.40	
900	1035	608	760	669	730	791	851	
1000	1150	676	845	743	811	878	946	
1100	1265	743	929	818	892	966	1041	
1200	1380	811	1014	892	973	1054	1135	
1300	1495	878	1098	966	1054	1142	1230	NO WIND
1400	1610	946	1182	1041	1135	1230	1324	
1500	1725	1014	1267	1115	1216	1318	1419	10 kt TAILWIND
1600	1840	1081	1351	1189	1297	1405	1514	
1700	1955	1149	1436	1264	1378	1493	1608	

Figure 9: QRH, PD35-1, LANDING DISTANCE CORRECTION

These values are below the values of the factored landing distance because in the case of a technical problem the unfactored landing distance will be used in principle as a basis for a correction. This unfactored landing distance is multiplied by the correction factor and compared with the available runway length in order to determine the remaining reserve, which among other things serves as a decision criterion for the pilot.

It must be noted that the correction factor of 1.3 in the above table (Figure 9) relates only to the unfactored landing distance dry and not to the unfactored landing distance wet. If one were to multiply the values of the unfactored landing distance wet by the factor of 1.3, this would produce a minimum required runway length of 1428 m without wind and 1648 m with a 10 kt tailwind.

The full landing distance of 1400 m on runway 10 at the St. Gallen-Altenrhein regional aerodrome was available at the time of the accident.

In relation to the above tables, it must also be noted that for a wet runway an additional 15 % is taken into account for the factored landing distance compared to a dry runway. This corresponds to the definition as specified in JAR-OPS 1.600. In the case of the unfactored landing distance, this addition in the above table is 25 %.

In this context, it should be mentioned that in JAR-OPS 1 Subpart F, among other things, the following is defined:

"(3) Damp runway. A runway is considered damp when the surface is not dry, but when the moisture on it does not give it a shiny appearance.

(4) Dry runway. A dry runway is one which is neither wet nor contaminated, and includes those paved runways which have been specially prepared with grooves or porous pavement and maintained to retain "effectively dry" braking action even when moisture is present.

(10) Wet runway. A runway is considered wet when the runway surface is covered with water, or equivalent, less than specified in sub- paragraph (a)(2) above or when there is sufficient moisture on the runway surface to cause it to appear reflective, but without significant areas of standing water."

As a result, a grooved runway has only an impact on calculating the landing distance, if the runway surface is considered as damp, because it then can be assumed as dry. At the time of the accident the runway was wet.

1.6.3.6 Warning devices

1.6.3.6.1 General

The Phenom 300 aircraft offers the crew various possibilities for displaying system states and warning the crew of faults and abnormal aircraft configurations. Master warning and master caution lights indicate system states. Warning messages are displayed to pilots on the respective PFD in the CAS window.

In addition, various warnings, aural and visual, gain the attention of pilots. For this purpose, a terrain awareness and warning system (TAWS) and a traffic alert and collision avoidance system (TCAS) were installed on the Phenom 300 aircraft.

The following chapters describe only those warnings which played a part at the time of the accident flight.

1.6.3.6.2 Visual warnings

Anomalies or status messages are displayed to the pilots in the CAS window on the PFD (cf. Annex 8). An additional message alert button flashes and indicates new messages to the crew, until these are acknowledged by the crew.

The CAS messages are subdivided, depending on their priority, into three different levels with corresponding colours, as follows:

Warning (red): Indicates an emergency operational or airplane system conditions that require immediate corrective or compensatory crew action.

Caution (amber): Indicates an abnormal operational or airplane system conditions that require immediate crew awareness and a subsequent corrective or compensatory action.

Advisory (white): Indicates operational or airplane conditions that require crew awareness. Subsequent or future crew action may be required.

In aircraft CN-MBR during the first approach the amber message FLAP FAIL appeared, which remained active until after the landing. During this time, the white message SPDBRK SW DISAG continued to appear always when the crew tried to extend the speed brakes or set the speed brake switch to the OPEN position (cf. Section 1.6.3.2.3).

1.6.3.6.3 Aural warnings

The electronic display system has two aural warning drivers, which are responsible for generating and prioritizing aural warnings. Aural warning sound in a sequence, are never broken, and are automatically cancelled when the alerting situation no longer exists, or when they are reset manually by the pilot.

There are four aural warning priority levels, from the highest to the lowest:

- Emergency (levels 5 and 4);
- Abnormal (levels 3 and 2);
- Advisory (level 1);
- Status (level 0).

The emergency levels 4 and 5 correspond to a situation that requires the pilot's immediate action.

In the present case the aural warning HIGH SPEED was triggered shortly after initiating the go around and a few seconds later the aural warning AUTOPILOT was triggered as well. Both warnings were active during about 20 seconds.

The aural level four warning HIGH SPEED means an overspeed condition in relation to the actual aircraft configuration.

The aural warning AUTOPILOT, a level four warning as well, means that the autopilot has been disengaged. When normal disengagement occurs, AP flashes in reverse video for five seconds, and then it is removed from view. In addition the aural alarm AUTOPILOT is triggered once. If the autopilot is abnormally disengaged, the aural warning sounds continuously until acknowledged by the crew by pressing the quick disconnect button.

1.6.3.6.4 Ground proximity warning system

The TAWS generates visual and aural warnings when the aircraft approaches the terrain in a hazardous fashion. It should be noted that TAWS warnings are always classified as level 5 (emergency level). The TAWS also generates aural altitude information to inform the pilots about convergence with the runway during landing. This aural altitude information starts at 500 ft and is (optionally) called out in 100 ft increments. In addition, the MINIMUMS message occurs when the minimum altitude selected previously in the system by the pilots (minimum descent altitude – MDA or decision height – DH) is reached.

The TAWS also generates enhanced information about the terrain surrounding the current position of the aircraft, among other things by means of a database. Certain aircraft signals are monitored, processed and correlated with the above-mentioned data. If the aircraft, in terms of configuration and spatial position, is in a condition which without correction will lead to an imminent critical situation, a corresponding warning is triggered.

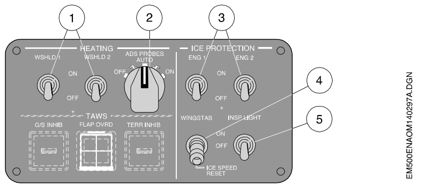
There are different modes, which provide a corresponding warning, including urgency, e.g.:

Excessive closure rate alert (ECR):
This generates the two aural warnings "< whoop > < whoop > PULL UP" or "TERRAIN, TERRAIN". In addition "PULL UP" or "TERRAIN" is displayed on the PFD/MFD. The ECR sounds when the aircraft converges with the ground at an excessive rate of descent and depends on the landing gear and flap settings of the aircraft.

Flight into terrain alert (FIT):
This warning sounds when the aircraft flies too close to the terrain and the landing gear and flap positions do not correspond to those for a landing. The aural warning is "TOO LOW GEAR" or "TOO LOW FLAPS" and on the PFD/MFD, the following message appears: "TERRAIN" or "TOO LOW GEAR" or "TOO LOW-FLAPS".

Regarding the TOO LOW-FLAPS warning it should be noted that this can be deactivated if it is desired to override this warning. Among other things, the manufacturer's Embraer Prodigy Flight Deck 300 Pilot's Guide, in the Section *Hazard avoidance* under the title *Flight into terrain alert* (FIT), states the following: *"To reduce nuisance FIT alerts on approach where flap extension is not desired (or is intentionally delayed), the pilot may override FIT alerting based on the flap position, while other FIT alerting remains in effect".* In addition, it describes how this deactivation is carried out, either via the TAWS-A page or via the MENU page using *flap override*. In both cases, the FLAP OVRD message is generated.

Separate TAWS control buttons are optionally available on the Phenom 300 aircraft. The function of these control buttons and their corresponding use is not described in the POH. Aircraft CN-MBR was equipped with this option.



NOTE: TWAS control buttons are available only on the HEATING/ICE PROTECTION control panel of airplanes with the TAWS (optional) installed.

Figure 10: HEATING/ICE PROTECTION control panel
(left: POH 2908, 6-11-05; right: in aircraft CN-MBR)

In addition, a warning about deviation from the glide slope was also available on aircraft CN-MBR. This warning sounds when the system detects that the aircraft with landing gear extended and below 1000 ft during the approach on the instrument landing system (ILS) is significantly below the glide slope. The aural warning is GLIDESLOPE and it also appears on the PFD/MFD.

On the flight in question, according to the recordings, the following aural altitude call outs and warnings were triggered one after the other on the first and second approach respectively:

First approach:

- *minimums, minimums*
- *five hundred*
- *four hundred*
- *three hundred*
- *two hundred*
- *one hundred*

Second approach:

- *terrain*
- *whoop whoop, pull up*
- *terrain*
- *minimums, minimums*
- *five hundred*
- *four hundred*
- *too low terrain*
- *three hundred*
- *too low flaps (two times)*
- *one hundred*
- *too low flaps*
- *glide slope*

It should be noted that the TOO LOW FLAPS warning was also generated by the system during the first approach. The fact that this warning is inaudible on the CVDR is because the pilots' cockpit conversations partly drowned out all other sounds and possible aural warnings.

1.7 Meteorological information

1.7.1 General meteorological situation

At high altitude, a trough extended from Spitzbergen to the Bay of Biscay. On the ground, cool maritime air flowed into Central Europe. The corresponding frontal zone was just east of Lake Constance at 12:00 UTC.

1.7.2 Meteorological information for flight preparation

The following weather data were available to the pilots for the flight preparation:

- Terminal aerodrome forecast (TAF) (30 h) for Zurich (LSZH), Geneva (LSGG), TAF (9 h) for St. Gallen-Altenrhein (LSZR) (cf. chapter 1.7.6); TAF (8 to 24 h) for various aerodromes in southern Germany.
- Aerodrome routine meteorological report (METAR) for Zurich, Geneva, St Gallen (cf. chapter 1.7.5) and various other aerodromes in southern Germany.
- Significant meteorological warning (SIGMET), airmen's meteorological information (AIRMET) for Switzerland (cf. chapter 1.7.8), and for Marseille and Milan Region. General weather charts "EUROC SIGNIFICANT WEATHER CHART" (SFC) up to FL 450.
- Wind and temperature charts at different flight levels (FL 050/100/140/180/ 240/300/340/390 and 450).

1.7.3 Weather at the time and location of the accident

According to ground analysis at 12:00 UTC there was a cold front just east of Lake Constance. The Feldberg radar data at 13:30 UTC indicated rain of moderate intensity between Constance and Bregenz. The German weather service (DWD) defines "moderate" as total precipitation from 0.5 to 4.0 mm in 60 minutes or 0.1 to 0.7 mm in ten minutes. At 13:45 UTC, the precipitation intensity was weaker and was classified in the "light" category. This means that within one hour there is a maximum of 0.5 mm precipitation, or less than 0.1 mm within ten minutes, respectively.

The westerly wind was picking up and becoming gusty behind the cold front. Between 13:00 and 13:10 UTC, the maximum one-second gust reached 23 knots. The gusts subsequently eased. Between 13:30 and 13:40 UTC the maximum one-second gust reached seven knots. The average wind was blowing at three knots from the north-west. Between 13:40-13:50 UTC the average wind was one knot. The highest value of the one-second gust was five knots.

Date/time (UTC)	Wind speed		Wind direction	
	second gust (kt)	10-minute average (kt)	Gust	Average wind
201208061300	16	11	295	291
201208061310	23	15	294	285
201208061320	17	9	271	272
201208061330	12	08	296	293
201208061340	7	3	308	321
201208061350	5	1	329	333
201208061400	17	8	291	306

Table 1: Recording of wind speed and wind direction by the anemometer south-west of the threshold of runway 28 between 13:00 and 14:00 UTC.

In the radar composite pictures based on MeteoSwiss data, the precipitation intensity was in the range of 1 to 1.6 mm per hour between 13:35 and 13:40 UTC, tending to decline.

1.7.4 Astronomical information

Position of the sun	Azimuth: 233°	Elevation: 49°
Lighting conditions	Daylight	

1.7.5 Aerodrome meteorological reports

In the period from 13:20 UTC up to the time of the accident, the following aerodrome routine meteorological report (METAR) applied:

LSZR 061320Z 28014KT 9000 +RA BKN045 18/16 Q1016 NOSIG RMK I=

In plain text, this means: On 6 August 2012, shortly before the 13:20 UTC issue time of the METAR, the following weather conditions were observed at St. Gallen-Altenrhein (LSZR) aerodrome:

Wind	from 280 degrees at 14 kt
Meteorological visibility	9 km
Precipitation	Heavy rain
Cloud	5/8-7/8 at 4500 ft AAL
Temperature	18 °C
Dewpoint	16 °C
Atmospheric pressure	1016 hPa, pressure reduced to sea level, calculated using the values of the ICAO standard atmosphere.
Landing weather forecast	No significant changes are expected within two hours of the observation period.
ATIS information	INDIA

1.7.6 ATIS reports for the St. Gallen-Altenrhein regional aerodrome

On 6 August 2012, between 12:45:50 and 13:45:20 UTC, the St. Gallen Altenrhein regional aerodrome broadcast the weather information INDIA for 12:50 UTC on the corresponding frequency in the form of the automatic terminal information system (ATIS).

"Good afternoon, St. Gallen information India. Expect ILS DME approach runway one zero, followed by visual right-hand circling runway two eight. Departure runway two eight. Met report time one two five zero. Wind three one zero degrees one one knots, visibility seven kilometres. Light rain. Clouds broken four thousand five hundred feet. Temperature two zero, due point one five. QNH one zero one six. NOSIG. Transition level seven zero. Additional information: Ground frequency not active. St. Gallen information India."

1.7.7 Terminal aerodrome forecast

At the time of the accident, the following terminal aerodrome forecast (TAF) applied for St. Gallen-Altenrhein regional aerodrome:

TAF LSZR 061125Z 0612/0621 34008KT 9999 FEW020 BKN050 TEMPO 0612/0618 SHRA FEW020 BKN040

PROB40 TEMPO 0612/0614 4500 TSRA SCT030CB BKN040

PROB40 TEMPO 0613/0617 28012G27KT=

In plain text, this means: On 6 August 2012, at 11:25 UTC, the following weather conditions were forecast for St. Gallen-Altenrhein aerodrome between 12:00 UTC and 21:00 UTC:

Wind	from 340 degrees at 8 kt
Meteorological visibility	10 km or more
Cloud	1/8-2/8 at 2000 ft AAL 5/8-7/8 at 5000 ft AAL
Trend	Between 12:00 and 18:00 UTC rain showers were expected, with 1/8-2/8 at 2000 ft AAL and 5/8-7/8 at 4000 ft AAL. These weather conditions affect less than half the forecast period in total, in the individual case less than one hour.
Conditional forecast	Between 12:00 UTC and 14:00 UTC there is a 40 percent probability that visibility will be reduced to 4500 metres, thunderstorms will set in and rain will fall. Cloud is 3/8-4/8 cumulonimbus with a main cloud layer of 5/8-7/8 at 4000 ft AAL. Between 13:00 UTC and 17:00 UTC wind predominantly from 280 degrees at 12 knots gusting to 27 knots. The probability is 40 percent.

1.7.8 Aviation meteorological information, forecasts and warnings

At the time of the accident there were no major weather phenomena hazardous to aviation (significant meteorological warning – SIGMET).

In the period from 09:00 UTC to 15:00 UTC the following general aviation meteorological information (GAMET) applied to the area of eastern Switzerland:

FASW41 LSSW 060759
LSAS GAMET VALID 060900/061500 LSZH-
CHECK FOR APPLICABLE AIRMET AND SIGMET
EASTERN SWITZERLAND
SECN I
SFC GUSTS: 12/15 30KT SIGWX: ISOL TS
ICE: 12/15 LCA MOD ABV FL110
SECN II
W/T: 5000FT 270/20KT PS11 10000FT 210/30KT PS04
FZLVL: FL120
MNM QNH: 1015 HPA

In plain text, this means:

Area of validity	Eastern Switzerland - east of a line from Basel to Steffisburg and north of a Steffisburg-Rheineck axis.
Weather phenomena SECN I	Between 12:00 and 15:00 UTC wind gusts on the ground may attain 30 knots. In addition, isolated thunderstorms can be expected. In the same period, above flight level 110, locally moderate icing is possible.
General Weather forecast SECN II	Wind/temperature 5000 ft, 270° / 20 kt, + 11 °C Wind/temperature 10 000 ft, 210° / 30 kt, + 4 °C Zero degree isotherm at 12 000 ft

	Minimum QNH 1015 hPa.

In the period from 11:50 UTC to 14:00 UTC the following airman's meteorological information (AIRMET) applied:

LSAS AIRMET 3 VALID 061150/061400 LSZH-LSAS SWITZERLAND FIR/UIR ISOL TS OBS ZURICH AREA MOV NE NC=

In plain text, this means:

Area of validity	Flight information region (FIR) and upper flight information region (UIR) of Switzerland east of a line from St-Imier to Simplonpass.
Weather phenomena	In the designated area, scattered thunderstorms were observed moving north-east subject to constant weather activity. The thunderstorms affect less than half of the surface area.
Intensity gradient	No change

1.7.9 Webcam images

Figures 11 and 12: Rorschacherberg webcam, 6 August 2012, 13:34 UTC

Figures 13 and 14: Rorschacherberg webcam, 6 August 2012, 13:44 UTC

Figure 15: Lindau webcam, 6 August 2012, 13:11 UTC

Figure 16: Lindau webcam, 6 August 2012, 13:21 UTC

Figure 17: Lindau webcam, 6 August 2012, 13:31 UTC

1.7.10 Weather according to eye witness reports

The bus driver, who was driving on the road named Rheinholzweg, commented on the weather as follows [translated from German]:

"A few minutes before, a rain cloud had passed through. When I was in the area of Buried it was still raining. The roads were wet. That's why I also saw water on the runway and on this area. I was consequently also thinking of aquaplaning. Water spraying left and right of the nose wheel. Visibility conditions were normal. It was no longer raining at this moment."

Regarding the weather, the air traffic control officer at St. Gallen-Altenrhein aerodrome control centre stated [translated from German]:

"At the time of the accident there was a weather front which was moving through. The wind was therefore very variable."

1.8 Aids to navigation

All navigation aids were in normal operation at the time of accident and were fully available.

1.9 Communications

The radio communications between the pilot and air traffic control took place without difficulties up to the time of the accident.

1.10 Aerodrome information

1.10.1 General

St. Gallen-Altenrhein (LSZR) regional aerodrome is located in the east of Switzerland, in the municipality of Thal. It is 14 km east-north-east of St. Gallen, in close proximity to the border with the Austrian Federal State of Vorarlberg on the shores of Lake Constance.

St. Gallen-Altenrhein regional aerodrome is the only Swiss regional aerodrome with scheduled flights with the status of a private aerodrome, i.e. an aerodrome without a licence or an obligation concerning operation and approval.

In 2011 a total traffic volume of more than 28 000 movements was recorded by the skyguide air navigation services company; of these more than 10 000 were arrivals and departures under instrument flight rules (IFR) and over 18 000 under visual flight rules (VFR).

In the same year just over 3000 scheduled flights with approximately 92 000 passengers and more than 70 charter flights with more than 2800 passengers were recorded.

The reference elevation of the airport is 1306 ft AMSL and the reference temperature is 23.5 °C. According to table 1-1 aerodrome reference code of ICAO annex 14, Volume 1, St. Gallen-Altenrhein regional aerodrome with an aerodrome reference field length of 1236 m is to be classified as aerodrome with code number 3 (1200 m up to but not including 1800 m). However, according to the Federal office of civil aviation (FOCA) St. Gallen-Altenrhein regional aerodrome was treated as aerodrome with code number 2.

1.10.2 History

St. Gallen-Altenrhein regional aerodrome was opened in 1927. In 1954, a 1200 m long and 30 m wide hard-surface runway was built; among other things this was also intended for military use in the event of war. In 1979 the runway was extended to 1500 m.

At both ends of the runway, at a distance of approximately 20 metres, hard surface roads run perpendicular to the runway direction. At the end of runway 10 is the road named Rheinholzweg, which is authorised only for agricultural traffic, with a permit for public transport vehicles. At the end of the runway 28 is the road named Dorftstrasse, which is authorised for public transport and which links Altenrhein with Staad and the feeder road to the freeway.

In order to mitigate the effects on traffic users on both these roads of exhaust air from military aircraft taking off, in conjunction with the extension of the runway to 1500 m and the erection of safety nets for Hunter type military aircraft, additional nets, so-called jetblast nets were erected at both ends of the runway. After the retirement of the Hunter military aircraft the safety nets were dismantled. The jetblast nets, however, were left in situ.

1.10.3 Runway equipment

St. Gallen-Altenrhein regional aerodrome has one hard-surface runway and one grass runway running parallel to it, to the north. The runways have the following dimensions:

Runway	Dimensions	Elevation of runway thresholds
10/28 hard surface	1500 x 30 m	1306/1306 ft AMSL
10/28 grass runway	600 x 23 m	

The runway 10 threshold is offset by 100 m, and that of runway 28 by 75 m. This results in a landing distance available (LDA) on runway 10 of 1400 m, and on runway 28 of 1425 m. At the time of the accident, a runway length of 1400 m was available for a landing on runway 10. At both ends of the runway approximately 60 m of hard surface with a width of 40 m is also available (cf. Annexes 10 and 12). A runway end safety area (RESA) of at least 90 m, as prescribed at the time of the accident by ICAO for aerodromes with code number 3 but not for those with code number 2, is not available.

The hard-surface runway is grooved between the two runway thresholds, i.e. several metres in addition to the runway length, (grooved runway[3]). In order to provide an accurate basis for calculation, a measurement of the current runway was carried out by the investigating authority. This measurement produced the following result:

The runway length available on runway 10 was 1400 metres, plus a further 56 metres of hard surface (stopway). The first 1328 metres of runway 10 were grooved.

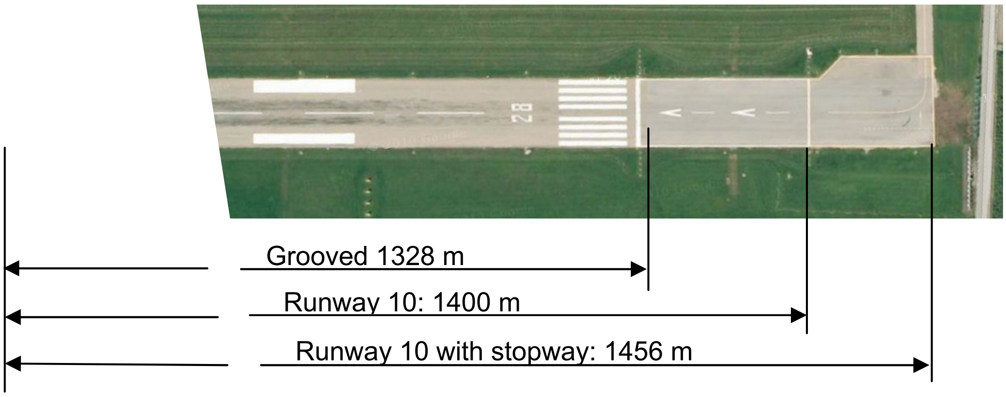


Figure 18: Longitudinal dimensions of runway 10

Runway 10 is equipped with instrument landing system (ILS). The glide slope is 4°. This value exceeds the maximum ICAO standard value of 3.5°. The approach itself is not categorised, since the runway does not meet the requirements for instrument approaches.

Runway 28 can be approached only visually, i.e. the first part of the approach is made on the ILS for runway 10 and then a circling approach must be carried out at the north of the aerodrome.

Both runways are equipped with a runway lighting system allowing arrivals and departures at night (cf. Annex 10).

1.10.4 Runway inspections and friction measurements

The airport operator describes various work processes in its operating documentation. With regard to runway inspections, it states the following in chapter 4.5.1 "Optische Inspektionen" [translated from German]:

"This process instruction describes the daily inspection of the movement area for foreign objects and obstacles in order to ensure safe flight operations."

It is further stipulated that a visual inspection has to be carried out at least twice a day and a verbal runway report must be given to the aerodrome control centre. Additional inspections are required after incidents on the runway, such as for example an aircraft leaving the runway. On 6 August 2012, such a visual inspection was conducted at 03:25 UTC, and at 11:00 UTC. No complaints were noted in the journal. There is no evidence of a further visual inspection after the accident. This circumstance must be criticized.

According to information from the airport operator, it carries out friction measurements only in the event of runway contamination by snow and ice. In the corre-

[3] The runway has a grooved surface. This means that grooves are milled into the surface at right angles to the runway direction, ensuring that when it rains the water can drain off better and no puddles of water can form.

sponding process description (chapter 4.16.5 "Einsatz Skiddometer") the following, among other things, is stated under Objective and Purpose [translated from German]:

"Readings are used to provide information on the condition of the runway for take-offs and landings and are used in the event of publication of a SNOWTAM."

It further stipulates that the skiddometer is not used if the runway is wet or dry because of the risk of damage.

Since on 6 August 2012 there was precipitation only in the form of rain, no such measurements were performed.

1.10.5 Rescue and fire-fighting services

St. Gallen-Altenrhein regional aerodrome was equipped with category 6 fire-fighting equipment for scheduled traffic and with category 2 fire-fighting equipment for other traffic. An increase from category 2 could be requested at least three hours before the scheduled time of arrival. At the time of the accident category 2 was in effect.

1.11 Flight recorders

Aircraft CN-MBR was equipped with two flight recorders: a flight data recorder (FDR) in the front fuselage and a combined cockpit voice and data recorder (CVDR) in the area behind the baggage compartment.

The CVDR recordings were used for the analyses of the accident under investigation.

The CVDR has four voice recording channels; only three of them are used. One channel is used for the cockpit area microphone (CAM) and the two other channels for the primary crew microphones. The recording time is 120 minutes.

In addition, the CVDR records the flight data at a rate of 256 words per second, over a period of 25 hours.

The recordings of the conversations in the cockpit, as well as the recordings of the digital flight recorder, were complete and could be analysed in full.

1.12 Wreckage and impact information

1.12.1 Site of the accident

The site of the accident is the eastern side of the road (Rheinholzweg) running perpendicular to the runway at a distance of 20 metres from the end of the runway, just 30 m from the end of runway 10.

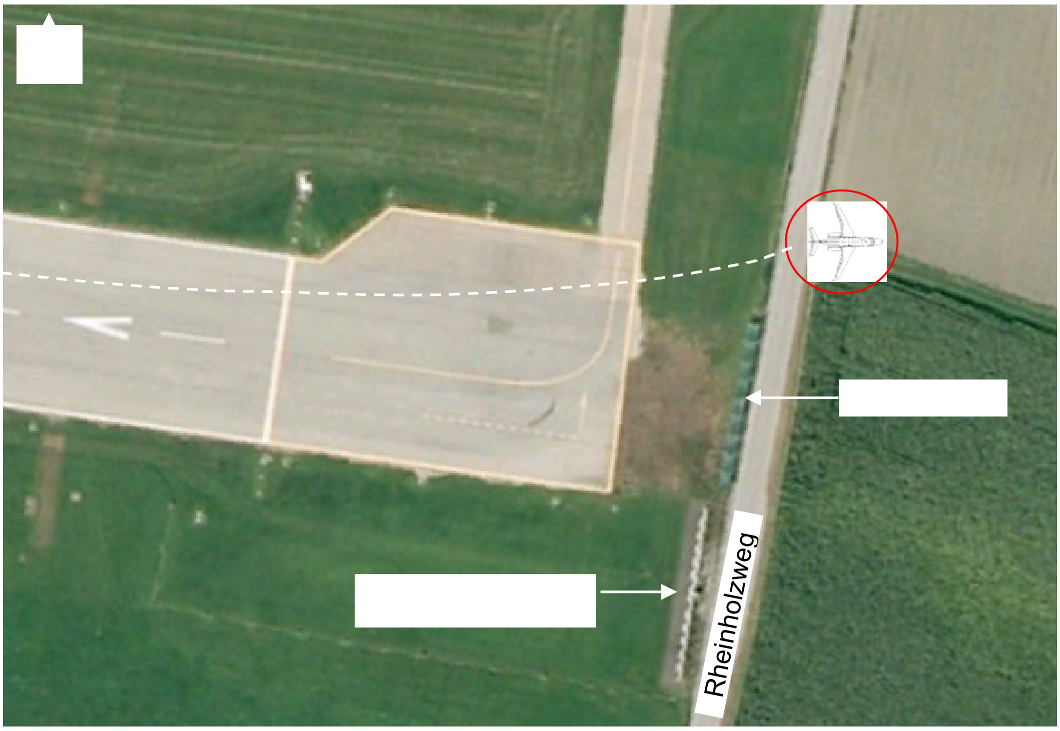


Figure 19: End of runway 10 with the road (Rheinholzweg) running perpendicular to it. Site of the accident marked in red on the edge of a maize field

The longitudinal axis of the aircraft was not parallel to the aircraft's vector of movement; it was rotated approximately 5 degrees to the left.

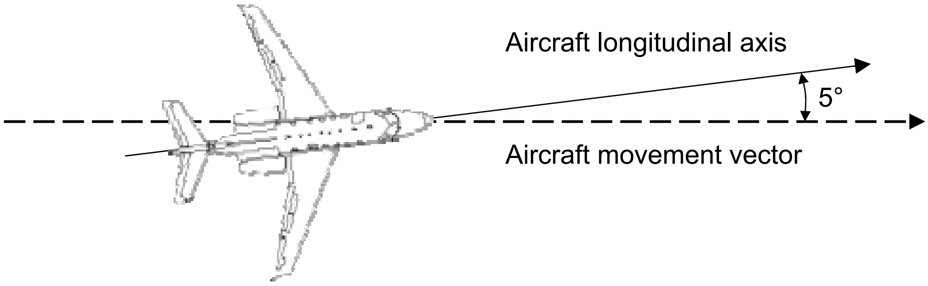


Figure 20: The longitudinal axis was rotated in relation to the movement vector

The aircraft, following a slight turn to the left, rolled past and to the north of the jetblast net which was located on the extended runway centre line. The recordings also show that during this phase the aileron was fully deflected to the left.

1.12.2 Impact

No real impact occurred, as the aircraft was negatively accelerating, or braking, only in the horizontal direction. The speed of the aircraft when it rolled over the end of the runway was 44 kt, according to the CVDR recordings. The subsequent slow deceleration caused by the roll over the soft ground, the breaching of the perimeter fence and the crossing of the adjacent road took place over a distance of approximately 30 m and was marginal.

Figure 21: Aircraft wheel marks after it rolled beyond the end of the runway

1.12.3 Wreckage

The aircraft was badly damaged during the roll over the soft ground, the breaching of the fence and the roll across the road running perpendicular to the runway.

The right main landing gear collapsed and pierced the wing surface, resulting in significant damage to the wing. The fuel tank was also damaged, causing a corresponding leak.

The lower part of the fuselage and the right wing, including the fuselage-wing panels, was severely damaged.

The two engines remained undamaged.

Figures 22 and **23:** Right main landing gear and left wing

1.13 Medical and pathological information

Approximately two and a half hours after the accident the police arranged for the crew a routine blood and urine sampling.

The blood alcohol analysis produced a negative result on both crew members. The cannabinoid content (THC-COOH) in the commander's urine was 120 µg/l. No cannabinoids were detected in the blood.

1.14 Fire

Fire did not break out.

1.15 Survival aspects

Due to the relatively low deceleration of the aircraft after it rolled off the end of the runway, there was no immediate threat to the lives of the pilots and passenger, who were strapped into their seats.

The two pilots and the passenger were able to vacate the aircraft unassisted and uninjured.

1.16 Tests and research

1.16.1 General

Since the flaps, when extending, remained at an approximately 10° position and were subsequently jammed, and since at the same time the FLAP FAIL warning was being displayed on the CAS, a visual inspection was carried out on the aircraft itself and the corresponding CVDR recordings were investigated in detail.

The same applies to the spoilers and the speed brakes, which were described by the crew as not fully functioning.

On the aircraft, the braking system was subjected to a detailed visual examination. In addition, the CVDR recordings of brake pressures were analysed in detail, as the crew reported that the brakes had functioned incompletely or not at all. In this context, the tyres on the main landing gear wheels were examined to determine whether there was pre-existing damage or damage caused by aquaplaning.

In addition, the engine data was analysed to verify the thrust performance values in idling mode, as well as their fault-free operation, on the one hand during the approach (flight idle) and on the other hand during the landing operation on the ground (ground idle). This also included an analysis of the fuel.

1.16.2 Examination of the flaps

1.16.2.1 Inspection in the aircraft

The flap selector lever (FSL) was found in position 3. In this position the flaps would have had to extend to 26°. However, they were in a position between 9 and 10°. This corresponded to the recorded values. In view of the general condition of the aircraft, no mechanical functional check of the flap system could be carried out. However, a visual inspection produced no evidence of any pre-existing defects.

Figure 24: Flap drive system

Figure 25: Flaps on left wing, 9.49° extended

In the course of the investigation, measurements of the aircraft's wiring proved to be necessary. These were necessary in order to exclude the possibility that the fault in the flap system had been caused by wiring problems. The following resistance measurements were taken:

Resistance measurement		**Test**	**Result**
From	To	Reference: AWM 27-53-50, Page 3	
P0901, Pin 76	P0917, Pin 12	Continuity test	ok
P0901, Pin 71	P0917, Pin 5	Continuity test	ok
P0901, Pin 67	P0917, Pin 13	Insulation test > 40MΩ	ok
P0901, Pin 72	P0917, Pin 6	Insulation test > 40MΩ	ok

In addition, it was also examined whether the FSL had a so-called stopper present, which prevents the flap selector lever from being set in the FULL position, as this position is not permitted. Figure 26 was taken on the day of the accident in the cockpit of CN-MBR. There was no stopper fitted. Figure 27 shows the fitted stopper. This picture was taken on another Phenom 300 aircraft.

In CN-MBR an FSL P/N 780501-7 was installed (cf. chapter 1.16.2.5).

Figure 26: FSL in CN-MBR

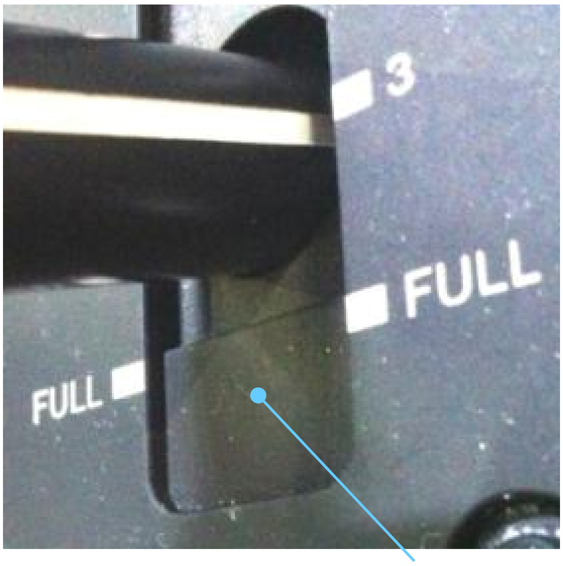


Figure 27: FSL with mechanical stopper

1.16.2.2 Analysis of the CVDR recordings

At 13:27:32 UTC the flap selector lever (FSL) was set to position 1, and the flaps began to extend. At 13:27:38 UTC, position 2 was selected (cf. Annex 4).

Between 13:27:40 UTC and 13:27:43 UTC the CVDR recorded a position 7 of the flap selector lever[4]. After that, position 3 was recorded.

At 13:27:42 UTC extension of the flaps stopped, with the left flap at 9.49° and the right flap at 9.43°. The flaps remained in these positions until the end of the recording.

At 13:27:44 UTC the CAS warning message FLAP FAIL was recorded at the same time as the MASTER CAUTION warning indicator. The latter disappeared at 13:27:49 UTC, whilst the CAS message remained until the end of the recording.

From 13:28:01 UTC to 13:37:44 UTC the flap selector lever was repeatedly moved back and forth between positions 3 and 0.

At approximately 13:37:45 UTC the above-mentioned event was repeated with position 7 of the flap selector lever.

From 13:40:16 UTC to 13:40:57 UTC the flap selector lever remained in position 3.

1.16.2.3 Analysis of the Centralized Maintenance Computer

At 13:27:45 UTC the centralized maintenance computer (CMC) registered the fault message: FCS FCE 1 / FLAP LEVER FAIL [POS].

In addition, the CMC recording showed that the Arinc 429 label 352, bit 18 (FSL Position Switch Failed CON) and label 357, bit 28 (FSL Position Switch Failed MON) were activated.

The ARINC 429 label 352, bit 18 (FSL Position Switch Failed CON) is activated when label 357, bit 20 (FSL Position Switch Invalid CON) is activated for more than 2 seconds.

The Arinc 429 label 357, bit 28 (FSL Position Switch Failed MON) is activated when label 357, bit 21 (FSL Position Switch Invalid MON) is activated for more than 2 seconds.

1.16.2.4 Examination of components

The following components were removed from CN-MBR and under the supervision of two representatives of the SAIB-AV underwent a thorough examination.

FCE 1 (Parker Control Systems Division)
P/N 462900-1007, Rev.F
SW Rev. 15
S/N 0168
MFD 1Q11

FCE 2 (Parker Control Systems Division)
P/N 462900-1007, Rev.F
SW Rev. 15
S/N 0090
MFD 3Q10

[4] The recorded position 7 of the flap selector lever is an invalid position (cf. chapter 1.16.2.6 and Annex 4)

FSL
E.T.N Sensing and Controls Division, Costa Mesa, CA
P/N 780501-7, Rev.C
S/N 1045
MFD 0912

The examination was carried out on a special test equipment, the so-called system integration lab (SIL). The SIL enables testing of the functions integrated into the flight control electronics (FCE) (flap system, spoiler system and pitch trim system). For testing the flap function, the SIL is equipped with a replica of the mechanical part of the flap system on the aircraft. It is controlled by a flap selector lever (FSL). The data delivered to the aircraft systems can be monitored on a screen.

The three listed devices from CN-MBR were first subjected to a visual inspection and then connected to the SIL. Then, a functional check was carried out according to a protocol developed specifically for this purpose by the manufacturer. On the basis of the recordings, the manipulations carried out by the pilots on the flap selector lever were known. These were reproduced as far as possible. The situation as recorded at 13:27:40 UTC and at 13:37:45 UTC (cf. Annex 4) could not be reproduced. Nor did any faults occur during a test in which the flap selector lever was moved very aggressively.

The recorded position 7 of the flap selector lever, however, could be reproduced if a wired connection between the flap selector lever and the FCE was interrupted.

1.16.2.5 Brief description of the flap selector lever

The flap selector lever (FSL) consists mainly of the selector lever, two rotary switches and two enable switches. The two rotary switches are connected to the selector lever via a gear mechanism. The two enable switches are attached to the selector lever. The FSL has five dedicated positions (0, 1, 2, 3, and FULL). These five positions are defined by a milled detent.

The rotary switches are such that they interrupt between the positions. The movable contact is connected to the aircraft earth. The enable switches are attached to the selector lever, as mentioned above. They close when the selector lever is raised and placed into another position. In this way they signal to the FCE that the selector lever is moving. Figure 28 shows the electrical wiring diagram of the FSL.

The interplay between the rotary switch and enable switch is very critical. The construction must be robust enough to handle the different ways it is manipulated by pilots.

In July 2012 Embraer released a service bulletin which replaces FSL with the P/N 780501-7 by one with the P/N 780501-9. The new FSL differs among other things by a much sturdier construction. Among other things it got a machined housing with integrated detents for accurate positioning of the switch. The mechanical play was reduced and adjustability improved.

The Embraer service bulletin SB 505-27-0010 is an inspection service bulletin. It causes operators of the aircraft to read the part number and if applicable to replace the FSL -7 with the FSL -9. Under the item "Compliance" it is recommended that the service bulletin be implemented at the first opportunity.

When delivered in December 2010 aircraft CN-MBR was equipped with a -9 FSL and a stopper was also fitted which according to the aircraft manufacturer had been fitted since August 2009 on the production line.

According to the available documentation, in April 2011 the -9 FSL was replaced with a -7 FSL (serial number 1045). In December 2011 this was again replaced with a -7 FSL (serial number 1171). However, because the latter did not pass the function test, it was removed on the same day and replaced with the original -7 FSL (serial number 1045).

During which of these three FSL replacements the stopper fitted on delivery was lost is not apparent from the available documentation.

In the aircraft maintenance manual (AMM), Rev. 2 of 26 February 2010 valid at this time, the stopper is mentioned explicitly both in relation to the removal of the FSL (AMM 27-53-01, page 3 of 8) and in relation to installation (AMM 27-53-01, *page* 7 *of* 8) *"FOR EASA CERTIFIED AIRCRAFT"*. The stopper is not mentioned *"FOR ANAC OR FAA CERTIFIED AIRCRAFT"*.

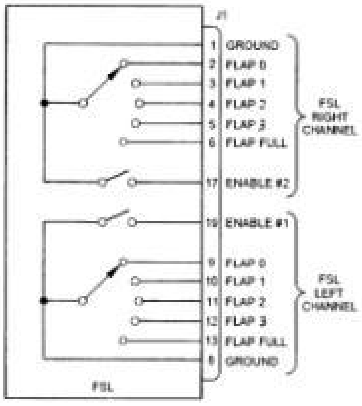


Figure 28: Wiring diagram of the flight selector lever (FSL)

1.16.2.6 Brief description of the Flight Control Electronics

Two flight control electronics (FCE) are installed on the Phenom 300. Each includes the hardware, firmware and software to perform the functions normal trim, back-up trim, flap control and spoiler control. The FCE 1 is responsible for the flap control and back-up trim functions whilst the FCE 2 performs the normal trim and spoiler control functions. The FCE are configured using pin programming in the aircraft for the corresponding functions.

The following description is essentially limited to the processing of the discrete signals of the flap selector lever (FSL). The FSL delivers two groups (channels) of signals to the FCE 1. The left FSL channel delivers the signals to the control lane and the right FSL channel delivers the signals to the monitor lane of FCE 1.

The signal inputs of the FCE are equipped with pull up resistors. For example, if position 3 is selected on the FSL, the corresponding signal input is applied to aircraft ground. This causes a change in the logical state from 1 to 0. The discrete signals at the input are then converted into binary coded numbers. In the example above, therefore expressed octally, a three is available (**0 I I**). If there is no signal input connected to ground, the octal number is seven (**I I I**). This would be the case, for example, if a wire between the FSL and the FCE was broken. Since the number 7 is invalid, the FLAP FAIL warning message is displayed in the CAS and movement of the flaps is blocked. On CN-MBR the wires of both FSL channels associated with the FULL position were isolated.

The position of the FSL is forwarded from the FCE to the electronic flight instrument system (EFIS) and via the ARINC 429 data bus (label 107) to the CVDR.

The analogue signals from the left and right flap position sensor unit (FPSU), as well as the discrete signals from the left and right FSL channel are processed separately in the control lane and monitor lane respectively. Among other things, the software monitor performs checks for miscompare, uncommanded motion or motion rate out of range. If an error is encountered, the CAS warning message FLAP FAIL is displayed on the MFD and the reason for the error is stored in the CMC. In the present case, the following message was stored in the CMC: FCS FCE 1/FLAP LEVER FAIL [POS]. As the origin of this message, the CMC recorded: FSL Position Switch Failed CON and FSL Position Switch Failed MON (cf. chapter 1.16.2.3).

When the CAS warning message FLAP FAIL appears, movement of the flaps is jammed. To restore the system, the cause of the error must be eliminated and the system must be restarted (power reset).

The FCE includes two types of built-in-tests (BITs). One is the so-called power-up BIT, which is executed on each restart. The other test is the continuous BIT, which is performed continuously in operation. Figure 29 shows a simplified block diagram of the FCE.

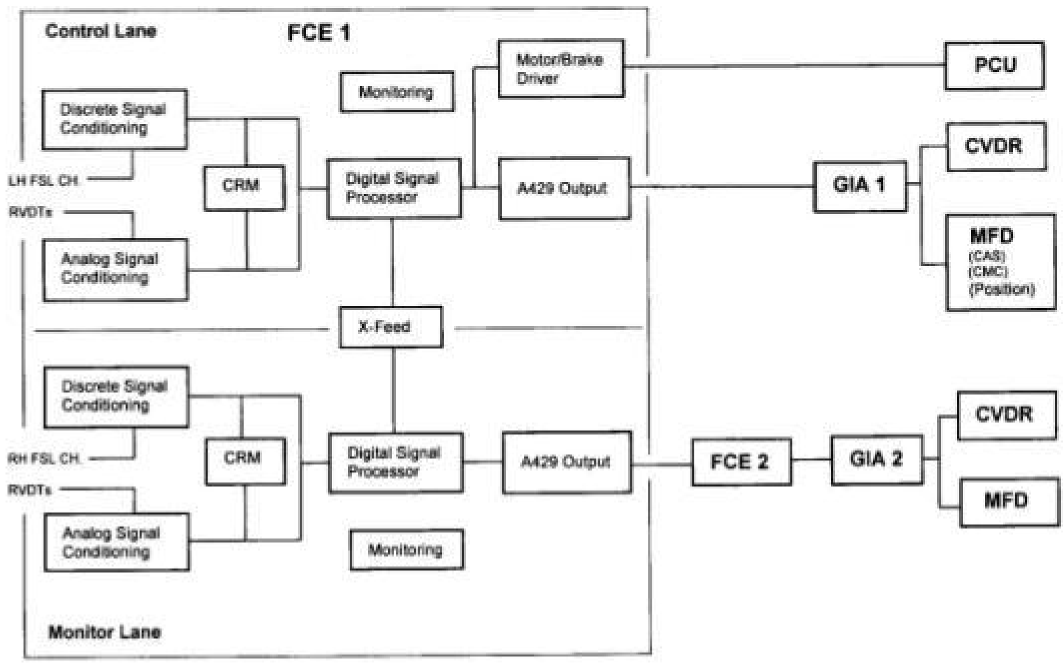


Figure 29: Simplified block diagram of the flight control electronics (FCE)

In February 2012 Embraer published a service bulletin which replaced FCE P/N 462900-1005 and -1007 respectively by one with the P/N 462900-1009. The new FCE solves various problems in relation to the flap and spoiler functions. Among other things, these included false warnings on the crew alerting system (CAS) and problems occurring during the power-up test.

Revision 01 of the Embraer service bulletin SB 505-27-0009 was released on 8 February 2012. Under the item "Compliance", it is recommended that the service bulletin be implemented at the first opportunity.

Aircraft CN-MBR was equipped with unmodified -1007 FCEs. This had no influence on the accident.

1.16.3 Examination of the spoilers

1.16.3.1 Inspection on the aircraft

The speed brake switch was found in the CLOSE position. The spoilers were retracted. In view of the general condition of the aircraft, no mechanical functional check of the spoiler system could be carried out. However, a visual inspection produced no evidence of pre-existing deficiencies.

1.16.3.2 Analysis of the CVDR recordings

Shortly before the flap selector lever (FSL) was set to position 1 at 13:27:31 UTC, the speed brake switch was set to the OPEN position. The extended speed brakes were then retracted normally and at 13:27:42 UTC the SPDBRK SW DISAG message appeared on the CAS.

At 13:27:56 UTC the speed brake switch was returned to the CLOSE position, and after a slight delay the SPDBRK SW DISAG message disappeared.

Between 13:38:15 UTC and 13:39:30 UTC, the speed brake switch was twice set to the OPEN position and then back to the CLOSE position, again triggering the SPDBRK SW DISAG message. The speed brakes themselves remained retracted.

During the landing, at 13:40:29 UTC, the ground spoilers were extended when the main landing gear wheels spun up to approximately 60 knots.

1.16.3.3 Examination of components

As described in chapter 1.16.2.4, the two FCEs from CN-MBR underwent a detailed inspection. Both FCEs were tested at the same time on the so-called system integration lab (SIL). The spoiler control function is performed, as described in chapter 1.16.2.6, by FCE 2. The SIL was fitted with hydraulic actuators to simulate the power control units (PCU) in the aircraft. With this set-up, it is possible to test the flap control and spoiler control functions as an integrated system. The tests which were carried out were free from any faults.

1.16.4 Examination of the brake system

1.16.4.1 Pre-history

On 6 February 2012 the brake control unit (BCU) P/N DAP00100-06, S/N 230000170 was removed from aircraft CN-MBR and sent to the manufacturer, to upgrade the unit to the -07 software. A replacement BCU was installed.

On the occasion of further maintenance work by the aircraft manufacturer, from 3 to 7 July 2012 in Le Bourget, among other things work was performed which was requested by the aircraft operator. The following was noted on a corresponding task card (no. W1498C-003):

"Work required: *following technical log book #431 entry #1, problem with the brake system during landing and taxi (right side unsynchronized with the left side – uncommanded braking).*

Action: *found brake control module leaking and "dissymmetrical braking value" on CMC. Brake control module must be replaced."*

A brake control module was replaced and in the process it was found that a BCU with the P/N DAP00100-03 was installed. This must have related to the BCU replacement on 6 February 2012. This unit was then replaced by the BCU DAP00100-07, S/N 230000170 modified in the meantime.

1.16.4.2 Inspection on the aircraft

Because of the general condition of the landing gear and the wheels, no functional checks could be carried out on the aircraft.

1.16.4.3 Analysis of the CVDR recordings

The analyses of the CVDR show that the brakes, as well as the anti-skid system worked correctly (cf. Annex 14). At the same time as the wheel spin up, the brake pedals were operated and the brake pressure was built up as a function of the pedal position without delay. However it has to be noticed that after landing the brake pedals were activated only hesistantly and that only shortly before reaching the runway end, only 14 seconds after the weight on wheel signal confirmed the aircraft on ground, the brake pedals were in the mechanical stop.

It is evident that after the transition from the grooved runway to the hard surface without grooves, the brake pressure varied more, or rather pulsated, which is attributable to the behaviour of the anti-skid system.

It is also evident that towards the end of the runway the right brake pedal was no longer being depressed and therefore the brake pressure was correspondingly reduced.

1.16.4.4 Examination of components

After the accident the brake control unit (BCU) P/N DAP 00100-07, SN 230000170 has been sent to the vendor for detailed examination.

The BCU contains a non-volatile memory (NVM) which stores fault data. There in, not only internal faults are being stored but also relevant faults that occur in the braking system (wheel speed transducer failure, brake position transducer failure, brake pressure failure).

A new recording period starts when the BCU is powered-up. Power-up #78 was counted at the beginning of the accident flight. An analysis of the memory revealed that since the power-up #23, including the accident flight, there were no faults of the braking system recorded.

Besides the analysis of the non-volatile memory, the vendor of the BCU also analysed the data recorded by the CVDR (independently of the analysis by the SAIB) with the following result: *"There is no evidence of malfunction of the braking system."*.

1.16.5 Examination of the tyres

The investigation of the tyres of the nose wheel and of the two wheels of the main landing gear indicated no visible abnormal traces. The corresponding forensic report notes, among other things [translated from German]:

"From the forensic viewpoint, there are traces on the three tyres which resulted from normal use. On the other hand, there are traces on the tyres concerned which may have been produced as the result of recent stress beyond normal usage during the accident (e.g. sustained and hard braking, rolling over the field, rolling over the aerodrome perimeter fence, rolling over gravel and the curb/road, rolling over aircraft components, etc.).

On the other hand, the relatively evenly tread wear of the main landing gear tyres (based on the measured depths of the longitudinal grooves, the general appearance and the general appearance of the tread) indicate from the forensic point of view that there was no defect in the aircraft's "anti-skid system" at the time of the accident.

Finally no melt marks were present on the tread of the three aircraft tyres examined suggesting that the present accident did not involve "rubber reversion hydroplaning", a type of aquaplaning."

1.16.6 Examination of the engines and fuel

The examination of the engine data indicated that these were within the range of the certificated values, both in the air (flight idle) and on the ground (ground idle).

It should be noted that the software of the engine control system (full authority digital engine control - FADEC) was the version 002, dated 19 April 2011. This version corresponded to the status which was current at the time of manufacture of the aircraft.

In the meantime the manufacturer published service bulletin (SB) 505-73-0001, which among other things reduced idling power on the ground. The revision 1 of this SB was issued on 30 October 2012. This revision describes the process for upgrading the FADECs to software version 4.3. Since the publication of the revision did not take place until October 2012, this SB could not be implemented at the time of the accident.

The chemical analysis of the fuel, in both the left and right tank, showed that the fuel complied with the specification. The following points were examined: appearance, flashpoint and freezing point, copper corrosion, evaporation residue, MSEP-A, density at 15 °C, FAME and water content. In addition, a boiling point analysis was performed.

The corresponding investigation report states [translated from German]: *"The present test object complies with the specification in the required points."*

1.17 Organisational and management information

1.17.1 The operator

The operator Dalia Air is specialised in international executive flights. The operator is based in Morocco and at the time of the accident operated two Embraer Legacy 600 aircraft and one Embraer Lineage 1000 in addition to the Embraer Phenom 300 involved in the accident.

1.17.1.1 Procedures for operation of the aircraft

The operating procedures and regulations relevant to the investigation are laid down in the operator's two operations manuals A and B (OM).

Within the airline company, in addition to his flying function, the copilot was employed as quality and flight safety manager. The corresponding duties are contained in the OM A, in chapter 1.2.7. With regard to his responsibilities, chapter 1.7.2.2 states the following, among other things:

"The Quality and Flight Safety Manager is monitoring the adequacy of and compliance with procedures, (company) rules and regulations required to ensure safe operational practices and airworthy aircraft."

In addition, the OM A chapter 4.1.1 states the following, among other things, for the operation of all the operator's aircraft:

"A two-pilot crew is the minimum required on all flights of Dalia Air aircraft.

Dalia Air will designate one pilot amongst the flight crew, qualified as a pilot-in-command, as Commander and one pilot as First Officer on each flight."

In addition, chapter 4.2 *Designation of the commander* states the following, among other things:

"If a management pilot or training captain is assigned to an operating seat, he is the Commander whichever seat he occupies.

The Commander may delegate the conduct of the flight to another suitably qualified pilot. The change of command shall be reported to the Flight Operations Department and shall be recorded in the Journey Log."

The copilot in his function as the operator's quality and flight safety manager was a "management pilot" and therefore the commander. In the journey log it was not stated that he had ceded this function to the commander of the flight involved in the accident.

The OM B describes the procedures for crews in normal, abnormal and emergency situations. They contain general procedures and aircraft-specific procedures.

Chapter 2.1.3 *Briefings* states the following for the approach, among other things:

*"**Approach briefing** - It is recommended to accomplish the briefing during cruise flight. The FMS, AFCS preparation for arrival and approach should be performed by the PNF at the PF's request.*

The Approach briefing should be accomplished by the PF. The PNF shall verify the STAR and APP on FMS, proper NAV and AFCS settings, and taxi procedures after landing. The active flight plan should be checked by verifying the charts against the MAP display and FMS."

Throughout the descent and approach from 10 000 ft QNH up to landing, i.e. from 13:23 UTC to 13:40 UTC, the CVDR audio recordings contain nothing which indicates that an approach briefing had been carried out.

In addition, chapter 2.1.10 *Callout procedures* in the OM B essentially states that all actions by the two pilots should take place in a so-called closed loop procedure. In other words, an action is ordered by one pilot and carried out by the other pilot. The latter acknowledges the action performed, and this is again checked by the first pilot.

Throughout the approach, the go around and the second approach until after the landing, nothing in the recordings indicates that work was carried out in accordance with this closed loop procedure.

Chapter 2.2.2 *Normal checklist* states what type of items the crew must process at which point in time. The crew always has this checklist at hand on a special paper. An extended checklist is available to the crew in the OM B in chapter 2.2.3 ff. There, for example, chapter 2.2.11 *Expanded landing checklist* states precisely which commands must be carried out with which acknowledgements. The yaw damper, landing gear, flaps and airspeed are explicitly addressed in the before landing checklist. According to the CVDR recordings, clear working according to this checklist cannot be established.

Concerning the standard operating procedures (SOP) the following is stated for the approach in chapter 2.3.8. *Approach*:

2.3.8. APPROACH

LSP : During Approach Passengers ADVISE – FUEL XFEED Knob……..OFF
LSP &RSP: Altimeters (pilots and IESI)……… SET & X-CHECK
Prior to Start of Arrival ………… Ensure that all of the required information regarding approach and landing is known and confirmed.

PF	PM
Green source shall be selected at least on one side before intercepting Localizer	
When on LOC intercept heading and cleared for the approach	
Approach Armed	
Flaps 1	Check the actual speed is below 180kts, select flaps to1, hold the Flap lever until on MFD flap indicator indicates flaps 1 and call:
Verify proper flap setting ON MFD indication	Flaps 1 Set
Switch ON the APP mode and check LOC and GS armed indication on PFD	Check LOC and GS armed indication on PFD
	Check
At first positive LOC movement:	
	Localizer alive
When LOC captured. Both pilots verify that PFD – LOC indication is green:	
Set Runway heading	Localizer captured, Runway heading _ _ _
Runway heading _ _ _ Set	
At first positive G/S movement:	
	Glide slope alive
Check	
It is recommended to select Flaps 1 no later then when one dot above G/S. If VIS < 2000m or Ceiling < 500 ft, it is mandatory to be stabilized in the landing configuration no later then at the FAF	
When one dot above G/S	
	One dot
Gear down, Flaps 2	Check the actual speed not below 150kts , select Gear down, select Flaps to 2, hold the Flap lever until MFD indicates Gear Down 3 greens, flaps 2 and call
	Gear down 3 greens, Flaps 2 Set
Check	
When G/S captured. Both pilots verify that PFD – GS indication is green:	
Check GS is green, Select Missed approach altitude:	Glide slope captured Missed approach altitude _ _ _ _
Missed approach altitude _ _ _ Set	
Passing Outer Marker under IMC, after checking that the altitude over the OM is correct.	
	"OUTER MARKER ____FEET ALTITUDE CROSS CHECKED"
ALTITUDE CROSS CHECKED	
Landing Flaps Before Landing Checklist	Check the speed not below 140kts, select Flaps to 3, hold the Flap lever until MFD indication indicates speed 120kts flaps 3 and call:
Verify proper flap setting ON MFD	Flaps 3 Set Perform Before Landing Checklist
Any significant deviation from the Localizer or GS (1/4 dot) or from target speed (+10/-0 KIAS).	
	"LOC" or "GLIDE" or "SPEED" as appropriate
100 ft above DA if under IMC.	
	"ONE HUNDRED"
	At DA(DH) : Minimums
Upon visual contact with the approach lights or with the runway.	
	"APPROACH LIGHTS" or "RUNWAY IN SIG HT" as appropriate
Reaching DA without visual contact. Perform Go-Around Procedure	
Go-Around	

Figure 30: Standard procedure for an approach published in the OM A

Chapter 2.3.11 *Go around* states the following:

2.3.11. GO AROUND

PF	PM
- Go around, Flaps 1 - TO/GA Button…Pressed. - Thrust Levers… TO/GA Rotate the airplane following the flight director guidance. In case the flight director inoperative, rotate the airplane according to the table below: - Landing Flaps Position : Go-Around Pitch Angle 8.0° Select flaps according to the table below: Landing Flaps Position 3 : Go-Around Flaps Position 1 Note: Do not press the TO/GA button after selecting go-around flaps. . - Minimal speed is Vac	Flaps 1 Check the GA indication on PFD, thrust setting, speed and proper pitch attitude. Select Flaps 1. When a positive rate of climb is verified on the altimeter and VSI / min 500 ft/min / call : Positive rate
Gear Up, Engage Heading or FMS and LNAV	Select Gear Up. Select HDG or FMS and LNAV when available, check that the requested mode is captured on the PFD. Check that TO/GA power is set. When Gear is indicating up and flaps 1:
Check the Gear is UP and Flaps 1 set and proper mode engaged	Gear Up, Flaps 1, Power Set, Heading or LNAV Engaged
Check	
	Call ATC, say intentions or request
	Call at : Alt 1000 ft V2 + 10 KIAS
check	
At 1000 ft (acceleration altitude) and V2 + 15 KIAS Proceed as in a normal takeoff. - AP…ON, - FLC..160 KIAS or as required by published procedure - Flaps….UP - Thrust Levers: CON/CLB Call for After Takeoff checklist	Autopilot: engage. Flight Level Change: press. Speed: 160 KIAS. Retract flaps on schedule. check proper indication on PFD and MFD. Perform After Takeoff checklist
	1000 ft below Missed App Altitude
Check	One to go

Figure 31: Procedure for a standard go-around published in the OM A

In addition, OM B chapter 2.11 *Steep approach* states the following, among other things:

"The information here is based on AFM Supplement 7 and is applicable when conducting approaches with a glide path angle greater than standard (normally 3°). The limitations, operating procedures and performance information for steep approach operations are based on the use of an approved approach path guidance system."

Runway 10 on St. Gallen-Altenrhein regional aerodrome is equipped with an instrument landing system (ILS), and the glide slope is 4°. According to the definition in the operator's OM B, the ILS approach made was therefore classified as a steep approach.[5]

Chapter 2.11.1 *Limitations* states the following, among other things:

"Operation is not permitted if the STEEP APPROACH mode is not armed" and *"The Steep Approach must be done at Landing Reference Speed (VREF)"*.

According to the aircraft manufacturer, there is no supplement 7 in the AFM, the STEEP APPROACH is not certified and nor is there a STEEP APPROACH mode on the Phenom 300 aircraft.

[5] According to ICAO, an approach is called steep approach whenever the glide angle is equal to 4.5° or more.

1.17.1.2 Procedures for abnormal situations

Regarding use of the checklist in abnormal situations, the OM B states the following in chapter 3. *Non-normal procedures*, among other things:

"Non-normal checklist use commences when the airplane flight path and configuration are properly established. Only a few situations require an immediate response (such as stall warning, ground proximity PULL UP and WNDSHEAR warnings, and rejected take off). Usually time is available to assess the situation before corrective action is initiated. All actions should be coordinated under the captain's supervision and performed in a deliberate, systematic manner. The flight path should never be compromised!"

"Checklist items are read aloud by the pilot monitoring (PM) with the appropriate action being taken by the crew member in whose area of responsibility each control is located and the action is confirmed aloud by the another crew member."

In relation to the unprepared evacuation of the aircraft in emergency situations, the OM B states the following in chapter 11.3. *Unprepared emergency evacuation* under 11.3.2 *Unprepared evacuation checklist:*

"Prior to an evacuation, the crew shall execute the critical items of the Evacuation Checklist (See Emergency Procedures). The exit by which the aeroplane is to be evacuated should always be included in the evacuation command."

The above-mentioned emergency procedures are to be found in the quick reference handbook (QRH) (EE-2) and under emergency evacuation the following is stated:

EMERGENCY EVACUATION

Thrust Levers.................IDLE
Emergency/Parking
Brake..........................ON
START/STOP Knobs......STOP
SHUTOFF 1 & 2
Buttons........................PUSH IN
PRESN MODE Switch....MAN
DUMP Button.................PUSH IN
ATC ....NOTIFY
Emergency
Evacuation ....PERFORM
BATT 1 & 2 Switches.....OFF

END

Figure 32: Emergency evacuation checklist according to the QRH

On the basis of the CVDR recordings, it cannot be stated whether this checklist was completed accordingly. According to the commander's statement, he looked after the passenger and the copilot executed the items in the emergency checklist. The commander said: *"the passenger was very much afraid so I took care of her. The copilot did the engine shut down and all that, he opened the door."*

1.17.1.3 Pilot's handbook

As described in chapter 1.6.3.1, the pilot's operating handbook (POH) describes features including the Phenom 300 systems. The POH and the airplane flight manual of the manufacturer Embraer were found in aircraft CN-MBR. The handbook and manual were in the left-hand locker immediately behind the cockpit.

It was apparent that the following note regarding the flap selector lever (FSL) was missing from the description of the system in this POH (Section 6-07-05, page 2, revision 1 dated 5 July 2010): *"**NOTE:** the FULL flap position is not available and is blocked by a mechanical stop added to the FSL."*

The corresponding note was first published in revision 2 dated 31 March 2011. This revision was not present in the POH on the aircraft. Sampling showed that other pages published with revision 2 had, however, been replaced. Revision 3 dated 4 November 2011 had also been implemented in the POH. It should be noted in this context that no changes were published in revision 3 regarding the FSL compared to revision 2.

1.17.2 Aircraft manufacturer

On 19 July 2012 the aircraft manufacturer published service bulletin (SB) No. 505-27-0010, entitled: *"Flight Controls - Inspection / Replacement of the Flap Selector Lever"*. Aircraft CN-MBR (S/N 50500025) was affected by this SB.

This SB stipulates, among other things:

"HISTORY

Investigation has revealed the possibility of a non-certified flaps selector lever PN 780501-7 being installed on EMB 505 "PH300" aircraft. This is due to the fact that the AIPC has classified this lever as two-way interchangeable with lever PN 785051-9.

OBJECTIVE

To inspect the part number of the flap selector lever (FSL) installed and if necessary provide instruction to do the replacement."

In Figure 1 of the SB (cf. Annex 15) the following is stated with regard to the stopper:

"If applicable, when you lift the FSL make sure that the stopper remains in its position."

It must be assumed that the aircraft manufacturer, with this *"applicable"*, was taking account of the fact that according to the AMM (aircraft maintenance manual) two types of certification existed. Aircraft which were certified according to ANAC or FAA did not have a stopper fitted and aircraft certified according to EASA did have a stopper. In the AMM, therefore, in contrast to the SB, two different exploded drawings existed:

AMM 27-53-01 Figure 401, page 4 of 8 (Rev 2 – Feb 26/10) *"EFFECTIVITY: FOR ANAC OR FAA CERTIFIED AIRCRAFT"*

AMM 27-53-01 Figure 402, page 5 of 8 (Rev 2 – Feb 26/10) *"EFFECTIVITY: FOR EASA CERTIFIED AIRCRAFT"* (cf. chapter 1.16.2.5).

Nowhere in the SB is it stated which serial number corresponds to which certification variant. According to the aircraft manufacturer, aircraft CN-MBR was EASA certified.

Under compliance the SB states: *"Embraer recommends that this bulletin be accomplished at the first maintenance opportunity."*

This SB had not been implemented on aircraft CN-MBR.

1.18 Additional information

1.18.1 Statements of the crew members

The Commander commented on the landing and braking performance as follows:

"I applied full brakes, after about the last quarter of the runway the aircraft slid to the left. I tried to maintain runway centerline, there was no braking effect anymore."

"At the beginning everything was normal and I was sure that the aircraft would stop. When it slid to the left, there was no braking effect anymore and I lost control of the brakes although I kept the pedals pressed down. Then it happened so fast, there was no time left for any emergency braking."

The copilot commented on the landing:

"The landing was perfect, right on the threshold. After touchdown we could brake normally. Towards the end of the runway the aircraft yawed to the left. I think we entered a slippery part of the runway. From that time on, the aircraft was no longer controllable and we overshot the runway by aircraft inertia less than ten metres."

1.18.2 Air traffic control officer's observations

The ATCO stated that he had observed CN-MBR on his radar display and had visually monitored the actual final approach until the go-around. Regarding this part of the approach, the ATCO stated the following [translated from German]: *"He was extremely way too fast, I never saw any possibility of him being able to land. He broke off the approach with a low go around, almost on the runway. At a guess, he would have touched down in the middle of the runway if he had continued the approach and landed."*

In relation to the question of why the ATCO did not ask for the reason for the go-around, the ATCO replied as follows [translated from German]: *"To me it was clear that he was too fast. That's why I didn't ask at all."*

For this reason he gave the crew clearance for a standard missed approach procedure and then immediately instructed the crew to make contact again with the "Zurich arrival" air traffic control unit.

1.19 Useful or effective investigation techniques

None.

2 Analysis

2.1 Technical aspects

2.1.1 General

The investigations into the relevant systems as described in chapter 1.16 did not produce any indications of pre-existing faults which might have caused or influenced the accident. With the exception of the flap system, all these systems also functioned without fault during the flight involved in the accident.

2.1.2 Flap system

Between 13:27:40 UTC and 13:27:43 UTC the combined cockpit voice and data recorder (CVDR) recorded the invalid position 7 on the flap selector lever (FSL). Positions 1, 2 and 3 had previously been selected (cf. Annex 4). The following table shows the chronological sequence of the FSL positions:

UTC	FSL position	recorded position	Remarks
13:27:32	1	1	
13:27:38	2	2	
13:27:40	3	3	Recording of position 7 is possible shortly after, if the FSL has been set into the position FULL, e.g.: 13:27:40.01 UTC
13:27:41	4 (FULL)	7	cf. Annex 4
13:27:42	4 (FULL)	7	cf. Annex 4
13:27:43	3	3	Recording of position 7 is possible until shortly before, if the FSL is still set into the position FULL, e.g.: 13:27:42.59 UTC

Table 2: Recording of the FSL position in chronological sequence

The position of the flap selector lever is only recorded once per second. It was thus possible that the lever was in position 7 for almost three seconds although it was only recorded twice.

As mentioned in chapter 1.16.2.2 the extension of the flaps was consequently jammed and the CAS warning message FLAP FAIL was displayed.

As described in chapter 1.16.2.6, an invalid position 7 is always recorded when a wired connection between the left FSL-channel and the FCE 1 is interrupted, regardless of the position of the FSL. In the CN-MBR the wired connections of both FSL channels associated with the FULL position were isolated and thus permanently interrupted.

If under these conditions the flap selector lever is set to the FULL position for more than two seconds, the invalid position 7 is recorded. At the same time the flaps are jammed and the FLAP FAIL warning is displayed on the CAS.

Normally a "stopper" prevents the flap selector lever from being set to the FULL position. At the time of the accident this position had not yet been cleared by the aircraft manufacturer. In the case of the CN-MBR aircraft there was no stopper available on the flight involved in the accident (cf. chapter 1.16.2.5).

It seems that upon instruction from the commander the copilot set the flap selector lever to the FULL position for a short time (but for longer than two seconds) and then returned it to position 3. The recordings confirm these manipulations and explain the blockage of the flaps.

2.2 Human and operational aspects

2.2.1 Crew

2.2.1.1 Implementation of procedures

Working together as a crew requires the tasks of the individual crew members to be defined and coordinated with one another. These entries can be found in the operator’s operations manuals (OM). As mentioned and sometimes cited in chapter 1.17.1.1, these are very detailed.

In the early 1980s the occurrence of numerous accidents in which insufficient co-operation between individual crew members was a causal factor led to the development of "crew resource management" (CRM) as training for flight crews and its consequent incorporation as part of (further) training for airline transport pilots. Crew resource management is designed to raise awareness of the fact that on board an aircraft not only technical understanding, but also the interpersonal domain are decisive factors for the safe conduct of flights. Both pilots were certified as having attended a corresponding CRM course *("Rafraîchissement en Facteurs Humains pour Personnel Aéronautique"* [Refresher course, human factors for aviation personnel]) on 19 December 2011.

The analysis of the CVDR recordings does not in any way indicate cooperation in accordance with CRM principles as contained in the operations manual of the operator.

This is even more incomprehensible as the copilot was also the operator's quality and flight safety manager and according to the company specifications was thus responsible for practical compliance with the procedures laid out and defined in the operations manuals.

2.2.1.2 Cooperation in the cockpit

After the copilot had listened to the information at cruising altitude (automatic terminal information system – ATIS) for St. Gallen-Altenrhein aerodrome, the approach to runway 28 was discussed in accordance with the instructions on the screens in the cockpit. However, an approach briefing as described in chapter 2.3.8 of the operations manual A (OM A) did not take place. This fact is reflected in the confused discussion between the crew members concerning the published approach altitudes. Similarly, the problem and the consequences of an approach on a glide slope of four degrees with a tailwind and the fact that the flap position FULL was not available were not addressed.

When at 13:26:52 UTC the air traffic control officer for St. Gallen-Altenrhein regional aerodrome offered runway 10 as an alternative during the first call for the approach, the landing gear was extended during the radio communication. This action was neither ordered by the commander nor confirmed by the copilot. This non-verbal action suggests that the crew had become aware of the approach classification as regards speed and configuration for a direct approach. It is also astonishing that until the confirmation by the crew for a landing on runway 10 at 13:27:06 UTC and in the subsequent period there was no exchange of words between the pilots in this regard. Decision to land on runway 10 would have required a corrective approach briefing by the commander.

There is evidence that the crew at this stage were already behind the progress of the flight in mental terms. This is the only way to explain the fact that they did not pay the necessary attention to the prevailing wind during the descent. In addition, wind information was provided to the crew upon each initial radio contact.

Regardless of the display selection on their primary flight display (PFD), the crew could have informed themselves about the prevailing wind at any point during the entire approach (cf. Annex 8). The time pressure on the crew is also evident in the fact that the flaps were extended slightly in excess of the maximum speed for position 1 and that consequently each of the following flap positions was commanded even before the last selected position had been achieved and checked. It must also be assumed that the crew was no longer aware that when extending the flaps, the speed brakes are automatically retracted by the system, because the warning to this effect (SPDBRK SW DISAG) was also not addressed. The command for the position FULL FLAPS, which was given by the commander and acknowledged by the copilot, leads to the conclusion that at that moment neither pilot was aware that this position should not be selected.

The selection of the flap position FULL, which led to the flaps jamming, occurred when the flaps were at around 10 degrees while they were being extended. This happens to correspond approximately to FSL position 1, which understandably led the crew to believe that the position 1 had caused the flaps to jam. However, it should be noted that this was not relevant for the continued conduct of the flight.

The aircraft was at 500 feet above ground on the glide slope and at a speed far higher than the approach speed. However, the continuation of the approach leaves no doubt that cooperation in the cockpit had collapsed. The commander commented that he had no visual contact with the runway and was misled by the copilot into continuing the approach in spite of this. It is possible that the commander let himself be influenced by the fact that the copilot had a management function and had flying experience both as a military commander and as a flight instructor. The CVDR recordings do not allow any conclusion to be drawn as to who was the actual commander of the flight.

From the perspective of flight safety it is incomprehensible that the approach was continued when the aircraft was 300 feet above ground displaying a rate of descent of more than 1000 ft/min and a speed of over 150 KIAS.

The commander only made the decision to go-around at the last moment, just before touchdown on the runway. The subsequent go-around was in turn, not performed in accordance with the procedures laid down in chapter 2.3.11 of the OM A (cf. chapter 1.17.1.1). The landing gear was not retracted. The commander's instruction*: "flaps one"* was not acknowledged by the copilot. The flap lever had already been set to this position without prompting.

The aural warnings HIGH SPEED and AUTOPILOT which sounded during the go-around were a systemic response to excessive speed with flaps extended. The fact that the crew responded to these warnings neither verbally nor with action suggests that they were overwhelmed.

The subsequent discussion in the cockpit regarding the lack of speed brakes also indicates that the crew was not able to access knowledge regarding the system-related functions of the aircraft.

From an operational perspective, it is not clear why the crew did not decide in favour of a holding in order to perform an error analysis, work through the checklist for the FLAP FAIL warning point by point and deal with the consequences, especially the bigger landing distance. It was at no point necessary for the crew to act swiftly. They had sufficient fuel on board and would in this respect not have been prevented from diverting to an airport with a longer runway. The conversations in the cockpit suggest that the copilot probably consulted the checklist, but did not work through it systematically point by point and in accordance with the rules as defined by the operator.

The recordings of the flap selector lever position (cf. Table 2, chapter 2.1.2) also show that it was not moved systematically and that even in critical flight phases, including the go-around, changes to the position were made which would have impaired flight stability if the flaps had not been jammed (see Annex 4).

As a result, there was a second approach without a preceding approach briefing. Critical points such as aircraft configuration, approach speed, runway condition and runway length were not addressed. The situation was therefore not optimal for the second approach: this is confirmed by the agitated operation of the controls (cf. Annexes 5 and 6). The communication in the cockpit and the lack of reaction by the crew to the aural warnings of the terrain awareness and warning system (TAWS) leave no doubt that the crew was overwhelmed.

The late touchdown on the runway at excessive speed was the direct consequence of the unstabilised approach and the lack of cooperation between the two pilots.

The CVDR data indicate (cf. Annex 14) that immediately after landing the brake pedals were activated only hesistantly and not fully and therefore maximum braking effect was also not used. Only shortly before reaching the runway end and 14 seconds after the weight on wheel signal confirmed the aircraft on ground, the data show the brake pedals in the mechanical stop. This brake behavior is one side in contrary to the commanders statement *"I applied full brakes"* and on the other hand from an operational standpoint not adapted to the situation.

After leaving the runway and on the subsequent stopway the CVDR recordings indicate that pressure was taken off the right brake pedal and the aileron was fully deflected to the left. It is therefore reasonable to conclude that over the last few metres, the commander attempted to steer the aircraft to the left, to the beginning of taxiway N (cf. Annexes 10 and 12). The fact that this was not successful was due to the speed of the aircraft and the direction in which it was moving in.

2.2.1.3 Medical ascertainment

Just a few hours after the accident the THC carboxylic acid (THC-COOH) content in the commander's urine was 120 µg/l. This is above the value of 75 µg/l, which is widely described in the literature as being indicative of chronic consumption.

Thresholds and values for blood and urine analyses have been largely harmonised by forensic institutes on the basis of national and international recommendations. In the case of chronic consumption, the detection time in the blood lasts for a few days and in urine for 30 days or more. Detection time is dependent on factors such as the dose taken and is subject to considerable individual variation. However, despite the fact that the blood samples were taken only three hours after the accident, no evidence of THC carboxylic acids could be found in the blood.

As described in the literature and studies, the influence on pilots' performance under the influence of THC is complex. On the one hand, those unused to cannabis displayed limited perception of, and responsiveness to, complex and unexpected stimuli in a flight simulator. On the other hand, only a slight impairment of behaviour could be proved in the case of habitual users of cannabis. However, different studies agree that chronic cannabis consumption may lead to long-term cognitive impairment in attention, memory and the ability to process complex information.

There are no indications based on the present data, that the consumption in the past could have affected the performance.

2.2.2 Operator

In order for it to be possible for an operator to work in accordance with internationally recognised principles and rules, the relevant procedures must be defined and specified: primarily in the corresponding operations manuals (OM) A and B. General rules are specified in the OM A, while aircraft-specific procedures are specified in the OM B. These operations manuals are inspected by the responsible official bodies of the relevant country before the operator is issued with an operator's licence.

The OM A of the operator involved in the accident states, among other things, that the Phenom 300 aircraft, which can be operated by a single pilot in accordance with certification, may only be operated by a two man crew. This regulation is to be welcomed from the perspective of flight safety.

In the accident which is the subject of the investigation the copilot had an additional management function as quality and flight safety manager of the operator. In the OM A the operator states that regardless of seating position, a pilot with a management function is always the commander. However, it also states that he can delegate this function provided that this is recorded in the journey log. This function was delegated by the management pilot on the flight involved in the accident. No corresponding evidence was found in the journey log. This must be criticized (cf. chapter 1.17.1.1).

The OM B states the principles according to which a two-man crew is to operate the aircraft. The closed loop principle is explicitly mentioned as part of this. Since the audio recordings of the CVDR do not reveal any signs of such cooperation, the question must be asked: by what criteria did the operator monitor whether the rules and procedures specified are adhered to in daily operation? From the perspective of flight safety, such a large discrepancy between theory and practice is prone to risks.

Furthermore, the specifications for steep approaches are stated in chapter 2.11 of the OM B. This is astonishing because, firstly, steep approaches are not certified on the Phenom 300 and secondly, the conditions stated do not apply to this aircraft type. They concern information pertaining to the 600 Legacy aircraft types, which are also operated by the operator concerned. Probably these errors occurred while transcribing the relevant passages.

2.2.3 Aircraft manufacturer

2.2.3.1 Service bulletin

At the time of the accident, service bulletin (SB) 505-27-0010 had not been implemented. This can be explained by the short interval between its publication and the date of the accident.

The following formulation in Figure 1 of the SB is astonishing:

"If applicable, when you lift the FSL make sure that the stopper remains in its position."

As mentioned in chapter 1.17.2, "applicable" refers to the two different types of certification: one in accordance with the ANAC and FAA and one in accordance with the EASA. However, this is of little help to the maintenance company, as in the SB and in the AMM there is no indication as to which aircraft serial number has been certified according to which guidelines. The fact that the affected serial numbers (fuselage nos.) are not listed under effectivity must therefore be described as a shortcoming.

Moreover, it is incomprehensible that a stopper is not necessary on aircraft certified in accordance with the ANAC and FAA, because the lack of stopper makes it possible to select the flap position FULL. If this position is selected for two seconds or more, the flaps become jammed - even in case of an FSL with the PN 780501-9 and regardless of the guidelines the aircraft has been certified in accordance with.

2.2.3.2 Aircraft manual

The revision of 31 March 2011 to the pilot's operation handbook (POH) was published with the following remark regarding the flap selector lever (FSL) in Section 06-07-05: *"**NOTE:** The flap FULL position is not available and is blocked by a mechanical stop added to the FSL."*

From the perspective of flight safety it is not acceptable that this information was only published in late March 2011 after the aircraft had been granted approval in 2008 and since then the flap selector lever position FULL was not certified until this date. This leads to the conclusion that the aircraft manufacturer was not initially aware of the consequences of erroneous setting of the flap selector lever to the FULL position.

2.2.3.3 Checklists

The quick reference handbook (QRH) contains, among other things, emergency and abnormal procedures in the form of checklists. These are designed to help pilots in dealing with abnormal situations and offer them assistance in making decisions. In the present case, the published procedures and tables did not offer pilots optimal assistance.

In the FLAP FAIL procedure (cf. Annex 13) the pilot is not made aware that he can avoid the aural warning "TOO LOW FLAPS" sounding on the final approach by using the flap override function. Similarly, in the Embraer Prodigy Flight Deck 300 Pilot's Guide published by the manufacturer, there is no information regarding the fact that this function can also be selected if due to a technical error the flaps cannot be brought to the landing position.

If for whatever reason the manufacturer does not wish the flap override function to be activated in such cases, pilots should at least be made aware of the fact that the aural warning "TOO LOW FLAPS" will sound on the final approach by way of a remark in the checklist.

Furthermore, it is incomprehensible that a landing distance calculation (QRH, PD35-1) in the published table only applies the correction factor for dry runways but not for wet runways. The figure calculated using this table gives pilots a false sense of safety when landing on wet runways.

It is equally incomprehensible that in the case of the optional fitting of the TAWS to the HEATING/ICE PROTECTION control panel (POH 2908, 6-11-05), there are three push buttons (G/S INHIB / FLAP OVRD / TERR INHIB) whose function and application are not described anywhere (cf. chapter 1.6.3.6.4).

2.2.4 Air traffic control

When the crew initially reported to the St. Gallen-Altenrhein aerodrome air traffic control officer (ATCO), he immediately offered them the alternative of a direct approach on runway 10. At the same time he reported to the crew a prevailing wind direction of 280 degrees at a wind speed of nine knots. The weather during the previous half hour (METAR at 13:20 UTC) indicated a wind from 280 degrees at 14 knots and heavy rain, whereas the ATIS information INDIA at 12:50 UTC (cf. chapter 1.7.6), broadcast information regarding wind from 310 degrees at eleven knots and light rain.

Although in principle the crew is responsible for the choice of runway direction, the ATCO's offer of a direct approach on runway 10 was from the perspective of aviation safety rather questionable given the wind conditions and a wet runway.

According to his statement, it seemed clear to the ATCO that the go-around for DLI 211 was because it was much too fast during the approach and would have touched down too late. He therefore omitted to inquire as to the reason for the go-around. This is understandable given the ATCO's visual contact with the aircraft, but it is not appropriate from the standpoint of cooperation between the ATC and the crew. A question by ATC as to the reason would have led to the crew addressing the technical error and an offered holding might have provided the impetus for a detailed situational assessment by the crew.

2.2.5 St. Gallen-Altenrhein regional aerodrome

As described in chapter 1.10, St. Gallen-Altenrhein (LSZR) regional aerodrome, according to ICAO, is to be classified as aerodrome with code number 3. However, according to the Federal office of civil aviation (FOCA) St. Gallen-Altenrhein regional aerodrome was treated as aerodrome with code number 2.

A runway end safety area (RESA) of at least 90 m, as prescribed at the time of the accident by ICAO for aerodromes with code number 3 but not for those with code number 2, is not available. This, however, had no impact on the cause of the presently investigated accident.

2.3 Meteorological aspects

On the forefront of a trough that extended from the Norwegian Sea to the Bay of Biscay, mild, humid and sometimes unstably stratified air was flowing over the Alps towards the northeast. A cold front associated with the trough was extending from the south-west to the north-east over the Swiss Alps, causing rainfall of varying intensity mainly along the prefrontal and frontal zone. There were radar echoes with moderate intensity from the cloud base up to altitudes of 7000 m AMSL.

At 12 UTC, the surface front was just east of Lake Constance. At the rear of the front the wind on the ground temporarily subsided and the precipitation also subsided. Above around 800 m AMSL the wind speed remained almost unchanged.

Due to the relief and waves along the frontal zone, the air in the eastern region of Lake Constance was subject to increased local uplift, which accentuated the precipitation intensity. Precipitation cooling resulted in the stratus fractus typical of poor weather conditions together with rapidly changing visibility and a variable cloud base.

Under the prevailing weather conditions the approach was challenging for the pilots. However, these conditions allowed a direct approach on runway 10 or a circling approach on runway 28.

3 Conclusions

3.1 Findings

3.1.1 Technical aspects

- The aircraft was licensed for commercial transport according to VFR/IFR.
- Both the mass and centre of gravity of the aircraft were within the permitted limits according to the AFM at the time of the accident.
- The investigation did not produce indications of any pre-existing technical faults which might have caused the accident.
- The last scheduled maintenance was carried out on 7 July 2012 after 480:45 operating hours.
- During the first approach, the flap selector lever was briefly set to the FULL position, which was not certified at the time of the accident and therefore was not allowed to be used.
- A mechanical stopper that was installed at the time of the aircraft delivery, preventing selection of the FULL position, was missing on the flight involved in the accident.
- The missing mechanical stopper made it possible to select the FULL position, which led to an invalid signal in the flight control electronic (FCE) upon which the flaps remained jammed at approximately 10 degrees and which caused the FLAP FAIL warning message being displayed constantly.

3.1.2 Crew

- The pilots were in possession of the necessary licences for the flight.
- There are no indications of the pilots suffering health problems during the flight involved in the accident.
- The blood alcohol analysis on both crew members produced a negative result.

3.1.3 History of the flight

- At 13:23:41 UTC the crew received a heading instruction. They were 13 NM north-east of waypoint ROLSA and descending. The tailwind component was just over 70 knots.
- At 13:24:57 UTC the crew received clearance for an approach on runway 28: *"(...) ILS approach runway one zero followed by visual right-hand circuit runway two eight (...)"*.
- At 13:25:42 UTC the commander asked the copilot about the aerodrome elevation. Subsequently a misunderstanding arouse between the pilots.
- After the frequency change to the St. Gallen-Altenrhein ATCO at 13:26:52 UTC, the crew were offered an approach with a landing on runway 10, which was accepted by the crew without delay.
- At 13:27:29 UTC, at 183 KIAS, the commander ordered the flaps to be extended.
- At 13:27:36 UTC the copilot reported that he had the runway in sight and the commander ordered the flaps to be set in position 2.
- At 13:27:45 UTC the master warning appeared together with the FLAP FAIL error message, which remained displayed until after landing. The flaps re-

mained jammed at approximately 10 degrees for the remainder of the flight, which by chance corresponded more or less to position 1 of the flap selector lever (FSL).

- At 13:27:53 UTC the synthetic voice reported "MINIMUMS, MINIMUMS" and then "FIVE HUNDRED".
- At 13:28:03 UTC, at a speed of 154 KIAS and a rate of decent in excess of 1000 ft/min the altitude call out "THREE HUNDRED" sounded.
- At 13:28:06 UTC the commander said that he could not see the runway and two seconds later, during the altitude call out "TWO HUNDRED", the commander repeated this statement.
- The copilot immediately said: *"voilà la piste, voilà la piste"* [there's the runway, there's the runway].
- At 13:28:13 UTC, during the altitude call out "ONE HUNDRED", the commander again said that he could not see anything.
- At 13:28:22 UTC the commander initiated a go-around. The landing gear remained extended.
- At 13:28:43 UTC the "HIGH SPEED" warning sounded and eleven seconds later the "AUTOPILOT" also sounded.
- Both warnings sounded alternately until 13:29:17 UTC.
- To the ATCO's question as to whether the crew would prefer a second approach, they replied at 13:29:48 UTC without delay: *"affirmative"*.
- At 13:30:19 UTC, the commander said to the copilot that the flaps were jammed and the high speed would persist.
- At 13:31:01 UTC the commander remarked that he wanted to leave the flaps in position 2 for the approach.
- The copilot replied that they were still in position 1 and that he had twice tried to move the flaps.
- Actually, in the period from 13:27:40 UTC to 13:40:15 UTC (during both approaches and the go-around) the copilot made more then ten attempts to move the flaps.
- At 13:33:54 UTC the commander asked the copilot what was in the checklist with reference to the problem with the flaps.
- The pilots agreed on the increased approach speed of 130 knots and the commander asked the copilot about the length of the runway.
- At 13:39:08 UTC the ATCO gave DLI 211 landing clearance and the copilot advised the commander to increase the rate of descent.
- The commander replied that they would have a problem because the speed was increasing and they had no speed brakes.
- At an altitude of 2330 ft QNH and at a speed of 162 KIAS and a rate of descent of approximately 2000 ft/min, at 13:39:34 UTC the ground proximity warning system generated a "TERRAIN" warning, followed four seconds later by the "< whoop > < whoop > PULL UP" warning.
- At 13:39:58 UTC, when the altitude call out "FOUR HUNDRED" sounded, the commander remarked that the approach speed was stabilised. At this moment

the aircraft was flying at 153 KIAS at a rate of descent of approximately 1000 ft/min.

- At 13:40:03 UTC various messages generated by the ground proximity warning system sounded in the cockpit, such as "TOO LOW TERRAIN" and "TOO LOW FLAPS".
- After the "ONE HUNDRED" altitude call out, the "TOO LOW FLAPS" and "GLIDESLOPE" warnings sounded. The plane was now 70 ft above the ground, at a rate of descent of 850 ft/min and at 143 KIAS.
- At 13:40:29 UTC the aircraft touched down on runway 10 with the right main landing gear, at 136 KIAS with a slight tailwind, approximately 290 m after the runway threshold, followed one second later, i.e. after another 70 metres, with the left main landing gear.
- At 13:40:31 UTC, at a speed of 135 KIAS and approximately 450 m after the runway threshold, all the weight on wheel sensors reported that the aircraft was on the ground.
- Only shortly before reaching the runway end and 14 seconds after the weight on wheel signal confirmed the aircraft on ground, the data show the brake pedals in the mechanical stop.
- At 13:40:51 UTC, the aircraft rolled over the end of runway 10 at a speed of 44 kt.
- One second later, it broke through the aerodrome perimeter fence, rolled across the road named Rheinholzweg, which runs perpendicular to the end of the runway centreline at a distance of approximately 20 m from the end of the runway and came to a standstill in a maize field after a further 10 m.
- The two pilots and the passenger were able to vacate the aircraft unassisted.

3.1.4 General conditions

- The procedures published in the quick reference handbook (QRH) were little user-friendly in many aspects.
- The cooling due to light to moderate rainfall from a cold front which had recently passed through resulted in rapidly changing visibilities and variable cloud bases.

3.2 Causes

The accident is attributable to the fact that the aircraft touched down late and at an excessively high speed on the wet runway after an unstabilised final approach and consequently rolled over the end of the runway.

The following factors contributed to the accident:

- The insufficient teamwork and deficient situation analysis by the crew.
- The flaps remained jammed at approximately 10 degrees, a position that is almost consistent with the flaps 1 position.
- Late initiation of full brake application after landing.

4 Safety recommendations and measures taken since the accident

According to the provisions of Annex 13 of the ICAO, all safety recommendations listed in this report are intended for the supervisory authority of the competent state, which has to decide on the extent to which these recommendations are to be implemented. Nonetheless, any agency, establishment or individual is invited to strive to improve aviation safety in the spirit of the safety recommendations pronounced.

In the Ordinance on the Investigation of Aircraft Accidents and Serious Incidents (OIAASI), the Swiss legislation provides for the following regulation regarding implementation:

"Art. 32 Safety recommendations

[1] DETEC, on the basis of the safety recommendations in the SAIB reports and in the foreign reports, addresses implementation orders or recommendations to the FOCA.

[2] The FOCA informs DETEC periodically about the implementation of the orders or recommendations pronounced.

[3] DETEC informs the SAIB at least twice a year on the state of implementation by the FOCA."

4.1 Safety recommendations

4.1.1 Minimising risks to third parties

4.1.1.1 Safety deficit

After the approach on the runway 10 instrument landing system (ILS) in St. Gallen-Altenrhein (LSZR) with flaps only partially extended, an Embraer EMB-505 Phenom aircraft overrun the runway end after landing, broke through the aerodrome perimeter fence and overrun the road named Rheinholzweg running perpendicular to the runway centreline, on which a public transport bus, licensed to transport 90 passengers, was travelling. The aircraft rolled very close behind the bus and came to a standstill in a maize field, approximately 30 m from the end of the runway.

In an interim report dated 31 January 2013 to the Federal Office of Civil Aviation (FOCA), the SAIB-AV issued the following safety recommendation:

4.1.1.2 Safety recommendation no. 461

"Das Bundesamt für Zivilluftfahrt (BAZL) sollte sicherstellen, dass auf allen Schweizer Flugplätzen in einer Gefahrenanalyse (hazard identification) auch die Gefährdung Dritter zumindest in der unmittelbaren Flugplatzumgebung erfasst und zu deren Minimierung geeignete Massnahmen getroffen werden."

[The Federal Office of Civil Aviation (FOCA) should ensure that on all Swiss aerodromes, in a hazard identification, also the endangering to third parties, at least in the immediate vicinity of the aerodrome, is determined and that appropriate measures will be taken to minimise it.]

4.1.1.3 Comment by the Federal Office of Civil Aviation dated 3 April 2013

[Translated from German]: *"Pursuant to art. 3 para. 1bis of the Ordinance concerning Aviation Infrastructure (SR 748.131.1), the standards and recommendations of the International Civil Aviation Organisation (ICAO), among others, those in Annex 14 to the Convention of 7 December 1944 on International Civil Aviation*

(ICAO Annexes), as well as the related technical regulations, are directly applicable to aerodromes. Airports and St. Gallen-Altenrhein aerodrome must also present to the Federal Office for approval, in accordance with Article 23a of the Ordinance, an aerodrome manual corresponding to the ICAO Document 9774 "Manual on Certification of Aerodromes" and prove that they are able to operate the aerodrome in accordance with this aerodrome manual. This also includes a functioning safety management system (SMS) in accordance with ICAO Document 9859 "Safety Management Manual".

As part of the SMS, existing hazards, as well as the associated risks, of the aerodromes concerned must be systematically determined and documented, together with the necessary actions, in a hazard library. The initial production of this aerodrome hazard library is monitored by the FOCA as part of the implementation of the SMS on aerodromes, under the title "Project Hazid". For this purpose the FOCA has produced a guide[1] in which the recommended procedure is explained. The guide indicates, among other things, the system to be considered, with an indication that in the event of any doubt a hazard should be recorded even if it does not fall within the airport operator's area of responsibility. The hazards to third parties in the immediate vicinity of the aerodrome are already included at present, and if possible mitigated by appropriate measures. Dealing with identified risks outside the area of responsibility of the aerodrome is not the remit of the aerodrome owner; however, in these cases the responsible agency will be informed. The "Hazid" Project is monitored and controlled within the framework of the COFA working groups[2]. Supervision of the risk identification process takes place within the framework of the periodic certification audits. To this end, the results of the "Hazid" Project are also examined on the basis of the cited FOCA guides and relevant comments are issued.

All other Swiss aerodromes (airfields) are not currently obliged to implement a Safety Management System; accordingly no systematic hazard identification by the aerodrome is provided for. However, supervision of the handling of risks on aerodromes does take place within the framework of the on-site inspections. In the process, risks to third parties are also determined, in so far as these are in the aerodrome area, and are addressed by the requirements of the ICAO standards. An extension of the SMS obligation to all Swiss aerodromes would be disproportionate in our opinion.

Conclusion: on all Swiss airports, as well as on the St. Gallen-Altenrhein aerodrome, hazard identification together with risk assessment and mitigation planning are implemented within the framework of the SMS; the impact on third parties in the immediate vicinity of the aerodrome is already currently included in this. The FOCA regularly monitors and supervises this process. On the other aerodromes, risks to third parties are recorded as part of the supervisory activities and are addressed on the basis of the ICAO standards. An extension of the SMS obligation to all Swiss aerodromes would be disproportionate in our opinion. Safety recommendation No. 461 is not necessary in our opinion, or it has already been implemented.

1) Federal Office of Civil Aviation, Guide to hazard identification and assessment, 29 May 2009, final report (1.3) - currently in revision

2) COFA (Certification of Aerodromes): COFA EASA (LSZH, LSGG, LSZB, LSZA, LSZR) and COFA ICAO (LSZQ, LSZF, LSGE, LSGC, LSZG, LSGL, LSZS, LSGS)"

4.1.2 Improvements to manuals

4.1.2.1 Safety deficit

On 6 August 2013 at 13:27:11 UTC the crew of a Phenom 300 aircraft, registration CN-MBR, received clearance for an instrument approach on runway 10 in St.

Gallen-Altenrhein. Shortly afterwards the commander, as PF (pilot flying) asked for the flaps to be set to position 1. Even before the flaps had attained this position, he ordered the further extension of the flaps up to the FULL position. Due to a technical abnormality, the flaps remained jammed at approximately 10 degrees, which roughly corresponds to position 1, and could not subsequently be moved. In addition, the FLAP FAIL warning was displayed.

The crew continued their approach and since the speed reduction did not take place as desired, initiated a go-around less than one foot above the runway.

On the second approach, the aircraft was not stabilised and in the final approach various aural alarms sounded in the cockpit, among others, the terrain awareness and warning system (TAWS) call out "TOO LOW FLAPS". This warning can be suppressed in various ways if one wishes to suppress it deliberately. In the present case, this would have made sense, as this warning was a logical consequence of the jammed flaps and therefore was not an actual warning that the aircraft was near the ground and the required flap position was not in effect.

In the checklist for the FLAP FAIL warning, this point is not addressed. Also, the corresponding note to the effect that this alarm will sound if it is not deactivated is missing. No instructions or descriptions of the push buttons provided for this purpose are given in the manual for pilots.

Furthermore, the reference in the checklist to the use of the corresponding tables for landing distance calculation are not particularly user-friendly and the correction factor is published only for a dry runway, but not for a wet runway. These are blatant shortcomings from a flight safety perspective.

4.1.2.2 Safety recommendation no. 482

"Die Europäische Agentur für Flugsicherheit (European Aviation Safety Agency – EASA) sollte zusammen mit dem Flugzeughersteller prüfen, wie die Handbücher angepasst werden können, sodass sie dem Piloten eine optimale Hilfe in abnormalen Situationen bieten."

[Together with the aircraft manufacturer, the European aviation safety agency (EASA) should examine how the manuals can be amended so as to provide optimal assistance to pilots in abnormal situations.]

4.2 Measures taken since the accident

4.2.1 General

Within the framework of an operator, manufacturer, air navigation service provider (OMA) meeting on 10 April 2013 the respective representatives were presented with the evidence obtained in the course of the investigation and this was checked for accuracy and completeness.

The ambiguities and shortcomings present, in the SAIB's opinion, in the published manuals were explicitly addressed at this meeting.

4.2.2 By the operator

In a letter to the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'Aviation civile of Morocco, dated January 2014, the aircraft operator stated the following:

«Dalia Air analysed the event of the Embraer Phenom 300 landing overrun carefully. Following action was taken from the operator side to avoid a future similar runway overrun:

A general training agreement was signed with Swiss Aviation Training to assure that the pilots of Dalia Air will be trained with a training facility which has a high *standard and a long experience in the aviation training sector.* [A copy of the respective contract is available to the SAIB]

Dalia Air focuses even more on the Crew Resource Management (CRM) skills and enforced the checking concerning CRM skills. The flight crew will be checked during simulator checks and flights on the observer seat on the aircraft to check to level of CRM used during daily operation to assure a high level of CRM proficiency.

The operation manuals where reviewed and revised with the special attention given to the high CRM level required by Dalia Air. The landing overrun is a main topic during our recurrent training.

No information is given in Switzerland to the pilots from the flight charts of differences to the ICAO standard of the airport St. Gallen□Altenrhein. The stopway of the runway should be in compliance with the ICAO standard (250 meters required according ICAO, in this case 22 meters actual available) and shall be checked on the appropriate chart prior each flight to make the crew aware of the differences which can implement a potential hazard to the operation in case of a runway overrun.»

Furthermore the operator has sent a copy of the revised chapter 3.2.1 in OM D as follows:

DALIAAIR PRIVATE JETS Training Department	OPERATIONS MANUAL PART D CHAPTER 3 FLIGHT TRAINING PROCEDURES	Edition No.: 3
		Revision No.: 0
		Date: 15/10/2013
		Chapter: 3.2 Page: 01

3.2 PROCEDURES IN CASE OF NOT ACHIEVING THE REQUIRED STANDARDS

3.2.1 Cockpit crew

CRM is one core part of the Dalia Air philosophy. It is noted here that poor CRM standard is not acceptable for Dalia Air and will lead to a failed check.

The principle of a "second chance" shall be adopted, every time:

- a FCM does not pass for the first time during a specific training an internal check or
- an official check or
- when the training staff decides not to present the candidate for a check because lack of progress.

Before a second check a supplementary training program will be established. As each case will be different, a selection of staff personnel will decide upon a specific program. Should the second check be unsuccessful, the FCM will:

- be dismissed in case he is undergoing the first conversion training within the company,
- return to his/her previous function or aircraft in case of promotion,
- be downgraded to first officer in case he failed two consecutive proficiency checks as commander,
- be dismissed in case he failed two consecutive proficiency checks as first officer and decided by the DFO who will send a report will be send to the DAC.

4.2.3 By the aircraft manufacturer

4.2.3.1 Checklists

In a letter dated 22 May 2013, the aircraft manufacturer stated that the following changes, among others, have been made to the checklists in the QRH Revision 4:

In the checklist for emergency and abnormal situations, the procedure for FLAP FAIL has been revised. The table for the minimum speeds and the correction factors have been extended to include the FULL FLAPS position, the minimum speeds have been increased by 2 kt and the CAUTION refers to a newly published correction table (cf. chapter 1.6.3.5 and Annex 13).

Valid at the time of the accident:

FLAP POSITION	MINIMUM AIRSPEED	
	NO ICING	IN ICING/WITH ICE
0	$V_{REF\ 3}$ + 25 KIAS	$V_{REF\ 3}$ + 36 KIAS
1	$V_{REF\ 3}$ + 17 KIAS	$V_{REF\ 3}$ + 25 KIAS
2 and 3	$V_{REF\ 3}$ + 4 KIAS	$V_{REF\ 3}$ + 13 KIAS

QRH, EAP7-3, Revision 2

<u>CAUTION:</u> TO DETERMINE THE MINIMUM REQUIRED LANDING DISTANCE, ENTER ONE OF THE FACTORS BELOW AND THE FLAP 3 FACTORED LANDING DISTANCE IN THE "LANDING DISTANCE CORRECTION" TABLE.

FLAP POSITION	CORRECTION FACTOR	
	NO ICING	IN ICING/WITH ICE
0	1.40	1.60
1	1.30	1.40
2 and 3	1.10	1.30

QRH, EAP7-4, Revision 1

FACTORED LANDING DISTANCE (m) – ISA
ENGINE ICE PROTECTION ON – WINGSTAB ON – ZERO SLOPE
NO WIND – FLAP 3

Alt. (ft)	Weight (kg)	V_{REF} (KIAS)	V_{AC} (KIAS)	V_{FS} (KIAS)	Dry (m)	Wet Unfact. (m)	Wet Fact. (m)	Std. Water (m)	Slush (m)	Wet Snow (m)
Sea Level	5600	108	108	126	1103	971	1323	1717	1725	1766
	5800	110	110	128	1127					
	6000	111	111	131	1150					
	6200	113	113	133	1173	1014	1380	1827	1839	1865
	6400	115	115	135	1197					
	6600	117	117	137	1219	1056	1438	1937	1953	1978
	6800	118	118	139	1243					
	7000	120	120	141	1266	1098	1495	2047	2067	2091
	7200	122	122	143	1290					
	7400	124	124	145	1318					

QRH, PD35-3, Revision 2

LANDING DISTANCE CORRECTION
(FOR ABNORMAL LANDING USE ONLY)

MINIMUM REQUIRED RUNWAY LENGTH (m)							
FACTORED (V_{REF})		UNFACTORED (V_{REF})		ABNORMAL LANDING FACTORS			
Dry	Wet	Dry	Wet	1.10	1.20	1.30	1.40
900	1035	608	760	669	730	791	851
1000	1150	676	845	743	811	878	946
1100	1265	743	929	818	892	966	1041
1200	1380	811	1014	892	973	1054	1135
1300	1495	878	1098	966	1054	1142	1230
1400	1610	946	1182	1041	1135	1230	1324
1500	1725	1014	1267	1115	1216	1318	1419
1600	1840	1081	1351	1189	1297	1405	1514
1700	1955	1149	1436	1264	1378	1493	1608

QRH, PD35-1, Revision 2

Revision 4, valid from 25 March 2013

FLAP POSITION	MINIMUM AIRSPEED	
	NO ICING	IN ICING/WITH ICE
0	$V_{REF\ FULL}$ + 27 KIAS	$V_{REF\ FULL}$ + 38 KIAS
1	$V_{REF\ FULL}$ + 19 KIAS	$V_{REF\ FULL}$ + 27 KIAS
2 and 3	$V_{REF\ FULL}$ + 6 KIAS	$V_{REF\ FULL}$ + 15 KIAS
FULL	$V_{REF\ FULL}$	$V_{REF\ FULL}$ + 10 KIAS

QRH, EAP7-3, Revision 4

<u>CAUTION:</u> MULTIPLY THE FLAP FULL UNFACTORED LANDING DISTANCE ACCORDING TO THE TABLE BELOW.

FLAP POSITION	CORRECTION FACTOR	
	NO ICING	IN ICING/WITH ICE
0	1.40	1.60
1	1.30	1.40
2 and 3	1.10	1.30
FULL	1.00	1.20

QRH, EAP7-4, Revision 4

LANDING DISTANCE (m) – ISA
ENGINE ICE PROTECTION OFF/ON – WINGSTAB OFF – ZERO SLOPE
NO WIND – FLAP 3

ALT (ft)	WEIGHT (kg)	SPEEDS			FACTORED		UNFACTORED		CONTAMINATED		
		V_{REF} (KIAS)	V_{AC} (KIAS)	V_{FS} (KIAS)	DRY (m)	WET (m)	DRY (m)	WET (m)	STD. WATER (m)	SLUSH (m)	WET SNOW (m)
Sea Level	5600	100	104	113	1009	1161	647	809	1365	1375	1466
	5800	102	105	115	1030	1184	662	827	1406	1416	1502
	6000	104	107	117	1050	1208	677	846	1447	1458	1539
	6200	106	109	119	1071	1232	692	865	1489	1500	1577
	6400	107	110	121	1092	1256	708	885	1532	1544	1615
	6600	109	112	123	1112	1279	722	903	1573	1586	1652
	6800	110	114	125	1132	1302	737	921	1616	1628	1689
	7000	112	115	126	1153	1326	752	940	1656	1670	1725
	7200	114	117	128	1174	1350	767	959	1697	1711	1760
	7400	115	118	130	1193	1372	781	976	1736	1751	1794

QRH, PD35-5, Revision 4

LANDING DISTANCE CORRECTION
(FOR ABNORMAL LANDING USE ONLY)
FLAP FULL

UNFACTORED LANDING DISTANCE (m)	MINIMUM REQUIRED RUNWAY LENGTH (m)					
	ABNORMAL LANDING FACTOR					
	1.0	1.1	1.2	1.3	1.4	1.5
600	600	660	720	780	840	900
700	700	770	840	910	980	1050
800	800	880	960	1040	1120	1200
900	900	990	1080	1170	1260	1350
1000	1000	1100	1200	1300	1400	1500
1100	1100	1210	1320	1430	1540	1650
1200	1200	1320	1440	1560	1680	1800
1300	1300	1430	1560	1690	1820	1950
1400	1400	1540	1680	1820	1960	2100
1500	1500	1650	1800	1950	2100	2250
1600	1600	1760	1920	2080	2240	2400
1700	1700	1870	2040	2210	2380	2550

QRH, PD35-3, Revision 4

Comment by the SAIB-AV:

- In the newly formulated CAUTION in the FLAP FAIL procedure (QRH, EAP7-3, Revision 4) the crew is required to apply the appropriate correction factor to the unfactored landing distance.
- In the LANDING DISTANCE table (QRH, PD35-5, Revision 4) the unfactored landing distance for dry runways is also published.
- In the LANDING DISTANCE CORRECTION table (QRH, PD35-3, Revision 4) only the unfactored landing distance is now listed, thereby taking into account the condition of the runway in the application of the correction factor.

4.2.3.2 Maintenance manuals

In a letter dated 27 June 2013, the aircraft manufacturer stated that the mention of two different variants of certification, ANAC and FAA on the one hand and EASA on the other, was a mistake which arose during the transfer of information from the documentation of the Phenom 100 aircraft. In the meantime, the FULL flap position has also been certified and the information in the aircraft maintenance manual (AMM) corrected accordingly:

- In the AMM 27-53-01 figure 401, page 3 of 4 (Rev 20- May 23/13) EFFECTIVITY now includes: *"ON EMBRAER 505 ACFT WITH FLAP FULL OR POST-MOD SB 505-27-0011"* [Exploded drawing without *stopper*].
- In the AMM 27-53-01 figure 402, page 4 of 4 (Rev 20 May 23/13) EFFECTIVITY now includes: *"ON EMBRAER 505 ACFT WITHOUT FLAP FULL OR PRE-MOD SB 505-27-0011"* [Exploded drawing with *stopper*].

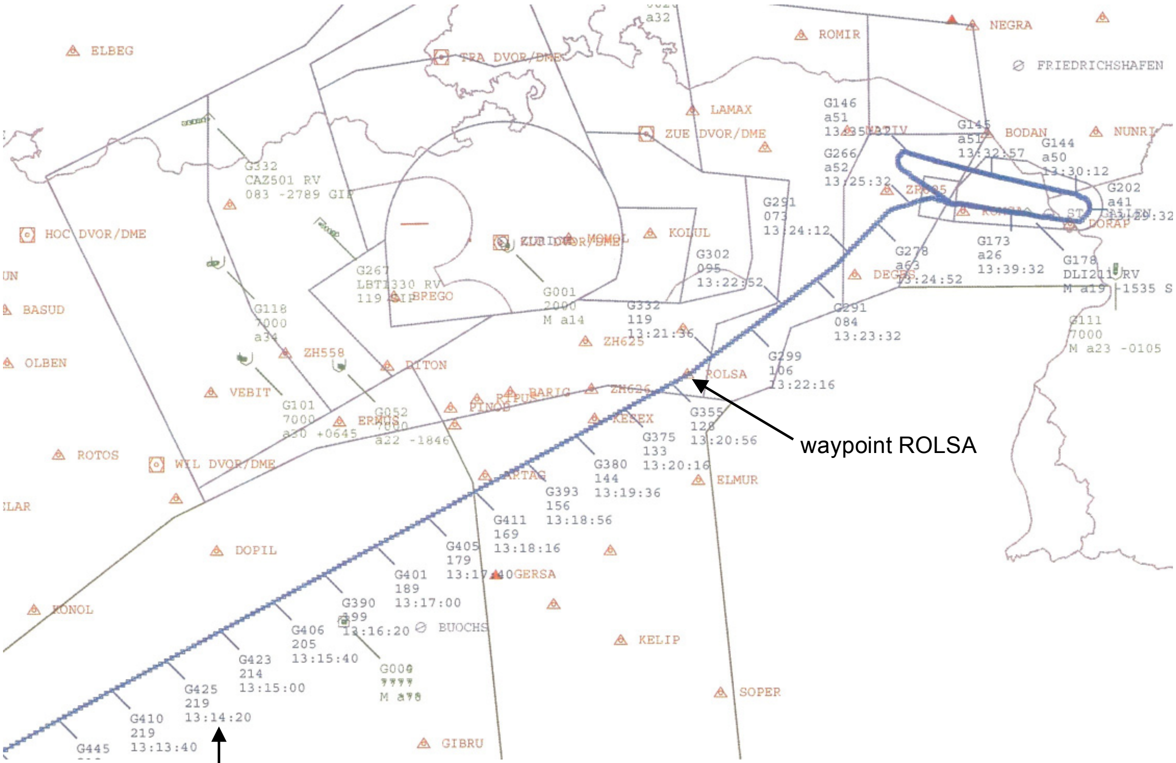
Payerne, 23 September 2014 Swiss Accident Investigation Board

This final report was approved by the management of the Swiss Accident Investigation Board SAIB (Art. 3 para. 4g of the Ordinance on the Organisation of the Swiss Accident Investigation Board of 23 March 2011).

Berne, 6 November 2014

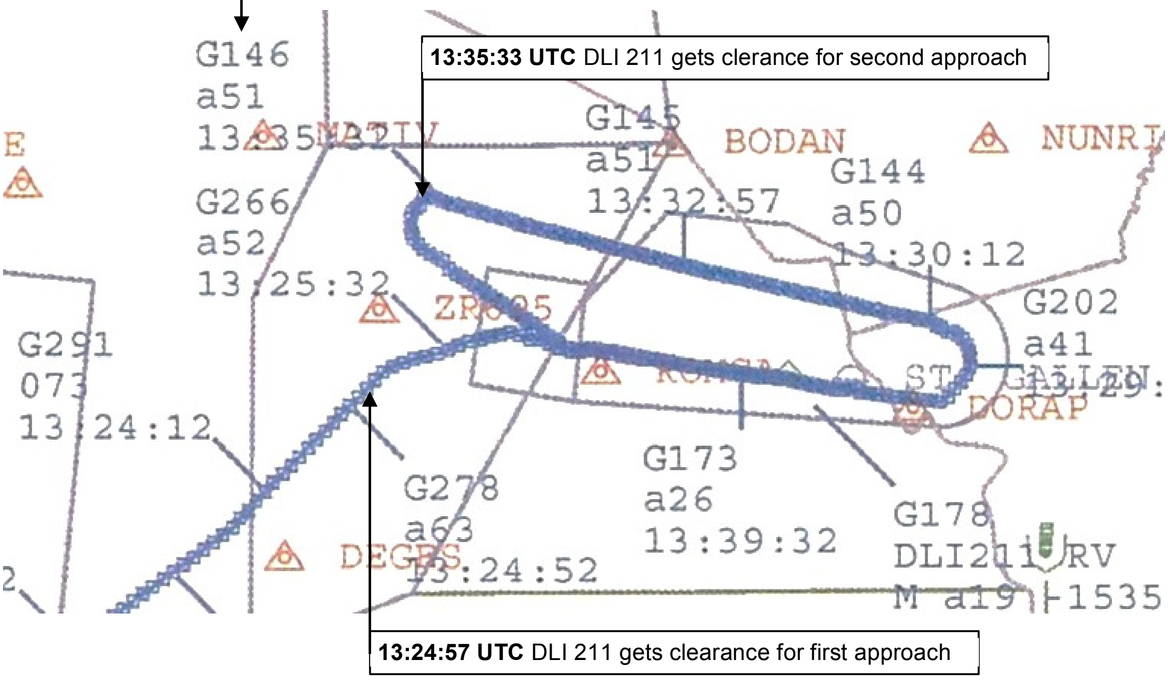
Annexes

Annex 1: Flightpath of DLI 211 according radar data

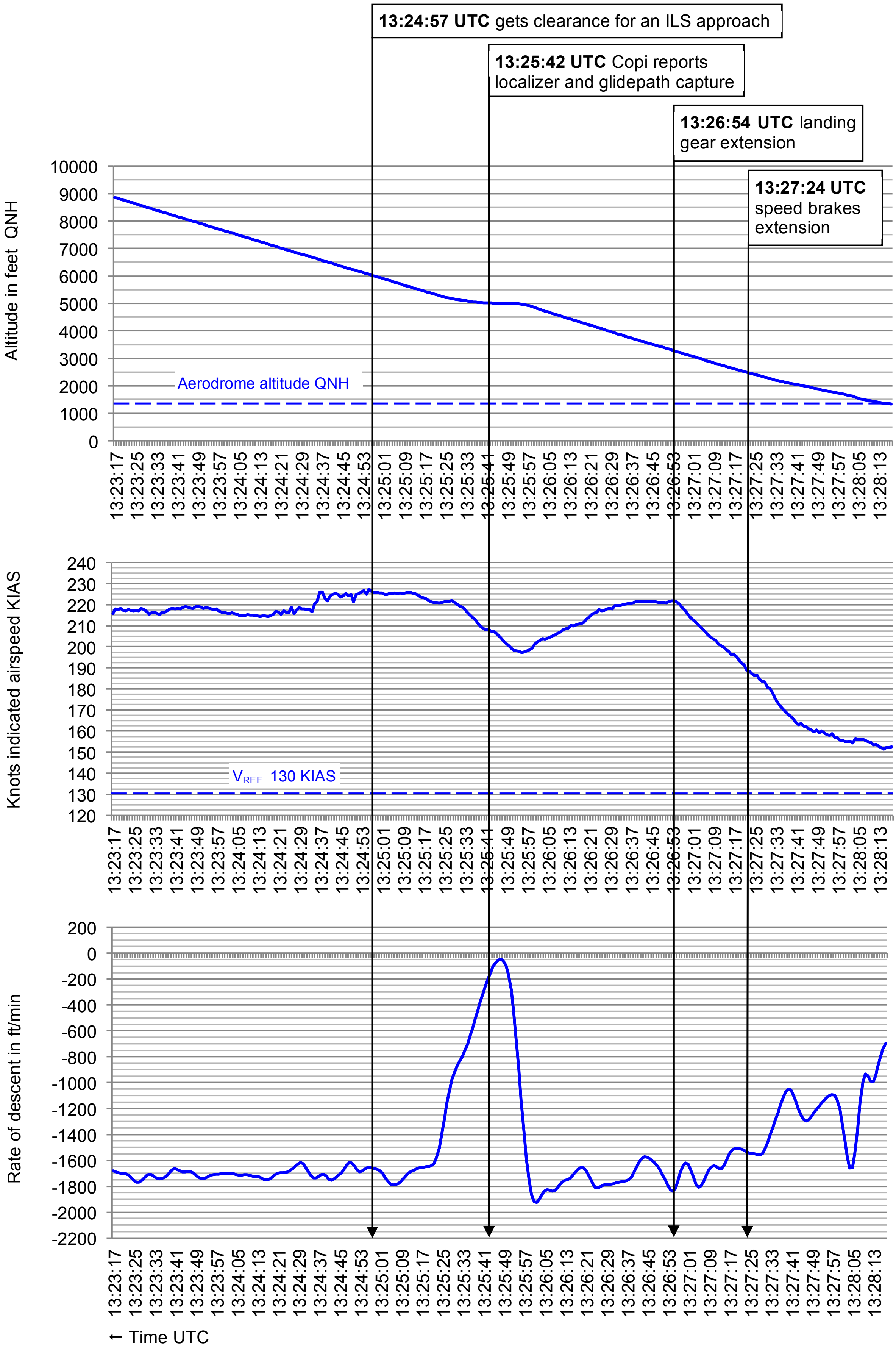


Legende:

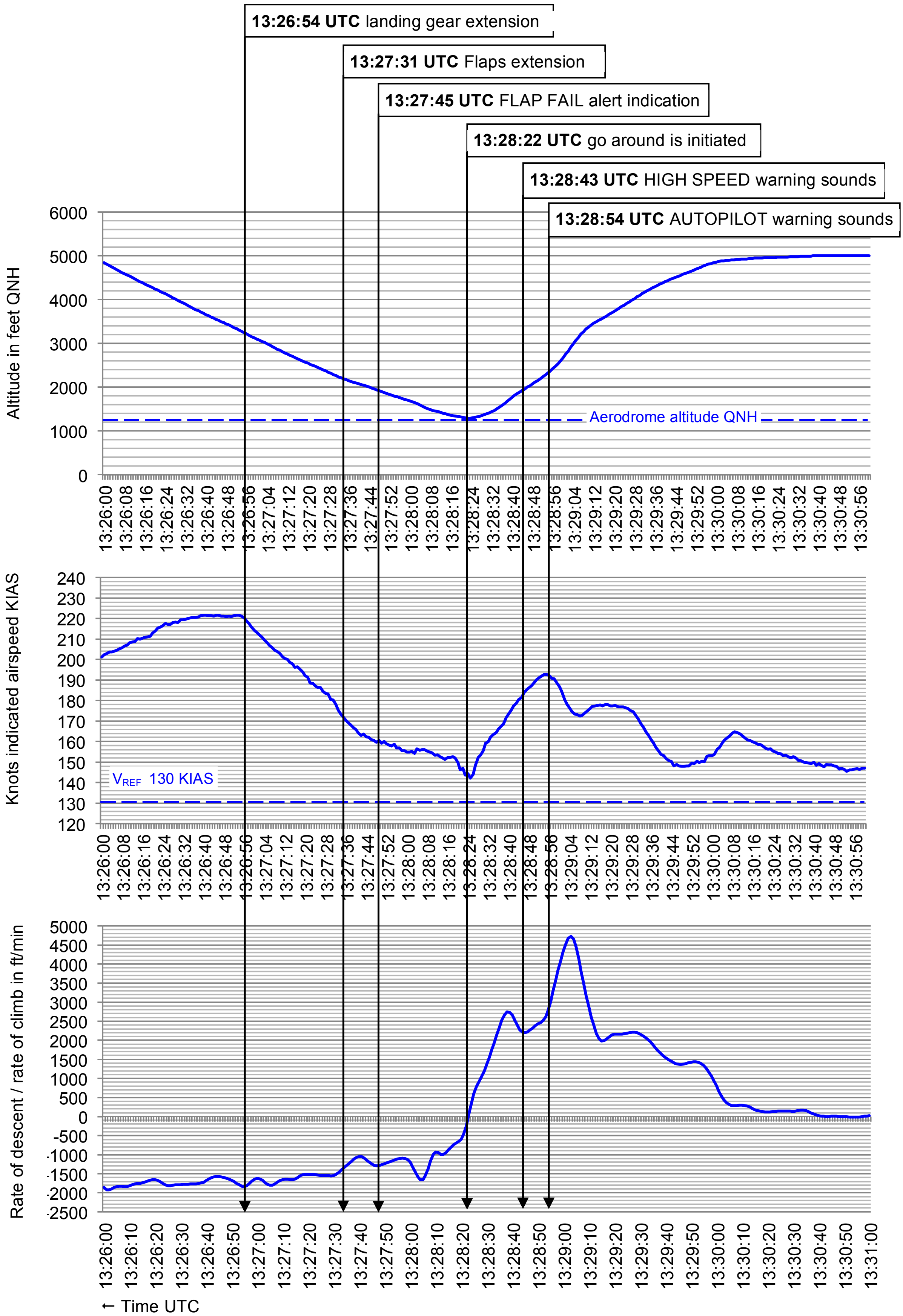
G	Groundspeed in knots
xxx	Altitude in hundred of feet
a xx	Altitude QNH in hundred of feet
xx:xx:xx	Time (UTC)



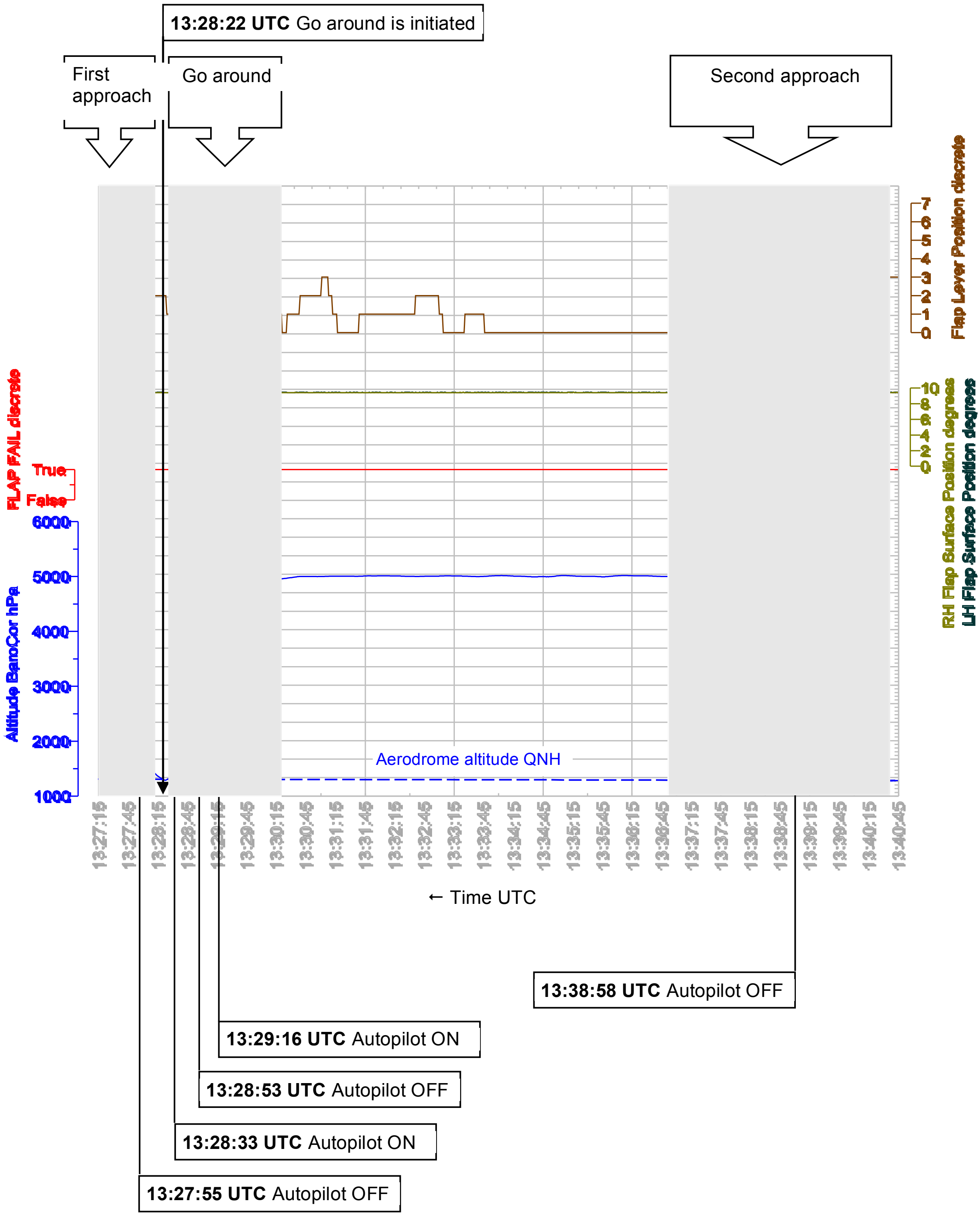
Annex 2: Vertical flightpath of DLI 211 on first approach



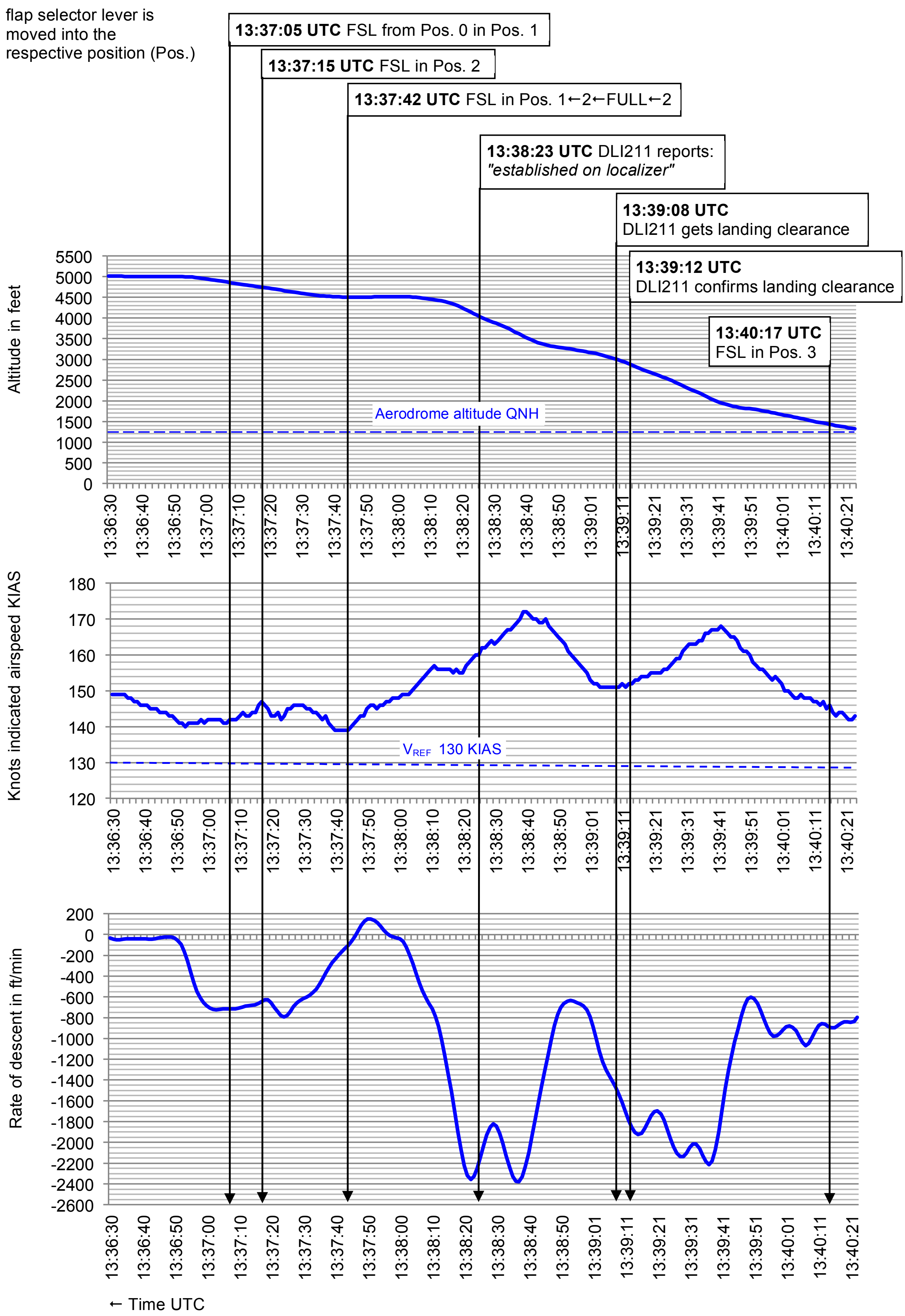
Annex 3: First approach and go around



Annex 4: Manipulations on the flap selector lever

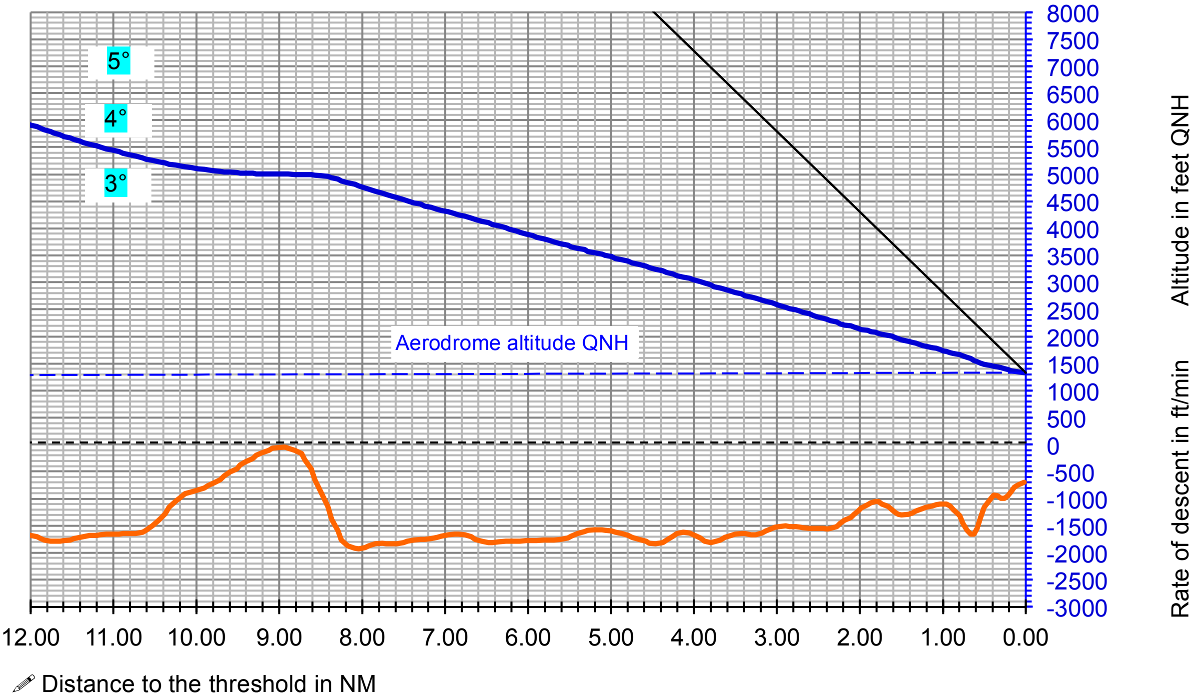


Annex 5: Second approach and landing

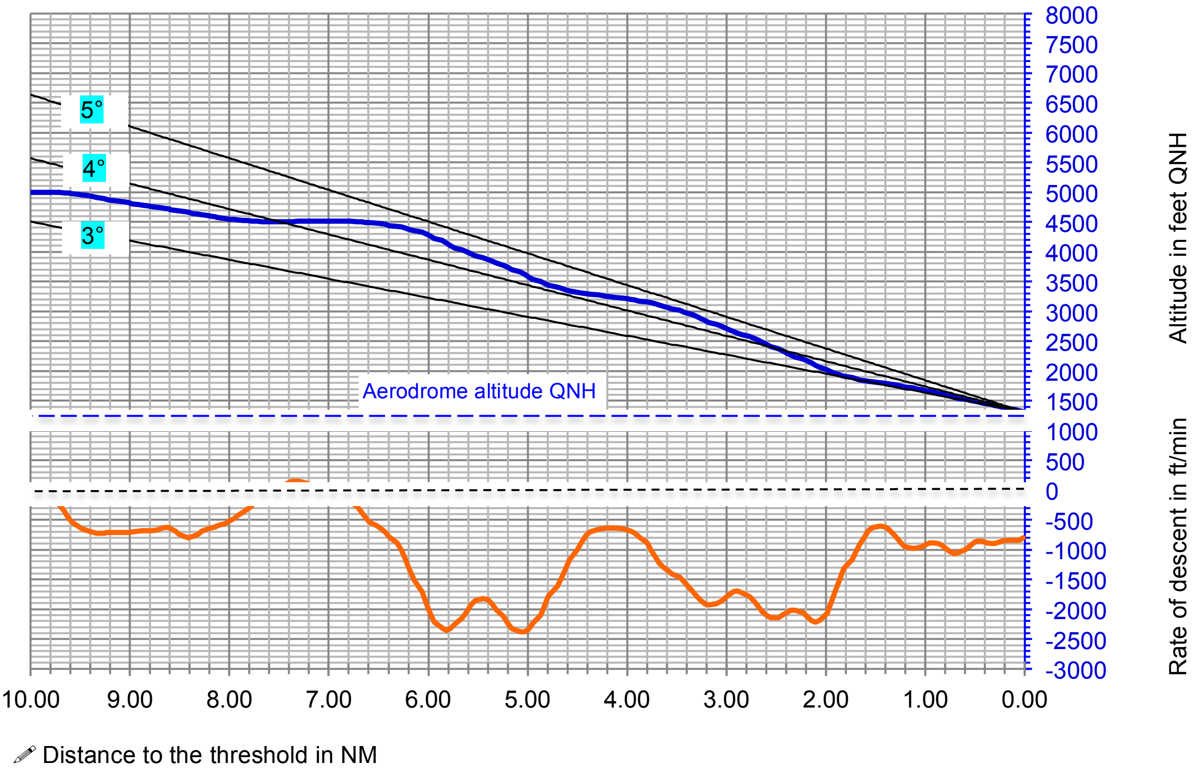


Annex 6: Approach angle and glidepath

First approach

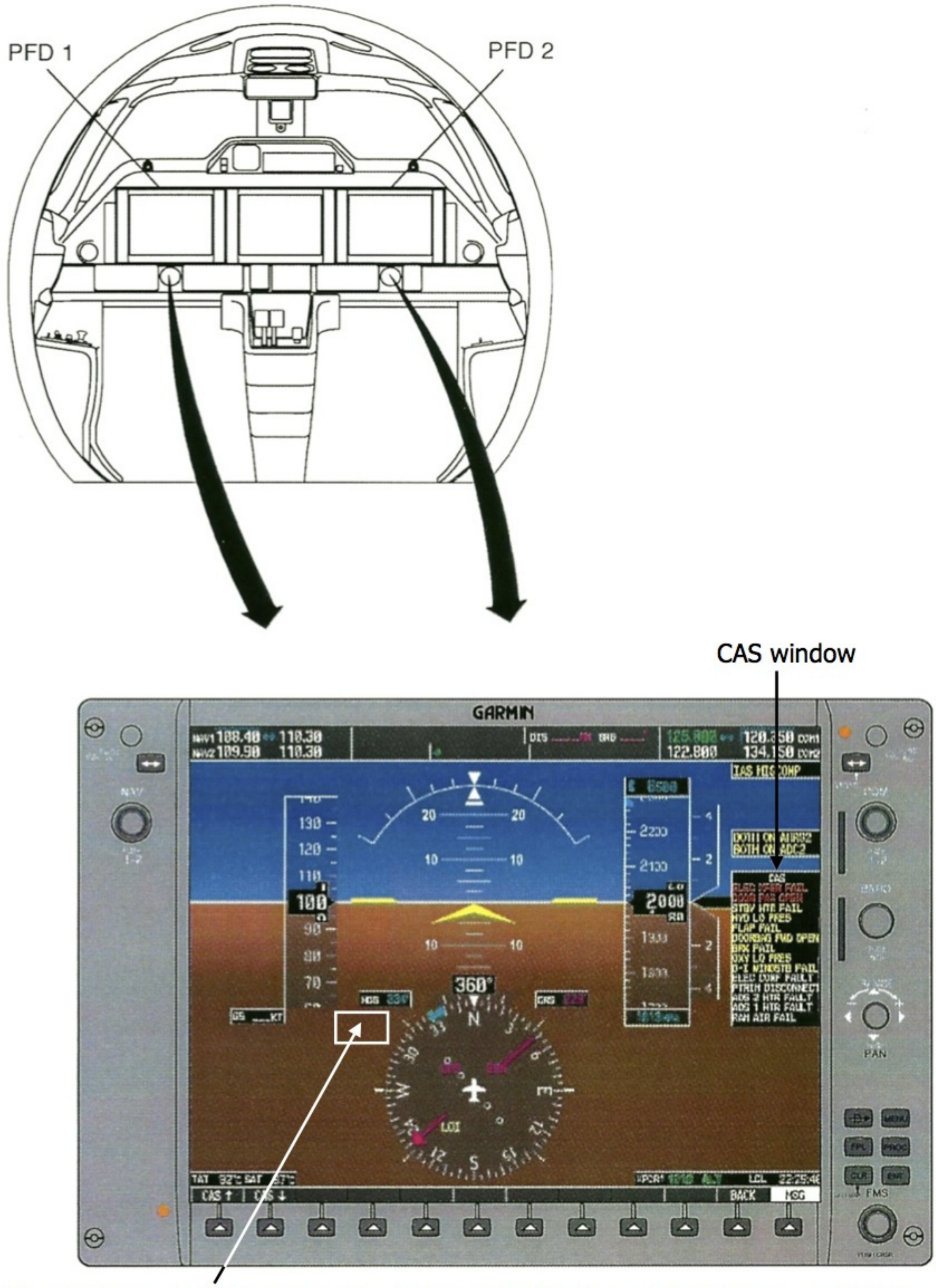


Second approach



Annex 7: Cockpit layout

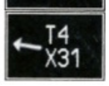
Annex 8: Primary Flight Display (PFD)



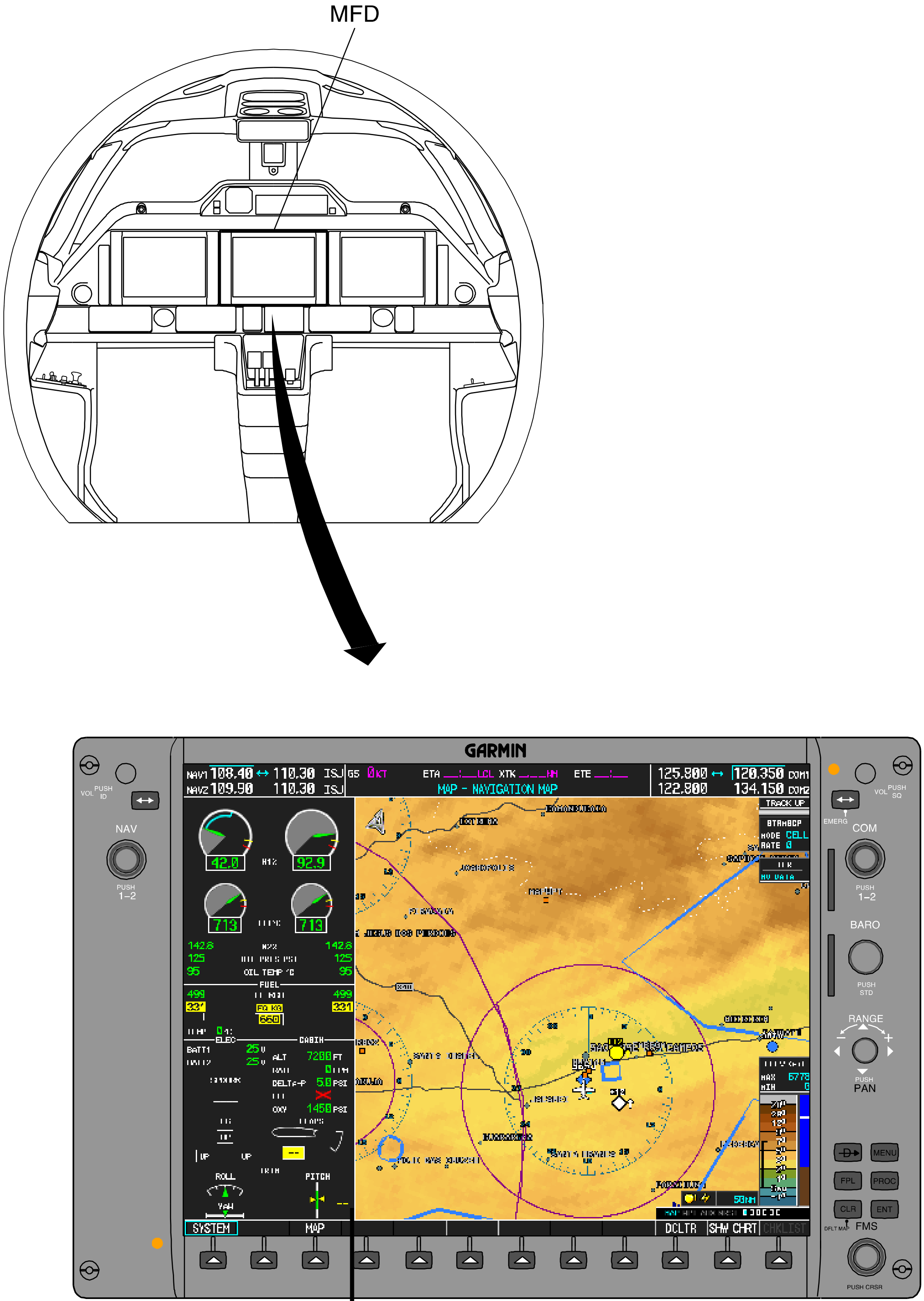
On the PFD the wind information can be displayed in three different ways as follows:

- Wind direction arrow with numerical value of the windcomponent 

- Wind direction arrow with numerical value of the windspeed 

- Wind direction arrow with headwind (H), tailwind (T) and crosswind (X) component 

Annex 9: Multi Function Display (MFD)



Left side of the MFD

To be intended to display engine data and system information

Center and right side of the MFD

For displaying charts and flightplan information and a wide range of additional information as e.g. traffic display, weather radar, terrain, approach charts and waypoint information

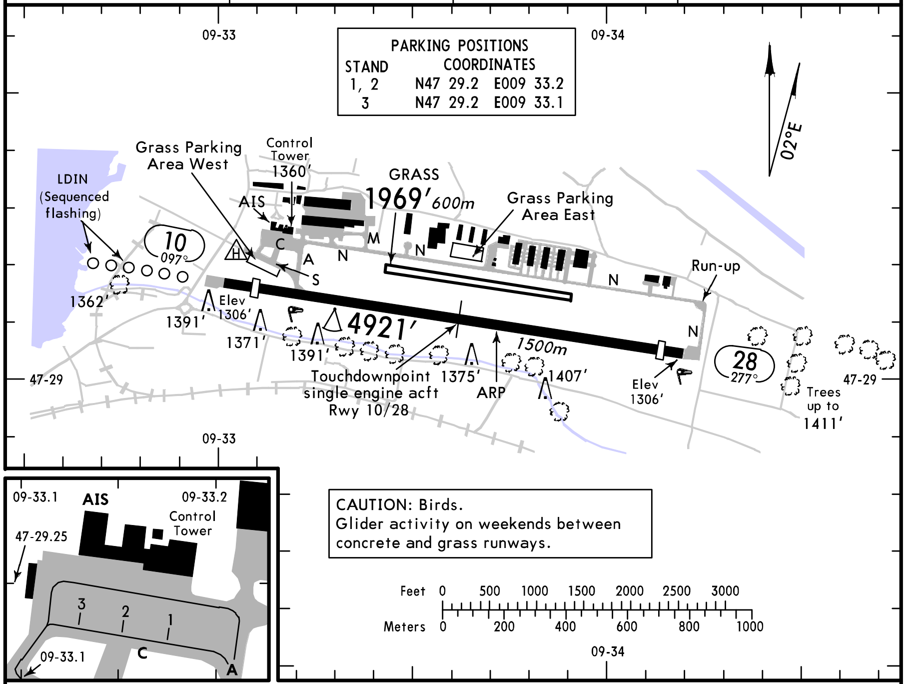
Annex 10: Aerodrome information chart according Jeppesen

LSZR/ACH JEPPESEN **ST GALLEN, SWITZERLAND**

Apt Elev **1306′** 9 JUL 10 (10-9) ALTENRHEIN

N47 29.1 E009 33.7

ATIS	*ST GALLEN Ground	*Tower	ZURICH Arrival (DEP)
123.77	121.8	118.65 119.7	119.92



ADDITIONAL RUNWAY INFORMATION

RWY		USABLE LENGTHS LANDING BEYOND Threshold	Glide Slope	TAKE-OFF	WIDTH
10 ❶	HIRL *(50m)* LDIN REIL PAPI (4.0°, MEHT 23′) RVR	4593′ ❷ *1400m*	3871′ *1180m*		98′ *30m*
28	HIRL *(50m)* PAPI-L (angle 4.0°)	4675′ ❸ *1425m*			
10 / 28	Grass runway				75′ *23m*

❶ Rwy grooved. ❷ Single engine aircraft: 2421′ (738m). ❸ Single engine aircraft: 2500′ (762m).

NOISE ABATEMENT PROCEDURES

Reverse thrust

For deceleration it is recommended to use entire rwy length available. Reverse thrust shall be used for safety or operational reasons only.

Taxi and holding

Acft shall be operated so as to reduce noise to a minimum during taxi and holding operations.
Recommendations for turbo-prop acft:
- Taxi: one engine idle power/low RPM;
- Holding: both engines idle power/low RPM.

Auxiliary Power Units (APU)

The following regulations are applicable to the use of APU:
- at maximum 20 min prior to the acft departure;
- at maximum 10 min after the acft arrival;
- longer duration only with special permission by AD authority.

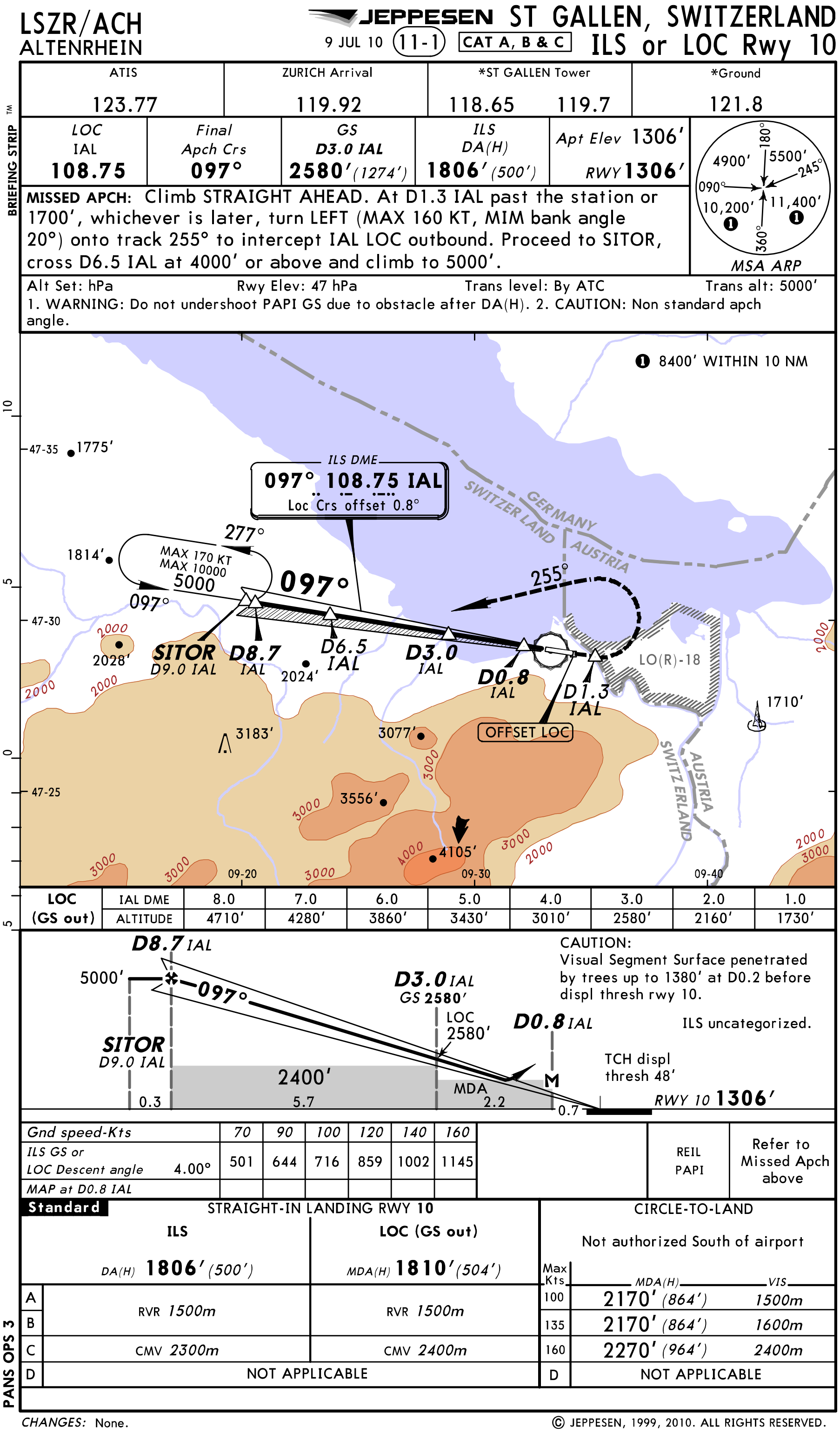
The use of APU for maintenance shall be restricted to a minimum duration.

Standard TAKE-OFF

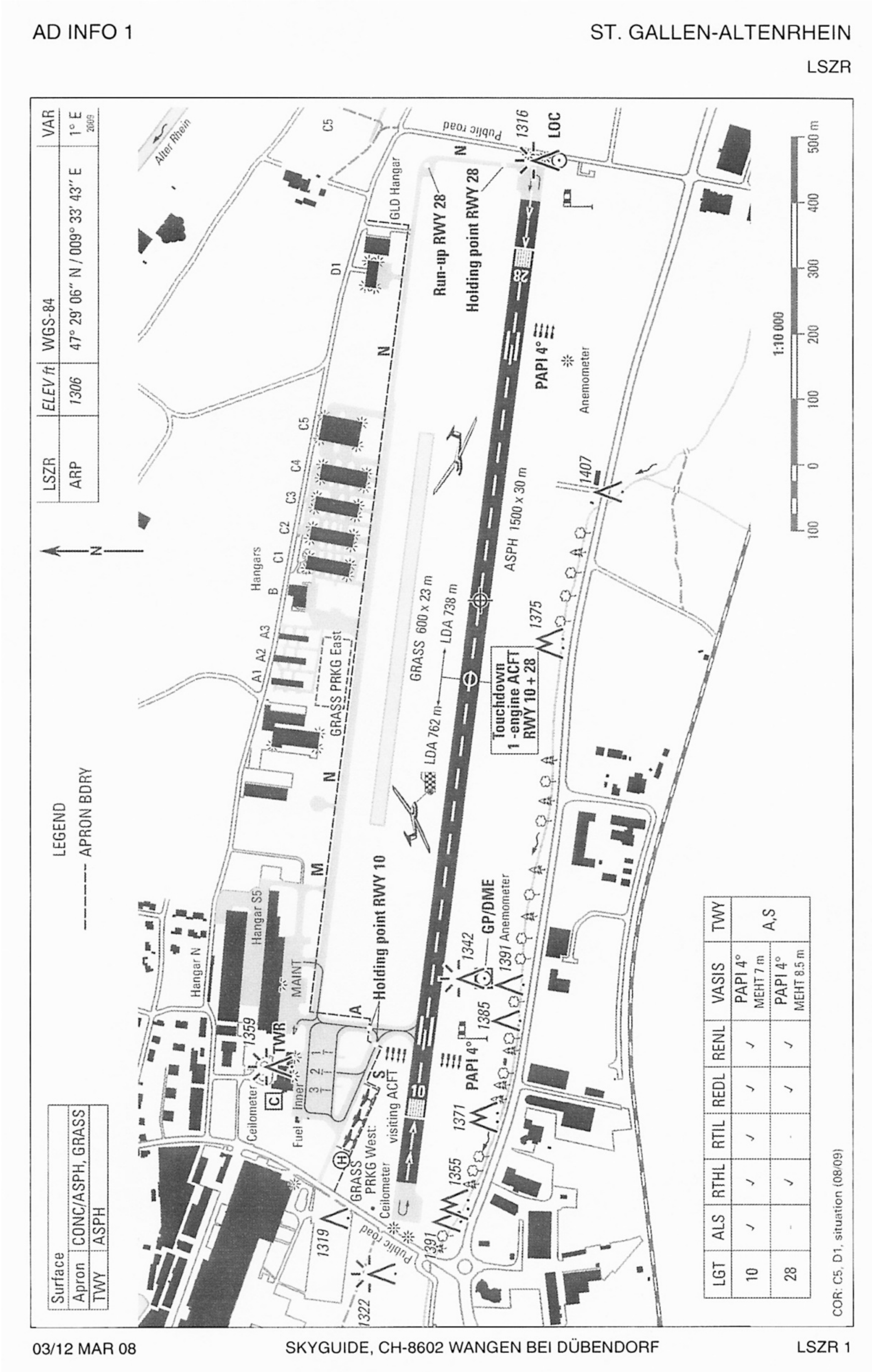
	Main Rwy	
	RCLM (DAY only) or RL	NIL (DAY only)
A B C	*400m*	*800m*
D	NOT APPLICABLE	

CHANGES: Minimums.

Annex 11: Aerodrome approach chart according Jeppesen



Annex 12: Aerodrome information chart according AIP Switzerland



Annex 13: Checklist for emergency and abnormal procedures

PREVIOUS

EMERGENCY AND ABNORMAL PROCEDURES

Flight Controls

FLAP FAIL

CAS Indication: Flap indication missing or yellow.
CAS Message: SWPS FAULT may also be displayed.

Flap Lever.. CYCLE
Up to three cycles may be attempted.

FLAP FAIL MESSAGE PERSISTS? — **No** (go to END)

Yes

Altitude.. MAX 18000 FT
Icing Conditions.............................. EXIT/AVOID

If it is not possible to avoid icing conditions:
LAND AS SOON AS POSSIBLE.

FOR LANDING:

- **Check the available airports within the current range and choose the one that best matches the required runway length. Considerations for uphill slope and occurrence of headwind should be also made.**
- **Burn as much fuel as possible to reduce the landing weight.**
- **Maintain bank angle below 40°.**
- **Maintain the airspeed according to the following:**

FLAP POSITION	MINIMUM AIRSPEED	
	NO ICING	IN ICING/WITH ICE
0	$V_{REF\ 3}$ + 25 KIAS	$V_{REF\ 3}$ + 36 KIAS
1	$V_{REF\ 3}$ + 17 KIAS	$V_{REF\ 3}$ + 25 KIAS
2 and 3	$V_{REF\ 3}$ + 4 KIAS	$V_{REF\ 3}$ + 13 KIAS

NOTE: - If flap stop between two positions, use the minimum airspeed associated with the next retracted position and the V_{FE} associated with the next extended position.
- Disregard green circle indication, as it may indicate slower speeds.

(Continues on the next page)

MENU PR

EMERGENCY AND ABNORMAL PROCEDURES

Flight Controls

(Continued from the previous page)

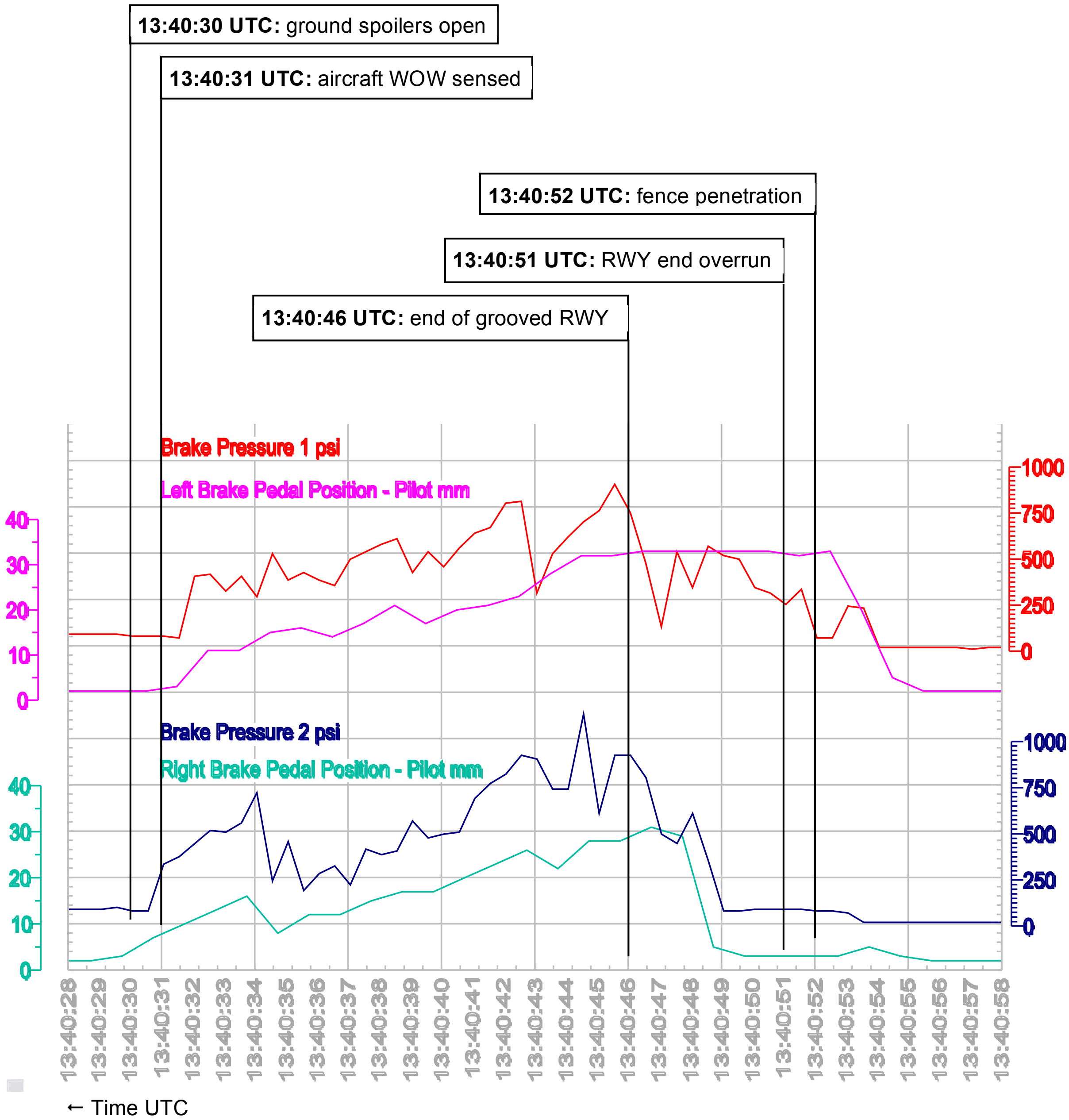
If a go-around is required, maintain the minimum airspeed presented in the applicable flap configuration, according to the previous table, until the acceleration altitude is reached.

<u>CAUTION:</u> TO DETERMINE THE MINIMUM REQUIRED LANDING DISTANCE, ENTER ONE OF THE FACTORS BELOW AND THE FLAP 3 FACTORED LANDING DISTANCE IN THE “LANDING DISTANCE CORRECTION” TABLE.

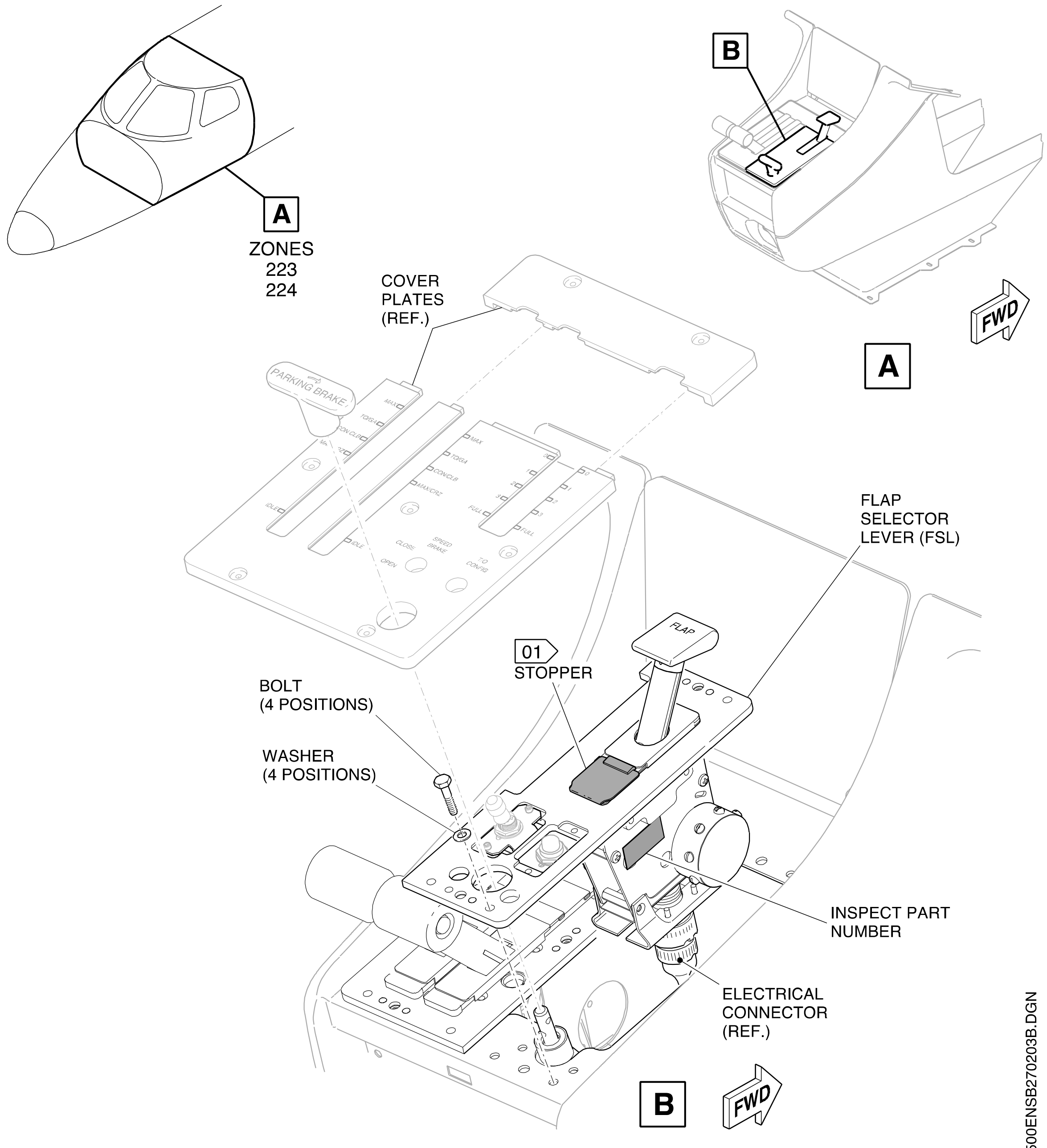
FLAP POSITION	CORRECTION FACTOR	
	NO ICING	IN ICING/WITH ICE
0	1.40	1.60
1	1.30	1.40
2 and 3	1.10	1.30

END

Annex 14: Function of brakes after landing



Annex 15: Extract from Service Bulletin No 505-27-0010



01 IF APPLICABLE, WHEN YOU LIFT THE FSL, MAKE SURE THAT THE STOPPER REMAINS IN ITS POSITION

FIGURE 1 - INSPECTION/REPLACEMENT OF THE FLAP SELECTOR LEVER (FSL)
(SHEET 01 OF 01)