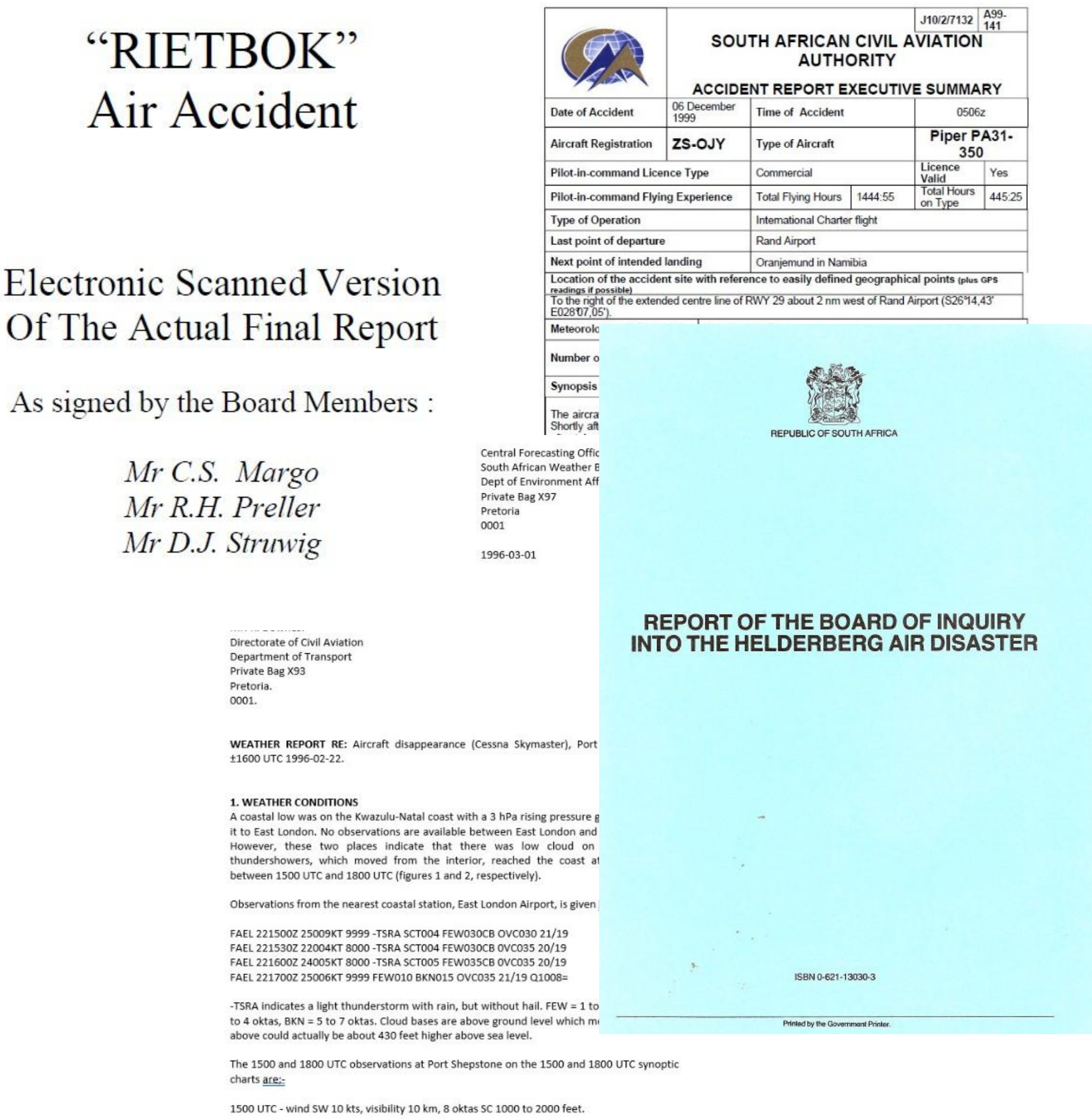
# A collection of South African aircraft accidents and incidents





**Michael Pierre de Villiers**

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Title page: Examples of official South African reports of accidents and incidents used to compile this collection.

**ABOUT THE AUTHOR**

Michael Pierre de Villiers was born in Durban, South Africa. He was trained to World Meteorological Organization class one meteorologist and multi-discipline weather forecaster in the South African Weather Service where he reached the rank of Director. He served on a weather ship in the South Atlantic. He served on World Meteorological Organization expert teams and was World Meteorological Organization rapporteur for the Africa region. He was also a commercial pilot and flying instructor. More recently he was a weather forecaster in the United Arab Emirates, then in England. Now retired.

M. P. de Villiers
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2025-01-26

# A collection of South African aircraft accidents and incidents

**M. P. de Villiers**

## INTRODUCTION

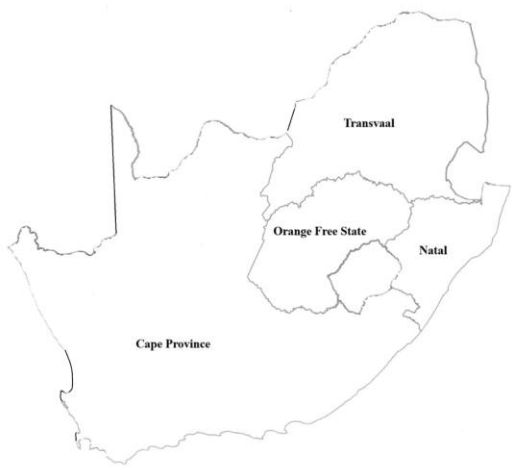
These pages consist of a selection from over 90 investigative reports into the weather conditions, and forecast weather of mostly general aviation accidents (fatal and non-fatal) and incidents relating to South Africa between 1992 to 2001. Some involving commercial aviation. They were investigated by me at the request of the South African Department of Civil Aviation Authority (SACAA). Occasionally other interested parties. These reports are not exact copies of those given to clients. They have been edited with additional information from other sources not always available at the time. For the sake of brevity, the numerous maps and charts that accompanied the original reports have been omitted. While primarily weather related, included are some not weather related examples that received thorough investigation and considerable public attention. These and other interesting events that did not involve me occurred while I was in the South African Weather Bureau (SAWB) from 1966 to the end of 2001. In 2001 the SAWB became the semi-commercial South African Weather Service.

It was always important to receive requests for weather information as soon as possible after the accident or incident. In accord with the World Meteorological Organisation (WMO) technical regulations, volume 2, Meteorological Services for International Air Navigation (C.3.1) 9.4.13, written or printed flight documentation should be kept for a period of at least 30 days. The SAWB central forecast office far exceeded this minimum period and stores all aviation information for 6 months, after which it was discarded. The point is that while it is still possible to reconstruct weather conditions, from other sources over longer periods, that have been archived, a certain amount of detail and/or relevant information is bound to be lost.

Most of the accidents or incidents were found by SACCA to be not weather related while some could not be classified with any certainty. The highest category (±30 reports) of weather related accidents or incidents was associated with low cloud and poor visibility, including fog. The next most prevalent category was thunderstorms (±10). This and the previous category were sometimes difficult to determine whether the cause was low cloud or thunder activity, both being present. Was the cause of the accident flight into cloud/thundercloud followed by uncontrolled flight or controlled flight into terrain (CFIT)? Other weather accidents or incidents were much less frequent. For example, there were only two strong surface wind events, one or two icing events, one clear air turbulence (CAT) incident of note and two mountain wave turbulence incidents. In the absence of official SACAA reports for many of the accidents or incidents, the category is, somewhat subjectively, deduced from the observed weather, satellite images, lightning records from the Eskom (Electricity Supply Commission) Lightning Position and Tracking System (LPATS), accident site evidence and witness evidence. At times media reports were consulted.

Some early reports refer to South African provinces that no longer exist. Prior to 1994, South Africa had four provinces; the Cape province, the Orange Free State, Transvaal and Natal (below left). Since 1994, South Africa has nine provinces (below right).

Lesotho is the unmarked landlcked country. Landlocked Eswatini is east of Mpumalanga, next to Mozambique that borders Mpumalanga and Limpopo provinces. Botswana is north of the North West and Northern Cape provinces with Namibia to the north of the Cape Province and west of Botswana.





Similarly, many of the airport names referenced have been changed. The old names, as stated in the reports and SACAA reports, have been retained. Airport information, such as altitudes and runways were obtained from the SACAA Aeronautical Information website. Except three, where the altitude is courtesy of Airport Guide, namely Ladysmith, Mossel Bay, Saldana/Vredenburg, Vredendal and Vryheid airports. The altitude of place names mentioned are courtesy of Worldwide Elevation Map Finder, Mapcarta and Topographic-map.com.

The primary intention is for the information of aviation forecasters to weather phenomena and circumstances, which have proven to be a danger to aviation. Some of the information provided may appear superfluous, but the intention is to give the reader as thorough presentation as possible of the weather situation at the time and if the reader so wishes, make their own judgements and conclusions. Some are included simply to provide information and insight that it is believed would be beneficial to the aviation forecaster.

Information with respect to the aircraft and people involved is given in good faith. Names have been removed in order to preserve anonymity. The opinions expressed are mine. They are not made with any malicious intent. Furthermore, the opinions were not included as part of the official reports, which provided only the facts.

Aviation parlance is strewn with terms and acronyms foreign to the lay person, even to people in aviation. Some of them are presented here. Others will be explained as and when they arise in the text.

AFB = air force base
AGL = above ground level
ATC = air traffic control
AWS = automatic weather station
DME = distance measuring equipment
FIC = flight information centre

GPWS = ground proximity warning system
HF = high frequency
hPa = hectoPascal
IAS = indicated air speed
IFR = instrument flight rules
ILS = instrument landing system
IMC = instrument meteorological conditions
MSL = (above) mean sea level. It is synonymous with altitude.
NDB = non-directional beacon
SYNOP = surface synoptic observation
VFR = visual flight rules
VMC = visual meteorological conditions
VOR = very high frequency omnidirectional range
VSI = vertical Speed indicator
QNH = air pressure reduced to sea level.

Meteorological Aviation Reports (METAR) and Terminal Aerodrome Forecasts (TAF) frequently appear in the reports. These are explained in the Appendix. They are not the latest World Meteorological Organization (WMO) and International Civil Aviation Organization (ICAO) amended versions, nor fully comprehensive. For example, some countries use MPS and KPH for wind speed, or add additional information. However, the codes are those as used in South Africa at the time. Automatic weather stations (AWS) are presented in METAR format. AWS reports do not include visibility, weather and cloud elements. At the time there was not the technology to measure and transmit these elements.

In accord with international aviation practise, Z (Zulu) time is used. Also known as Z (Universal Time Coordinated), previously GMT (Greenwich Mean Time). Local time is B (Bravo). South African Standard Time (SAST) is 2 hours ahead of Zulu time. For example, in South Africa, 0600Z is 0800B or 0800 SAST.

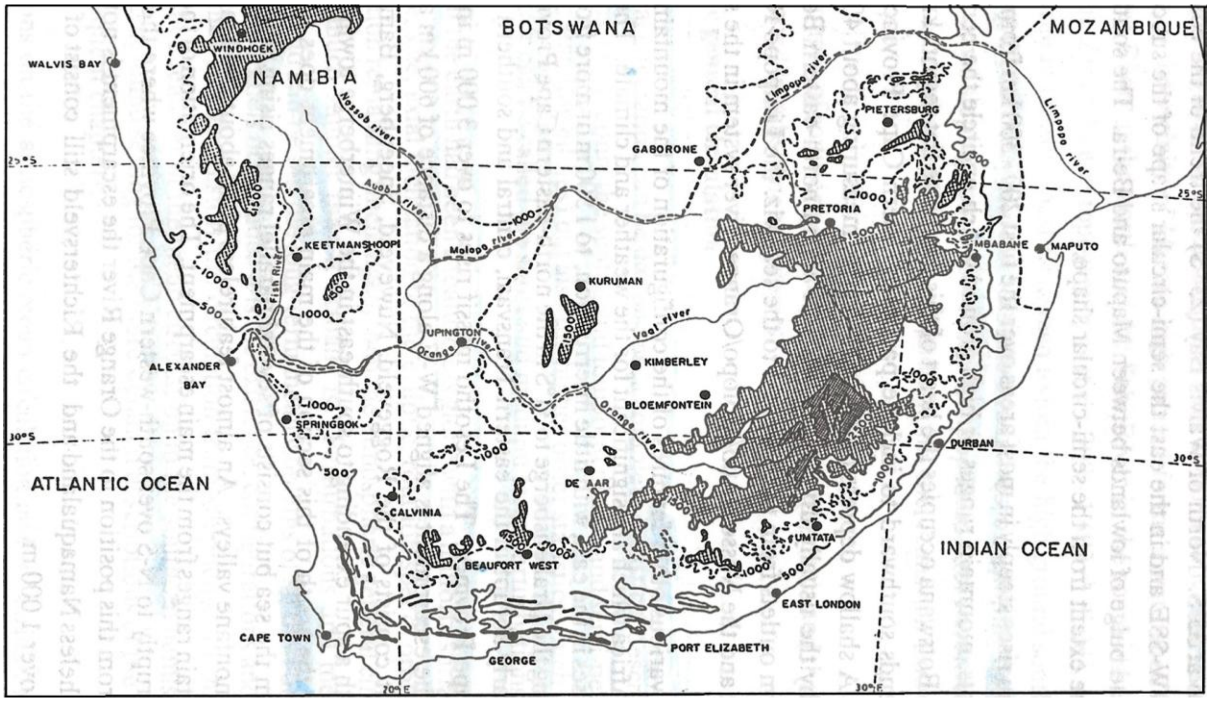
Standard aviation specifications are knots (kt) for speed, nautical miles (nm) distance, metres (m) for visibility, feet (ft) for cloud base, temperatures °C. Wind directions re in degrees true. That is, not magnetic directions. Cloud cover is expressed in oktas. Few (FEW) = 1-2 oktas, scattered (SCT) = 3-4, broken (BKN) = 5-7 and overcast (OVC) = 8.

Aircraft are flown and separated according to flight levels (FL) in graduations of 500ft, with the altimeter set to mean sea level (MSL) pressure 1013hPa. For example, FL060 is approximately 6000ft above MSL while FL065 is approximately 6500ft. This is an approximation because the sea level pressure is rarely exactly 1013hPa. This can result in significant errors with the flight level (FL) higher than the real altitude and the Fl lower than the real altitude. This FL error can be significantly and dangerously lower. Hence when the minimum safety altitude above ground level (AGL) is below usually 5000ft, but can be higher, the altimeter must be set to the local sea level pressure. En-route, the pilot must always maintain minimum en-route altitude so that the aircraft will be safely higher than the highest obstacle along the route and a safe distance horizontally.

## SUMMARY OF WEATHER SYSTEMS OVER SOUTH AFRICA

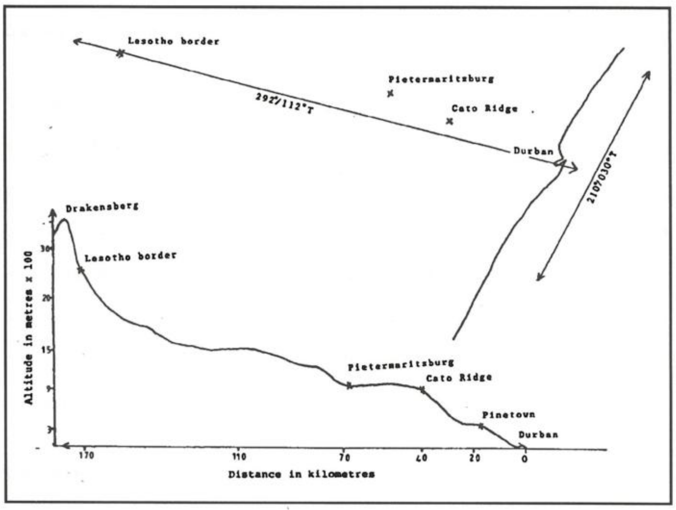
South Africa lies beneath the Southern Hemisphere subtropical high-pressure belt centred at about 30°S, the position of which varies by about 3 to 4 degrees further north in winter than in summer with higher pressure in winter. The effect is widely sunny and dry weather with the country susceptible to droughts. It is skirted in the south by the circumpolar westerly air stream within which low-pressure systems migrate eastward bringing inclement weather.

Cyclones (low-pressure cells), usually with associated cold fronts, progress eastward. Eastward progression is on average, at $10ms^{-1}$ but may be more than $15ms^{-1}$ and have an average life of three to four days, but occasionally can be tracked for a week or more. Anticyclones (high-pressure cells) move eastward more unsteadily than cyclones and can become semi-stationary. In particular, the Indian Ocean anticyclone over eastern South Africa, more so in winter (Taljaard 1994).



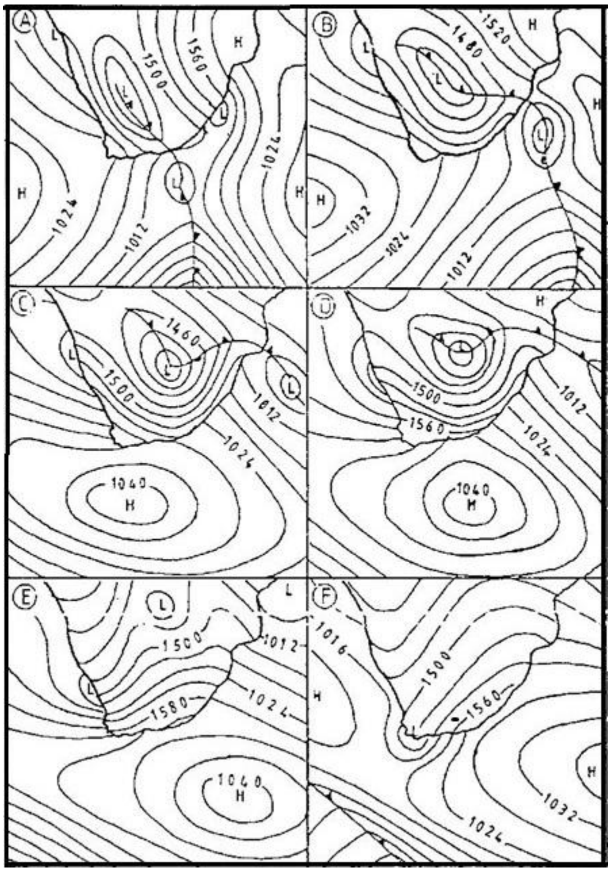

South Africa topographical map. Contours are 500m (1640ft), 1000m (3280ft), 1500m (4921ft) and 2500m (8202ft). Courtesy of Taljaard 1994.

The topography of South Africa is one of a plateau that mostly rises steeply within 200-300 kilometres (km) from the coast. Referring to the map below, one can see that the main escarpment is in the east where the Drakensberg Mountains begin in the north bordering the Lowveld in Mpumalanga, rising to 1500m or more while it extends, with little interruption, along the border of KwaZulu-Natal, reaching 3000m passing Lesotho, to the Eastern Cape. At the border between KwaZulu-Natal and Lesotho the Drakensberg at Thadentsonyane it attains a maximum peak of 3482m (11425ft (3398 Durban World Aeronautical Chart)). Further south in the Cape Province, the east to west escarpment lies about 250km from the coast. Here the escarpment consists of several parallel ranges rising from 500m to 1000m. At the south-western Cape the escarpment become south to north oriented, becoming much less noticeable further




north at around 500m (Taljaard 1994). The escarpment tends to act as a barrier to inclement weather spreading inland to the plateau with most of the weather kept seaward of the barrier. Not always of course. The marked escarpment in the KwaZulu-Natal area can be seen in the diagram on the left (de Villiers 1992). Its significant will be evident in the accidents over KwaZulu-Natal.

A model of the sequence of synoptic weather systems experienced over South Africa is shown in the figure below. Viewing from top to bottom, left to right, map (A) starts with a cold front south of the country extending northward to a secondary low off the coast and a trough over the western interior, preceded by a coastal low on the KwaZulu-Natal coast. The following map (B) shows the cold front passing to the east with the Atlantic Ocean Anticyclone (AOA) beginning to ridge eastward. The next two maps (C and D) show the AOA ridging strongly eastward south of the country. Meanwhile, a coastal low forms along the Namibia coast under a developing offshore flow from the land mass. Map E shows broadly pressure recovery over the land mass with the coastal moving southward to the south-west Cape in map F ahead of an approaching cold front with the now established Indian Ocean Anticyclone (IOA). The sequence then returns to map A.



Model of the sequence of synoptic events (de Villiers 1992).

Overcast low stratus cloud with reduced visibility often follows the coastal low seawards of the escarpment (maps A and B) and quickly spreads inland over KwaZulu-Natal with mist and fog where the ground protrudes into the cloud layer then northward over the Lowveld in Mpumalanga pushing against the eastern escarpment. Hot and dry Berg winds (known in Europe as a Foehn wind) can pre cede the coastal low over KwaZulu-Natal, usually around September.

In the summer months thunderstorms in the Intertropical Convergence Zone (ITCZ) move southward ahead of the interior trough (maps A and B) over the Northern Cape eastward to the Free State, Eastern Cape, Mpumalanga and KwaZulu-Natal. The ITCZ is a region where the north-easterly and south-easterly trade winds converge, forming an often continuous band of clouds or thunderstorms near the geographical equator. The ITCZ moves with the thermal equator to north of the geographical equator in the Northern Hemisphere and to the south in the Southern Hemisphere summer. Thunderstorms also occur along a cold front.

While showery precipitation with a higher cloud base and improved visibility can follow the cold front (map B), more often than not the following ridging AOA (maps C and D) with moist air over the ocean maintains the feed of low cloud and poor visibility over KwaZulu-Natal and the Lowveld, until a north-easterly to north-north-easterly flow develops in the east such as in map F due to the now IOA. In the winter months cyclones (low-pressure cells) pass close to the south coast bringing low cloud, rain and wind to the coastal belt. Marked cyclones can bring cold front strong to gale force winds, heavy rain and thunderstorms to the south-west Cape and the south coast. The south-west Cape under dominant high-pressure is sunny warm to hot and dry in summer.

The Mozambique Channel is occasionally influenced by tropical cyclones that affect Mozambique, the Lowveld area and the northern KwaZulu-Natal coastal area causing flooding and wind damage. They originate east of the Seychelles between about 5° and 15° S; these usually travel south-west and then re curve to the south-east, seldom reaching the Seychelles but frequently affecting Madagascar, Mozambique, the Comoro Islands, Reunion and Mauritius. They are liable to occur from November to May and are most frequent from January to April.

## LOW CLOUD AND FOG

Low cloud and poor visibility are the most common causes of fatal weather related accidents in the Republic of South Africa. My experience is that most of them occur over KwaZulu-Natal when VFR (visual flight rules) pilots attempt to go from the coast to the Highveld in IMC (instrument meteorological conditions).

### Low cloud over KwaZulu-Natal 1994-12-18

Report Ref: 16/7/1 1994-12-30.


The author's stock photograph of a Piper Cherokee 180 from which the Arrow was developed.

A retractable tricycle undercarriage, 4 seat, single piston engine Piper PA-28R-180 Cherokee Arrow aircraft was on a flight from the East Rand to Pietermaritzburg's Oribi Airport (2423ft, 738m) when it went missing at about 0930Z on the 18th December 1994. The following day, the crashed aircraft was found in misty weather, by the crew of a South African Air Force (SAAF) Alouette helicopter, about 15nm (28km), north-west of Pietermaritzburg in the Loskop area. Loskop is a mountain 5131ft (1564m) MSL (Worldwide Elevation Map Finder). One occupant was killed, but the other occupant survived with head injuries after being thrown from the aircraft on impact.

A coastal low had passed north of the KwaZulu-Natal coast with a cold front passing over the area in the early afternoon. The 0600Z synoptic weather map showed that broken (5-7 oktas) to overcast (8 oktas) low level cloud had already moved as far inland as Estcourt and into the northern interior. It may have spread further inland. At 0600Z the cloud base varied from SYNOP (surface synoptic observation) code height 4 (300-600m, or 1000-2000ft AGL) in the south to as low as code 1 (50-100m, or 150-300ft AGL) in the north. The surface wind was generally light southerly to easterly.

Due to the lack of manual METAR observations it could not be stated, with any certainty, what was the cloud base. The nearest was the Pietermaritzburg Automatic Weather Station (AWS) at 29.6°S 30.4°E, which is 2211 (674m) MSL. Using the 2° difference between the surface air temperatures and the dew point temperature and the parcel method of condensation level calculation at Pietermaritzburg, the calculated cloud base would be ±800ft AGL or 3000ft MSL at 0600Z (0800B). However, a word of caution. This could be a false assumption. Sunrise at this time of the year is at ±0500B and the minimum air temperature and hour or two later. The low temperature difference at this time of the morning could be due to overnight radiation cooling. The surface air temperature not yet begun to rise due to increasing incoming solar radiation.

The fact that 0900Z observations indicated the base was about 4500 ft MSL (±2300ft AGL) suggests ±800ft AGL may well be an underestimation. At 0900Z, an AWS nearby to the south-east west-south-west indicated recent rain and a possible cloud base of about 1500ft AGL. Other AWS's indicated possible bases of about 2500 to 3000ft AGL.

At 1200Z, the synoptic weather map indicated cloud was scattered to broken over the KwaZulu-Natal interior. The AWS dew-point depressions, and the single 1500ft cloud base observation at Cedara (altitude 3514ft, 1071m, Worldwide Elevation Map Finder) on higher ground north of Pietermaritzburg, led one to believe the cloud base was about 4000-5000ft AGL.

The atmospheric sounding at Durban (on the coast 25ft, 8m MSL) at 0000Z, indicated that there was sufficient low level moisture for the cloud to have been present from ground level to about 4500ft MSL with another layer at 6000 to 8000ft MSL, but at 1200Z about 5000ft to 7000ft MSL.

The conclusion is that at 0600Z the cloud base varied 1000-2000ft (300-600m) AGL in the south to as low as 150-300ft (50-100m) AGL, increasing to about 2500-3000ft AGL by 0900Z. Although, in places, still down to about 1500ft AGL in rain patches with higher ground close to or in the cloud base, such as higher ground to the nearby north of Pietermaritzburg and generally 3000-5000ft AGL by 1200Z.

The TAF for Pietermaritzburg (FAPM, 2423ft, 738m MSL) reproduced below, tended to underestimate the weather conditions. TAF cloud bases are always AGL.
FAPM 0615 14012KT 9999 SCT020 BKN050 BECMG 0912 BKN040TCU TEMPO 1315 5000 TSRA SCT040CB.
That is, expected cloud bases were expected to be ±4500 and 7500ft MSL becoming ±6500ft MSL.

However, the 0800Z low level significant weather chart gave a better picture of the weather with broken cloud given at 6000ft MSL. This would mean a base of about 1000ft or less above higher ground in places, particularly to the west toward the Drakensberg where the cloud base would be lower than rising ground. At 1100Z, the significant weather chart forecast scattered Cu (Cumulus) cloud, with a base about 3000ft higher than observed or calculated from dew-point depressions. The forecast was generally adequate, but tended to the optimistic. This is not a good bias.

From experience I knew that the passage of a coastal low rapidly spreads low cloud as far inland as Pietermaritzburg and north-east at Greytown, particularly in the summer months. On one occasion, a pilot at Greytown, that regularly provided weather information, telephoned 30 minutes after the coastal low had passed Durban, to say that the area was overcast with low stratus from the south.

What added to the complexity of this situation and an important consideration, was that low cloud from the Mozambique Channel had also spread from the north-east over Mpumalanga, Gauteng, the north-eastern Free State and into northern KwaZulu-Natal.

On the basis of the above, cloud could be expected to lift and develop into Cumulus cloud in the north, but tend to remain cloudier seaward of the escarpment in the area that extends along Estcourt to Greytown.

It was not possible to obtain a SACAA inquiry report, nor further information from an internet search. Furthermore, it is not known whether it was a VFR or IFR (instrument flight rules) flight. If it was a VFR flight it would seem the pilot managed to get close to Pietermaritzburg, about 15nm to the north-west, before being unable to avoid high ground. Loskop is nearby to the north of Estcourt on the higher ground of the escarpment.

If it was an IFR flight it could be a case of being in cloud and colliding with terrain below the minimum safe altitude for the area while navigating toward the Oribi Airport NDB (non-directional beacon). In other words, CFIT (controlled flight into terrain). The fact that there was a survivor, leads me to believe the former scenario. Unable to avoid high ground

In some aspects the forecast was generally adequate, but tended to the optimistic. This is not a good bias. Low cloud was indicated early at 0600Z in the synoptic map. Less than reliable AWS estimations indicated an improved cloud base. However, it would appear that cloud base improvement was too soon.

**Post cold front low cloud over the Lowveld 1996-02-27**

Report Ref: 16/7/1 1996-02-27

A retractable tricycle undercarriage twin engine Piper Navajo Chieftain, crashed into mountainous terrain. It was on a flight from Tzaneen airport (1914ft, 583m MSL in Limpopo Province) to Nelspruit (Mpumalanga) in the Lowveld, a distance of 108nm (200km), in poor weather conditions. Nelspruit airport, at 2901ft (884m) MSL, considered to be in the Lowveld, is in the foothill area of the steep and mountainous escarpment west of the southern Lowveld. The accident site was near the Long Tom Pass, about 27nm (50km) north-west of Nelspruit, at about 1000Z on the 27th February 1996. Both occupants, the experienced, instrument rated commercial pilot and passenger, were killed. The Long Tom Pass through the escarpment is really part of the northern end of the Drakensberg. It starts at 4776ft (1456m) altitude on the Lowveld side to an altitude of 7053ft (2150m) at its summit.

Moist air was in circulation due to a high off the east coast with extensive low cloud advected westward over the north-east of South Africa, as evidenced by 0900Z and 1200Z synoptic weather maps with rain present over the northern part of the Northern Province.

The available 1000Z to 1200Z METARs are given below. Note, -DZ indicates a light drizzle and -RA light rain. FEW = 1 to 2 oktas, SCT = 3 to 4 oktas, BKN = 5 to 7 oktas OVC = 8 oktas. The temperature elements at FAHS were unserviceable. TCU at FAPB is towering cumulus cloud. Cloud bases are AGL

FAHS 271000Z 13008G18KT 9999 BKN015 XX/XX Q1017 NOSIG=
FALT 271000Z 11018KT 4000 -DZ OVC007 20/18 Q1019=
FAPB 271000Z 10009KT 9999 BKN030TCU 22/17 Q1019=
FAPH 271000Z AUTO 15008KT //// 23/18 Q1016=

FAHS 271100Z 13008G18KT 9999 BKN030 XX/XX Q1016=
FALT 271100Z 12007KT 4000 -RA 0VC005 19/18 Q1019=
FAPB 271100Z 08013KT 9999 BKN035TCU 22/17 Q1019=
FAPH 271100Z AUTO 17006KT //// 22/19 Q1016=

FAHS 271200Z 11007KT 9999 BKN030 XX/XX Q1016=
FALT 271200Z 12010KT 9999 OVC008 19/18 Q1019=
FAPB 271200Z 07013KT 9999 BKN035TCU 21/16 Q1019=
FAPH 271200Z AUTO 16006KT //// 23/19 Q1015=

FALT (Louis Trichardt airport) at 3069ft (935m) MSL is on higher ground west of the less mountainous escarpment in the north. Its low 500-800ft AGL cloud was ±3500-3800fr above MSL. The 3500ft cloud base at FAPH (Phalaborwa airport) 1432ft (436m) MSL, midway along the western border of the Kruger National Park in the Lowveld, equates to ±4900ft MSL. FAHS (Hoedspruit AFB and civilian airport), at 1738ft (530m) MSL, is adjacent to the northern Kruger National Park in the Lowveld. Here the cloud base at 1500ft and later 3000ft was ±3200ft and ±4700ft MSL, respectively. FAPB (Pietersburg airport) at 4076ft (1242m) much further to the west. Reporting 3000-3500ft converts to ±7000-7500ft MSL.

At 1200Z the following additional information was available: Grenshoek near Tzaneen (1914ft, 583m MSL) reported 8 oktas at 1000 to 2000ft (±2900-3900ft MSL) with good visibility and no wind. Skukuza airport (1040ft, 317m MSL) reported 8 oktas at 3000 to 4000ft AGL (or ±4000-5000ft MSL) with a 10kt south-easterly wind. Skukuza airport is the only commercial airport in the Kruger National Park, near Skukuza Camp, in the Lowveld, in the Mpumalanga Province.

The radiosonde balloon ascent at Pietersburg at 1200Z indicated very moist air from 780hPa to 700hPa, about 7000 to 10000ft above MSL, where the main layer of cloud probably existed. There was a deep easterly (onshore) flow from the Mozambique channel. A similar layer of moisture was present on the atmosphere sounding at the SAWB Irene (FAIR ICAO code) upper atmosphere research station south of Pretoria. A higher layer of cloud was seen on the satellite image, probably present between about 600hPa to 510hPa (14000 to 18000ft MSL) according to the Pietersburg ascent and 550hPa to 475hPa (16000 to 19000ft) on the Irene ascent. The nearest ascent on the seaward side of the escarpment was well south at Durban. It indicated enough moisture for cloud at 850hPa to 775hPa (5000 to 7500ft MSL).

The forecast weather for the area in the low level significant weather chart at 1100Z, was broken cloud from 4000ft MSL to 8000ft MSL over the Lowveld, along the escarpment and into the Limpopo Valley. Reduced visibility due to drizzle was forecast along the escarpment with broken cloud at 8000ft MSL west of the escarpment. The forecast cloud compared favourably with the observed data.

TAF's applicable to the area are given below. FANS = Nelspruit.
FAHS 270700Z 270918 11005KT 9999 SCT030CB BKN030 INTER 0918 6000 TSRA=
FAPH 270700Z 270918 13004KT 9999 SCT030CB BKN030 INTER 0918 6000 TSRA=
FANS 270700Z 270918 VRB05KT 9999 SCT030CB BKN030 INTER 0918 6000 TSRA=

FAPB 270700Z 270918 VRB05KT 9999 BKN020 BECMG 1114 SCT030CB SCT030 TEMPO 1418 6000 TSRA=
FALT 270700Z 270918 VRB05KT 9999 BKN020 BECMG 1114 SCT030CB SCT030 TEMPO 1418 6000 TSRA=

The observations indicated that there was widespread low level cloud over the area. According to these observations it is most likely that the escarpment area and higher ground had cloud down to ground level, or the terrain extended upward into the cloud. This was also the message conveyed by the low level significant weather chart, although a lower forecast visibility would have been more appropriate.

Icing was likely present in cloud above the freezing level, which was about 14500ft according to the soundings at Pietersburg and Irene, but which was indicated as 15000ft on the significant weather chart.

The ground in the area where the aircraft crashed is about 6500ft MSL, with a peak altitude of 7498ft. In other words, the ground extended well into the cloud layer. It would appear that the aircraft was in cloud when it flew into the high ground, which lay across the route between Tzaneen and Nelspruit.

In the absence of access to the official SACAA enquiry, what is not understood, is why an experienced instrument rated pilot chose to fly below the minimum safe altitude for the area. On the other hand, it is possible that he began his descent too soon to the Nelspruit NDB, rather than stay at a safe altitude until overhead the beacon, then do an approved let-down. The beacon is 868m (2848ft) MSL Whatever the reason, the forecasters involved recognised the synoptic situation and correctly forecast the weather in the area.

**Low cloud over the Highveld 1996-04-05**

Report ref: 16/7/ 1996 04 10

On the morning of 5th April 1996 an aircraft, a single engine, four seat, Cessna 182 was en route from Vereeniging (Gauteng) to Victoria Falls (Zimbabwe) via Lanseria, north-west of Johannesburg, where the occupants were to clear customs and border control. The aircraft crashed not long after departure on a farm near Hartebeesfontein (North West Province) at about 0600Z. A farmer heard the aircraft pass over and then saw it fall out of low cloud into the ground. Both occupants were killed.

The analysed 0600Z synoptic weather map revealed a high pressure cell along and off the east coast caused extensive low cloud over the Mpumalanga, Gauteng, north-eastern Free State, the eastern and Central parts of the Northern Province and the extreme eastern part of the North-West Province. The following synoptic reports were recorded around the area in question. Cloud bases are AGL:
Potchefstroom: Wind calm, 8 oktas at 3000-4000ft, visibility 3800m with recent rain.
Johannesburg International Airport: Wind easterly 5kt, 8 oktas at 150-300ft, visibility 1500m with fog patches.
Irene: Wind easterly 19kt, 8 oktas 1000-2000ft, visibility good although with drizzle.

Pretoria: Wind north-easterly 5kt, 5 oktas 600-1000ft with 7 oktas middle layer cloud above, visibility good.

Previously, at 0500Z, the weather office at Johannesburg International Airport issued the following:
FAJS 050500Z 12003KT 3000 BR BKN003 11/10 Q1028 TEMPO 2000 BCFG=
(BR = mist and BCFG = broken fog, FEW = 1-2 oktas, SCT = 3-4 oktas, BKN = 5-7 oktas, OVC = 8 oktas).

Below are the 0600 and 0630Z METAR observations. FAIR = Irene, FAPR + SAWB headquarter in central Pretoria.
FAIR 050600Z 08005KT 9999 -DZ FEW010 BKN025 12/11 Q1027=
FAJS 050600Z 10005KT 1500 -DZ BCFG OVC002 11/11 Q1028 NOSIG=
FAPR 050600Z 05003KT 9999 BKN008 14/14 Q1027=
FAJS 050630Z 09005KT 1500 -DZ BCFG OVC002 12/11 Q1028 BECMG FM0730 4000 BKN005=

The sequence of synoptic weather maps from the previous afternoon to the afternoon of the 5th indicated that the surge of moisture and low cloud had already started the previous afternoon and continued on the 5th.

The 0000Z atmospheric sounding at Irene (south of Pretoria) indicated moist conditions, sufficient for cloud, from the surface to about 575hPa (about 15000ft above MSL) with a shallow moist layer at 525hPa (17000ft MSL). The low level winds obtained from this ascent were 070°T/10kt at 5000ft MSL and 030°T/20 kt at 7000ft MSL.

The low level significant weather charts valid at 0500Z, issued at 0200Z and updated at 0400Z forecast broken low level cloud at FL060 (6000ft MSL) with tops at FL090 (9000ft MSL) with rain/drizzle and visibility reduced to 6000m. The forecast low cloud tended to agree with the observed. At 6000ft above sea level in the low level significant weather chart, this meant cloud not more than about 500ft above ground level in the area of the accident, which tallied with the observations. However, the visibility, in rain and fog patches, in the forecast, was higher than observed.

The nearest TAFs covering the time of the accident are listed below. FAJS = Johannesburg International Airport (5558ft, 1248m MSL), FAWB = Wonderboom airport (4095ft, 1248m MSL) north of Pretoria, FAWK = SAAF Waterkloof AFB (4940, 1506m MSL) south of Pretoria and FALA = Lanseria airport (4517ft, 1378m MSL) north-west of Johannesburg. Worthy of note is the use PROB in the TAFs, PROB40 is the highest percentage probability one can use before indicating it is a permanent change. The lowest probability is PROB30. Any lower risk, in others words the forecaster does not really believe is will occur, must be omitted from the forecast.

FAJS 050000Z 050312 04007KT 6000 SCT007 BKN080 TEMPO 4000 -RA BKN002 FM10 36013KT 9999 BKN015 BKN080=
FAWB 050000Z 050312 06006KT 9999 SCT010 BKN080 TEMPO 0308 9999 BKN010 BECMG 0810 02012KT 9999 BKN025 SCT100=

FAWK 050000Z 050312 06006KT 9999 SCT010 BKN080 TEMPO 0308 9999 BKN007 BECMG 0810 02012KT 9999 BKN020 SCT100=

FAJS 050300Z 050615 07006KT 6000 BKN005 BKN080 TEMPO 0607 2000 BCFG OVC003 FM09 02015KT 9999 BKN015 PROB40 TEMPO 1115 4000 -SHRA SCT007 FEW025CB BKN070=
FALA 050300Z 050615 08006KT 8000 BKN010 BKN080 TEMPO 0607 4000 BCFG BKN008 FM09 04013KT 9999 BKN015 PROB40 TEMPO 1115 4000 -SHRA SCT007 FEW025CB BKN070=
FAWB 050300Z 050615 06006KT 9999 BKN010 BKN080 BECMG 0810 02012KT 9999 BKN025 SCT100 PROB30 TEMPO 1315 6000 SHRA FEW030CB=
FAWK 050300Z 050615 06006KT 9999 BKN008 BKN080 BECMG 0810 02012KT 9999 BKN020 SCT100 PROB30 TEMPO 1315 6000 SHRA FEW030CB=

Clearly observations revealed in places cloud below VFR limits. That is, IMC (instrument meteorological conditions), as did the TAFs while the low level significant charts forecast cloud above FL060 (6000ft MSL) that was lower than 500ft AGL in the region and even lower than high ground in places.

The witness testimony indicates that the aircraft entered cloud, the pilot became spatially disoriented, lost control of the aircraft and crashed. Accident statistics prove that a pilot who is not instrument flying trained and instrument flying qualified will soon lose control of the aeroplane when flying solely with reference to flight instruments. A sometimes quoted rule of thumb is that loss of control will be within 90 seconds of entering cloud.

**Low cloud in the Sabie area on the edge of the Lowveld 1996-06-09**

Report ref: Unknown

The aircraft, a single engine, four seat, Grumman AA 5B was one of a loose flight of three aircraft when it crashed into a forest in the Sabie area between 1230Z to 1430Z on the 9th June 1996. All three on board were killed. Sabie, at 3497ft (1066m) MSL, is on upper edge of the escarpment bordering the Lowveld.

The absence of cloud and visibility observations in the area was emphasised. The only available report was at Skukuza Airport at 1200Z that had 3 oktas cloud at 6000ft AGL (±7000ft MSL). All that can be determined elsewhere from AWS SYNOP reports at Nelspruit airport (2901ft, 884m MSL), Graskop (4711ft, 1436m MSL, ) and Lydenburg (4498ft, 1371m MSL) at 1200Z, was that there was an easterly wind of about 5 to 10 knots, which became calm by 1500Z. Graskop and Lydenburg are also in Mpumalanga, but located on the higher western edge of the steep escarpment. Graskop and Lydenburg altitudes courtesy of Worldwide Elevation Map Finder. Other reports much further north and south at 1200Z gave cloud amounts of 4-6 oktas with the base varying between 1000 to 2000ft AGL.

The satellite images from 1230Z to 1330Z indicated the presence of broken low level cloud patches (5-7 oktas) in the lowveld to the escarpment in the west. The patchy pattern indicates that there were areas where less cloud, that is less than 4 oktas. Clear or scattered cloud (up to

4 oktas) were indicated west of the escarpment. In an easterly air flow, there is often less cloud west of the escarpment The sequence of images also showed the cloud in the lowveld decreasing with time and becoming less deep.

The analysed synoptic weather map indicated an onshore flow of moist air, which developed during the preceding night in the wake of a coastal low, becoming very weak by the afternoon of the 9th due to the development of an anticyclone over the area.

No atmospheric sounding are made in the area. However, considering the sounding at Pietersburg at 1200Z, the cloud appears to have been at about 7000ft to 8000ft above MSL (around 750hPa). The Durban sounding at 1200Z is too far from the scene of the accident, but it did indicate that there could have been lower level cloud in the lowveld east of the escarpment. The sounding at Irene at 1200Z, confirmed that the cloud much further to the west was middle layer cloud at about 14000ft above MSL level (600hPa).

The nearest TAFs were for Nelspruit airport (2901ft, 884m MSL) are presented below. No significant variation was expected during either of the 9 hour TAFs.
FANS 090600Z 090918 26007KT 9999 SCT020=
FANS 090900Z 091221 VRB03KT 9999 SCT025=

The 1100Z forecast low level significant weather chart indicated scattered low level cloud in the Lowveld but broken along the escarpment while scattered cloud with a higher base was given west of the escarpment. Less cloud was forecast at 1400Z.

Although low cloud was present in the vicinity of the accident, the few reports of cloud amount and base indicate that conditions were not below VFR, but there could have been more adverse conditions along the escarpment. The fact that three aircraft could fly in the area, seemingly on pleasure flights, suggests that the weather was not that bad. There is also the suspicion that not all the pilot's concentration was on flying.

What is clear is that the forecaster must be extremely vigilant in conditions where low cloud is involved, particularly in areas which are known to favour inclement weather., such as the escarpment in an easterly air flow.

**Post coastal low weather over the Lowveld 1996-11-06**

Report ref: Unknown

A six seat, retractable tricycle undercarriage, single turboprop engine, Piper Saratoga crashed near Nelspruit ((altitude 2901ft, 884m in Mpumalanga) in inclement weather between 0500Z and 0730Z on the 6th November 1996. The occupants were killed.

Extensive low cloud was over the extreme eastern part of the country according to the 0600Z synoptic weather map. Levubu at 2316ft, 706m MSL (Worldwide Elevation Map Finder) on the higher northern edge of the Lowveld, reported 8 oktas at 300-600ft, Tzaneen airport (altitude 1914ft, 583m) had 8 oktas at 1000 to 2000ft, Hoedspruit airport (altitude 1738ft, 530m in the northern Lowveld), had 8 oktas at 300-600ft with 7000m visibility and Skukuza Airport (altitude 1040ft, 317m in the southern Lowveld) reported 8 oktas at 150 to 300ft with drizzle. A coastal low passed to the north of the KwaZulu-Natal coast the previous afternoon. This led to a prefrontal surge of moist maritime air from the south-east over the Lowveld. The cold front was on the southern KwaZulu-Natal coast close to Durban.

The METARS available during the morning up to the time of the accident are given below. The ICAO airport codes, altitudes and locations are the same as those listed previously.

FAHS 060400Z 15015KT 8000 SCT035 21/17 Q1019=
FALT 060400Z 12010KT 9999 BKN010 20/17 Q1020=
FANS 060400Z AUTO 09003KT //// // ////// 19/17 Q1022=
FAPB 060400Z 06008KT 9999 FEW015 19/16 Q1020=
FAPH 060400Z AUTO 12005G15KT //// // ////// 23/19 Q1017=

FAHS 060500Z 13017KT 5000 -DZ OVC008 20/17 Q1020 REHZ=
FALT 060500Z 12014KT 7000 BKN010 20/17 Q1020=
FANS 060500Z AUTO 10005KT //// // ////// 20/16 Q1023=
FAPB 060500Z 05009KT 9999 SCT015 20/16 Q1021=
FAPH 060500Z AUTO 15008KT //// // ////// 23/19 Q1018=

FAHS 060600Z 14015KT 7000 OVC005 20/17 Q1021 REHZ=
FALT 060500Z 12018KT 8000 BKN018 22/17 Q1021=
FANS 060600Z AUTO 12002KT //// // ////// 19/16 Q1023=
FAPB 060600Z 07018KT 9999 SCT025 22/16 Q1021=
FAPH 060600Z AUTO 15007KT //// // ////// 25/20 Q1019=

FAHS 060700Z 14015KT 6000 OVC005 20/17 Q1021 REHZ=
FALT 060700Z 12018KT 9000 BKN015 22/17 Q1020=
FANS 060700Z AUTO 03006KT //// // ////// 20/16 Q1023=
FAPB 060700Z 07016KT 9999 SCT030 23/16 Q1022=
FAPH 060700Z AUTO 15007G17KT //// // ////// 25/19 Q1020=

From the above it can be seen that there was quite a surge of moist air with moderate to fresh winds at Hoedspruit airport (FAHS), Louis Trichardt airport (FALT) and later Pietersburg airport (FAPB). The cloud extended as far north as the northern Lowveld and up against the escarpment. Some cloud managed to spill over the escarpment as evidenced by the scattered cloud at Pietersburg (FAPB).

Initially no low cloud was forecast for the area on the 0500Z low level significant chart issued at 0200Z. This was probably due to the lack of information and an underestimation of the progress of the low cloud to the north. In the light of later information at 0300 and 0400Z, the chart was amended at 0400Z to give broken (5-7 oktas) of cloud over the southern lowveld and scattered (2-4 oktas) in the north.

The earliest available Aerodrome forecasts issued at 0300Z valid for 0600-1500Z for the area are:
FAPH 060300Z 060615 02012KT 9999 SCT015 PROB30 0608 BKN005 BECMG 0709

SCT045 BECMG 1013 FEW055CB SCT060=
FALT 060300Z 060615 05010KT 9999 SCT020 PROB30 0608 BKN006 BECMG 0709 SCT055=
FAHS 060300Z 060615 10012KT 9999 BKN020 PROB30 0607 BKN010 BECMG 1012 BKN030=
FANS 060300Z 060615 10012KT 9999 BKN010 PROB30 0607 BKN005 BECMG 1012 BKN020=

The absence of an atmospheric sounding in the area makes it impossible to determine the cloud top.

This event is similar to a previous event in that low cloud spread over the area in association with the usual coastal low followed by a cold front. It differs in that the cold front was still to the south, but post coastal low moist maritime air had reached the region. It also occurred earlier in the morning, when the forecasters involved had to make a decision based on AWS data and scant surface observations of cloud and visibility until after the initial forecast deadline time of 0300Z.
Allowing for the fact that in the early morning not one observation of cloud and visibility is available over Mpumalanga and the Northern Province at 0200Z, it is disconcerting that when observations became available at 0300Z and 0400Z, the cloud in the area was still under represented in the 0400Z update. Louis Trichardt (FALT), well to the north, already had broken low cloud at 0300Z while patches of low cloud had already found its way over the escarpment to Pietersburg (FAPB).

The accident is similar to some of the previous events. It was not possible to obtain a SACAA inquiry report, nor further information from an internet search. It is not known whether it was a VFR or IFR flight. Whether it was inability to avoid high ground and a misjudged forced landing, or being in cloud below minimum safe altitude, a case of CFIT. The accident site was not far from Nelspruit and the NDB. Perhaps an error when executing a let-down to or over the beacon. The beacon is 868m (2848ft) above MSL Whatever the reason, the forecasters involved recognised the synoptic situation and correctly forecast the weather in the area.

**Low cloud over Midrand 1997-01-10**

Report ref: Unknown

A pilot plus four passengers Bell 206 Jet Ranger helicopter crashed at Midrand (Gauteng Province) shortly after 0500Z (0700 SAST) on the 10th January 1997 while, at the request of the police, engaged in a search for crime suspects. An eye-witness, out jogging, said he saw the helicopter suddenly swerve to the left and crash. Another witness said there were between six to eight shots fired before the helicopter crashed (Die Beeld 11th January 1997).

The synoptic weather map sequence indicated that a low developed over eastern Gauteng and adjacent North-West Province, with a weak ridge in the east ahead of a cold front which reached Gauteng in the afternoon. The weak ridge of high pressure, which extended northward over southern Mozambique, ahead of a cold front, identified on the map over KwaZulu-Natal at 0000Z. The ridge of higher pressure advected moist maritime air over the lowveld and westward to the northern Province and Gauteng. These areas were covered by broken to overcast low cloud with rain or drizzle and fog patches. Middle layer moisture from the north-west, with embedded thunderstorm cloud, was evident in the infrared satellite image at 0600Z and the visual image at 0630Z. Middle layer cloud was clearly evident on the sounding at Irene at 0000Z from about 600hPa to 450hPa.

The nearest observations at Johannesburg International Airport (FAJS, 5558ft, 1694m MSL) reveal that low cloud reached the area between 0300 and 0400Z. Observations at the airport (FAJS) and north of Midrand at Irene (FAIR), are provided below.

FAIR 100300Z 13009KT 9999 FEW025 FEW035TCU 19/18 Q1014=
FAJS 100300Z 12006KT 5000 HZ BKN080 17/17 Q1016 NOSIG=
FAIR 100400Z 12008KT CAVOK 19/18 Q1015=
FAJS 100400Z 11006KT 2800 BR BKN004 BKN080 18/18 Q1016 NOSIG=
FAJS 100430Z 10008KT 2800 BR BKN004 BKN080 18/18 Q1017 NOSIG=
FAJS 100500Z 09009KT 3000 BR BKN004 BKN080 18/18 Q1017 BECMG FM0630 6000=
FAIR 100500Z 11008KT 9999 FEW015 BKN100 19/18 Q1016=
FAJS 100530Z 08006KT 3500 BR BKN004 BKN080 18/18 Q1017 BECMG FM0630 6000=
FAIR 100600Z 09007KT 9999 SCT015 BKN080 20/18 Q1017=
FAJS 100600Z 07008KT 3000 BR BKN005 BKN080 19/18 Q1018 BECMG FM0630 6000=
Note, HZ indicates haze and BR indicates mist. Visibility is in metres and cloud heights are AGL. BKN = 5-7 oktas.

The TAFs issued at Johannesburg International Airport (FAJS) are:
FAJS 100000Z 100312 08006KT 9999 FEW010 FEW030CB BKN080 PROB30 TEMPO 0307 4000 BR SCT008 BECMG 0709 02010KT SCT025 BKN080=
FAJS 100300Z 100615 07005KT 9999 FEW010 BKN090 PBOR30 TEMPO 0607 4000 BR SCT008 BECMG 0709 01010KT SCT025 BKN090 BECMG 1113 FEW025CB SCT030 BKN090 PROB30 TEMPO 1315 5000 TSRA SCT025CB=

The area forecast issued by FAJS indicated SCT (2-4 oktas) at 7000ft above MSL with tops at 9000ft.

From the available eye-witness reports in Die Beeld newspaper it would appear that the helicopter was clear of cloud and obstacles when it crashed. The possibility exists that shots fired at the helicopter caused mechanical failure. It is not likely that the shots were heard by the pilot above the noise of the helicopter. In the absence of access to the official inquiry, it is also possible that the pilot's attention was divided between avoiding the low cloud base and the ground and neglected to maintain a safe flying attitude (hence the swerve according to a witness), which resulted in the accident. This is speculation on my part.

It is disturbing is that, in spite of the indication of fog by AWS to the east (with an easterly wind) and low cloud at Pretoria and Johannesburg International Airport, no low cloud was forecast anywhere over Gauteng, Mpumalanga and the Northern Province on the 0500Z significant weather chart, issued at 0200Z. The Johannesburg International Airport office came closest to reality by forecasting a probability of scattered low stratus at 800ft AGL with mist patches and 4000m visibility, but well short of BKN 400ft and 2800m visibility being reported by their observer. Admittedly there are little or no observations of cloud and visibility at this time of the morning, there were enough clues on the 0000Z synoptic weather map mentioned above. There was also a ridge over KwaZulu-Natal with a low west of the Highveld, which could be expected to advect moist air toward the low.

Another aspect worth noting is that, irrespective of the forecast, the pilot became airborne in weather conditions which were likely already below VFR minimums.

**Fatal accident, St Helena Bay area, 1998-05-04.**

Report ref: W16/7/1 1998-05-11

A Cessna 177RG, registration ZS-IYU, crashed at 1053Z on the farm Patrysberg (32°49.146´S 18°05.085´E Global Positioning System (GPS)) in the St Helena Bay area. The Cessna 177RG is a Lycoming piston single engined, high wing, four seat aircraft with retractable tricycle undercarriage.

The nearest surface weather observations were at Langebaanweg AFB (FALW, 100ft, 30m MSL) ±5nm (10km) from the Saldanha Bay coast.
FALW 040900Z 35012KT 5000 BCFG OVC012 15/14 Q1018=
FALW 041000Z 35014KT 9999 BKN018 17/14 Q1017=
FALW 041100Z 35013KT 9999 BKN018 18/13 Q1017=

Notice fog patches at 0900Z and overcast 1200ft AGL. According to a weather forecaster based at Langebaanweg, the hill where the accident occurred is visible from his house and at 1120Z (1320B) this hill was still in mist and cloud.

The 1200Z synoptic weather map showed a cold front approaching the south-western tip of the country. Hence the wind was north-westerly between 10kt to 20kt plotted on the map. Meanwhile, broken to overcast low cloud was reported over the area as low as around 660ft and as high as around 3300ft AGL. The satellite images at 1030Z and 1100Z confirmed the cloudy to overcast weather.

The nearest upper air wind observations at Cape Town at 1200Z are given for the lower layers at these altitudes: 2000ft 320/25, 3000ft 310/25 and 5000ft 290/30.

Broken low level cloud between 2000-7000ft MSL was forecast at 0900Z on the low level significant weather chart forecast. This was changed to scattered at 800-1500ft MSL at 1200Z with overcast 1500ft and higher. A 4000m visibility with rain was also given. These charts were issued by the Central Forecast Office in Pretoria.

The nearest TAFs were at Langebaanweg.
FALW 040600Z 040918 34010KT BKN020 T20/12Z=
FALW 040900Z 041221 34010KT 9999 BKN020 TEMPO 1921 8000 -DZ OVC016 T20/12Z=

The Cape Town office aviation telephone call log had a record of a telephone call from the pilot of ZS-IYU at 0607Z requesting a forecast for a VFR flight from Saldanha/Vredenburg airport (50ft, 15m MSL) to Vredendal airport (330ft, 101m MSL), a distance of about 80nm (±150km). The remarks column states SAFOR. This implies that the forecast given was as per the current SAFOR. St Helena Bay is ±5nm north of Vredenburg.

The relevant areas of the SAFOR, valid at 0900Z, were CTAA in the south and CTBB in the north for the Vredendal area. The forecast in the CTAA area was BKNSC 020070 BKNAC 100170 CTBB BKNST 010030 BKNAC 100170. That is, BKN 2000ft MSL for the CTAA area and BKN 1000ft for the CTBB area.

The second issue valid at 1200Z was SAFOR FACT 0412 CTAA 4000 -RA SCTST 008015 OVCSC 015150 LYRS CTBB BKNSC 020050 LOC EXT S AS CTAA. That is SCT 800ft 4000m visibility in light rain for CTAA and the south of CTBB.

There appears to have been an underestimation of the low cloud at 0900Z that was rectified on the low level significant weather chart valid at 1200Zaccording to the SAFOR valid at 1200Z.

The SACAA Accident Report, Executive Summary J10/2/6876, synopsis was that: "After the aircraft was out of operation for some time due to a mayor inspection and an engine overhaul, the pilot attempted to fly the aircraft from Saldanha Aerodrome to his home town of Vredendal. The meteorological conditions were not favourable for a visual flight rules flight, there were low clouds over the area. The non-instrument rated pilot most probably entered the clouds and became spatially disorientated. He lost control of the aircraft and dived into the ground at high speed. Probable Cause: The pilot flew the aircraft into instrument meteorological conditions while he was not qualified to fly in such conditions. He became spatially disorientated, lost control of the aircraft and dived into the ground at high speed."

**Robinson helicopter accident near Greytown 1998-12-27**

Report ref: W16/7/1 1998-12-28

A Robinson R44 helicopter, registration ZS-RGY, departed from a Phoenix helipad, near Virginia Airport Durban, for a flight to Muden (KwaZulu-Natal), about 13nm (25km) north-west of Greytown airport (FAGY, 3531ft, 1076m MSL), on the 27th December 1998. It crashed at approximately 0905Z 30 km north-west of Greytown. The four occupants were killed.

The surface synoptic weather chart indicated that there was an onshore flow of moist maritime air from a weak high pressure cell to an interior low over the eastern Free State. This resulted in cloudy to overcast low cloud conditions over KwaZulu-Natal with rain and misty conditions. At Cedara (3514ft, 1071m MSL), north of Pietermaritzburg, a SYNOP decoded cloud base of 500-1000ft AGL (±4000-4500ft MSL) was reported with drizzle, recent fog and 2000m visibility.

The nearest surface observation consists of an Automatic Weather Station (AWS) at Greytown. The observations are given below at 1000Z to 1200Z:
FAGY 271000Z AUTO 06005KT //// // ////// 18/17 Q1017=
FAGY 271100Z AUTO 08006KT //// // ////// 18/17 Q1017=

FAGY 271200Z AUTO 11005KT //// // ////// 19/18 Q1016=
Given the cloud base to the west at Cedara (altitude 3514ft, 1071m), the high dew-point temperatures (1°C lower than the air temperature) are indicative of moist surface conditions and potentially very low cloud on higher ground that extended to Greytown (altitude 3531ft (1076m). That is, 500-1000ft AGL, or ±4000-4500ft MSL.

The visual spectrum satellite images at 1000-1200Z confirmed the presence of extensive low layer cloud over KwaZulu-Natal with thunderstorms which developed in the early afternoon in the vicinity of the Drakensberg.

The Durban sounding at 1200Z on the 27th indicated very moist air from 850hPa (±5000ft MSL) to 750hPa (±9000ft MSL). This is believed to be the base and tops of the main cloud layer. The air was also sufficiently moist below this layer for patchy cloud layers down to about 4000ft MSL, or lower. Compared with the morning 0000Z ascent a higher cloud layer thickened during the morning to form a layer which had a base at about 8000ft MSL and top at 10000ft MSL. The freezing level was 14211ft MSL.

Given the moist conditions and the low level onshore flow, it is believed that the escarpments inland of the coast had extensive low level cloud packed along the eastern seaward side, likely to ground level. Thie low cloud was confirmed by the report from Cedara mentioned earlier.

Broken low level cloud at 3500ft MSL was forecast for the interior of KwaZulu-Natal with the base down to 2000ft MSL at the coast. Ground higher than this was therefore expected to be in the cloud.
The nearest Terminal Aerodrome Forecast applicable to the time of the accident was at Pietermaritzburg's Oribi Airport (FAPM, 2423ft, 738m MSL) about 8nm (15km) south-east of the higher ground at Cedara (altitude 3514ft, 1072m MSL). The 3-4 oktas 3000ft cloud base (5000ft MSL) was perhaps optimistic.
FAPM 270600Z 270918 07007KT 9999 SCT030 PROB30 TEMPO 1218 3000 -TSRA BKN015 SCT035CB=

The SACAA Accident Report, Executive Summary A98-164-6987, synopsis was that "The pilot, accompanied by his brother-in-law and his two grandsons, departed Phoenix (10 nm North from Durban) on the morning of 27 December 1998 for a private VFR (Visual Flight Rules) flight to Muden where they would have visited family. Muden is situated approximately 55 nm North West from Durban and 12 nm North West from Greytown.

The surface synoptic chart indicated that there was an onshore flow of moist maritime air from a weak high pressure cell to an interior low over the eastern Free State. This resulted in cloudy to overcast low cloud conditions over Kwa-Zulu Natal with associated rain and mist.

At approximately 0830 Z the pilot contacted his family while in the vicinity of Merthley Lake, which is located 2 nm NW from Greytown, and stated that he was experiencing bad weather with mist in the region. He then stated that he would try and fly to Muden via Keats Drift, which is a low lying area located 12 nm NW from Greytown.

At approximately 0845 Z, a farm labourer was working on a farm in the Regina region (8 nm

NE from Greytown) when he heard the sound of a helicopter. He heard the engine noise increase and saw the helicopter appearing out of the cloud (low mist) above a hill-side flying in a Northerly direction. According to the eye-witness, the helicopter was banked slightly to the right and was flying straight along the hill when it suddenly banked sharply to the right and flew back along the low lying valley in a Southerly direction. The helicopter was flying with its nose pitched down with a high engine note. It then impacted the side of the mountain. He ran towards the wreckage and noticed that three of the occupants had apparently been fatally injured with one child in a critical condition. The child died a short while later.

Probable Cause: The pilot was not instrument rated and attempted to continue a VFR flight into IMC conditions. The root cause of the accident is therefore attributed to poor decision making."

**Fatal accident close to Plettenberg Bay 1999-12-12**

Report ref: W16/7/1 date unknown.

A single Lycoming 300hp engine, fixed tricycle undercarriage, 6 seat, Piper PA32-300 Cherokee six, registration ZS-NAR, was on a flight from Kimberely to Plettenberg Bay airport (465ft, 142m MSL) on the 12$^{th}$ December 1999. It crashed 2nm north-west of Plettenberg Bay Airport (at 34°04′76′′S 23°17′83′′E) on encountering mist and fog at 0745Z (0915B). The aircraft struck high tension wires and crashed where it had contacted the wires. The accident occurred in daylight with poor visibility. The three occupants were killed. Eyewitnesses at the airport and near the accident scene confirmed the poor weather, fog and poor visibility.

A high pressure cell south of the land caused the spread of moist maritime air inland along the south coast. At 0600Z low cloud was reported along the coastal belt. Very little in the way of surface observations were available. It is believed Mossel Bay (531ft, 162m MSL), some distance to the west, had a south-easterly wind 10 knots, 5 oktas cloud at 150-300ft AGL with drizzle and 5000m visibility. Cape St. Francis airport (134ft, 41m MSL), some distance to the east, had wind calm, 8 oktas cloud at 1000-2000ft AGL with 10km visibility. The Plettenberg Bay AWS reports at 0700Z and 0800Z did not include weather visibility and cloud. At 0700Z, the wind was 070° 6kt, air temperature 22°C, dew-point temperature 20°C and QNH air pressure 1019hPa. At 0800Z the wind was 090° 6kt, air temperature 23°C, dew-point temperature 21°C and QNH air pressure 1018hPa.

The SACAA Accident Report, Executive Summary J10/2/6876 A99-144, synopsis (fully quoted) was that "the owners of the aircraft had a new engine fitted to the aircraft on 11 December 1999 and the pilot (co-owner) took delivery of the aircraft on Saturday 12 December 1999. The pilot/owner did the acceptance flight before leaving for Kimberley, the first leg of his journey down to Plettenberg Bay, where he did a night stop. He was to pick up his friend's wife and their domestic worker, which accompanied him to their destination. The pilot and his two passengers departed Kimberly on Sunday morning 12 December 1999 for their journey to Plettenberg Bay.

According to eyewitnesses at the airport, the fog started to move in at about 0700Z and was "tree top" height with very poor visibility. The airport manager was one of the eyewitnesses and overheard the pilot of the ill-fated aircraft transmitting that he was descending through

1500ft. he then radioed the pilot and warned him about the weather and told him that he should not attempt the landing. The aerodrome at Plettenberg Bay was equipped with a NDB.

The eyewitnesses saw the aircraft passing their house in a very steep right hand bank and the right hand wing was lower than the roof of their double story house. The aircraft managed to clear the house and garage before levelling out, but then collided with telephone wires and then the high tension conductors on the other side of the road next to the house where the eyewitnesses were standing. Due to the fog/mist in the area, the eyewitnesses lost sight of the aircraft after it collided with the high-tension conductors.

The aircraft then impacted the ground 0.5 NM (0.9 km) from the high-tension conductors with the left wing tip first, which caused the aircraft to nose dive into the ground with relative high speed. Marks on the propeller and on the ground indicated that the engine was operative at the time of impact, although not a high percentage of power. After the aircraft impacted the ground in a nose down right hand wing low attitude, it cart-wheeled twice before coming to rest 38m from the initial impact point. Evidence of the high-tension conductors were imprinted on the propeller root and the left-hand wing leading edge.

The first veld fire was started when the high-tension wires which created a spark at the initial impact point. This fire was swept on by a strong easterly wind. The aircraft, exploding on impact, 0.5 NM (0.9 km) from the initial impact point, started the second veld fire.

The wreckage was completely destroyed by the post impact fire. Due to the extreme impact forces and post impact fire this would not have been a survivable accident."

**Fatal accident Cessna 172 at Rand Airport. 2000-04-19**

Report ref: W16/7/1 2000-04-20

Cessna 172, registration ZS-ILI departed Rand Airport at 0505Z 19$^{th}$ April 2000 destined to Messina. On board was the pilot and three passengers. The Cessna 172 is a high wing, fixed tricycle undercarriage, 4 seat aircraft with a single Lycoming engine. The aircraft crashed within the circuit area of the airport. Three occupants were injured, one killed. The pilot was highly experienced with an airline transport licence and 32500 flying hours at the last licence renewal.

After being asked to prepare the report, it was thought that low cloud and fog was the cause of the accident.

A high pressure cell over the Indian Ocean brought low cloud and fog patches to the area in question around Rand Airport (5474ft, 1668m MSL). This was confirmed by the observations at Johannesburg International Airport (5558ft, 1694m MSL) which is the nearest observation station to rand Airport. The observations around the time of the accident are given below.

FAJS190400Z 04004KT 1500 BCFG BKN002 10/10 Q1026 TEMPO 0800 FG VV001=
FAJS190412Z 03003KT 1500 BCFG SCT002 SCT080 10/10 Q1026 TEMPO BKN002=
FAJS190430Z 04002KT 1500 R03L/0600V1400DR03R/1200V1500D BCFG SCT002

SCT080 10/10 Q1026 TEMPO BKN002=
FAJS190443Z 06003KT 1200 R03L/0200V0500D R03R/1000V1500U BCFG BKN002 BKN080 10/10 Q1026 TEMPO 0900 FG=
FAJS190500Z 06003KT 1200 R03L/0175U R03R/1400V1500U PRFG SCT002 SCT080 09/09 Q1026 TEMPO BKN002=
FAJS190530Z 07003KT 1500 R03L/0350V1400U R03R/0450V0700D BCFG BKN002 SCT080 11/11 Q1027 BECMG FM0630 4000 BKN006=

The reports indicate that there was low cloud down to 200ft AGL with fog patches. This is particularly evident in the report issued at 0443Z, about 20 minutes before the time of the accident. 6-7 oktas of cloud at 200 feet, observed visibility of 1200m while the Runway Visual Range (RVR) equipment on runway 03 left gave between 200-500m and runway 03 right was 1000-1500m. At 0500Z there were still fog patches being reported with the RVR down to 175m on runway 03L, but only scattered low cloud at 200ft AGL.

In view of the above was probable that the weather in the vicinity of Rand Airport had low cloud which varied between scattered and broken at about 200ft AGL with fog patches and much reduced visibility. However, it was possible that there were no fog patches at Rand Airport and that the visibility therefore could have been better.

The nearest TAF was at Johannesburg International Airport.
FAJS190100Z 190312 05004KT 9999 FEW010 BKN080 PROB30 TEMPO 0306 2000 BCFG BKN003 FM 0700 03008KT 9999 BKN020 BECMG 1012 SCT035 FEW040CB T08/03Z T21/12Z=
Note, the forecast included low cloud and fog patches from 0300-0600Z.

However, the SACAA Accident Report, Executive Summary J10/2/7184 A00-042, received at a much later date, revealed what really happened. It is quoted in full.

"The pilot with 3 passengers was cleared for take of from RWY 29 at Rand Airport for a flight to Messina. After departure he was instructed to turn out right and to report zone outbound. The ATC at Rand observed that the aircraft remained low and turned out left instead of right. According to the ATC the pilot was requested to confirm that operations were normal. Initially there was no answer and shortly afterwards the pilot requested that he wants to return to the Airport. The pilot was then instructed to join left base for RWY 35 and at that stage the controller lost sight of the aircraft The controller then asked for his position and the pilot advised that he was overhead Alberton. The pilot was again instructed to join left base for RWY 35 and controller observed the aircraft on a very low left base for RWY 35 and it did not appear as if the aircraft was losing any altitude. The pilot reported left base and was cleared to final approach No 1. On late base before the aircraft turned onto final approach the controller observed the aircraft losing height and disappearing below the horizon to the south. No further radio communication could be established and the fire crew was dispatched immediately.

Probable Cause: Due to a loose magneto causing incorrect ignition timing, the engine produced insufficient power. As a result thereof the aircraft was unable to maintain or gain altitude."

**Devil's Peak. Three SAAF HS125 aircraft accident 1971-05-26**

This tragic accident occurred long before I compiled accident and incident reports. Nevertheless, I remember it well. It demonstrates that even well trained and professional pilots in the SAAF need to be extra vigilant when flying in low cloud condition and limited visibility. In particular maintaining height above the sector minimum safety altitude.

On 26 May 1971, three SAAF Hawker-Siddeley HS-125-400B (SAAF code name Mercurius) aircraft crashed into the eastern slope of Devil's Peak just above the Rhodes Memorial, killing all 11 on board the three aircraft (Aviation Safety Network 1971-05-26). The peak of the mountain is 3280ft (1000m) MSL, about 290ft (±90m) lower than Table Mountain. The aircraft were flying in close formation, practicing for a 220 aircraft fly-past during the upcoming 10th-anniversary Republic Day celebrations on the 31st May.


The mountain was shrouded in mist and low cloud. It is believed the pilot of the lead aircraft most probably miscalculated the arc of its turning circle coming from the direction of the Athlone cooling towers. The lead pilot's error in judgement meant the other two tragically followed it into the mountain with the loss of all three. The impact was heard throughout the surrounding suburbs. The accident meant that only one HS-125 Mercurius remained in the fleet (Dickens 2015). The three lost aircraft, with SAAF serial numbers 01, 02 and 03, were replaced in 1972, although not the serial numbers. The replacement aircraft became 05, 06 and 07. Number 06 (left) was photographed by me in Durban circa later 1970s. A 5th aircraft was added in 1983, numbered 08.

**AIRCRAFT DISAPPEARANCE. CAUSE UNCERTAIN**

**Cessna Skymaster 336 East London to Pietermaritzburg 1996-02-22**

Report ref: W16/7/1 1996-03-01

A Skymasters Flying Services Cessna Skymaster 336, registration ZS-JVK, disappeared while on a flight from East London, on the coast in the Eastern Cape, to Pietermaritzburg (Aviation Safety Network 1996-02-22) at about 1600Z on the 22nd February 1996. Pietermaritzburg Oribi Airport (2423ft, 738m MSL) is 36nm (67km) inland from Durban Airport on the coast. The Cessna Skymaster is a push/pull twin engine propelled aircraft with a boom tail and retractable tricycle undercarriage.

Weather conditions along the route were poor, with low cloud extending in layers into the middle layers of the atmosphere as well as embedded thunderstorms. The aircraft, along with the two occupants, was not found, but fragments that may have come from the aircraft, were washed up at spots along the coast such as at Port St. Johns between East London and Port Shepstone.

A coastal low was on the KwaZulu-Natal coast with a 3hPa rising pressure gradient south-west of it to East London. No observations are available between East London and Port Shepstone. However, observations at these two places indicate that there was low cloud on the coast and thundershowers that moved from the interior and reached the coast at various places according to the synoptic weather maps at 1500Z and 1800Z. These two maps indicate that the coastal low was south of Durban at 1500Z, but north of it at 1800Z. The broader synoptic picture is that a cold front was at Cape Town, with an interior trough extending from the coastal low in a dog leg over the south-west Free State to western Botswana.

Meteorological Aviation Reports (METARs) at East London Airport, are given below.
FAEL 221500Z 25009KT 9999 -TSRA SCT004 FEW030CB OVC030 21/19 Q1007=
FAEL 221530Z 22004KT 8000 -TSRA SCT004 FEW030CB 0VC035 20/19 Q1006=
FAEL 221600Z 24005KT 8000 -TSRA SCT005 FEW035CB 0VC035 20/19 Q1006=
FAEL 221700Z 25006KT 9999 FEW010 BKN015 OVC035 21/19 Q1008=
Note, -TSRA indicates a light thunderstorm with rain, but without hail. FEW = 1 to 2 oktas cloud, SCT = 3 to 4 oktas, BKN = 5 to 7 oktas. East London airport is 431ft (131m) MSL. Scattered cloud at 400-500ft AGK would be ±800-900ft MSL. Cloud bases are AGL which means the lowest level scattered cloud would have been about ±800-900ft MSL.

The 1500Z and 1800Z synoptic maps observations at Port Shepstone were:
1500Z wind SW 10kt, visibility 10 km, 8 oktas stratocumulus at 1000-2000ft.
1800Z wind SW 10kt, visibility 6 km in haze, 8 oktas stratus 600-1000ft.
Port Shepstone observations were at the lighthouse keepers house 52ft (16m) MSL (Wikipedia (a)).

Upper air soundings were not available in the area but the 1200Z ascent at Port Elizabeth, a considerable distance ahead of the cold front, but post-coastal low, indicated the top of the low cloud was about 6000ft above MSL with enough moisture present for middle layer cloud at 10000-12000ft MSL, while the freezing level was 15000ft MSL. At Durban the sounding indicated the top of the low cloud was probably at about 3000ft above MSL with middle layers from 10000- 14000ft and the freezing level at 15000ft.

The low level significant weather charts at 1700Z and 2000Z indicated scattered thunderstorms were expected to occur over the interior, with isolated storms spreading to the coast. Broken low cloud was also indicated along the coastal belt.

While occasional embedded thunderstorms were forecast for the area, low cloud was confined mainly to the coast, while the 1800Z synoptic observations indicate that there was a lot of low cloud over the southern Kwazulu-Natal interior. It is important to remember that low cloud spreads rapidly over the coastal belt and adjacent interior of the Transkei (in the Eastern Cape) and KwaZulu-Natal in the wake of a coastal low, particularly in the summer months.

Speculation is that the pilot diverted seaward of the coast to avoid low cloud and thunderstorms, or the aircraft was already in cloud when a course was set seaward in an effort to avoid the worst weather. What happened after this is anybody's guess. Three possibilities are; the pilot could have been distracted, spatially disoriented and the aircraft flown into the sea; control was lost in cloud over the sea; or it broke up in a storm over the sea.

**Helicopter missing in the Wilderness area 1999-03-06**

Report ref: W16/7/1 1999-03-10

A Bell 206 B Jet Ranger III helicopter, registration ZS-REB, with 3 three occupants (pilot, wife and father), departed Port Elizabeth International Airport for a flight to Hildesheim Guest House in the Wilderness area on the 10th March 1999. The aircraft never arrived. After an extensive search, until the 15th March, the 3 occupants were declared missing, presumed dead. A private search by family members was continued until 13th April 1999 (SACAA 7023).

The pilot had a valid private pilot's license with a night rating. The helicopter, approved for five place seating was certified for land operations under day or night VFR (Visual Flight Rules) non-icing conditions (SACAA J10/2/7023 A99-032, SACAA 7023 and Aviation Safety Network 1999-03-06).

The accident site was found seven years later on the 21st April 2006 at Diepwalle Forest, Knysna (GPS position: 33° 58.174´S 23° 10.591´E, at ± 920 feet above MSL. The wreckage was found "by a forest worker who was preparing cut lines for the harvesting of indigenous trees, an event that is only repeated once every ten years. The three occupants that were onboard the helicopter sustained fatal injuries" (SACAA 7023).

The surface synoptic chart at 1500Z on the 10th March 1999 indicated a weak high pressure cell south of the land with a low over the interior. A south-easterly onshore flow of moist maritime air resulted in low level cloud along the coastal belt.

The METAR observations from 1400 to 1600Z from west to east along the coast are provided below. FAGG = George airport (225ft, 218m MSL), FAPG = Plettenberg Bay airport (465ft, 142m MSL) and FAPE = Port Elizabeth (225ft, 69m MSL).
FAGG 061400Z AUTO 13008KT //// // ////// 22/17 Q1015=
FAPG 061400Z AUTO 07008KT //// // ////// 22/20 Q1013=
FAPE 061400Z 12017G27KT 9000 BKN006 OVC012 22/19 Q1011 NOSIG=

FAGG 061500Z AUTO 14008KT //// // ////// 21/18 Q1012=
FAPG 061500Z AUTO 09009KT //// // ////// 21/19 Q1012=
FAPE 061500Z 13016KT 8000 BKN005 OVC012 21/19 Q1012 NOSIG=

FAPE 061530Z 13014KT 8000 BKN006 OVC012 21/19 Q1012 NOSIG=
FAGG 061600Z AUTO 11006KT //// // ////// 21/18 Q1012=
FAPG 061600Z NIL=

FAPE 061600Z 11011KT 8000 FEW006 OVC025 21/19 Q1012 NOSIG=

From the few reports available the cloud base was predominately from about 500-600ft AGL with an overcast layer at about 1200ft. Although, at 1500Z the observer at the Cape Hermes Lighthouse (138ft, 42m MSL) (Wikipedia (a)) at Port St Johns, on the Transkei coast, gave a base of 1000ft. While a ship south-west of George gave a base of about 700ft above MSL.

The visible spectrum satellite images from 1600Z to the last visible image of the day at 1700Z revealed a band of low cloud along the coastal belt and seawards from False Bay in the west to well east of East London. The cloud appears to go inland to roughly the 500m (1600ft) contour line.

The nearest upper air information was from Port Elizabeth. Unfortunately, balloon ascents were now only done in the early morning and are therefore less likely to be representative of the conditions late in the afternoon of the 6th. However, comparing the ascent at 0000Z on the 6$^{th}$ with the ascent at 0000Z on the 7$^{th}$ it is evident that there was enough moisture for cloud between 950hPa to 800hPa (2000-6000ft above MSL) early on the 6$^{th}$ and between 950hPa to 830hPa (2000-5500ft) early on the 7$^{th}$.

The low level significant weather forecast map, indicated low cloud was forecast for the coastal land area, with broken low cloud inland.

The TAF for Port Elizabeth was:
FAPE 060900Z 061221 10014KT 9999 SCT010 BKN025 PROB40 TEMPO 1216 5000 -RA BKN008 BECMG 1719 SCT025 T19/18Z=
This was a fair reflection of the low cloud, indicating temporary broken cloud at 800ft AGL (±1000ft MSL). A reminder, the use PROB in the TAFs, PROB40 is the highest percentage probability one can use before indicating it is a permanent change. The lowest probability is PROB30. Any lower risk, in others words the forecaster does not really believe is will occur, must be omitted from the forecast.

The SACAA Accident Report, Executive Summary 7023, synopsis was that "On the morning of 5$^{th}$ March 1999 the pilot accompanied by his wife and his father departed on a private flight from Wonderboom Airport (near Pretoria) to Port Alfred. En route they landed at Tempe Aerodrome near Bloemfontein as well as East London Aerodrome, where fuel was uplifted. On the afternoon of 6$^{th}$ March 1999, they departed Port Alfred and they flew to Port Elizabeth Aerodrome (FAPE) where they landed and the helicopter was refuelled to capacity, with 149 litres of Jet A1 being uplifted.

Shortly thereafter, they departed FAPE en route to the Hildesheim Guest House near Hoekwil in the Wilderness area. The flight was conducted under visual flight rules (VFR) and no Flight Plan was filed. The pilot was the holder of a valid private pilot's license with a night rating. The helicopter was approved for five place seating and was certified for land operations under day or night VFR (Visual Flight Rules) non-icing conditions.

Apart from standard navigational equipment there was two Global Positioning Systems (GPS's) units onboard of which one had a moving map display. The helicopter was not equipped with an Emergency Locator Transmitter (ELT). It became evident that the helicopter was missing when the person intending to meet the pilot and his passengers at Cape Town International Airport on 7th March 1999 phoned one of the pilot's sons to enquire if they were going to be late, as they haven't arrived at Cape Town yet. After phoning the guesthouse in an attempt to find out what time they had departed from the Wilderness area, they were informed that they had never arrived at the guesthouse on the afternoon of 6th March 1999.

The ARCC (Aviation Rescue Co-ordination Centre) at Johannesburg was alerted by the family on Sunday, 7th March 1999 at 1645Z. After the information was evaluated and the Department of Transport was informed, a DETRESFA (Distress phase) was declared at 1904Z. An extensive aerial, ground and sea search was initiated with the official search being terminated on 15th March 1999, after the search was futile. Family members continued with a private search in the area until 13th April 1999. The wreckage of the missing helicopter was located on 21st April 2006 by a forest worker who was preparing cut lines for the harvesting of indigenous trees, an event that is only repeated once every ten years. The three occupants that were onboard the helicopter sustained fatal injuries. With the new evidence that became available, following the discovery of the wreckage the investigation into the accident was reopened.

Probable Cause. It would appear that the pilot attempted to remain visual with reference to the ground (VFR) underneath cloud, and in doing so had to descend and was most probably left with no other option but to penetrate obscured weather conditions, and in doing so collided with terrain/trees."

## STRONG WIND

### Non-fatal Cessna 152 in strong surface and near surface wind Houtbaai, 1999-10-24

Report Ref: W16/7/1   1999-11-02

An unusual event for which to provide a report, although something pilots of small light aircraft pilots have to be wary.


The author's 1979 oil painting of a similar Cessna 152.

A single engine, fixed tricycle undercarriage, two seat, Cessna 152, registration ZS-KGH, with pilot and passenger had departed Cape Town International Airport for a short round trip flight south to the Houtbaai area when it encountered strong and turbulent low level wind at 0940Z (1140 SAST).

A strong high pressure cell was in the process of moving eastward south of the country. This resulted in strong south-easterly surface and low level winds over the Cape Peninsula region.

The nearest surface observations were at Cape Town International Airport (151ft, 46m MSL).
FACT 240900Z 15021KT 9999 FEW025 19/09 Q1022 NOSIG=
FACT 240930Z 14021KT 9999 FEW025 19/09 Q1022 NOSIG=
FACT 241000Z 15023KT 9999 FEW025 19/08 Q1021 NOSIG=

The wind anemometer recording trace at Cape Town Airport between 0900Z and 1000Z, showed the surface wind varied from 20 $ms^{-1}$ to 22 $ms^{-1}$ (± 20kt to 24kt) with gusts of 13.5 $ms^{-1}$ to 15.5 $ms^{-1}$ (±27kt to 31kt). A peak gust of 18.5 $ms^{-1}$ (37kt) occurred at 110Z. These winds are only representative in the vicinity of Cape Town airport and may have been stronger or weaker elsewhere nearby.

The upper air sounding at 0000Z, produced wind velocities of 145/31 at 1000ft, 140/32 at 2000ft and 135/30 at 3000ft. Directions are °True and speeds in knots.

The TAF at Cape Town International Airport was:
FACT 240600Z 240918 15025G40KT 9999 FEW030 T22/12Z=

The area forecast was for 1-2 oktas stratocumulus cloud base FL030 tops FL050 (3000-5000ft above MSL).

Houtbaai and the place nearby to the south where the aircraft force landed, Noordhoek Beach, are on the western lee side of the peninsula. The strong south-easterly wind off the peninsula in the lee would have been extremely turbulent, especially for a small Cessna 152 with only a ±110hp (±80kW) Lycoming engine.

The SACAA Accident Report, Executive Summary J10/2/7107 A99-8-116, synopsis was that "The pilot accompanied by a passenger was engaged in a private flight in the Hout Bay, Chapmans Peak area when they experienced severe turbulence. They were unable to maintain height. The pilot decided to execute a precautionary landing on the Noordhoek Beach. On landing the propeller struck the ground and the nose gear was bent extensively. Both occupants disembarked uninjured. Probable cause: The pilot was unable to control the aircraft when he experienced strong wind and severe turbulence conditions while flying in the vicinity of Hout Bay and Chapmans Peak. He took evasive action and executed a precautionary landing on the beach with the propeller striking the ground and bending the nose gear."

## THUNDERSTORMS

The intensity of thunderstorms over Africa and the height to which they may grow must not be underestimated. They can be a particular problem over KwaZulu-Natal in summer in the afternoon and the evening, usually reaching a maximum intensity in the late afternoon and early evening, with night time insolation at times playing a part in keeping them going late into the night. Tops can easily be to FL450, at times approaching FL500. The movement being from the Lesotho area of the Drakensberg drifting to the south-east across the KwaZulu-Natal coast across the well used route between Durban and Johannesburg. On one occasion a SAA pilot told me they had to divert so far to the east before turning toward Durban they were almost at Maputo in Mozambique.

**King Air accident in Vrede 1994-12-23**

Report ref: 16/7/1 1994-12-29

A twin engine turboprop Beechcraft B100 King Air, registration ZS-MSG, was en route from Johannesburg International Airport to Durban International Airport when it crashed near Vrede at approximately 1800Z about 109nm (200 km) south of Johannesburg. Both occupants were killed.

Extensive thunder activity developed, in the evening, east of a trough over the north-eastern part of the country. This was evident on 1800Z satellite imagery and an 1800Z surface synoptic map. No manual observation was available at Vrede. However, to the west, a thunderstorm with rain was reported at Frankfort with good visibility and a cloud base at 3000ft AGL. Bethlehem airport (5561ft, 1695m MSL), further south, at 1800Z, was overcast with rain, but good visibility with 2-4 oktas large Cumulus cloud at 3000ft AGL (±8500ft MSL) with 5-7 oktas middle layer cloud at 10000ft.

The Bethlehem upper air sounding at 1200Z indicated air sufficiently moist for cloud layers between 14000-26000ft above MSL while 14000-22000ft above MSL at Bloemfontein. Using the parcel method on the Bethlehem sounding, the tops of the thunderstorm clouds would have been about 40000ft.

The Bloemfontein weather office issued a Sigmet at 1400Z (reproduced below) for a line of thunderstorms moving eastward toward Vrede with strong surface wind gusts. A telephonic report was received, via the South African Broadcasting Corporation (SABC), of an employee who was driving in this eastern part of the Free State who encountered very strong wind gusts.
WSZA43 FABL 231400
SIGMET 1 VALID TILL 2000Z
LINE CB OBS/FCST FABL NORTHWARDS TO KLERKSDORP. INTS MOD BUT WITH STRONG SURFACE WIND GUST >50KT TOPS FL380 MOVING W TO E.

The significant weather forecasts, valid at 1700Z and 2000Z, forecast their presence and spreading of thunderstorms as well as middle layer cloud during the evening and icing expected in this layer. The presence of CB cloud, or its symbol, on a map always implies the potential for severe icing, hail and turbulence.

In view of the above, it was believed that there was extensive and fairly deep middle layer cloud from about 14000ft MSL to about 22000-26000 ft MSL with thunderstorm clouds, extending through the middle layer cloud, from about 3000ft AGL to about 40000ft above MSL. Apart from the normal aviation hazards associated with thunderstorms, the gusty wind conditions forecast at the surface could have been indicative of strong vertical downdraft velocities in the thunderstorm clouds. Icing in the layer cloud was also likely

The investigation found that the aircraft inadvertently entered a thunderstorm while passing Vrede, control was lost, the aircraft entered a high speed descent and broke up in flight. The main fuselage fell in the front garden of a house and was completely destroyed. The tail section approximately one kilometre away on a hockey field. A post impact fire destroyed a large part of the house (Aviation Safety Network. 1994-12-23).

**Electrical storm and heavy rain Bulwer/Donnybrook area 1995-05-02**

Report ref: W16/7/1 1995-05-03

This episode emphasises how dangerous the weather can be in KwaZulu-Natal. The aircraft, a light twin propeller engine Beechcraft Baron, crashed in the Bulwer/Donnybrook area on the 2nd May 1995. According to newspaper reports the area was under a severe electrical storm with heavy rain at about the time of the accident at 1800Z. Rescue workers found the scene of the accident to be very muddy, confirming the heavier than normal rain. A police spokesman described the area as resembling a bomb blast with no pieces big enough to identify anything. Five people including a three year old girl died in the accident.

According to a report in the Pretoria News later in the month (1995-05-20), the SACAA stated that the pilot-in-command was not instrument rated. He filed a flight plan from the coast inland to the Highveld for instrument flying in weather conditions not favourable in terms of visual flight rules concerning visibility. That is, Instrument Meteorological Conditions (IMC). The pilot-in-command indicated he was experiencing adverse weather in his last transmission to air traffic control (ATC), but did not declare an emergency or request assistance.

A strong high pressure cell was seaward of the KwaZulu-Natal coast with an onshore flow of moist air over the province, as indicated in the 1800Z synoptic weather map. The area around the approximate accident site was generally cloudy with thunderstorms and/or lightening reported at Port Shepstone (68584 on the map), Matatiele (68570), Durban (68588) and Cedara (68580) while Underberg (68572) reported a recent thunderstorm. The Cedara observer reported thundershowers with 5000m visibility and the Pietermaritzburg AWS (68581) recorded rain that could have been associated with a thunderstorm. The cloud bases varied from 1000ft AGL (±6000ft MSL) at Underberg (3 oktas) to 3000ft AGL (±6500ft MSL) reported at Cedara (3514ft, 1071m MSL). Note, a dispersed lower cloud base with poor visibility was possibly present in the rain below the thunderstorms. Underberg is 5092ft or 1552m MSL (Topographic-map.com).

Observations indicate that there was low cloud along the coast, which varied from 1 to 8 oktas between 400ft to over 1000ft AGL with a main layer about 3000-3500ft AGL. Thunderstorms were also present above the low cloud with reduced visibility. Middle layer cloud was also likely at about 10000ft AGL.

The infrared Satellite images at 1600Z, 1700Z and 1830Z confirmed the area was cloudy to overcast. Distinctive thunderstorm cell cloud patterns were obvious on the images.

The air temperature and dew-point temperature traces from the atmospheric sounding at Durban at 1100Z, indicated that the air was sufficiently moist for layers of cloud from about 2000-7500ft MSL with possibly a layer at 11500-1300ft MSL. The 0200Z sounding the following morning indicated that the air was considerably moister after the thunder activity with cloud layers possibly having developed from about 2000-21000ft MSL. The freezing level remained at about 11000ft MSL.

Broken (5-7 oktas) low cloud was forecast with thunderstorm activity and visibility down to 4000m in the 1700Z and 2000Z low level significant weather charts. Along the coast inland to the first escarpment scattered cloud was given from 2000ft MSL to broken at 4000ft MSL further inland. The latter means that a good deal of the ground inland of the coastal escarpment was expected to be in the cloud. The forecaster at the Durban office also added that VFR flight was not recommended in their SAFOR forecast issued at 1200Z.

The forecast significant weather charts appear to have adequately reflected the weather conditions. However, they have a serious flaw in that they indicated scattered cumuliform (Cu) cloud from FL070, but also indicated broken Stratocumulus (Sc) cloud up to FL085. This is a contradiction in that it says that instability convective Cu cloud will grow out of the top of a stable stratified layer of Sc cloud, or will have its base in the tops of the Sc cloud. Furthermore, it was not clear whether these low clouds were confined to the coast, or were they to spread into the Free State as indicated by the demarcated cloud area? It emphasised the fact that the forecaster must exercise care when compiling the charts and think logically. It is also important to see the charts through the eyes and mind of a pilot.

The accident site was some way off the normal route inland being nearer to increasingly higher ground toward the Drakensberg Mountains. Bulwer is 4911ft (1487m) MSL and Donnybrook is 4498ft (1371m) MSL (Mapcarta (a) and (b)). While thunderstorms were in the area and in the absence of access to the official enquiry, it is concluded that the VFR pilot while attempting to remain in visual meteorological conditions (VMC) flew off course into heavy rain and cloud and IMC then collided with higher ground.

**King Air en route Luanda to Lanseria 1995-10-21**

Report ref 16/7/1 1995-11-11

A twin engine, turboprop Beechcraft 200 Super King Air, registration, ZS-MGR, operated by Balmoral Air Service for the United Nations World Food Programme, crashed on the 21st October 1995 at ±1900Z at approximately 13°S 19°E (near central Angola) while en-route from Luanda (FNLU) to Lanseria (FALA). All five occupants were killed.

At the time, it was normal not to receive any surface or upper air observations from Angola. This was also the case on the day in question. The only source of information was from satellite images. The images at 1800Z to 2000Z showed thunderstorm activity in the area around the time of the accident. The 1800Z image, with extensive cloud in the vicinity over western central Angola with a spur to the south-east had particularly bright cloud masses, was an indication of very cold cloud tops. That is high vertical extent. The images were also still fairly sharply defined. This suggests that the cells were either still developing or had recently reached the mature stage. Smaller less well defined individual cells were also visible to the north-east of the cloud mass. By 2000Z the echo's showed a decrease in brightness, which was even more apparent at 2200Z, indicative of storm dissipation. The spread of cirrus anvil cloud at the top of the cells was also limited in comparison with thunderstorm cells north of Angola. This is likely further indication that the cells in the vicinity of the accident were more recent. It is also possible that the wind at this level was lighter than further north.

Reportedly a wing failed in severe weather (Aviation Safety Network 1995-10-21). Another report states that the aircraft entered an uncontrolled descent and crashed and that left aileron and a part of the left wing were never recovered and probably separated from the aircraft prior to the loss of control (Bureau of Aircraft Accidents Archives 1995). The most likely cause of the accident was penetration of severe thunderstorm with severe turbulence resulting in catastrophic structural failure.

**SAA B747SP-44 Johannesburg to Jeddah 1996-01-19**

This is mostly a report submitted to SAA Cabin Safety and SACAA as 16/7/1 1993-03-05 and published in the South African Weather Bureau Newsletter by de Villiers, 1996. And courtesy of the South African Weather Service.


The author’s stock photograph at Johannesburg of a B747SP-44. Luxair’s B747SP LX-LGX was ZS-SPB leased from SAA.

In the early evening of the 19th January 1996 a South African Airways (SAA) Boeing 747SP-44, registration ZS-SPE (Aviation Safety Network 1996-01-19), encountered severe turbulence at FL370 about 4 minutes south of the Makir reporting point which is at 16º11'S 31º33'E on the Zambian Flight Information Region (FIR) border.

The flight was en route from Johannesburg International Airport (FAJS) to Jeddah. According to reports in the Sunday Times (1966) and You (1996), numerous passengers were injured and damage was caused to the interior of the passenger cabin when the aircraft suddenly climbed about 250m and then immediately fell approximately 460m. The seatbelt sign had been illuminated and the passengers were warned of turbulence. Nevertheless, passengers that did not have seatbelts fastened were injured. There was also the suggestion that the public address system was faulty (Aviation Safety Network 1996-01-19).

According to discussion at a meeting with a SAA Cabin Safety official, the aircraft was in cloud at the time of the incident and a passenger in the forward part of the 1st class section heard a noise on the nose cone which is consistent with hail or ice striking the aircraft.

Sources of weather information were satellite imagery and numerical model forecast weather from the World Area Forecast Centre (WAFC) at Bracknell, United Kingdom. Flight data from the aircraft was also available, as well as evidence from crew reports given during verbal discussion with the person from SAA Cabin Safety. Conclusions reached in this report are mine and are not to be construed as the findings of any official aviation authority.

Analysis of the surface synoptic observations at 1500Z and 1800Z on the 19$^{th}$ January 1996 indicated that thunderstorm activity was present or developing along the entire route from FAJS to the Zambian FIR. This was confirmed by the 1600Z and 1630Z infrared satellite images. By

2400Z most of the thunder activity appears to have passed with lightening reported at some stations and light rain at others.

Upper air conditions from radiosonde balloon ascents were unknown due to the total lack of atmospheric soundings north of Pietersburg (FAPB) during the preceding afternoon at 1200Z. The nearest available sounding the next morning, at 0000Z on the 20$^{th}$, was at Harare (FVHA) and Bulawayo (FVBU), which at 250hPa (FL340 ISA), reported air temperatures of -38 ºC and -40ºC, respectively, but no wind data. The temperatures differ slightly from the WAFC forecast temperatures at the same time at FL340 by about 1ºC to 3ºC.

The forecast wind and temperature fields, valid at 0000Z on the 20$^{th}$ at FL340 and FL390 from the WAFC, indicated light winds for these levels over northern Zimbabwe with very weak vertical and horizontal wind velocity and/or directional shear. Horizontal temperature shear was virtually non-existent, while vertical cooling was about 2.8ºC/1000 feet. The forecast temperature at 15ºS 30ºE at FL340 was -42ºC and at FL390 -56ºC. Thunderstorms with tops up to FL450 were forecast for the area by the weather forecast office at Johannesburg International Airport. The light winds recorded on board the aircraft and shown in table below.

| LATITUDE | LONGITUDE | WIND | TAT EC | PALT | G/S |
|---|---|---|---|---|---|
| 20 31.70ºS | 29 54.80ºE | 273/03 | -15.8 | 36997 | 504 |
| 20 31.10ºS | 29 55.00ºE | 283/01 | -15.3 | 37007 | 504 |
| 20 30.70ºS | 29 55.20ºE | 338/01 | -15.3 | 37005 | 504 |
| 20 30.10ºS | 29 55.40ºE | 205/03 | -15.4 | 37003 | 504 |
| 16 53.30ES | 31 13.60ºE | 268/11 | -08.8 | 37182 | 499 |

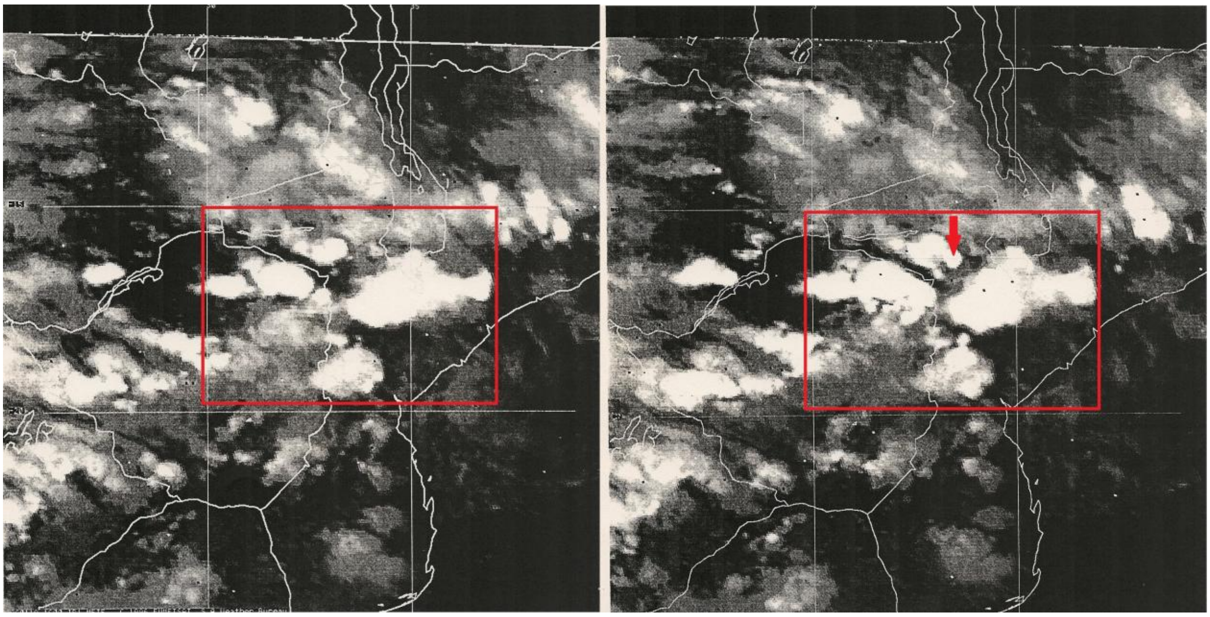
Position, Wind velocity, Total Air Temperature, Pressure Altitude (ft) and Ground Speed (kt) from the aircraft flight data.

The Total Air Temperature (TAT), in the table, is the sum of the ambient air temperature and the frictional heating effect of the aircraft fuselage. Using a ground speed of 504kt and the last position point in the table, a time of 4 minutes from the Makir reporting point is obtained. Allowing for minor calculation discrepancies, this places the aircraft very close to where the turbulence was encountered (about 4 minutes south of Makir was quoted by the SAA official).

The report of the aircraft suddenly rising and then falling is consistent with it having encountered a strong updraft associated with a developing thunderstorm cloud and then falling again once it exited the updraught. The nearly 7ºC higher temperature at the last position report (in the table above) near to or at the time of onset of the turbulence, is further confirmation of a rising column of air warmer than the surrounding atmosphere that would be found in a developing thunderstorm. Notice in the last row of the table above, the aircraft altitude at this point is also nearly 180ft (55m) higher than the earlier nearly consistent altitude and the ground speed shows a compensatory decrease.

In view of the above and the lack of vertical and horizontal wind shear, as well as light winds, it is believed that high altitude clear air turbulence can be ruled out as the cause of the severe turbulence. Discussion with the SAA person revealed that the aircraft was already passing between two radar identified thunderstorm echoes and a female steward was in the cockpit enquiring how much longer before they can start serving meals when the severe turbulence was experienced. It is possible that the aircraft was subjected to turbulence between the two cells and/or thunderstorm wake turbulence (Lester et al, 1991).

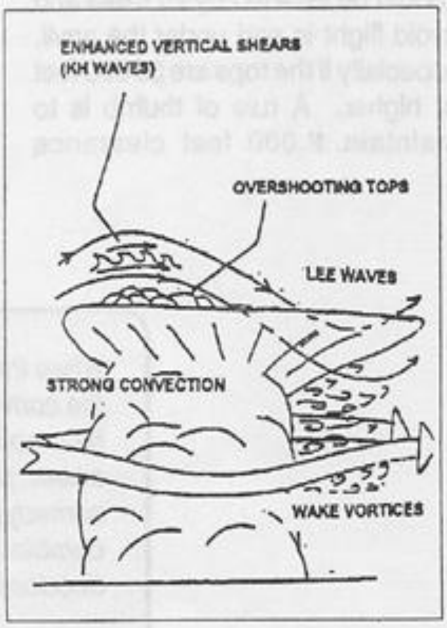
However, comparison of the two satellite images on the next page at 1600Z and 1630Z shows enlargement of two large thunderstorm anvils in the area of the incident over northern Zimbabwe with a smaller cell to the north of the large western cell. Significantly, development of a new small cell is evident on the eastern edge of this smaller cell, marked with a red arrow on the image on the right. Clearly the aircraft was flying toward an area of developing thunderstorm activity.



From the weather conditions discussed above and the report in the You magazine, where thunderstorm activity and prior turbulence is mentioned, it is believed that the severe turbulence was not caused when passing between the two large anvil areas, but suddenly a little time later there was severe turbulence near a thunderstorm top (TNTT) (Lester 1993) caused by the smaller developing cell.

Lester et al (1991) cite an incident where a DC-10 flight through the top of a thunderstorm near Bermuda at FL370 on the $10^{th}$ December 1983 resulted in G-loads of +1.6 and -0.6. The turbulent period lasted 86 seconds with G-load in excess of 1.0 for 1% of the time. Also, a L-1011 experienced +2.1 and -1.0. These compare favourably with the G-loads of +2.1 and -1.5 experienced by this Boeing 747SP incident.

According to Lester (1993) the "primary causes of TNTT are convection within the main body of the storm and a variety of atmospheric gravity wave phenomena caused by interactions between the thunderstorm and it's stable environment" as shown in the figure left. In more simple terms, the severe TNTT can result from an encounter with a rapidly growing



Source of TNTT from Lester, et al. 1993:468

cumulonimbus cloud, or flight in the overshooting top above the anvil into a stable layer such as the stratosphere. Lester (1993) adds that TNTT may be produced in weak winds with "thunderstorms protruding into an otherwise quiescent, stable environment."

The United States of America FAA Advisory Circular 00-24B, Thunderstorms (1983), from Lester (1993), gives some guidelines to avoiding TNTT, which are briefly repeated. Shear turbulence has been encountered several thousand feet above and 20 miles (17nm 32km) laterally from a severe storm. It is suggested that any storm identified as severe should be avoided by 20nm (37km) laterally and vertically above by 5000ft miles (17nm 32km) and avoid flight in and under the anvil, especially if the tops are 35000ft or higher. A rule of thumb is to maintain 1000ft clearance above for every 10kt of wind speed, while another rule is a minimum of 5000 feet above the top. Also beware of an overshooting top. Occasionally tilting the airborne radar downwards will permit detection of thunderstorm activity at lower altitudes.

Weather radar detects droplets of precipitation. It is less effective at detecting dry hail and ice particles. The strength of the return depends on the size, composition and number of droplets. Water particles are almost five times more radar reflective than ice particles of the same size. Weather radar is therefore effective in detecting rainfall and wet hail, but not effective in detecting the upper level of a storm cell where most moisture exists in a dry, frozen state. Regularly tilting the antenna downward improves the detection of storm cells.

A problem that arises is that the convective elements that overshoot a smooth anvil top or rapidly rising pre-anvil tops often lack a radar echo (Lester 1993). Furthermore, restricted forward and downward vision from the cockpit and/or darkness creates added problems. Inspection of the 1600Z satellite image showed that there was another horizontally less developed small cell north of and between the two large cells. This cell may have been developing at a lower level and not visible in the radar cone, as well as not visible to the crew due to their being in cloud. Due to the scale of the images, it is not possible to determine the exact geographical location of the aircraft on the satellite image relative to the cells. Consequently, it is not certain which of the cells caused the turbulence, but the last position in the table is very close to the small cell between the two large cells and immediately to the north of them.

The available information leads one to believe that the aircraft encountered severe turbulence in the top of a strongly developing thunderstorm (TNTT), the tops of which were forecast to reach 45000ft. While the aircraft no doubt encountered turbulence while threading its way between the two large cells, it is also possible that the aircraft encountered wake turbulence from one of two large cells. This is considered to be less likely.

Unfortunately, SAA ZS-SPE on the 19th January 1996, happened to pass through the area at a critical time in the level of thunderstorm activity and development. Given the erratic and temporary nature of such activity, it is highly likely that passing a short time earlier or later would have been much less eventful.

By the way, on the 31st September 1996, at about 1330Z, I was on board a SAA B747-200B, flight SA365 from Johannesburg to Cape Town, that had to climb steeply after take-off to FL410 in an attempt to get sufficient height before reaching thunderstorms. The flight still got bumped around while in and out of the cirrus anvils.

**Air France over Burkina Faso 1996-09-05**

In the early hours of the 5th September 1996, an Air France B747-428, registration F-GITF, flight AF437 at FL350 on a flight from Cape Town to Johannesburg to Paris, at 0020Z encountered severe thunderstorm (cumulonimbus cloud) turbulence at FL350 over Burkina Faso, in West Africa. Thirty passengers were injured, nine seriously and one died later on the 22nd. The flight continued north and diverted to Marseilles. It is believed that the passenger that died was hit by falling video equipment.

The probable causes were concluded as:
1. Despite repeated intermittent weather radar faults, it was not repaired.
2. The crew did not consider the non-operation and continued the flight into deteriorating weather.
3. The flight was undertaken on the basis of insufficient and misinterpreted meteorological information (Aviation Safety Network 1996-09-05).

With regard to the last statement Air France attempted to shift the blame to a poor South African Weather Bureau forecast. However, the forecast significant weather chart for the area above FL250 indicated ISOL EMBD CB (isolated embedded thunderstorms) in the area in the Intertropical Convergence Zone (ITCZ). More prevalent thunderstorms would be indicated as OCNL CB (occasional thunderstorms). Irrespective of the level, all charts have a warning thar CB implies TS (thunderstorm), GR (hail), moderate or severe TRUB (turbulence and ICE (icing). The ITCZ is a region where the north-easterly and south-easterly trade winds converge, forming an often continuous band of clouds or thunderstorms near the geographical equator. The ITCZ tends to move with the thermal equator to north of the geographical equator in the Northern Hemisphere summer and to the south in the Southern Hemisphere summer. Isolated CB cells (that is not embedded) are not indicated on the chart on the understanding that they can be identified from afar and avoided.

**Fatal accident climbing from Johannesburg International Airport 1996-01-26**

Report ref: 16/7/1 1996-01-29

A Magnum Airlines cargo flight, twin engine, Piper PA-31-35-Navajo Chieftain aircraft, registration ZS-KBY, departed Johannesburg International Airport and crashed in the dark in poor weather conditions. Both occupants were killed (Aviation Safety Network 1996-01-26 and Bureau of Aircraft Accidents Archives 1996). The accident site was in the Boksburg suburb of Witfield at approximately 2000Z 1996-01-26. Witfield is about 5km (2.7nm) from the southern end of Johannesburg International Airport.

Very moist air was in circulation in association with a low pressure cell over South-eastern Botswana. The synoptic situation at 1800Z on the $26^{th}$ January 1996 indicated widespread rain with embedded thundershowers in the area of the accident with cloudy to overcast cloud cover and reduced visibility.

The nearest meteorological aviation reports (METARs) around the time of the accident were at Johannesburg International Airport.
FAJS 261900Z 20006KT 6000 -TSRA SCT003 FEW025CB BKN080 18/18 Q1012 TEMPO BKN003=
FAJS 261930Z 20006KT 6000 -RA SCT003 FEW025CB BKN080 18/17 Q1012 TEMPO BKN003=
FAJS 262000Z 20005KT 6000 -RA SCT003 FEW025CB BKN080 17/17 Q1012 TEMPO BKN003=
FAJS 262030Z NOT ISSUED
FAJS 262100Z 21005KT 6000 -RA SCT003 FEW040CB BKN080 17/17 Q1012 TEMPO BKN003=
Visibility in metres. -TSRA indicates a light thunderstorm with rain, but without hail, while -RA indicates light rain. Cloud base AGL in hundreds of feet. FEW = 1 to 2 oktas, SCT = 3 to 4 oktas, BKN = 5 to 7 oktas). TEMPO = temporary trend during the next 2 hours from the time of issue of the report.

The upper air sounding at Irene, south of Pretoria at 1200Z on the $26^{th}$ indicated air sufficiently moist for cloud almost from the ground up to about 400hPa (±23000ft) and later in the night at 0000Z on the $27^{th}$ up to 380hPa (± 25000ft) with north-westerly winds aloft.

The forecast weather for the area in low and medium level significant weather charts for 2000Z indicated broken cloud from 6000ft MSL, which in the Johannesburg International Airport area would have been about 500ft AGL to 11000ft MSL with broken middle/high layer cloud from 12000-25000ft MSL with embedded thunderstorm cloud and reduced visibility.

The TAFs at Johannesburg International Airport are given below. The third group in the TAFs indicates the period of validity. For example, the first TAF was valid from the $26^{th}$ at 1200 Z to 2100 Z.
FAJS 260900Z 261221 36010KT 9999 BKN020 FEW025CB TEMPO 4000 SHRA/TSRA BKN007 BKN090=
FAJS 261200Z 261524 35010KT 9999 BKN020 FEW025CB BKN080 PROB40 TEMPO 1524 5000 SHRA SCT007 PROB40 TEMPO 1520 4000 BKN007 TSRA BECMG 2124 BKN005=
FAJS 261500Z 261803 02008KT 9999 BKN020 FEW025CB BKN080 PROB40 TEMPO 1824 5000 SHRA SCT007 PROB40 TEMPO 1822 4000 TSRA BKN007 BECMG 2202 BKN005=
Note, SHRA indicates rain showers, TSRA thunderstorm with rain.

The observations indicate that there was widespread cloud over the area up to about FL250

(25000ft MSL) with rain, reduced visibility and embedded isolated thunderstorms. Icing was probably present in cloud above the freezing level. This is also understood by the presence of thunderstorms which also inferred the risk of hail, severe turbulence and icing.

The forecast weather tended to be slightly worse than the observed. Broken cloud was given at FL060 which is about 500ft AGL in the vicinity of Johannesburg on the significant weather charts, whereas the observations gave 3-4 oktas at 300ft AGL. The METAR trend forecasts also tended to give worse conditions, that is broken cloud at 300ft AGL and 5000m visibility was forecast, whereas the observations varied from 4000-6000m. The depth of cloud forecast correlated well with that indicated by the Irene sounding.

Although isolated thunderstorm cloud (Cumulonimbus) was reported in the vicinity at the airport at the time thunderstorm activity was not reported. In the absence access to the official enquiry, it is suggested that while aware of thunderstorm cloud in the vicinity, the pilot became distracted and possibly to some extent spatially disorientated, flew the aircraft below the sector minimum safe altitude and into the ground.

**Fatal aircraft accident Vryheid area 1998-01-09**

Report ref: W16/7/1 1998-01-15

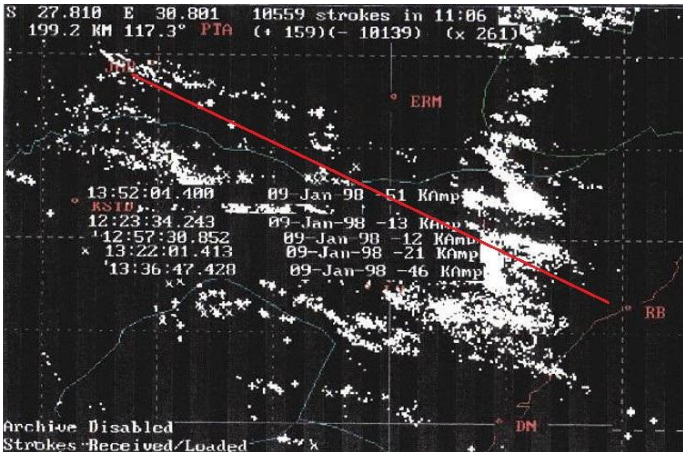
Friday the 9$^{th}$ January 1998, at approximately 1100Z (1300 SAST) a family of four were killed when their aircraft, en route from Richards Bay airport (FARB, 109ft, 33m MSL) to Lanseria, crashed about 10km from Vryheid. Wreckage was strewn over a large area. Preliminary thoughts as to the cause of the accident included the possibility the aircraft broke up in flight as indicated by the wreckage spread. The single engine aircraft was equipped with a wing mounted radar pod while the pilot was not instrument rated. That is, a VFR pilot.

A surface low was off the KwaZulu-Natal coast which resulted in an onshore flow of cooler and moist maritime air over the south-eastern part of the province with cloudy to overcast weather and rain in the south. Further north, over the western and north-eastern part of the province and in the vicinity of Vryheid, warm to hot and moist air was in circulation. Thunderstorms developed at the confluence of these two air masses as indicated by weather reports in the 1200Z (1400B) synoptic chart to the south of Vryheid from Estcourt and Cedara to the north-east at Matsapa airport in Swaziland (now Eswatini).

Unfortunately, surface meteorological aviation AWS reports at 1100Z (1300B) at Vryheid airport (FAVY, 3799ft, 1158m MSL), nearby at Newcastle airport (FANC, 4074ft, 1242m MSL) and Ladysmith airport (FALY, 3548ft, 1081m MSL) and further afield at Greytown airport (FAGY, 3531ft, 1076m MSL), Pietermaritzburg airport (FAPM, 2423ft, 738m MSL), Ulundi airport (FAUL, 3643ft, 1720m MSL) and Richards Bay airport (FARB, 109ft, 33m MSL) did not include visibility, weather and cloud elements. There was not the technology at the time. The report at FDMS (Matsapa airport 2104ft, 641m MSL) did. It indicated a thunderstorm in progress (TSRA) at the approximate time of the accident. Durban airport (FADN) to the south was under post coastal low weather. The reports are shown below.

FADN 091100Z 18014KT 9999 FEW018 BKN040 25/21 Q1002 NOSIG=
FAGY 091100Z AUTO 36008KT //// // ////// 27/22 Q1006=
FALY 091100Z AUTO 36006KT //// // ////// 28/20 Q1005=
FANC 091100Z AUTO 31011KT //// // ////// 30/20 Q1006=
FAPM 091100Z AUTO 09007KT //// // ////// 26/22 Q1004=
FARB 091100Z AUTO 18006KT //// // ////// 29/25 Q1001=.
FAUL 091100Z AUTO 05010KT //// // ////// 29/24 Q1005=
FAVY 091100Z AUTO 04005KT //// // ////// 23/06 Q1007=
FDMS 09110Z 09006KT 9999 TSRA SCT035 SCT040CB 26/23 Q1005 NOSIG=

While no manual visual observations were available in the Vryheid area, the infrared and visual satellite images at 1100Z confirmed that there was thunder activity in the area onward to Swaziland. Judging by the visual image texture and surface observations in the synoptic map mentioned above, cloud in the area consisted of patches of broken to overcast low and/or medium level cloud. Later images at 1200Z and 1300Z showed the activity had spread to a larger area.




At the time, from 1993, Eskom, the South African Electricity Supply Commission, operated a network known as the Lightning Position and Tracking System (LPATS). This real time data and archived data was available to the SAWB. The LPATS map clearly indicates extensive lightning activity where the red track passes through in the Vryheid area. Individual flashes have been highlighted at times ranging from 12:24 to 13:52 SAST at the Vryheid location 27.8°S 30.8°E shown in the top left corner of the figure. In a total of 11.6 hours the figure captured 10559 strokes, 10139 negative (-ve) and 159 positive (+ve) strokes. Negative lightning it is the transfer of -ve charge from the lower part of the cloud to the ground. Positive strokes, so called because there is a net transfer of +ve charge from the cloud to the ground, originate near top/upper part of the thunderstorm cloud. The descending stepped leader carries a positive charge, but the subsequent ground streamers are -ve charged. The +ve strokes are much less frequent than -ve strokes, because they must travel, or burn, through more air. However, for this reason +ve strokes are much stronger, cause a longer flash and a peak charge up to ten times stronger than a -ve stroke (NOAA). From October 2005 the South African Weather Service has owned and operated the Southern African Lightning Detection Network with complete national coverage from early 2006.

According to the Durban upper air sounding the freezing level was at 14577ft MSL at 0000Z and 14796ft MSL at 1200Z. The freezing level may have been lower in down draught areas of thunderstorms, but taking a saturated parcel of air from the 0°C level earthward, at the saturated adiabatic lapse rate with a dew point depression of 5°C (according to the sounding), produces a lowering of the freezing level to 14 000ft above MSL at the most. In saturated conditions in thunderstorm clouds the lowering would have been much less marked or negligible. It is believed that it would take an extremely exceptional case for the freezing level to lower 4000-5000ft to the believed aircraft flight level of FL105, which would be confined to down draught areas only. Airframe icing was therefore an unlikely cause of the accident.

The upper air sounding at Durban at 1200Z indicated enough moisture for cloud to extend from the surface up to 8000ft MSL with another layer between 16000-19000ft. However, it must be born in mind that this does not necessarily apply in the vicinity of convective cloud development. Other layers associated with thunderstorm development may have been present in the Vryheid area.

The upper level winds observed at Durban at 1200 Z are given in the following table.

| ALTITUDE | WIND (KTS, TRUE) |
|---|---|
| 2000 ft | 190-10 |
| 3000 ft | 105-03 |
| 5000 ft | 360-15 |
| 7000 ft | 325-28 |
| 10000 ft | 325-18 |
| 13000 ft | 325-18 |
| 15000 ft | 320-26 |

The nearest TAFs are for Newcastle airport (4074ft, 1242m MSL) and Ladysmith airport (3548ft, 1081m MSL) issued at 0600Z, valid from 0900-1800Z were:
FANC 090600Z 090918 12010KT 9999 SCT030 TEMPO 1218 2000 TSRA BKN010 SCT030CB T26/09Z T22/18Z=
FALY 090600Z 090918 12010KT 9999 SCT030 TEMPO 1218 2000 TSRA BKN010 SCT030CB T27/09Z T22/18Z=

The relevant portion is the TEMPO part that indicates thunderstorms with 2000m visibility 5-7 oktas of cloud at 1000ft AGL and scattered 3-4 oktas of thunderstorm cloud at 3000ft at the expected times of 1200-1800Z. Clearly not VFR weather

The significant weather charts for the low and medium levels at 1200Z indicated that thunderstorms were forecast for the area of the accident with cumulus cloud and more broken cloud towards the coast.

Although the aircraft was radar equipped, there was no way of ascertaining if it was switched on, or if the pilot knew how to use it. All radio communication was normal and there was no distress call.

It is believed the non-instrument rated pilot, flying in IMC, flew into cloud, whereupon control was lost and the aircraft crashed. Given the spread of wreckage, it was highly likely the aircraft broke apart due to the turbulent force of the up and downdrafts within a thunderstorm then falling to the ground in pieces.

**Downburst at Johannesburg International Airport 1998-10-08**

This incident is from the SAWB, Directorate Forecasting Internal Report No FOR/14 (de Villiers 1999) courtesy of the now SAWS. I also appeared on SABC TV and radio broadcasts.

A cold front with thunderstorm activity was in the process of passing over Johannesburg International Airport in Gauteng Provence at about 8 o'clock (0600Z) on the morning of Thursday the 8th October 1998 around the time when early morning flights from other domestic airports and overnight international flights were arriving.

During its approach to land from the south on runway 03R, the pilot of a Jetstream 41 aircraft reported 35 knot wind shear. An Airbus A300, flight from Durban, following about 5 minutes behind suddenly encountered a +1.78G force south of the airport, the radio altimeter registered large height fluctuations and the aircraft radar indicated heavy rain. Heavy rain in thunderstorm conditions is a sign that there is a strong downdraught ahead. The pilot decided that safety was the best option, initiated a climb and diverted back to Durban. Following behind on short final, a Boeing 737 suddenly encountered heavy rain and the aircraft fell 100 feet. The pilot also climbed away from the situation, but thereafter made a circuit of the airfield and landed at the second attempt. Altogether 5 flights diverted, two of them long distance international flights.

The news media got wind of fragmented bits of information and began to talk about a mircoburst and an aircraft dropping 2000ft over Heidelberg. This is an analysis of what happened. Did the aircraft encounter a downdraught often associated with thunder activity, or was it a more intense microburst? Fujita (1985) divides downbursts into a greater than 4km macroburst and a less than 4km a microburst.

The surface analysis at 0600Z (0800 B) showed a trough and cold front lying from east to west over the northern provinces of South Africa. Further to the south and east, cold and overcast weather with rain existed ahead of an anticyclone off the Transkei and KwaZulu-Natal coasts, while to the west a trough was over north-eastern Namibia to the central Free State. The presence of the cold front was confirmed by the surface air temperatures and 850hPa wet-bulb potential temperatures changes over Gauteng. Surface air temperatures changed from 20°C at Warmbad north of Pretoria to 17°C at Pretoria, 15°C at Irene south of Pretoria and 10°C at Johannesburg International Airport, with 14°C at Vereeniging to the west of Johannesburg. A marked wet-bulb potential temperature gradient was also present. These ranged from 20°C to 22°C at Warmbad, Irene and Pretoria, but fell to 17°C at Johannesburg international Airport with a 13°C cold pool evident at Vereeniging. Charts have not been included for the sake of brevity, although provided in the internal report. The same applies to the other figures, such as upper atmosphere analysis, upper air soundings, satellite images and numerical weather prediction model data, discussed later.

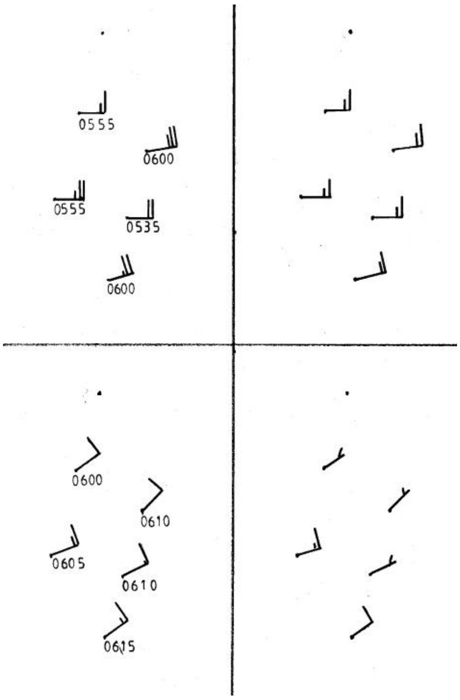
Rain was reported at Johannesburg and Vereeniging and thundershowers at Irene and Pretoria, while recent thunder was reported at Warmbad. The infrared satellite images at 0500Z and 0600Z, indicated thunderstorms over northern Gauteng, which moved to the south-east during the hour between the two images. Separate thunderstorm development over south-western Gauteng also moved towards the south-east and spread out at the same time.

Wolfson (1990) stated that analysis of the downdraft at the time of the accident of Delta 191, on the 2nd August 1985, showed that the rain bearing downdraft air was ±8°C colder than the ambient air temperature. With this in mind, Johannesburg, Vereeniging, Irene and Pretoria reported precipitation, yet Johannesburg's temperature was 4°C to 7°C colder than the other places. This makes one wonder; was this colder air due to Johannesburg's higher altitude; was colder frontal air present; or was it colder due to a cold downdraught air?

The surface wind immediately north of the colder air at Pretoria and Irene, at 0600Z (0800B) was north-north-easterly 5k at Pretoria and north-easterly 10kt at Irene, but at Johannesburg international Airport there was a shift to east-south-easterly and an increase in speed to 17kt, as shown in the surface Johannesburg airport (FAJS) METARs below.

FAJS 080500Z 11012KT 3000 BCFG OVC003 12/12 Q1026 TEMPO 1000 FG=
FAJS 080530Z 11012KT 3500 BCFG OVC003 12/11 Q1026 BECMG 0630 BKN007=
FAJS 080600Z 09017KT 3500 -RA BCFG BKN004 FEW030CB 10/10 Q1027 BECMG FM0630 BKN007=

The landing forecasts appended to the observations also show that the forecaster's attention was focussed on fog and later low cloud, not the embedded thunderstorms. This is not unusual. Experience has shown that although heavy rain may occur under these circumstances, a bigger problem landing at Johannesburg International Airport can be low cloud and poor visibility.




Vital visual clues to the presence of a downburst are a shaft of heavy rain. In a dry downburst, dust, raised in a circle by the downburst reaching the ground and fanning out horizontally, is another clue. Another method is to have wind measuring devices spread over the airport. Diverging wind directions with increased velocity would be a clue to the presence of a downdraft. Ideally, the way to detect a downburst is through the use of Doppler radar, as evidenced by the Nimrod (1978) and Jaws (1982) field experiments (Fujita 1985).

Johannesburg international Airport did not have Doppler radar, but it did have six wind recording automatic weather stations (AWS) situated along the two parallel runways. They are positioned at the thresholds of the southern and northern ends of each runway with one each at the two middle points of the runways. The AWS wind direction, at the threshold to runway 21R, was faulty and has therefore not been considered. It is represented by a dot in the figure above.

Unfortunately, no divergent wind pattern is evident from the various AWS. However, a sudden increase in wind speed and gustiness, followed by a sudden drop and change in wind direction was noted at the time that aircraft experienced loss of height. Referring to the figure left, immediately prior to 0600Z all six AWS showed a sudden increase in wind gusts from the east (top left). The mean wind is shown in the figure at the top right. Within minutes there was a drop in the maximum wind gusts with a change to a more north-easterly wind (bottom left), while the mean wind speed also showed a marked drop (bottom right). A more detailed picture of the wind was evident from the different AWS recorded instantaneous wind traces from 0000-2400 SAST. These have not been included, although provided in the internal report.

It must be borne in mind that the AWS wind recordings are at the airport, while the aircraft were immediately south of the airport on approach and short final approach. Therefore, the surface wind observations cannot be considered to be truly representative of the surface conditions experienced by aircraft approaching to land.

In the upper air, the atmospheric sounding at Irene at 0000Z indicated moist air from 700hPa (±10000ft MSL) to 500hPa (±17000ft MSL). With a suitable trigger action, such as surface convergence at an air mass boundary, there would be enough convective available potential energy for thunderstorms to grow to over 200hPa (±40000ft MSL).

The Eta numerical weather prediction (NWP) model, initialised at 0000Z on the 8th, clearly indicated the change in air mass that would take place at t+6 (0600Z) in the vicinity of Johannesburg, with increased mixing ratio moisture flux (change) at 800hPa, increased moisture at 800hPa and a marked band of colder air at the same level. The potential temperature changes were very similar to the air temperature. A similar pattern was visible in the wet-bulb potential temperature gradient over the area. Finally, Johannesburg was under a zone of marked wind convergence at 800hPa. 800hPa is ±6500ft MSL. The airport is at 5558ft MSL.

Time sections at Johannesburg International Airport were obtained for wind velocity, divergence and vertical velocities. The model wind time section over Johannesburg forecast a north-easterly wind of 20kt at t+06 hours at 850hPa (±5000ft MSL), with considerable wind shear above between 700hPa to 500hPa. Taken in context with the observed upper air conditions, on the 700hPa and 500hPa synoptic charts and the Irene tephigram (upper air sounding), the low level winds brought the colder moist maritime air, which undercut warmer moist continental air from the west-north-west. Velocity divergence/convergence reflected the wind changes by indicating surface convergence replaced by divergence at the 700hPa level, where the wind above this increased in speed and changed direction, but at 500hPa there was again a layer of convergence. Vertical velocities reflected this continual change in that values were around zero until above 500hPa where they became negative (upward motion) and reached a still weak maximum at 300hPa.

Instability indicators for thunderstorm development were disappointing with all of them either weak or marginal. Those inspected were convective available potential energy (CAPE), best lifted index, Showalter, Total Totals index, Maximum updraught and dry microburst. The wet microburst also gave an unfavourable result. The K index was the most favourable which indicated moderate or adequate conditions for development. The composite thunderstorm probability indicated a 50% to 60% probability of scattered or frequent thunderstorms.

Although the Eta model gave a correct prognosis of the atmospheric conditions, its 48km grid is considered too large to determine if it would have been able to give advance warning of such small scale weather aspects as strong updraughts and downdraughts in a thunderstorm.

However, there were enough larger scale indicators that an air mass boundary would be over the area. In association with the development visible on the satellite image, this could have been enough evidence to be wary of severe thunderstorm development. The Eta model was, at the time, the smallest scale model in use by the SAWB. Other NWP models available to the SAWB, such as the United Kingdom global model, the United States National Meteorological Centre global spectral model and the European Centre for medium range Weather Forecasting global model had larger resolutions and are therefore even less suitable.

The problem with the argument for severe thunderstorm development, is that the normally accepted factors, such as a marked dry line or wedge in the middle layer; backing of the wind with height accompanied by marked vertical wind shear; instability above a strong inversion and high surface temperature (Agee 1982, Bennetts et al 1986, Eagleman 1983), were absent. Although marked surface moisture and temperature gradients, with low level convergence were present.

The author's stock photograph of a SAA Airbus A300 at Johannesburg.

During its approach to land the pilot of an Airlink Jetstream 41 aircraft reported 35kts and wind shear. An A300, flight from Durban, following about 5 minutes behind, at FL075 (±1950ft AGL) and 9nm DME (distance measuring equipment) south of the airport, suddenly encountered +1.78G at 0556Z (07:56B). The radio altimeter registered height fluctuations from 3000-100 ft AGL. The radar showed a thick red line ahead, which indicated heavy rain. Heavy rain in thunderstorm conditions is a sign that there is a strong downdraught ahead. The pilot decided that safety was the best option, initiated a climb and diverted back to Durban. A following Boeing 737, on approach to runway 03R, at 2nm out at 300ft AGL suddenly encountered heavy rain with a strong crosswind of 30 to 40kt. The aircraft dropped to 200ft AGL in very heavy rain and the pilot lost sight of the runway in the rain. He applied full thrust, that is greater than climb power, retracted the undercarriage and with 15° flap, 125kt IAS $V_{ref}$ (indicated air speed) and 15° to 17° pitch up, could not cause the aircraft to climb remaining at 200ft AGL. The pilot said that after a frightening period of time the aircraft suddenly began a rapid climb. No doubt, because it was now out of the downdraught. The pilot made a circuit of the airfield and managed to land at the second attempt.

Careful scrutiny of the A300 aircraft data, including overlaying graphs on a light table. The figures A to D have been placed in sequence on following below. Figure A revealed there was a slight rise in altitude with increased airspeed at the beginning of the 0556Z minute. This would be consistent with encountering the advance downward and outward flow of air associated with a downdraft (Wolfson 1990). At the same time there was a drop in the pitch angle. A drop in the pitch angle would produce an increase in airspeed. Also prior to this there was an increase in engine thrust. So, although it looks as though the aircraft encountered an outward splaying downdraught, it is more likely that the pilot was correcting an earlier slight descent and the aircraft was responding to the application of power.

A fall in pressure altitude of about 100ft occurred slightly later into the 0556Z minute, with a weak drop in calibrated airspeed (CAS) and slight pitch up attitude (figures A and B). The radio altimeter also displayed a slight fall (figure A). Not many seconds after this there was a sudden drop in the radio altimeter height to a few hundred feet above ground level (figure A). This is not indicated in the pressure altitude trace (figure A). The radio altitude drop and subsequent fluctuations are attributed to the onset of heavy rain which threw back the radio altimeter signals and gave a false impression of rapid and deep loss of height.

The sudden drop in radio altimeter height was followed by the application of $N_1$ 90% engine power (figure C) with a pitch up to 14° and a sympathetic drop in airspeed (figure B). The back pressure on the flying control was relaxed slightly and then increased to 30° pitch up with a $N_1$ power increase to 125% and a drop in airspeed to ±190kt. The +1.8G force coincides with the application of 14° pitch up (figures D and B, respectively).

It would appear that the aircraft fell about 100ft in a downdraught and flew into a wall of rain. Whereupon the pilot reacted so strongly to the sight of the low radio altimeter height by applying such back pressure on the stick that it induced a temporary +1.8 G force. Temporary relaxation to about 7° pitch resulted in a drop in G force, but increase in pitch again to 30° caused increased G forces which at one time reached +1.6G. Later when the pitch was again decreased to about 7°, 0.1G was experienced (figures B and D).

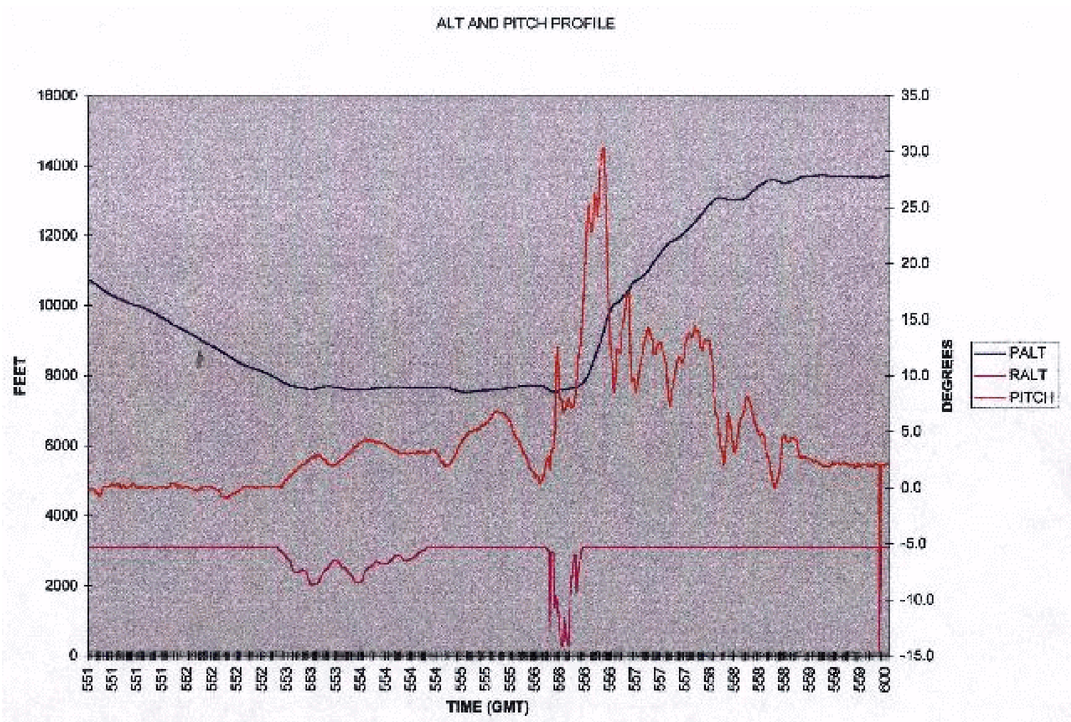



**Figure A.** Airbus A300 pressure altitude (top blue), pitch profile (middle red) and radio altimeter height (bottom mauve) from 0551Z to 0600Z 1998-10-08.

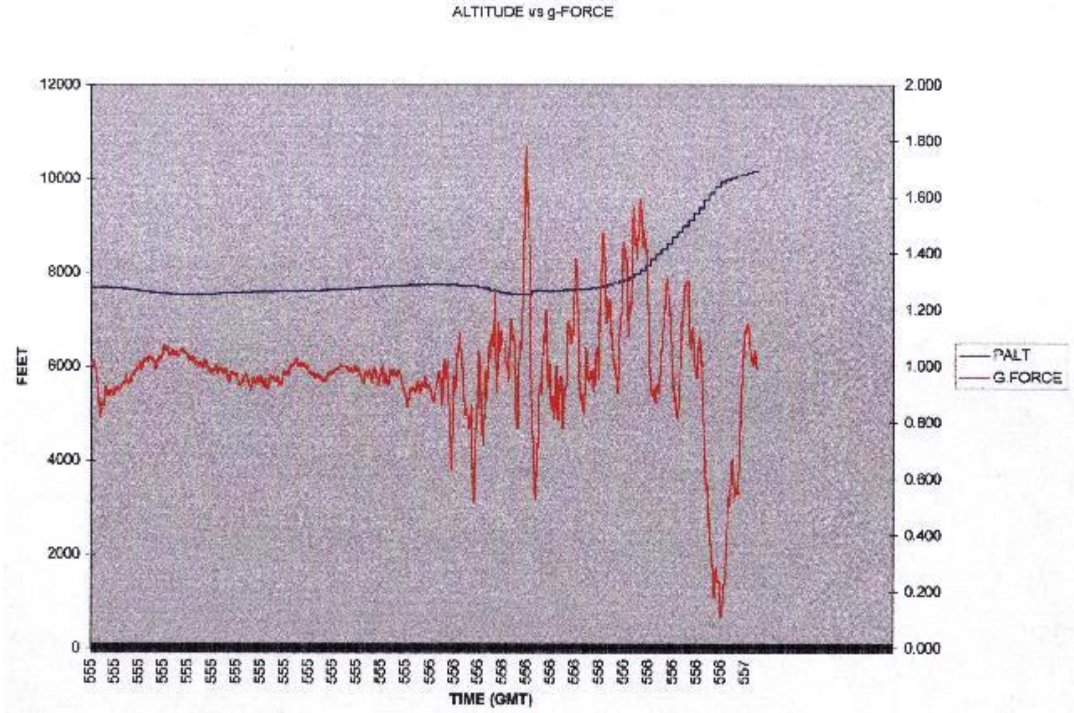



**Figure B.** Airbus A300 air speed (top blue), pitch profile (bottom red) from 0551Z to 0600Z 1998-10-08.

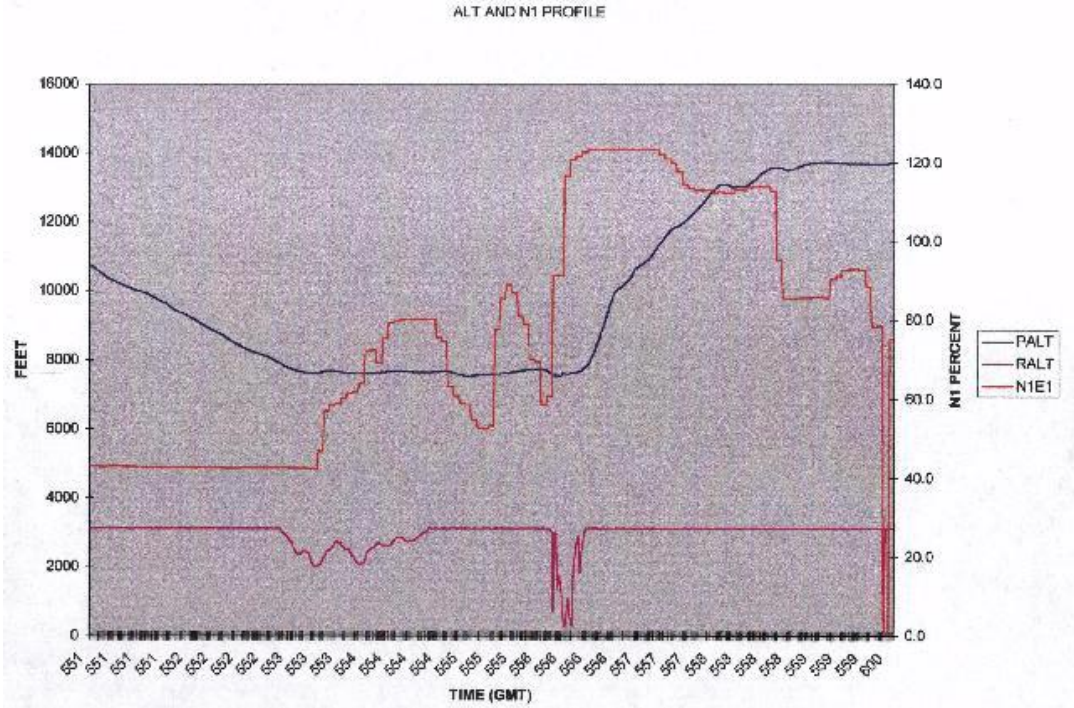



**Figure C.** Airbus A300 pressure altitude (top blue), engine N1% thrust (middle red) and radio altimeter height (bottom mauve) from 0551Z to 0600Z 1998-10-08.

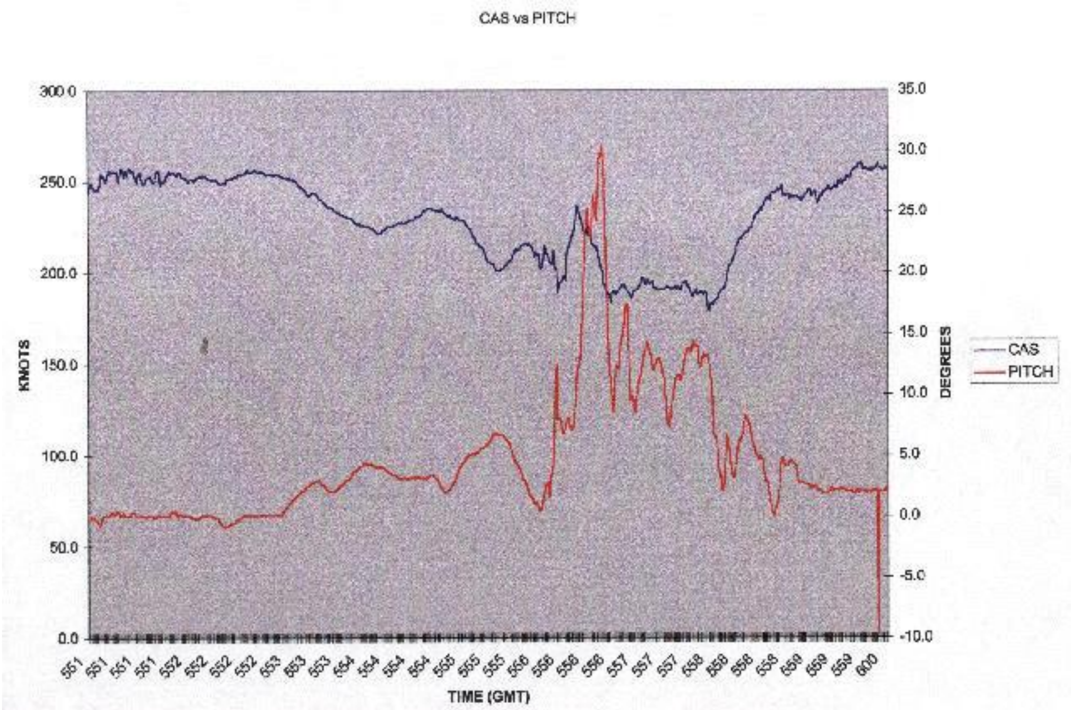



**Figure D.** Airbus A300 pressure altitude (top blue) and G force (red below) from 0551Z to 0600Z 1998-10-08.

It must be borne in mind that the changes in G force were momentary and that the whole sequence of events took place in less than 2 minutes, during which time the aircraft climbed from about 8000ft to 14000ft AGL. That is, over 3000ft per minute while travelling forward about 5nm (9km).

During interviews with airline pilots, after the event, I was reminded that Doppler radar would have been of great assistance in indicating wind shear at an airport. Correctly operated this would enable an ATC to give advance warning to pilots of the presence of wind shear.

It is significant that the thunderstorm with heavy rain and marked downdraught coincided with the position of a surface cold front. The position of the cold front and the change in air mass was clearly indicated by the surface analysis at exactly the same time as the aircraft were experiencing the heavy rain and turbulence. Obviously, if similar surface analysis conditions are observed in the future it would be wise to consider issuing a warning of severe thunderstorm conditions and downdrafts along the boundary.

The resolution of the most suitable NWP model available to the aviation forecaster, namely the Eta model, was not small enough to be able to detect mesoscale development such as thunderstorm downdrafts. However, there was enough evidence on a large scale that an air mass boundary would be over the area. Taken in conjunction with the development visible on the satellite image, this could have been enough evidence for the aviation forecaster to be wary of severe thunderstorm development. Bear in mind it is easy to be clever with hindsight.

The conclusion is that aircraft flew into a downdraught, with very heavy rain, during which two aircraft lost about 100 feet altitude. In the one instance, the very heavy rain gave a false indication of great height loss on the radio altimeter, to which the pilot, understandably, reacted most positively.

One hundred feet height loss at about 2500ft AGL is not serious, but it is critical nearer the ground, as evidenced by the drop from 300ft to 200ft AGL experienced by the B737. In this situation, as described previously, the aircraft remained at 200ft, unable to climb, although the aircraft was in the correct climb attitude with full power, until it had flown clear of the heavy rain and associated downdraught. If the downdraught had been stronger, or the aircraft had been at about 100ft AGL when the drop in height was experienced, the consequences would have been disastrous.

The use of Doppler radar is a valuable tool for providing advance warning of the presence of wind shear. It is also essential that this equipment and other ground equipment, such as surface wind anemometers (via AWS), be properly maintained.

In this instance, one can be thankful that the conditions were not more severe, otherwise the consequences could have been catastrophic.

I thank SAA for supplying aircraft technical data. Thanks also to SAA and British Airways/Comair for information provided by telephone and in person. The information provided not only made the study more interesting, but provided better insight into the incident while it unfolded. One is also impressed by how quickly it takes place and how little time is available to flight crews to take the correct action.

**Piper Saratoga accident Rorke's Drift area 1998-12-12**

Report ref: W16/7/1 1998-12-14

A single engine Piper Saratoga, registration ZS-LGI, crashed at approximately 1345Z on the 12th December 1998 in the Rorke's Drift area at 28°01´S 30°47´E, KwaZulu-Natal. The four occupants were killed. The aircraft was en route from Zeerust, North-West province, to Durban's Virginia Airport.

Surface observations in the area were non-existent. However, the surface synoptic weather analysis at 1200Z indicated that the accident site was under a belt of surface low pressure and that it was an area of convergence between cooler moist maritime air from the north-east and warmer, moist air from the north-west. Thunderstorms were observed along this border.

The nearest surface observations consisted of an Automatic Weather Station (AWS) at Ladysmith airport (3548ft, 1081m MSL) and another at Newcastle airport (4074ft, 1242m). These are presented below at 1300 Z and 1400 Z.

FALY 121300Z AUTO 30009KT //// // ////// 32/15 Q1013=
FANC 121300Z AUTO 36008KT //// // ////// 30/20 Q1015=

FALY 121400Z AUTO 29007G18KT //// // ////// 33/13 Q1012=
FANC 121400Z AUTO 34010KT //// // ////// 31/17 Q1014=

The visual spectrum satellite image at 1300Z indicated a band of thunderstorms had developed along the surface low pressure air mass convergence zone. At the 30°S 30°E grid location on the image, close to the accident location, there was clear identification of characteristic thunderstorm cloud development. The prevailing westerly winds aloft showed the cloud top being carried downwind to the coast and over the sea.

The Durban sounding at 1200Z on the 12$^{th}$ indicated cooler and moist air extending up to about 825hPa (±6000ft MSL). Above this level and inland, away from the cooler coastal air influence, the sounding revealed the air would be sufficiently unstable for thunderstorm development. The freezing level was 13742ft MSL.

Thunderstorms were forecast for the area as indicated on the significant weather charts valid at 1200Z and 1500Z.

The nearest TAFs were at Ladysmith and Newcastle:
FALY 120900Z 121221 30012KT 9999 SCT040 TEMPO 1220 3000 TSRA SCT030CB BKN080 T29/12Z T19/18Z=
FANC 120900Z 121221 30012KT 9999 SCT040 TEMPO 1221 3000 TSRA SCT030CB BKN080 T28/12Z T20/18Z=

The SACAA Accident Report, Executive Summary A98-161-6981, synopsis was that "The aircraft was on a flight from Zeerust to Virginia when it encountered poor weather conditions in the Rourcke's drift area. Witnesses on the ground stated that a thunderstorm was raging in the area. Witnesses saw the aircraft broke up in mid-air and fall to the ground. The aircraft was flown at Flight Level 135 for about 1 hour and 30 minutes. The pilot was possibly hypoxic due to the low level of Oxygen and contributing to this state was the restrictions in his arteries. The aircraft was fitted with some components of a speed kit and an intercooler was fitted in the induction system. None of these modifications were approved.

Probable Cause The non-instrument rated pilot flew the aircraft into meteorological conditions associated with severe thunderstorm activities. In the turbulent conditions associated with these meteorological conditions, the pilot lost control of the aircraft most probably reached and exceeded it's Never Exceed Speed (Vne). The aircraft was unable to withstand the forces imposed on it and broke up in mid-air."

**Hail damage to a B727 during descent to Johannesburg 1999-04-22**

Report ref: W16/7/1 15-07-1999

On the 22$^{nd}$ April 1999, a Million Air Charter B727-23, registration ZS-IJE, operating a scheduled flight on behalf of Zimbabwe Express Airlines from Harare to Johannesburg, encountered large hail nearing Johannesburg at approximately 1545Z

The surface synoptic chart at 1500Z indicated thunderstorm activity at about the time of the incident, with thunderstorm cloud observed at Johannesburg International Airport, Pretoria and Warmbad.

The nearest observations were at Johannesburg International Airport:

The author's stock photograph of a SAA B727-44 (ZS-SBA) at Johannesburg.

FAJS 221500Z 34008KT 9999 FEW045CB FEW050TCU SCT050 21/11 Q1025 TEMPO 7000 -TSRA=
FAJS 221530Z 36007KT 9999 FEW045CB SCT050TCU SCT090 20/11 Q1025 TEMPO 7000 -TSRA=
FAJS 221600Z 02008KT 9999 FEW045CB SCT050TCU BKN070 19/12 Q1025 TEMPO 5000 -TSRA=
FAJS 221630Z 02014KT 9999 TS SCT045CB BKN070 19/13 Q1025 TEMPO 5000 TSRA=

A newspaper report the following day the 23rd (Die Beeld), carried a report of a severe thunderstorm causing thousands of Rand damage at Fourways, on the 22nd with hail the size of pigeon eggs. Thereby confirming the presence of thunderstorms in the area. Apparently, the flight crew reported the hailstones the size of Avocados. Fourways is not too distant south of HBV, the Hartebeespoortdam VOR to which the aircraft was heading.

As a matter if interest, the following day Friday the 23rd, Lanseria airport received hailstones the size of golf balls with 120 km/h winds that caused damage to four aircraft and a hanger was destroyed (Saturday Star, 24th).

| Flight Level | Wind | T°C |
|---|---|---|
| 100 | 300-10 | 09 |
| 130 | 280-15 | 01 |
| 150 | 290-25 | -3 |
| 170 | 300-30 | -9 |
| 200 | 290-30 | -15 |
| 230 | 280-35 | -18 |
| 250 | 290-40 | -21 |
| 270 | 280-45 | -27 |
| 300 | 280-60 | -36 |
| 350 | 290-60 | -47 |

Unfortunately, due to archiving problems, no satellite images were available.

According to the atmospheric sounding at Irene, Pretoria, thunderstorms would have developed up to about FL370. The air was moderately unstable. Wind shear tends to destroy up and down draughts. The implication is that it requires a strong up draught, such as in a severe storm to overcome this restriction. On the other hand, wind shear fosters updraught rotation and storm intensification. The wind speeds shown on the next page indicate the wind speed steadily increased to around 40-50 knots at a suitable height above ground level to foster updraught rotation and storm intensification (de Villiers 1996, de Villiers 2010).

The TAF issued at 0900Z Johannesburg International Airport (5558ft, 1694m MSL) was:

FAJS 220900Z 221221 36010KT 9999 FEW035CB SCT040 SCT090 PROB30 TEMPO 1316 5000 -TSRA BECMG 1719 CAVOK T15/18Z=

Thunderstorms were forecast in the significant weather map valid at 1500Z with forecast upper wind and temperature charts.

The SACAA Accident Report, Executive Summary J10/2/7070 A99-8079 stated that the aircraft was inbound at FL350 to HBV (Hartebeespoortdam VOR) beacon and 90 nm from JSV (Johannesburg VOR-DME) beacon when it started its descent for a downwind lefthand approach to Johannesburg's runway 03. VOR means very high frequency omnidirectional range. DME means distance measuring equipment. The aircraft weather radar indicated two small thunderstorm cells in the vicinity of HBV. The pilot reduced the IAS (indicated air speed) to 250kt and maneuvered the aircraft to the east of track to avoid these cells when he experienced light turbulence while the aircraft passed abeam the cells. Approximately 10nm after passing the cells, the pilot experienced a severe updrauft with the aircraft climbing between 1500 to 2000 feet/min at FL200 an IAS of 230kt. During the updraught however, the pilot encountered severe turbulence followed by very large hailstones for approximately 30 seconds. The aircraft then flew into VMC conditions after approximately one minute. According to the pilot, the radar showed no returns to indicate any hail. The aircraft landed safely at Johannesburg International Airport. No injuries were sustained to the crew or passengers. The aircraft was damaged beyond economical repair due to hail damage It was written off by the insurers.

It is known that large hail can be carried aloft, spewed out of the anvil top and downwind some distance, to fall clear of the thunderstorm cell. For this reason, the threat of hail greater downwind of the CB cloud than upwind. In this instance downwind would be ESE of the cell, the reciprocal of the winds in the table above where the aircraft was flying south to the east of the storm at about 10 nm. It is also known that strong turbulence can be encountered some distance from the thunderstorm cell. A general rule of thumb is to avoid a storm by 1 nm for every 2 000ft of vertical development. Given the expected development to 37000ft MSL minus ground ±5000ft above MSL, this suggests, in this instance, avoiding the cells by 16nm (preferably 20nm distant). At 10nm the aircraft was well within this limit.

## ICING

### Icing over the Western Cape 1996-10-12

A complaint was received, via the SACAA, from a pilot who said he encountered unexpected icing over the Western Cape, at FL100 between 1400Z to 1700Z on the 12th September 1996. Investigation of the forecasts revealed that icing was forecast.

The presence of cloudy conditions in the area was confirmed by the 1200Z synoptic weather chart that indicated an extensive post cold front cloud and a strong westerly wind. Broken low and middle level clouds were observed. Rain in the west became more extensive by 1800Z and had spread to Port Elizabeth along the coast and well inland to Beaufort West;

Inspection of the low and medium level significant weather charts issued by the Central Forecast Office at 1400Z and 1700Z indicated extensive low and middle level cloud was forecast for the area with the presence of thunderstorm clouds.

Broken (4-7 oktas) cloud was given between FL045-FL080 at 1400Z but FL040-FL080 at 1700Z. Broken middle layer cloud was forecast between FL100-FL210 at 1400Z and FL100-FL250 at 1700Z. CB cloud was indicated at a base of FL080 with tops extending beyond the top of the medium layer chart at FL250.

Moderate icing was indicated on both of the low level significant weather charts and on both of the high level charts at 1400Z and 1700Z. The forecast presence of CB cloud and CB symbol also implied the presence of moderate or severe icing, as explained in the legend at the right of the chart. Icing could therefore be expected where there was cloud higher than the freezing level. The freezing level fell to as low as FL085 at 1400Z at Cape Town and FL090 over the western part of the northern Cape. At 1700Z it was given down to FL065 at Cape Town and FL070 over the western part of the Northern Cape.

Text area forecasts (SAFORS) issued by the Cape Town office at 1000Z and 1300Z, available at all of the regional aviation forecast offices, also included icing in cloud above FL085 and the presence of thunderstorms.

It was not understood why the pilot complained of unexpected icing conditions, because it was forecast. Perhaps he did not obtain, or have access to, en route weather prior to the flight, or did not understand the charts. All forecast folders issued by forecast offices carried a symbol and definition sheet. If the forecast was a verbal one, possibly issued over the telephone, the forecasters at the various forecast offices would have mentioned icing, because the Cape Town office included it in their SAFORS and significant weather charts.

From the aviation forecaster's point of view, it is worth remembering that aircraft ice accretion must always be expected when flight takes place through cloud, or rain at temperatures below 0°C.

## CLEAR AIR TURBULENCE

### Aircraft turbulence encounter north-east of Durban 1999-05-09

A SAA flight SA192, from Durban to Mauritius on Sunday 9th May 1999 with a scheduled departure time from Durban of 0750Z encountered en-route turbulence (de Villiers 1999). If memory serves me correctly, it was a B747SP, or less likely a B747-200. The flight was at cruise altitude of FL290 (±29000ft) when passengers and cabin crew were injured. It is not known at what point along the flight path the turbulence was encountered. Nor is it known whether the passengers were forewarned, by methods such as a cabin announcement and seatbelt warning lights.

This weather conditions forecast for the route were investigated, the weather as presented by the Eta Numerical Weather Prediction (NWP) model analysed and provides the categories of clear air turbulence (CAT). Presented here courtesy of the SAWB.

Flight documentation issued by the Weather Office at Johannesburg International Airport, included the official significant weather chart for the route, issued by the World Area Forecast Centre, London. It indicated moderate CAT could be expected on the route from north of Durban to approximately just over halfway between Durban and the southern tip of Madagascar. The associated CAT symbol in the key box indicated that moderate CAT was expected between FL330 and FL440. A jet stream was indicated at FL390 with a core of 110kt, decreasing to 90kt further to the east.

The Eta Numerical Weather Prediction (NWP) model runs, at 0000Z and 1200Z on the 9$^{th}$ May 1999 were used to analyse the weather around the time of the incident. The 0000Z initialised run was used to obtain 0600Z prognostic information and the 1200Z run was used to obtain 1200Z analysis data. Wind speeds around 40kt at 400hPa (±FL235) were indicated, increasing to around 50kt at 300hPa (±FL300). The jet stream core exceeded 80kt at about 200hPa (±FL400). It was located between 35°E to 45°E at 200hPa.

Of particular interest is the area of marked vertical wind shear. According to the model, a core of 40kt difference for the 6500ft layer, between FL235 and FL300, existed at 0600Z over Swaziland decreasing to 25kt while displaced to east of the flight track at 1200Z. At the time of crossing the flight path the vertical wind shear was somewhere between 40kt and 25kt, probably nearer to 30kt. The portion of the flight path affected would have been 35°E to 40°E.

A vertical wind shear of 40kt in a 6500 feet layer equates to 6.1kt/1000ft, while 30kt equals 4.6kt/1000ft and 25kt is equal to 3.8kt/1000ft. Therefore, it can be assumed that the vertical shear was somewhere between 6-4kt/1000ft. That is, moderate in the table below.

In a study of clear air turbulence (CAT) over South Africa (de Villiers 1998), it was found that vertical wind shear >4kt/1000ft produced moderate CAT, while vertical wind shear >8kt/1000ft produced severe CAT. This is shown in table below.

Summary of ETI (Ellrod Turbulence Index), wind shear, stability conditions and CAT severity.

| CAT | MODERATE | SEVERE |
|---|---|---|
| ETI | >4 | >8 |
| Vertical wind shear | >4 kt/1000 ft | >8 kt/1000 ft |
| Horizontal wind shear | >20 kt/° latitude | >30 kt/° latitude |
| Vertical stability | >+1.5°K/1000 ft | >+4.5°K/1000 ft |

The criteria of >4kt/1000ft for moderate CAT and >8kt/1000ft is not a hard and fast rule, because during the study, reports of severe CAT were received from pilots when the vertical wind shear was lower than 8kt/1000ft. It must also be borne in mind that the human factor introduces a certain degree of subjectivity to the results. As a matter of interest, the United Kingdom Meteorological office uses a limit of >6kt/1000ft for moderate CAT and >9 kt/1000ft for severe CAT (Starr 1996).
From the wind charts it was noted that horizontal wind shear at FL300 (±300hPa) was much

less than 20kt/°latitude at 0600Z, but at 1200Z it was about 20kt/°latitude between 29°S and 30°S from 35°E to 40°E. In the moderate category according to the table above.

The model data was also tested for vertical stability using vertical temperature cross sections. The stability changed from +1.1°K/1000ft at 35°E to +1.5°K/1000ft at 45°E. That is, vertical stability was low to moderate in the table above.

The United States of America Department of Commerce National Committee for Clear Air Turbulence (December 1966 report) and the UKMO Handbook of Aviation Meteorology (1994), divide CAT into three categories; light, moderate and severe (with a sub-division of extremely severe CAT). Note, the gust velocities mentioned below are vertical gust velocities obtained from the Vertical Speed indicator (VSI) on the aircraft instrument panel.

Light: 2.6 - 8 m/s (5-15 knot) aircraft airspeed fluctuations occur with gust velocities in the order of 1.5 - 6 m/s (5-20 feet/second). Passengers may be required to use seat belts but loose objects within the aircraft remain at rest.
Moderate: 8 - 13 m/s (15-25 knot) airspeed fluctuations occur with 6 - 11 m/s (20-35 feet/second) gust velocities. Passengers require seat belts and are occasionally thrown against the seat belt. Loose objects in the aircraft move about. Frequent rolling of the aircraft occurs and there is difficulty in walking about in the aircraft.
Severe: Air speed fluctuations are greater than 13 m/s (25 knots) occur with 11 - 30 m/s (35 - 50 feet/second) gust velocities. The aircraft may be momentarily out of control and it is difficult to maintain flight altitude. Passengers are thrown violently against the seat belt and back into the seat and loose objects are tossed about.
Extremely severe: A sub-division of severe CAT, which fortunately rarely occurs. The criteria are: rapid air speed fluctuations in excess of 13 m/s (25 knots) occur with gust velocities greater than 30 m/s (50 feet/second): the aircraft is violently tossed about and is almost impossible to control. Structural damage is likely,

The forecast significant weather chart correctly indicated that CAT could be expected along the route flown by the aircraft, although the lower forecast level (FL330) of the turbulence at about 4000ft above the FL290 level where it was encountered by flight SA192.

The forecast level of the jet stream was close to that analysed by the Eta model. The forecast core of the jet stream was FL390. Model cross section fields indicated that the core was at 200hPa which corresponds to about FL400. The speed and direction of the jet stream was accurately forecast.

Eta NWP products indicated that there was a region of increased vertical wind shear, between FL235 and FL300, and significant horizontal wind shear at FL300 that crossed the flight path between 35°E to 40°E. Although the levels of vertical wind shear and horizontal wind shear indicated moderate CAT, it is not unlikely that the intensity could have been greater.

The fact that passengers and crew were injured indicates that the intensity of CAT was possibly more than moderate and the intensity was more in accord with the severe criteria. However, if the persons on board were caught unawares by the turbulence and were not strapped in, injuries could have been sustained in moderately turbulent conditions.

In view of the above it is believed that the aircraft encountered moderate to severe CAT between about 35°E to 40°E, which resulted in injury to passengers and cabin crew.

**MOUNTAIN WAVE TURBULENCE**

**Lear Jet descent to Cape Town 1996-06-07**

A Lear Jet V.I.P. flight was on a radar vectored descent to Cape Town from FL100 to FL080, at about 1500Z on the 7th June 1996, when it suddenly dropped about 5000-6000ft. Recovery was made at about 2500ft MSL. This was well below the minimum safe altitude of 8000ft for the area. Fortunately, the aircraft made its uncontrolled descent into a valley and landed safely at Cape Town International Airport.

The SACAA approached the Weather Bureau for a report on the weather. The pilot believed turbulence was the cause and that it was not forecast. The pilot stated that the aircraft went into a dive of its own accord. However, it is also possible the auto-pilot reacted to the sudden turbulence and disconnected, which led to the pilot taking control and over-reacting. This is not an unheard of occurrence.

Inspection of the prevailing upper air conditions indicated that the situation was ripe for mountain wave turbulence. Comparing the Port Elizabeth (FAPE) and Cape Town (FACT) afternoon soundings, it was seen that stable prefrontal conditions existed east of FACT, with a strong north-westerly wind which increased with height and almost perpendicular to the mountains in the region. FACT still had pre cold front associated upper air trough strong north-westerly winds aloft, while the surface cold front was over the station, with the freezing level having fallen to about 8000 feet. This was confirmed by the upper air sounding at 1200Z on the 7th.

As early as 1100Z mountain wave turbulence was forecast on the FL100 to FL250 medium level significant weather forecast chart to the east over the FAPE FAEL FIR's (Flight Information Region) with moderate clear air turbulence (CAT) above FL250 over the FACT FIR. At 1400Z mountain wave turbulence with middle layer cloud was forecast over the FACT FIR in the medium layer with high level CAT. The mountain wave turbulence was maintained at 1700Z, but the high level CAT was moved to the FAPE FIR. The forecast winds valid at 1200Z and 1800Z were in close accord with the observed data at 1200Z.

The conclusion is that whatever the cause of the aircraft upset, the turbulence was clearly anticipated and communicated to pilots in the significant weather charts, although initially it was not forecast far enough to the west, and seems to have been given too far to the east. However, there is reason for the pilot to be justified that the turbulence was not forecast in the specific area where it was encountered. Considering the incident occurred at 1500Z with the flight beginning at or before 1400Z, the prior briefing and filing the flight plan, the 1400Z significant weather chart with the amended mountain wave forecast in the Cape Town area would not have been available.

Mountain wave turbulence does not occur with every cold front that approaches the Western

Cape. However, the aviation forecaster must be alert to the situation and expect mountain wave turbulence in stable pre-frontal north-westerly winds at the Western Cape, especially if the winds are strong. The same must be borne in mind as the synoptic system moves eastward over the mountains of the eastern Cape and further east over the Drakensberg.

**KwaZulu-Natal 1976-12-04**

An interesting weather encounter occurred on the 4th December 1976. I was flying as instructor with a student on a cross country training flight from Durban's Virginia Airport to Melmoth, Riverview, Empangeni returning to Durban when we encountered mountain wave turbulence (de Villiers, 1977). As already alluded to, mountain waves are up and down draughts that develop in stable air in the lee of mountains.

Other than the temperature being unusually high at 18°C at FL075, the flight was normal until turning onto the Melmoth to Riverview leg, about 120nm downwind from the Drakensberg Mountains, we encountered updraughts and downdraughts averaging about 1000 ft/min on the VSI with 4 waves occurring in about a 7 minutes.

The single engine, two seat, Cessna 150 could not cope. In the updraughts we would go up at about 1500 feet per minute with the stick well forward and power off in order to try and stay at our assigned flight level. In the downdraughts it was the opposite. Power on and stick as far back as safely possible just short of the stall speed. We had to call the tower to warn them of our situation and that it would be best for other traffic to keep away.

We turned headed directly downwind to Empangeni near the coast. Where we intended to do a touch and go (landing and take off). However, arriving at Empangeni airport the windsock indicated a north-westerly wind estimated at about 30-35kt, that is 90° to the runway. Definitely above the cross-wind capability of the aircraft. We therefore returned to Durban.

Back on the ground, using our true air speed, true heading and true course adjusted for 10° drift and calculated ground speed with the waves on average 1 minute 45 seconds apart, it was roughly determined that the waves were 4nm apart while the wind was 323°/30kt.

Subsequent inspection of upper air wind and temperature data from a midday instrumented balloon atmospheric sounding, it was determined that we also encountered Berg wind conditions, known elsewhere in the world as a Foehn wind. It is dry and warm wind that occurs in the lee, or downward side of a mountain range. The mountain waves that we experienced were not directly due to the Drakensberg Mountains, but due to an escarpment ridge of higher ground nearer to us to the north of Melmoth along an axis of about 210° south-west to 030° north-north-east.

The atmospheric sounding at Bloemfontein, upwind of the Drakensberg Mountains with is axis also about 210°/030°, did indicate the correct conditions for mountain waves at a much higher altitude in the lee of these mountains. The WMO 1958 criteria being:

1. Marked stability in the lower layers with comparatively low stability aloft
2. Wind speeds at the level of the summit exceeding a minimum which varies from about 8-13

m/sec (16-26 kt) depending upon the ridge generating the waves and either increasing or at least remaining constant with height up to the tropopause.
3. Wind direction from within 30° of the direction normal to the ridge and not changing substantially with height.

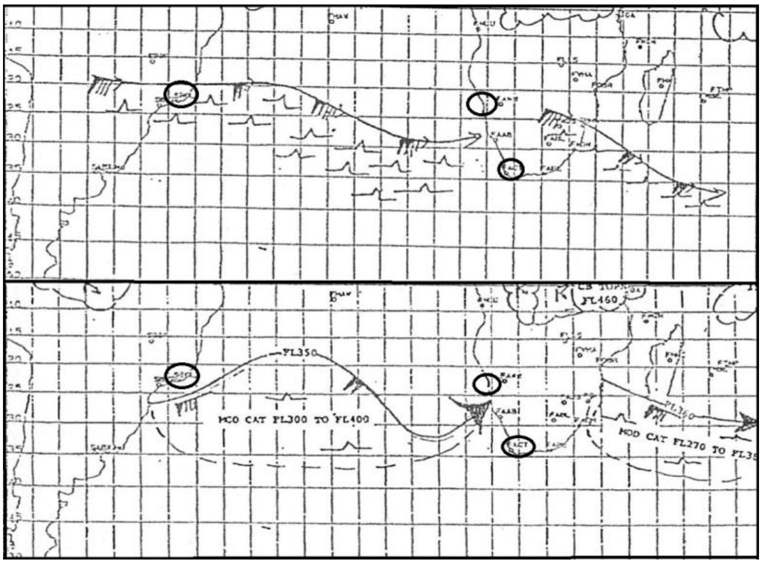
## UPPER WIND

### South African Air Force V.I.P. Falcon 900 flight 1993-08-22

On 22nd August 1993 a SAAF V.I.P. Falcon 900B, registered ZS-NAN, flew from SAAF Air Force Base (AFB) Rooikop (FYWB) at Walvis Bay, Namibia to Rio de Janeiro (SBGL), Brazil. The flight originated at Pretoria. On board was the State President and entourage. The aircraft landed at Rio de Janeiro too long after the flight plan time for comfort. It was feared the aircraft could have ended up in the ocean. An enquiry was instigated. It was subsequently learnt that the flight was delayed at AFB Rooikop and departed considerably later than the flight plan time. The whole incident was therefore a false alarm. Nevertheless, the research was an instructive exercise.

Two sets of forecasts were issued by Johannesburg International Airport Weather Office. One valid at 1200Z on the 22nd, the other one at 0000Z on the 23rd. Each forecast comprised a set of relevant TAFs (including diversion airports), significant en route weather and wind velocity/ temperature charts at FL390, FL350 and FL180. The winds and temperatures were obtained from the Bracknell (EGRR) numerical model.

The significant weather chart above FL240, valid at 22/1200Z indicted a not particularly strong jet stream that coincided closely with a great circle route from Rooikop to Rio de Janeiro with an area of 115kt maximum wind at 1200Z. Because it was winter in the Southern Hemisphere, the jet stream was further north that it would be in the rest of the seasonal year, possibly its f urthest north. Then, at 23/0000Z, the chart showed the jet stream passing through the great circle route from south to n orth of the route and back to the south of it again later with a maximum wind of 100kt. These maxima were similar to those found on the two FL340 charts. The altitude of the jet stream core was not indicated on the 22/1200Z chart, nor were the lower and upper boundaries of associated moderate CAT. Although, the core was shown at




Portions of the significant weather charts valid at 22/1200Z and 23/0000Z on the 22nd August 1993 with the airports ringed.

FL350 in the 23/0000Z chart with moderate turbulence between FL300 and FL400. Overall, it was seen that the forecast FL390 winds were not quite as strong as at FL340. Comparing the two significant weather charts with the two wind forecasts at FL340, it appears the jet stream strength was slightly under forecast. The jet stream, imbedded in a weak trough at about 30°W at 22/1200Z was expected to move to 20°W at 23/0000Z with the trough becoming more noticeable. That is, winds veer more to the north-west ahead of the trough while backing more to the south-west following the trough.

European Centre for Medium term Weather Forecasting (ECMWF) model analysis of the 1200Z winds at 200hPa (±FL390) was available. Comparison of the ECMWF 22/1200Z analysis chart at FL390 with the forecast FL390 winds on the 22/1200Z chart based on the 21/1200Z model run, was found to be very closely similar along the route. In other words, the forecast winds would appear to be very accurate. In view of this it was assumed that the winds at FL350 were probably also accurate, but could not be conclusively proven with the available data.

The FL340 wind forecast, valid 23/0000 UTC, in the second forecast issued by Johannesburg International Airport Weather Office maintained similar winds along the estimated aircraft track, albeit with a slight shift of the wind pattern to the east.

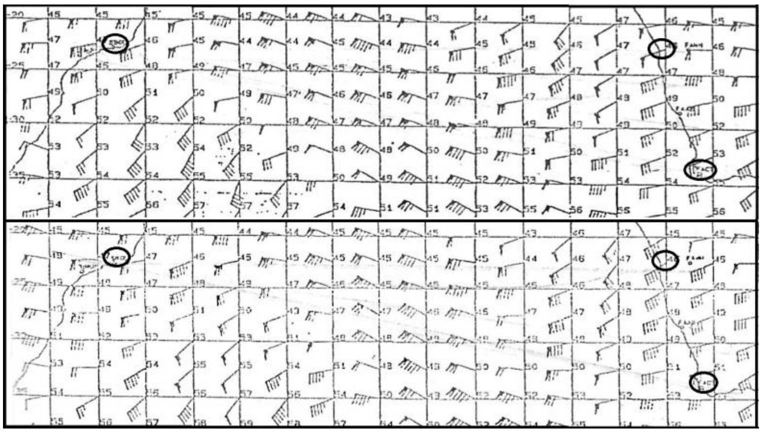
The Bracknell analysis of the wind velocities at 250hPa (~FL350) on the 22nd at 1200Z and 0000Z on the 23rd were available. Unfortunately, the wind velocities and temperatures only extended as far west as 0° longitude. Information further west was unavailable either from the Central Forecast Office or Jan Smuts Weather Office.

For what it is worth, a comparison of the 22/1200Z and 23/0000Z Bracknell wind analysis at 250hPa (±FL340) with forecast winds at FL340 at the same times along the routes west from Rooikop and Cape Town, revealed mostly good similarity, ranging from +5kt to -5kt. All told there were 6 observation points between Rooikop and 0° at 22/1200 and 23/0000Z and 8 between 0° and Cape Town. Although there were four locations where the analysis wind was 15kt to 35kt lower than the forecasts.

Considering the forecasts issued and the limited means of evaluation, the forecasts appear to have been accurate. Where there were discrepancies, the forecasts seem to have erred slightly on the side of safety. That is, the forecast head winds tended to be slightly stronger than indicated by the various analysis fields.

Calculation of the aircraft's ground speed were made to determine the duration of the flight. The aim being to determine if it exceeded its endurance in the air. It must be borne in mind that not having access to the aircraft's manual, limited data were available regarding the aircraft's specifications. Two sources gave the optimum cruise level FL360 and a range of 4000nm with 2 crew and 8 passengers. The cruise speed being 513kt or Mach 0.85 at 36000ft (±FL360, 11000m (Finlay 2022 and Wikipedia (b)). That is, 4000nm at 513kt = 7 hours 48 minutes flight time. Air Charter Advisors (2025) gave the range 4598nm with two crew and 7 passengers (one less). The same cruise speed 513kt, at Mach 0.87. Maximum speed is are stated as between Mach 0.84 to 0.87. The flight level is not specified. 4598nm at 513kt = 8 hours 58 minutes flight time. Perhaps this is a newer model with improved performance. All three indicated a service ceiling 50900ft (~15500 m)

Calculation of the great circle route were complicated by the use of Mercator Projection charts where lines of latitude are of equal length, irrespective of latitude south from the equator. Aircraft follow great circle routes. Contrary to popular belief, the shortest distance between two points is not a straight line. The shortest distance is a great circle. A great circle is any circle drawn on the earth (or a globe) with its centre at the centre of the earth so that its circumference divides the earth into two equal halves. Lines of longitude are great circles, lines of latitude are not, except the equator.



Portions of the wind velocity forecasts at FL340 22/1200Z above and 23/0000Z below. Airports ringed.

Routes investigated were one from Rooikop Airport (FYWB) to Rio de Janeiro (SBGL) and one, the longer route for comparison, from Cape Town (FACT) to Rio de Janeiro (SBGL). Four online sources were accessed to obtain the great circle distances. The Airport Distance Calculator, which required entering two airport names, produced 3178nm from Rooikop and 3285nm from Cape Town. The Omni Calculator, which allowed one to enter degrees, minutes and seconds airport location, and using official airport locations, produced 3180nm from Rooikop and 3287nm from Cape Town. The positions being: FYWB 22°58′45′′S, 14°38′43′′E; FACT 33°58′17′′S, 18°36′16′′E; SBGL 22°48′36′′S, 43°15′02′′W. The Great circle Mapper, which uses IATA airport codes, produced 3185nm from Rooikop and 3273nm from Cape Town. The National Oceanic and Atmospheric Administration National Hurricane centre, (NOAA NHC) using decimal locations, produced 3178nm from Rooikop and 3287nm from Cape Town.

The Omni Calculator results, namely 3180nm from Rooikop and 3287nm from Cape Town, were used, because the most accurate official locations could be used, although the NOAA NHC calculator was practically the same. Airport elevation difference as a factor was ignored both being at low altitude. Rooikop being 299ft (91m) above MSL and Cape Town 151ft (46m) and Rio de Janeiro at 28ft (9m).

Two tracks, one from Rooikop to Rio de Janeiro and one from Cape Town, were used calculate the mean wind velocity using spot winds every 5° on the 22/1200Z and 23/0000Z FL340 wind velocity forecasts nearest to the aircraft's FL360 cruise level mentioned earlier. As an afterthought, the mean wind velocity was also determined from Rooikop to Rio de Janeiro at FL390 at 22/1200Z and 23/0000Z. It is immediately apparent that the aircraft was flying into a westerly wind for the entire journey and the area of strongest wind.
Ground speed (GS) was then calculated using the aircraft velocity (the estimated mean direction and 513kt airspeed) and the mean wind velocity. Factors affecting airspeed were

ignored, being regarded as an unnecessary complication. Airspeed depends on altitude, atmospheric conditions (such as air temperature and density and wind), the aircraft's weight and configuration. Less resistance in less dense air at higher altitude allows an aircraft to fly faster. However, it also means less lift, so speed must be increased. Warmer air, that is higher temperature means less dense air than colder air which influences lift and drag, necessitating an increase in airspeed. A heavier aircraft requires more lift. Therefore, higher speed to increase lift on the wings to maintain height.

The IAS is the speed of the aircraft moving through the air seen on the aircraft's airspeed indicator, which requires corrections for altitude and temperature. The stall speed is the minimum speed an aircraft can be flown to maintain sufficient lift. Another important speed is the Vne (never exceed velocity). For faster and higher flying aircraft this is expressed as a critical Mack Number. The Mack Number "refers to the speed at which an aircraft is travelling in relation to the speed of sound" (Kermode 1972). The speed of sound varies according to the temperature of the air. Therefore, the speed of sound is the speed that corresponds to the temperature of the air. The lower the temperature (such as at high altitude), the lower the speed of sound. Density (measured as pressure) also plays a role. The lower the density (such as at high altitude), lower the speed of sound. However, temperature is the overriding critical factor.

From Rooikop to Rio de Janeiro, on a mean track of 270°, the aircraft was in the core of jet stream for most of the flight. Winds of 90-115kt from 270°-290° were experienced from 15°W to 35°W at 1200Z and 10°W to 35°W at 0000Z. The mean velocities and mean ground speeds being respectively 270/87kt, 426kt and 267/86kt, 427kt. At FL390 at 1200Z and 0000Z, the mean wind velocities and ground speeds were respectively 272/79kt, 434kt and 270/85kt, 428kt.

By way of comparison, the Cape Town to Rio de Janeiro route, although ±107nm longer generally fared better, because being from a more southerly starting point missed most of the jet stream. On a mean track of 282°, the mean wind velocities and ground speeds were 272/75kt, 439kt at 1200Z and 273/72k, 442kt at 0000Z. Maximum winds of 90-110kt being experienced at only 0° to 10°W and 95kt at 30°W at 1200Z while at 0000Z 100kt at 10°W and 90kt at 35°W.

| Time | ° Heading | Wind kt | GS kt | Distance nm | Flight time |
|---|---|---|---|---|---|
| FL340 Rooikop to Rio de Janeiro | | | | | |
| 22/1200Z | ~272 | 270/87 | 426 | 3180 | 7 hours 28 minutes |
| 23/0000Z | ~272 | 267/86 | 427 | 3180 | 7 hours 27 minutes |
| FL340 Cape Town to Rio de Janeiro | | | | | |
| 22/1200Z | ~282 | 272/75 | 439 | 3287 | 7 hours 29 minutes |
| 23/0000Z | ~282 | 273/72 | 442 | 3287 | 7 hours 26 minutes |
| FL390 Rooikop to Rio de Janeiro | | | | | |
| 22/1200Z | ~272 | 272/79 | 434 | 3180 | 7 hours 20 minutes |
| 23/0000Z | ~272 | 270/85 | 428 | 3180 | 7 hours 26 minutes |

In view of the 7 hours 48 minutes endurance over 4000nm at 513kt, mentioned previously, there was not much of a margin for error in view of the 7 hours 34 minutes and 7 hours 27 minutes from Rooikop to Rio de Janeiro. Without more data from the aircraft manual, it is not known if this 4000nm range includes the aircraft carrying mandatory reserve fuel. This is that is required to fly to an alternate airport and 30 minutes at holding speed at 1500ft AGL at alternate airport. In which case there is more flexibility. It is certainly within safe limits if 4598nm range at 513kt at 8 hours 58 minutes with 7 passengers applies, but more information is needed as to how this was calculated. The main concern is that the aircraft arrived safely.

## MISCELLANEOUS: NOT WEATHER RELATED

### South African Airways Flight 406 1967-04-13

13th March 1967, a SAA Viscount 818, registration ZS-CVA, named Rietbok, departed from the then named Jan Smuts International Airport (Johannesburg, FAJS) in the early afternoon bound for Bloemfontein, East London then Port Elizabeth.

It had been a busy afternoon for the crew. The aircraft and crew departed from Johannesburg then immediately returned, because the nosewheel undercarriage would not retract. The fault was soon rectified, the flight arrived at East London in poor weather at 1550Z (1750B). On take-off there was a bird strike. The aircraft continued the short flight to Port Elizabeth where it was determined the aircraft was airworthy.

The author's stock photograph of a SAA Vickers Viscount 813 at Johannesburg.

The return flight, SA406, to Johannesburg was the reciprocal of outbound with the same crew. Due to the known poor weather at East London, extra 2000lb (907kg) of fuel for the sector was loaded with the intention continuing to Bloemfontein in the event of not being able to land at East London then on to Johannesburg. Passengers were made aware of the possibility with East London the two East London bound passengers given the option of taking a later flight. One decided to stay in Port Elizabeth, one to stay with the flight even though the captain said there was only a 10% chance of landing ("Rietbok" air accident report 1967).

Port Elizabeth to East London flight 406 departed at 1658Z (1858B) flying at FL090 for the short hop. "There was no tape recorder at East London, but the RT transmissions from the aircraft to East London were received at Port Elizabeth and, except for the last message, were recorded on the tape there" ("Rietbok" air accident report 1967). East London ATC informed them the weather at the airport was continuous drizzle, visibility 1200m, cloud 8/8ths nimbostratus at 200-300ft, QNH 1025hPa. Descent clearance was requested from East London ATC. This was granted with the request to call passing through 4500ft. The pilot reported passing 4000ft about 20nm (37km) from East London at 1706Z (1906B).

"According to the Tower Controller at East London the aircraft was advised after reporting that it would attempt an approach to runway 10, that "runway 10 is out for landing" because of 1ow cloud, but that the VASI lights on runway 10 and on runway 28 had been turned full on. He added that this was acknowledged by the aircraft, but this is not recorded on the tape at Port Elizabeth ("Rietbok" air accident report 1967). VASI is a Visual Approach Slope Indicator. The modern equivalent is PAPI (Precision Approach Path Indicator). Navigation aids available were NDB (Non-Directional Beacon), VOR (Very high frequency Omnidirectional Range beacon), DME (Distance Measuring Equipment coupled with the VOR) and VDF (Very high frequency Direction Finder). The VOR and VDF were not operating. NDB and DME were serviceable ("Rietbok" air accident report 1967).

The last report from the pilot was the coast in sight on the approach at 2000ft at approximately 1709Z (1909B). "This reference to 2,000 feet with the coastline in sight (but not the reference to seaward) was heard by the ATC at Port Elizabeth, but was too faint to be recorded on the Port Elizabeth tape" ("Rietbok" air accident report 1967). Nothing was heard thereafter.

"The aircraft probably crashed, according to the best estimates available to the Board, at 1710.08 GMT. Eye-witnesses on land, who observed the aircraft's anti-collision beacon from distances of approximately 1½ to 2½ miles, describe it as having been visible for some seconds. It was fairly low, out to sea, moving approximately parallel with the coastline towards East London, and flying approximately straight and descending. The inference from an examination of these portions of the wreckage which have been recovered is that it probably struck the water in a nose down attitude with the port wing low. Two of the three eyewitnesses heard the noise of the engines (the third witness was elderly and deaf), and all three heard the report of the aircraft hitting the water" and "that it struck the sea at a fairly high speed" ("Rietbok" air accident report 1967).

The aircraft had crashed into the sea about 1.3nm offshore at "approximately 33°13.45'S 27°38.3'E, at 1710.08 GMT. At this time darkness had already fallen" ("Rietbok" air accident report. 1967). The location being about 15-20nm (28-37km) south-west of the airport. All 20 passengers and 5 crew were killed. Very little wreckage was found. Wreckage consisted of parts of the bulkhead, and interior cabin panelling, portable galley equipment, seats, windows, cushions and a hydraulic accumulator from the nose-wheel compartment. One piece washed ashore over 260nm away ("Rietbok" air accident report1967).

At the time the aircraft type was still regularly seen in Durban, although they were being relegated to thinner routes, being replaced on the higher passenger load routes by the Boeing 727 that was introduced from 1965.

The cause of the accident was not determined. "When the accident occurred, the aircraft was not yet in the approach phase and should not have been below an altitude of 2,000 feet. How then did it come to be at sea level?" and the "cessation of communication from the aircraft, after reporting that it was at 2,000 feet, is significant" ("Rietbok" air accident report 1967). The official investigation board was of the opinion that certain possibilities could be regarded as remote or improbable. Such as, failure of the controls, or control surfaces, multiple engine failure, instrument failure, explosion, fire, turbulence, poor visibility in bad weather and darkness, altimeter error or misreading, disorientation, too low altitude in the pre-approach phase, collision with an object, such as a bird, sabotage and incapacitation.

It was speculated that the captain, the pilot flying, suffered a heart attack and the first officer was unable to take control of the aircraft in time ("Rietbok" air accident report 1967). Later it was suggested/rumoured that the cause was a wing spar failure, based on a Viscount that crashed on land crash in Australia where a failed wing spar was the cause of in-flight disintegration

**South African Airways Flight 228 1968-03-20**

20th April 1968, SAA flight SA228, B707-344C, registration ZS-EUW, named Pretoria, from Jan Smuts International Airport (FAJS) arrived at Windhoek's J. G. Strijdom Airport in South West Africa (now Namibia). Its route was then to Luanda (Angola), Las Palmas (Canary Islands), Frankfurt am Main (West Germany, now part of unified Germany) and London (England).

During the late 1960's, political relations between South Africa and Africa deteriorated due to the South Africa's Apartheid policy. The result was the refusal of overflight rights over African countries to Europe and SAA had to fly via the bulge, that is, seaward around the western bulge of Africa and take about 3 hours longer to get to Europe. They had to refuel at Las Palmas (Canary Islands, Spain). Due to political pressure this was later changed to Ilha do Sal (Cape Verde, a Portuguese possession).

The author's stock photograph of a SAA B707-344A (ZS-SAG) at Johannesburg 1969 or 1970.

The six weeks old aircraft was the first of the C models ordered by SAA. The C meant it could be converted for passenger or freight. It had a strengthened floor and the addition of a forward cargo door.

The following is a brief summary of the 108 page final report of the board of inquiry appointed by the South African Minister of Transport (Final report Boeing 707 ZS-EUW 1968).

The aircraft took off from runway 08 at 1849Z (2049B) with no wind into a dark, moonless and clear night sky over desert with few, if any, ground lights and an indistinct horizon. The aircraft climbed to an altitude of 650ft (198m) AGL, then levelled and began to descend. About 30 seconds after levelling and fifty seconds after take-off, at about 270kt, it flew into the ground about 5327m from the eastern end of runway 08, ±100ft (30m) below the point of lift-off. In total descending approximately 750ft and estimated at as much as 2000ft/second. The last communication by the flight crew was acknowledgement of ATC's permission to take-off. Of the 128 occupants, 5 passengers survived, none of the 12 crew survived. Wreckage and bodies were strewn over about 1400m by 200m wide.

The investigation was hampered because the aircraft had no flight data recorder or cockpit voice recorder. Resulting in some approximations, such as heights and timings. Although mandatory from 1st January 1968, the airline still did not have enough recorders to install in all aircraft. The official investigation concluded that there was no defect in the aircraft or the engines and instruments.

The undercarriage was retracted after take-off and flaps fully retracted approaching 650ft on a heading of 080° magnetic. It is suggested that the 707B series flap retraction sequence was used. This reduced the flaps in larger increments, leading to loss of lift, lack of climb and beginning descent. The pilot believing the aircraft was still climbing trimmed the elevator to maintain the aircraft at the present pitch attitude, apparently believing this was an attitude of climb, but it was a descent attitude. The pilot flying and co-pilot failed to monitor the flight instruments, specifically the pitch attitude and VSIs. Temporary confusion was probably caused by the instrument panel layout in the C model compared with the A and B models with which both pilots were accustomed. Pre-occupation with after-take-off checks is a possible factor. Added to the problem is probable spatial awareness due to take-off into total darkness with no external visual reference. In other words, failed to concentrate on the instruments and maintain a positive rate of climb by increasing pitch and power. Something that was impressed upon me when I began flying, particularly when on instruments in poor weather and night flying, which I in turn impressed upon students when an instructor. Pitch and power being paramount and instruments scan.

The conclusion was that the "effective cause of the accident was the human factor" (Final report Boeing 707 ZS-EUW 1968).

Flaps must not be retracted until acceleration altitude is reached, that is the altitude when the airspeed is sufficient so that flaps are no longer needed. These days, for larger aircraft this is at least 1000ft, or as Boeing seems to recommend, 3000ft. Others use take-off power and take-off flaps to 1500ft AGL then climb power and take-off flaps until 3000ft.

**Force landing on the sea 1973-12-28**

Friday the 28th December 1973, while at work as Durban's International Airport, an ATC telephoned to say that an aircraft had force landed in the sea close inshore at Tiger Rocks beach, Isipingo, immediately south of the airport. After obtaining permission from the boss, I picked up my camera and within minutes I was at the site.

When I arrived, the chartered passenger Douglas C-49, registration ZS-DAK, was close inshore in shallow water caught on rocks. The 3 crew and 21 of the 22 passengers had already made it to shore and been taken away when I arrived. One passenger, a woman was never found, believed to have drowned and washed out to sea. I took some photographs of the aircraft stuck on rocks and left. The attached photograph was scanned from a slide photograph taken at the time.

Notice the absence of the passenger door that probably broke loose after opening for passengers to escape.

When turning onto final approach runway 05, number 1, port, engine stopped. Then number 2, starboard failed. Fuel tank selectors were changed. Engines remained starved of fuel. The undercarriage was raised to improve gliding. Unable to glide to the airport, the aircraft was turned to starboard toward the sea and successfully ditched close inshore. The verdict was that the aircraft ran out of fuel.

Sadly, with hindsight, everyone could have been saved because the aircraft floated to become high and dry on the rocks.

The C-49 was one of the US military's designations for a Douglas DC-3, also known as a Dakota in the Royal Air Force and the SAAF.

Built as a model DST-144 for American Airlines on 4 July 1936 as NC16004 and named California. After numerous owners, including the USAAF from 1942-1944 during World War II. It was bought 4 months prior to the forced landing by Executive Funds (Pty) Ltd, Durban in July 1973 as ZS-DAK (The Dakota Association of South Africa).

**Mozambican Tupolev Tu-134 accident 1986-10-19**

Sunday 19$^{th}$ October, a Tupolev Tu-134A-3 operated by the República de Moçambique, flown with a Russian crew was returning from Mbala Airport (FLBA, Zambia) after a meeting of African leaders with the Mozambique president Samora Machel and entourage on board. The aircraft crashed into hilly terrain at 1922Z (2122B) at 25°54´41´´S 31°57´26´´E near Mbuzini, Komatipoort district in South Africa.

The following is a brief summary of the 227 page final report of the board of inquiry appointed by the South African Minister of Transport (Report of the Board of inquiry into the accident to Tupolev 134A-3 aircraft C9-CAA on 19$^{th}$ October 1986. 2$^{nd}$ July 1987).

The history of the flight was established using information from the Digital Flight Data Recorder (DFDR), the Cockpit Voice Recorder (CVR), the Air Traffic Control (ATC) tape, a SAAF radar plot, accident site inspection, as well as verbal and written witness testimonies.

The cockpit crew consisted of pilot, co-pilot, navigator, radio operator and flight engineer with four cabin crew. All aircraft communication was via the radio operator

At 1847Z the radio operator contacted Maputo Information that they were overhead Kurla at FL350. At 1849Z the radio operator acknowledged that no delay was expected for an ILS (Instrument Landing System) approach to runway 23. The 1800Z weather information was passed to the flight crew. namely, surface wind 090/10, visibility greater than 10km, 3 octas cumulus cloud at 1800ft and 6 oktas cirrus at an undetermined height (high level cloud - author), air temperature 23°C, dew point temperature 20°C and airport sea level air pressure QNH 1016hPa.

At 1902Z the radio operator reported they were at top of descent. They were instructed to report runway lights in sight or reaching 3000ft. During the descent the aircraft was turned 37° starboard (to the right). Had the turn been made 8 minutes later "it would have resulted in the interception of radial 045 VMA (VMA is the Maputo VOR – author) for an ILS landing on runway 23 at Maputo airport" (Report of the Tupolev 134A-3 accident 1987).

"At 1918Z the radio operator reported that they were at 3000ft and were cleared for an ILS approach to runway 23. Later, when the aircraft radio operator reported (erroneously) that the ILS was unserviceable, the controller cleared the aircraft for a visual approach to runway 05" (Report of the Tupolev 134A-3 accident 1987).

The aircraft continued to descend in the dark and cloud while attempting visual sighting of the runway lights when it was still "out of range of most of the Maputo navigational aids" and the "radio operator continued communications with the Maputo controller until 1921Z, after which time there was no response to calls from the controller" (Report of the Tupolev 134A-3 accident 1987). At 1921Z (21:21:39B or SAST). The aircraft had crashed.

The wreckage was found about 35nm west of Maputo airport about 150m inside the Republic of South Africa at 2187ft (666.75m) MSL. The minimum safe altitude for the Maputo area is 3600ft with transition altitude 4000ft. (That is, change the altimeter setting from the international standard atmosphere sea level1013.2hPa to the latest local QNH 1017hPa, an error of 120ft - author). Of the 44 persons on board there were 34 fatalities. Ten survived the accident, although one died 2½ months later. The seriously injured flight engineer survived. President Samora Machel died instantly. Everything possible was done to get the injured medically treated at the site and flown by helicopter to the nearest hospital at Nelspruit, a distance of about 65nm (120km). One survivor refused to fly in the helicopter and was taken to Nelspriut by road in an ambulance (Report of the Tupolev 134A-3 accident 1987).

1. While descending toward Maputo and anticipating an ILS approach to runway 23, the crew inadvertently selected the Matsapa (Swaziland, now Eswatini) VOR on 112.3 MHz frequency instead of Maputo (Mozambique) VOR 112.7 MHz. This caused the crew to make a premature 37-degrees course change from 184°M (magnetic) to 221°M. The pilot queried this with his navigator who said the VOR indicates this way and that they were 100km from Maputo (54nm).

2. The navigator also said the ILS and DME were switched off and that the NDBs (non-directional beacons) were not working. Although they were in communication with ATC, they concluded there was no power at the airport, The airport had emergency UPS (Uninterrupted Power Supply) equipment that would have automatically started had there been a power failure.

3. There was confusion and misunderstanding, at times ambiguous, communication between the ATC and flight crew. The flight crew repeatedly said check your navigation equipment, runway lights, etcetera. ATC thought that, in aviation parlance, check meant they had checked and were receiving. ATC gave them clearance for an ILS approach to runway 23.

4. Meanwhile, the flight continued to descend in cloud below 3000ft minimum sector safe altitude while believing they were seaward east of the airport.

5. At an altitude of 796 metres (2611 ft) AGL the GPWS (Ground Proximity Warning System) sounded and remained on, which they ignored. The pilot continued the descent. The TU 134A-3 Flight Manual states that at the sound of the warning, the aircraft must be pulled into the climb with a decisive movement and maintain the climb for 20-30 seconds at full power. Had this been down the accident would have been averted.

6. The navigator said they were now 25km to 30km (13-16nm, 16-19 miles) from the airport. The captain said something was wrong while the co-pilot said the runway was not lit and radioed ATC "check your runway lights", repeated twice. However, it did not occur to them they were not where they thought they were.

7. Cockpit resource management (CRM) was poor with "a certain lack of flight discipline" including failure to adhere to specified procedures such as a lack of callouts and cross-checks. There was no sterile cockpit. The CVR revealed the co-pilot "was listening on the HF (high frequency) radio to a Russian language radio broadcast of music and news." The captain "was engrossed in a discussion regarding previous flights when the fuel had been low" and the allocation of beer and cokes (Coca-Cola – author) to members of the crew. The fuel required had been incorrectly calculated. They had insufficient fuel to an alternate diversion airport (Report of the Tupolev 134A-3 accident 1987).

The Board found that the cause of the accident "was that the flight crew failed to follow procedural requirements for an instrument let-down approach, but continued to descend under visual flight rules in darkness and cloud, i.e., without having visual contact with the ground, below minimum safe altitude and minimum assigned altitude and in addition ignored the GPWS alarm" (Report of the Tupolev 134A-3 accident 1987).

At the time relations between Mozambique and South Africa were strained to put it mildly. There were accusations in newspaper reports it was a plot to kill the presidential and that a false beacon had been used to lead the aircraft astray. The Board was "completely satisfied" that there was no false beacon (Report of the Tupolev 134A-3 accident 1987).

Due to suspicions of South African culpability, the board of enquiry into the accident asked the United States National Transportation Safety Board and the British Air Accidents Investigation Branch to officially participate, however, both were unwilling (Wikipedia (c)). The six member board of inquiry consisted of: Chairman of the Board Mr Justice C S Margo, DSO, DFC, FRAes, of the Suprime Court of South Africa; the Rt Hon Sir Edward Eveleigh, former Lord Justice of Appeal of the UK; Col Frank Borman, former chief test pilot, astronaut, aeronautical engineer and an aeronautical engineer and President and Chief Executive of Eastern Air Lines (USA); Mr Geoffrey Crichton Wilkinson, CBE, AFC, FRAes, former test pilot, aeronautical engineer and Chief Inspector of the Accidents Investigation Branch, Ministry of Transport, of the UK; Mr J J S Germishuys, former South African Commissioner for Civil Aviation of the Republic of South Africa; and Mr P van Hoven, Chairman of the Airlines Association of SA. The report was unanimously endorsed. "Representatives of the USSR and Mozambique did not formally participate in the hearings, but were helpful in submitting further information and documents" (Report of the Tupolev 134A-3 accident 1987). The USSR also played an important part in forensic analysis of the Russian aircraft wreckage components. It was noted that; Mozambique and USSR delegation contested that there was a false signal and that the investigation should be continued to determine the origin of the VOR signal.

2nd February 2006, the South African Minister of Safety and Security, Charles Nqakula announced the accident inquiry would be reopened. It was expected to be concluded in October 2006 (Wikipedia (c)). No further information available. To date nothing appears to have happened.

**South African Airways Flight 295 1987-11-28**

Unless otherwise referenced, this is a summary of the 274 page Report of the Helderberg air disaster.

SAA flight SA295 (or Springbok 295), a Boeing 747-244B Combi, registered ZS-SAS, named Helderberg, was a scheduled flight from Chiang Kai-shek International Airport, Taipei, Taiwan, to Jan Smuts International Airport, Johannesburg, South Africa, with a stopover at Plaisance Airport, Mauritius. The Combi model permits a mix of passengers and cargo on the main deck, separated by a partition, according to load factors on the applicable route and according to Class B cargo compartment regulations. The aircraft was imported new to SAA late in 1980. The aircraft had flown 26743.48 hours during 4877 operation cycles. This flight had 140 passengers, 19 crew (5 flight crew) and six cargo pallets on the rear main deck. The aircraft crashed into the sea east of Mauritius. There were no survivors.

The author's stock photograph circa 1970s of a SAA B747-244B just landed at Durban with dust raised by the braking reverse thrust.

Scheduled departure time at Chiang Kai-shek was 13:00Z 27th November 1987. Departure was delayed until 14:23Z due to adverse weather and late arrival of a connecting flight. The take-off and the flight at FL310, later FL350, was normal with handovers to and communication with the relevant Flight Information Centres (FICs). After Taipei, contact was made with Hong Kong, Bangkok, Kuala Lumpur, Colombo, Cocos Islands and Mauritius. At 15:55:18Z a routine message was sent to the operator's Jan Smuts (ZUR) base. At 2230Z contact was made with Mauritius FIC via HF radio frequency 3476 KHz giving a position report at 070°E at 2229Z, FL350 and estimated time at 065°E at 2312Z. At 23:13Z Mauritius FIC was informed they were at 065°E at FL350 with an ETA (estimated time of arrival) at 060° at 2358Z. Accepting that the aircraft was on track the aircraft was at 15°40′S at 065°E and 18°58′S at 060°E.

Approximately 23:45Z the master fire warning alarm sounded on the flight deck, more specifically the main deck cargo. The pilot requested the relevant check list be read. At 23:49Z on 119.1 MHz frequency Mauritius Approach Control was told there was a smoke problem and were doing an emergency descent to FL140. The controller gave clearance asked if full emergency services were required. The reply was affirmative. At 2351Z the approach controller asked for their position and DME. The pilot replied "we haven't got DME yet. That is not yet in range of the airport. Then "Now we have lost a lot of electrics, we haven't got anything on the … aircraft now." At 2352Z the approach controller asked for a Plaisance ETA and was told 0030Z. At 2352 the pilot inadvertently transmitted speaking to the senior flight engineer "Hey Joe, shut down the oxygen left." At 0002Z the pilot gave a distance of 65nm. The approach controller understood this to be to the airport. It was really the distance to the next way-point at Xagal. That is, 145 miles from the airport. Consequently, the approach controller cleared descent to FL050. At 0003Z the approach controller provided the weather at the airport. The pilot acknowledged. The approach controller then asked which runway they intended to use. After brief confusion, runway 14 with ILS was selected. At 0004Z, the approach controller cleared the flight for a direct approach to the Flic-en-Flic (Foxtrot Foxtrot) NDB and to report at FL050. The last transmission from the aircraft was an acknowledgement at 00:04:02Z. From 00:08Z to 0030Z the approach controller repeatedly called the aircraft with no reply. After no communication for thirty-six minutes a formal emergency was declared at 00:44Z (04:44B). It was determined that the aircraft crashed into the Indian Ocean approximately 134nm north-east of Plaisance Airport (Mauritius) in the dark at about 00:07Z (04:07B) Saturday 28$^{th}$ November 1987. The time was determined from two damaged watches found in recovered luggage.

There is a report that the first bits of surface wreckage were located twelve hours later, as well as oil slicks and eight bodies showing signs of extreme trauma (Wikipedia (d)). However, according to the official report air search identified wreckage 136nm north-east of Plaisance at 19°04´S 59°36´E at 1247Z on the 28$^{th}$. On the 29$^{th}$ ships started the retrieval of bodies and floating wreckage spread over a large area. Furthermore, "The search for bodies and wreckage commenced on November 30$^{th}$ 1987 after a decision was made to abandon the search for survivors." By this time only 8 bodies substantial enough for medico-legal post-mortem examination were found.

"The search for floating wreckage continued in earnest until December 10$^{th}$ 1987" when three ships began to search for underwater locator beacons (pingers) fitted to the CVR and DFDR. The quick access recorder (QAR) for logging flight data and the digital flight data recorder (DFDR), which had a pinger, were never found. The cockpit voice recorder (CVR) was found and recovered. A piece of wreckage eventually washed up on South Africa's Natal coast over 2000nm away from the accident site.

On the 28$^{th}$ January 1988 wreckage area was found at 19°10´S 58°37´E at 4400m (±14400ft) on the sea bed. Wreckage recovered, consisting the fuselage and cabin interior was partly assembled in a SAA hanger at Jan Smuts Airport. The CVR was recovered nearly a year later on the 6$^{th}$ January 1989 (Aviation Safety Network. 1987-11-27). The CVR was analysed by the US National Transportation Safety Board (NTSB) in Washington, DC. Around 28 minutes into the recording the fire alarm was heard.

It was soon noticed that many retrieved articles had been subjected to extreme heat. It was found that the temperatures in the main deck cargo compartment ranged from 240°C at the rear to 600°C at the front cargo/passenger partition. Two elevator control cables installed in the fuselage crown of the main deck cargo compartment had been subjected to temperatures around 700°C where they fractured.

Main deck cargo consisted of electrical components and parts, hardware, paper articles, textiles, medicines and sports equipment. Some main deck articles recovered had evidence of fire damage. None of the cargo items from the lower holds had any evidence of exposure to heat or smoke deposit, nor was there either in the forward upper deck in zones A, B and C of the passenger compartment. Only two items recovered from zone D had evidence of exposure to heat and smoke.

Pallets from front to rear on the port (left) side were PL, RL and SL. On the starboard (right) side PR, RR and SR. Most of the pallets showing evidence of heat were on PR, RL and SR. No heat exposed cargo items were found on pallets PL, SL and RR. It was determined that the fire started in pallet PR (front starboard of the cargo hold). "The fire developed rapidly and could not be controlled. It generated smoke, carbon monoxide and carbon dioxide, some of which penetrated to the passenger cabin and possibly to the flight deck." That the smoke reached the cockpit, Mr Hill, the Federal Aviation Authority (FAA) expert, said that without knowledge of all the conditions inside the aircraft, "I couldn't tell you whether it would or it wouldn't" reach the cockpit. There was no declared dangerous cargo in pallet PR. Testimony was that any number of materials and triggers that could have started the fire. The Board concluded that there was "insufficient evidence to determine the source of ignition."

Nickel-cadmium, lithium-carbon monofluoride and lithium-thionyl chloride batteries that were on board were of small size either coin or cylindrical design were regarded as safe to transport. However, if abused such as by sudden short-circuiting or excess heating, the possibility of cells exploding could not be entirely discounted.

According to officials (airline operator, security of cargo and customs) at Taipei's Chaing Kai Shek Airport, no dangerous cargo was on board. The Chief of the South African Defence Force (SADF) confirmed no weapons or explosive devices for the SADF were carried. The Executive General Manager of Armscor confirmed there no consignment of cargo for Armscor was carried. Six consignments of electronic equipment containing small lithium battery cells were considered non-dangerous. A small quantity (300g) of granular activated carbon was in the lower hold. It was considered non-dangerous because it had been cooled for more than 8 days, 180 days according to the manufacturer. In any case none of the observed cargo from the lower had any evidence of fire damage.

No sign of explosion could be found on floating wreckage recovered shortly after the accident. No evidence of explosives were found on recovered wreckage, nor explosion evidence of a fuselage vibration signature on the CVR when analysed in Canada. An explosion would have resulted in depressurisation. There was no mention of this on the CVR and ATC tapes. There was also no claim of a terrorist attack by any organisation.

"The effects of the fire eventually led to the aircraft crashing into the sea with severe impact damage and disintegration of the aircraft." The causal chain between the fire and the aircraft crashing into the sea. The inference was that the cause of the accident was the fire, the fire became out of control, smoke led the pilots to initiate an emergency descent to FL140, something catastrophic happened. Possibilities were:

1. The crew were incapacitated by carbon monoxide and carbon dioxide or unable to see instruments because of smoke and ceased control of the aircraft.
2. Crew distraction.
3. The aircraft broke apart through weakening of the structure by fire damage.
4. The aircraft became uncontrollable through expansion beyond limits of tolerance, or fracture, of control cables or cable pulley clusters.
5. The aircraft became uncontrollable through fuselage deformation by fire heat.

Point one appears to have been inconclusive with the options being described as a possibility or unlikely possibility. Point two, judging by the ATC tapes, particularly the last few minutes up 0004Z three minutes before impact, the impression is that the crew felt the situation "was now under control and that a safe landing at Mauritius was possible." After which the situation rapidly deteriorated with no time to communicate. (The priority rule being aviate, navigate, communicate – author).

Regarding breaking apart of the aircraft, there were arguments for and against. Those for break up were two separate wreckage fields 200m apart, the engines showed evidence of low power at impact. The fans had ceased or almost ceased to rotate, indicating the aircraft was falling, or tumbling or some other unusual manoeuvre. Those against were that even if there was damaged skin and break away of underlying stringers and frames, there would not have been "any structural failure of the airframe within the normal operating parameters. Other similar aircraft cases, with worse damage in areas more critical to the aircraft's structure, there was no catastrophic failure, The wreckage pattern is not consistent with structural failure unless it occurred a very low altitude, The engines were attached to the airframe at impact, although engines not shed is "not necessarily inconsistent with prior break-up of the rear portion of the aircraft." The manufacturers of the Pratt & Whitney engines stated that, from the photographs, "the aircraft must have hit the water with wings perpendicular to the surface of the sea. That could mean either that the aircraft was out of control (but there is still no indication of precisely how that could have been caused), or that the aircraft "bounced" after its initial impact with the water and then proceeded to tumble." The Board's view was that it would not be helpful to pursue the pros and cons, because no sure findings could be made.

In over 20 years of operations by Combi aircraft, the Helderberg accident was the first in-flight fire which resulted in the loss of the aircraft." While Class B cargo compartments had been in use for about 40 years, the size of the compartments have become bigger, certification has remained virtually the same and inadequate. A test by SAA (1st March 1988) in a Combi aircraft stationary on the ground with no passengers or obstacles, using a trained cabin attendant, took 5 minutes and 15 seconds to locate the simulated fire among the pallets and begin fire-fighting. Judged to be too long. A FAA review found that the existing regulations "do not provide an acceptable level of safety in terms of smoke and fire protection."

The official commission board of inquiry consisted of: Chair South African Mr Justice Cecil Margo DSO, DFC, FRAeS (with co-operation from the NTSB and the aircraft's manufacturer, Boeing), Mr Justice Hurrylall Goburdhun (Mauritius), Mr George N. Tompkins Jr (USA), Mr G. C. Wilkinson CBE, FRAeS (UK), Dr Y. Funatsu (Japan), Colonel Liang Lung (Republic of

China), Dr J. Gilliland (South Africa) and J.J.S. Germishuys (South Africa). The unanimous conclusions of the Board were:

1. "The aircraft was not under control when it crashed into the sea. The only possible causes for loss of control were one or more of the following: (a) pilot incapacity from carbon monoxide and carbon dioxide poisoning and/or smoke inhalation, or disorientation consequent on reduced cockpit visibility in smoke, or pilot distraction; (b) damage to the structure and/or to the control systems of the aircraft directly or indirectly caused by the fire."
2. It is virtually certain that there was no sabotage.
3. "The Board was unable to find or conclude that fireworks, or any other illegal cargo, were carried in the aircraft."
4. The accident followed an uncontrolled fire in the forward right pallet (pallet PR).
5. The aircraft crashed into the sea at high speed following a loss of control as a consequence of the fire.
6. The conclusion of the inquiry board was that was "not possible to apportion blame to any one individual for the fire".

SAA ceased Combi operations. The inadequate main deck cargo compartment regulations were improved including that manual firefighting must not be the primary means of fire suppression. Additional automatic systems meant weight increase, which made the 747 Combi no longer financially viable (Wikipedia (d)).

The suggestion that the aircraft broke apart in-flight because fire burned through several control cables causing caused loss of control due to deformation of the aircraft fuselage was contested by Boeing (Wikipedia (d)). Other statements found at Wikipedia (d) were that on the CVR circuit breakers could be heard popping. It is believed that about eighty circuit breakers failed. (this was stated in the official Final report Boeing 707 ZS-EUW – author). Furthermore, the fierce fire started in the front right pallet that contained computers and lithium batteries could have caused the fire. (This was discussed in the Final report Boeing 707 ZS-EUW – author). Parts of fire damaged wreckage recovered indicated temperatures over 300°C, while tests revealed that temperatures of 600°C were necessary to melt a carbon-fibre tennis racket recovered among the wreckage (Wikipedia (d)). (The statement regarding the tennis racket was not found in the Final report Boeing 707 ZS-EUW. Maybe an oversight – author).

There was immediately speculation that the cause was terrorism ((Wikipedia (d)). (This was discounted in the Final report Boeing 707 ZS-EUW – author). The apartheid government was, domestically and internationally under terrorist attack as had SAA offices. No evidence such as surface pitting, impact and spatter cavities caused by white-hot fragments from explosives were found among the wreckage. Blood samples from two bodies and soot in their tracheae showed death from smoke inhalation, indication that they were dead before the aircraft crashed. Wikipedia (d) also reported the suggest that the aircraft had an illicit cargo, such as for the South African arms agency, Armscor. There were rumours of ammunition and missile rocket fuel. Also red mercury for a South African Defence Force atomic bomb project. It was also suggested there was a waybill for 300gms of activated carbon for use in the top-secret South African Project Coast, a 1980s chemical and biological weapons programme. Also, in January 1992, the journal of the Royal Aeronautical Society (RAeS) reported that SAA had allegedly confirmed that its passenger jets had carried cargo for Armscor, (Wikipedia (d)).

At the time nefarious activities by the government were suspected/believed by sections of the public, myself included due to employment and access to some information. Much of which was exposed at the Truth and Reconciliation Commission. One can understand the persistent scepticism of the finding of the board of inquiry.

**SAA 747SP un-contained engine failure at Maputo 1998-10-05**

The aircraft was a B747SP, registration ZS-SPF. On a scheduled flight from Maputo (Mozambique) to Lisbon (Portugal) with 16 crew and 50 passengers. The aircraft was operating for LAM (Linhas Aéreas de Moçambique) on lease from SAA (Aviation Safety Network. 1998-10-05). Presumably a wet lease.

A wet-lease occurs when the aircraft is provided to an airline that includes crew, maintenance, airline certificates and third party liability insurance. Other operation costs, such as fuel, catering, airport fees, ground handling and navigation fees are by the airline.

Shortly after take-off, there was a severe uncontained failure of No 3 engine inboard on the starboard (right) wing. Debris from the engine damaged the No 4 engine outboard on the starboard wing which was operating under full power. The No 4 engine was damaged beyond repair. The airframe was also damaged (Bureau of Aircraft Accidents Archives. 1998, Aviation Safety Network. 1998-10-05).

Below is a verbatim account of the uncontained engine failure by the captain. It was placed on the internet, plus photographs, by Tommy Morgan (at 747SP website) who adds that reportedly the damage was estimated at US$ 6 million while the aircraft was insured for US$ 1 million. The aircraft was scrapped at the airport during February and March 2000. SAA brought useful parts back to Johannesburg.

“When passing FL060 the no3 motor literally blew up, huge yaw and vibration, no3 thrust lever slammed shut, I got to the cut off lever a nano second later thinking it was in reverse. That was closely followed by the fire bell, the FEO froze on his recalls and by look on his face I could see he couldn't believe what was happening, took three times to get him to pull the fire handle.

It was then that a dead heading captain in the back raced forward face pale as snow shouting there was a raging fire consuming the wing; we had already fired both bottles!

One showed it had gone the 2nd did not. There was only one option left, I rolled her into a steep diving turn, had a squint at no4 (avm's fine) and took max continuous (power – author) while heading back to the field as fast as possible while trying to extinguish the fire. (The AVM, airborne vibration monitor, monitors vibrations experienced by the aircraft during flight. Valuable data for the flight crew and ground maintenance – author).

At 340kts it went out, then it was fun trying to slow down for the field which was almost below us by now, a couple hammerheads (a manoeuvre -author), speedbrake with flap plus gear and we went straight in, did a short landing and took the first exit and stopped. There were still clouds of smoke but no fire.

What happened after that, is what is expected in Africa, the one and only fire truck arrived and of course we had no comms (radio stolen or broken) then when they fired their extinguishant it ran for a minute and in that time never reached the motor. They then tried water hoses from the truck which only just made it.

Boeing has had a team out and at this stage they're talking of scrapping it, unbeknown to us, no4 was extensively damaged.

15% of the n1 blades missing also the main engine support had been severed by the hp turbine rotor exiting the top of the motor. The fire bottles had not worked because all the rear cowls had blown away. The blades had gone everywhere, no4 motor, the fuse, ailerons, flaps the inboard leading edge flap drive was completely burnt away as was the leading edge.

Frightening to know so much could take place in just 3 minutes which is how long it was after the fire to landing."

**Fatal accident, Piper Navajo near Rand Airport, (Germiston) 1999-12-06**

Report ref: Unknown

An interesting accident. The twin engine Piper PA31-350 Navajo, registration ZS-OJY, crashed shortly after take-off at 0506Z for a flight from Rand Airport, Germiston, to Oranjemund in Namibia at the mouth of the Orange River. The pilot and nine passengers died. The request from SACAA, as usual, was simply to provide a weather report. The vagueness of the request intended so as not to prejudice the evidence.

A surface trough extended from Gauteng Province to Maputo (in Mozambique) with warm and moist tropical air in circulation to the east of it and cooler maritime air from the south-west. Thundershowers and showers that occurred along this line during the night, were in the final dissipating stage at 0500Z (0700B). The 0500Z infrared image showed convective cloud over Gauteng to northern KwaZulu-Natal.

The nearest surface observations were at Johannesburg international Airport:
FAJS 060400Z 35009KT 8000 FEW040CB FEW045TCU BKN080 15/15 Q1021 TEMPO SCT006=
FAJS 060430Z 34009KT 9999 FEW040CB SCT080 16/16 Q1022 TEMPO SCT006=
FAJS 060500Z 34010KT 9999 FEW040CB SCT080 17/16 Q1022 TEMPO SCT006=
FAJS 060530Z 33013KT 9999 SCT010 FEW040CB SCT080 19/17 Q1023 TEMPO SCT006=

The nearest TAF, valid around the time of the accident, was at Johannesburg International Airport and is provided below:
FAJS 060000Z 060312 34010KT 9999 FEW030CB SCT080 PROB30 0306 4000 HZ SCTOO8 BECMG 0608 27010KT SCT020 T14/03Z T28/12Z=
The forecast significant weather chart, valid at 0600Z nearest to the time of the accident, gave isolated thunderstorms base 9000ft MSL, about 4500ft AGL.

A tentative conclusion (obviously not expressed) was that a thunderstorm was an influencing factor, or low stratus cloud at 600-800ft AGL. However, the extremely thorough 58 page SACAA accident report (J10/2/7132), released on the 22nd May 2001, proved this to be entirely incorrect. Below is a summary of the report. Quotations are verbatim from the report.

The aircraft took-off from RWY 29 at Rand airport. Shortly after take-off the pilot declared an engine failure (most likely at rotation and lift-off) and requested a lefthand circuit back to short final for RWY 29. (The correct turn with a righthand engine failure. Always turn toward the live engine – author). Shortly after ATC clearance the pilot communicated "we going down sir we going down." There was no further communication. The pilot did not have time to begin the turn. The aircraft crashed to the right of the extended centre line of runway 29 about 2nm from the airport about 2 minutes after take-off. Witnesses stated that the aircraft was very low when it passed over the highway close to the accident site. One of the witnesses said that the righthand engine had stopped because he could see the blades of the propeller.

It was found that the initial cause of the accident was "the failure of the exhaust pipe segment, which caused righthand engine to lose power/fail." Operators of Piper Chieftain aircraft were consulted. They agreed that the aircraft, fully loaded on one engine, would "not climb at maximum mass in the high-altitude and temperature conditions of Rand Airport, if the speed were not maintained at 106 knots (blue line speed). Any speed lower than this speed or unbalanced flight is very critical to the climb performance of the aircraft." Furthermore, the operators consulted were of the opinion that "this type of aircraft usually does not maintain height under full load conditions with one engine inoperative."

The aircraft was overloaded. It was calculated that the aircraft was "operated 785.715lb. in excess of its maximum certified take-off mass" and that it was "overloaded on most of the flights to Oranjemund." In its overloaded state the aircraft was unable to maintain altitude on one engine.

Furthermore, at the time, regulation of civil aviation in South Africa, from the 1st January 1998, was changed from Air Navigation Regulations of 1976 implemented by the Chief Directorate, Department for Transport to the Civil Aviation Regulations of 1997 and the SACAA. "The complexity of the situation was compounded by the fact that this change is still ongoing" and "Several factors relating to the documentation and management actions of the charter operator and those of the CAA as the regulator were a source of concern during the investigation."

Sadly, although the pilot feathered the failing righthand engine in accord with recommended operating procedure, the failure of the exhaust pipe segment connected to the turbocharger reduced the engine power 40-50%. The engine, now operating in a normal aspirated state, should still have delivered power. With hindsight, possibly keeping the engine operating might have been enough to save the flight. It must be remembered that flight duration was 2 minutes. In that time the pilot had seconds to assess the situation and react. "Taking all this into consideration the most probable reason why the aircraft was not able to maintain altitude was the overloaded situation" (SACAA accident report J10/2/7132).

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**APPENDIX**

**TERMINAL AERODROME FORECAST (TAF)**

**TAF CCCC DDHHmmZ DDFMTL DDDSSGSSKT VVVV WW NNNhhh (VVhhh) BECMG HHHH / FMHHmm / TEMPO HHHH / PROB % HHHH TXTtTt/HHZTNTtTt/HHZ =**

**TAF**
May be followed by **AMD** (Amended. Amendments or changes were made to previous TAF.
**COR** (Corrected. Correction/s was/were made to the TAF.
**CCCC**
Location or Place. Four letter ICAO designator is used. Example: FADN.
**DDHHmmZ**
Time of origin. DD - Day, HH - Hour, mm – Minutes Z (Zulu time, Z). Note, all times in TAFs are Z time. Example: 261153Z.
**DDFMTL**
Period of validity. DD - Day, FM - from hour, TL - till hour.
TAFs can be valid for 9 hours, 12 hours, 18 hours, 24 hours and 30 hours. Example: 261818
**CNL and NIL**
These may sometimes follow the period of validity.
The TAF is cancelled (CNL) because

a) No observation (METAR) available.
b) The TAF could not be kept under constant review.

The TAF is missing (NIL) because it is not available, or not received.
Example: TAF NONE 110900Z 111021 CNL=
**DDDSSGSSKT**
Wind group
DDD - Wind Direction in degrees, SS - Wind Speed, G - GUST, KT - Knots.
Wind direction in tens of degrees from true North.
A variable direction less than 3 KT (or during thunderstorms) is given as VRB.
A speed less than 1 KT is given as CALM
Wind speed is measured in knots(KT).
Gust is added only if the average wind speed is exceeded by 10 KT or more of the mean wind speed for previous 10 minutes.
Other wind speed units in use are MPS (metres per second) and KMH (kilometres per hour)
Example: 23016G28KT, or 23008G14MPS, or 23030G52KMH. Example: VRB03KT.
**WW**
Weather group. Used to report significant weather according to the table below that shows the abbreviations.
Up to a maximum of three weather phenomena listed below, or combinations thereof, together with their characteristics and, where appropriate, intensity:

- freezing precipitation
- freezing fog
- moderate or heavy precipitation (including showers thereof)
- low drifting dust, sand or snow
- blowing dust, sand or snow

- dust storm
- sand storm
- thunderstorm (with or without precipitation)
- squall
- funnel cloud (tornado or waterspout)

- other weather phenomena only if they are expected to cause a significant change in visibility. See significant weather below.

Example: +TSRA

The expected end of occurrence of those phenomena should be indicated by the abbreviation "NSW".

**SIGNIFICANT WEATHER**

| **QUALIFIER** | | **WEATHER PHENOMENA** | | |
|---|---|---|---|---|
| **Intensity of Proximity 1** | **Descriptor 2** | **Precipitation 3** | **Obscuration 4** | **Other 5** |
| - Light | MI Shallow | DZ Drizzle | BR Mist | PO Dust/sand whirls (dust devils) |
| Moderate (no qualifier) | BC Patches | RA Rain | FG Fog | SQ Squalls |
| + Heavy (well-developed in the case of dust/sand whirls (dust devils) and funnel clouds | PR Partial (covering part of the aerodrome) | SN Snow | FU Smoke | FC Funnel cloud(s) (tornado or waterspout) |
| VC In the vicinity | DR Low drifting | SG Snow grains | VA Volcanic ash | SS Sand storm |
| | BL Blowing | IC Ice crystals (diamond dust) | DU Widespread dust | DS Dust storm |
| | SH Shower(s) | PE Ice pellets | SA Sand | |
| | TS Thunderstorm | GR Hail | HZ Haze | |
| | FZ Freezing (supercooled) | GS Small hail and/or snow pellets | | |

The WW groups shall be constructed by considering columns 1 to 5 in the table above in sequence, that is intensity, followed by description, followed by weather phenomena. An example could be: +SHRA (heavy shower(s) of rain).

More than one form of precipitation shall be combined, the dominant type of precipitation

being reported first, for example +SNRA.
More than one phenomenon other than a precipitation combination noted shall be reported in separate WW groups in the order of the columns, for example: DZ FG.

Intensity shall be indicated only with precipitation, precipitation associated with showers and/or thunderstorms, blowing dust, sand or snow, dust storm or sand storm. Well developed dust/sand whirls or funnel clouds (tornadoes or water-spouts) shall be reported using the indicator +, for example +FC.
Not more than one descriptor shall be included in a WW group, for example -FZDZ.
The descriptors MI, BC and PR shall be used only in combination with the letter abbreviation FG, for example MIFG.
The descriptor DR (low drifting) shall be used for dust, sand or snow raised by the wind to less than 2 metres above the ground. BL (blowing) shall be used to indicate dust, sand or snow raised by the wind to a height of 2 metres or more above the ground.
The descriptors DR and BL shall be used only in combination with the letter abbreviation DU, SA and SN, for example BLSN.
When blowing snow is observed with snow falling from cloud, both phenomena are reported, e.g. SN BLSN. When due to heavy blowing snow the observer cannot determine whether or not snow is also falling from cloud, the only +BLSN shall be reported.
The descriptor SH shall be used only in combination with one or more of the letter abbreviations RA, SN, PE, GS and GR, to indicate precipitation of the shower type at the time of observation, for example SHSN.
The descriptor TS shall be used only in combination with one or more of the letter abbreviations RA, SN, PE, GS and GR, to indicate thunderstorm with precipitation at the aerodrome, for example TSSNGS.
The descriptor FZ shall be used only in combination with the letter abbreviations FG, DZ and RA, for example FZRA.
The proximity qualifier VC shall be used only in combination with the letter abbreviations TS, DS, SS, FG, FC, SH, PO, BLDU, BLSA and BLSN.

**VVVV**

Horizontal Visibility. See also CAVOK.
Visibility is measured in metres.
The following increments are used:

| | |
|---|---|
| 50 m | - below 800 |
| 100 m | - 800 m to 5000 m |
| 1000 m | - 5000 m to 9000 m |
| 9999 | - >9000 metres. |

Example: 1500
Some countries still use statute miles (SM).

**NNNhhh**

Cloud group/s See also CAVOK and NSC
NNN - Cloud amount according to the following abbreviations:

| | |
|---|---|
| FEW | - 1 to 2 oktas |
| SCT | - 3 to 4 oktas |
| BKN | - 5 to 7 oktas |
| OVC | - 8 oktas |

In the following order:

a) the lowest layer or mass regardless of amount, to be forecast as FEW, SCT, BKN or OVC as appropriate;
b) the next layer or mass covering more than 2/8, to be forecast as SCT, BKN or OVC as appropriate;
c) the next higher layer or mass covering more than 4/8, to be forecast as BKN or OVC as appropriate; and
d) Cumulonimbus clouds, whenever forecast and not already included under a) to c).

**hhh**

Cloud height in 100's of feet above station level (or AGL).
The only cloud type used in a TAF is Cumulonimbus (CB)
Cloud groups are always given from lowest to highest base. This includes a CB group.
Example: FEW008 SCT020CB BKN030 OVC050

**VVhhh**

Vertical visibility
When the sky is obscured and instrumentation is available to measure vertical visibility, hhh is given in increments of 100ft.

**CAVOK**

Used when the visibility greater than 9000 metres, no cloud below 5000 ft, or below the highest minimum sector altitude whichever is greater, no CB cloud and no significant weather.

**SKC and NSC**

Used when CAVOK is not appropriate. Such as when there is reduced visibility and no cloud, or cloud above 5000 ft or highest minimum sector altitude whichever is greater.
Example: 7000 SKC, or 7000 NSC

**BECMG HHHH**

Used to indicate a gradual change in some, or all, of the forecast elements. BECMG is always followed by a time group HHHH. HH on the left is the hour indicating the start of time while HH on the right will be the end of the period. The change period preferably not more than 2 hours and shall not exceed 4 hours.
Only those elements for which a significant change is expected should be included following a change indicator. However, in the case of significant changes in respect of cloud, all cloud groups including layers or masses not expected to change, should be indicated.
Example: BECMG 1214

**FMHHmm**

Used when a change is expected to be abrupt, such as the rapid onset of fog. HH - Hour, mm - minutes from when the change is expected.
Example: FM0430 0400 FG VV///

**TEMPO HHHH**

Used to describe expected frequent or infrequent temporary fluctuations in the meteorological conditions which reach or pass specified threshold values and last for a period of less than one hour in each instance and, in the aggregate, cover less than one-half of the forecast period during which the fluctuations are expected to occur.
The time of the temporary changes being between the hours indicated by HHHH.
If the temporary fluctuations are expected to last one hour or longer, the change group BECMG should be used
Example: TEMPO 1218 2000 BR BKN004

**PROB % HHHH**

Probability. The probability of occurrence of an alternative value of a forecast element or

elements should be indicated by a percentage of either 30 or 40. If a higher probability than 40% is expected then BECMG or TEMPO is used. If lower than 30% then it is left out.
It can be used in conjunction with TEMPO.
The probability group should not be used to qualify BECMG nor the time indicator FM.
Example: PROB40 0407 0800 FG. Example: PROB40 TEMPO 0407 0800 FG.
**TXTtTt/HHZTNTtTt/HHZ**
Forecast maximum and minimum temperature during the valid time of the TAF. This group is included by local agreement.. TX Indicator for maximum temperature. TN Indicator for minimum temperature. TtTt Temperature value in Celsius. HH Forecast hour when the temperature is expected. Z Zulu time (Z). Example: TX48/1100ZTN28/0200Z
= Indicates the end of the TAF.
**CHANGE GROUPS AND AMENDMENT CRITERIA**
The number of change and probability groups should be kept to a minimum and should not normally exceed five groups.
Only those elements for which a significant change is expected should be included following a change indicator. However, in the case of significant changes in respect of cloud, all cloud groups, including layers or masses not expected to change, should be indicated.
**WIND**
When the surface wind is forecast to change through values of operational significance. The threshold values should be established by the meteorological authority in consultation with the appropriate ATS authority and operators concerned, taking into account changes in the wind which would:
a) Require a change in runway(s) in use.
b) Indicate that the runway tailwind and crosswind components will change through values representing the main operating limits for typical aircraft operating at the aerodrome.
c) When the mean surface wind direction is forecast to change by 60° or more from that already forecast, the mean speed before and/or after the change being 10 KT or more. Example: 03007KT BECMG 0709 12015KT.
d) When the mean surface wind speed is forecast to change by 10 KT or more from that already forecast. Example: 12012KT BECMG 0709 12023KT.
e) When the variation from the mean surface wind speed (gusts) is forecast to increase by 10 KT or more from that already forecast, the mean speed before and/or after the change being 15 KT or more. Example: 03016KT BECMG 03016G27KT
**VISIBILITY**
When the visibility is forecast to improve or deteriorate to, or pass through, one or more of the following values:
1) 150, 350, 600, 800, 1500 or 3000 m. Note, 800 metres and below are also Runway Visual Range (RVR) thresholds.
Or
2) 5000 m in cases where significant numbers of flights are operated in accordance with visual flight rules (VFR).
**WEATHER**
When any of the following weather phenomena, or combinations thereof, is forecast to begin or end or change in intensity:

- freezing precipitation
- moderate or heavy precipitation (including showers thereof)
- dust storm

- sand storm
- other weather phenomena given in the significant weather table if they are expected to cause a significant change in visibility;

When the onset or cessation of any of the following weather phenomena or combinations thereof are forecast to begin or end:

- ice crystals
- freezing fog
- low drifting dust, sand or snow
- blowing dust, sand or snow
- thunderstorm (with or without precipitation) - squall
- funnel cloud (tornado or waterspout);

**CLOUD AMOUNT AND BASE**

When the amount of a layer or mass of cloud below 1500 ft is forecast to change:
1) From SKC, FEW or SCT to BKN or OVC.
2) From BKN or OVC to SKC, FEW or SCT.
3) When cumulonimbus clouds are forecast to develop or dissipate;

When the height of base of the lowest layer of BKN or OVC cloud is forecast to lift, or lower, to or through one or more of the following values:
1) 100, 200, 500 or 1000 ft.
Or
2) 1500 ft in cases where significant numbers of flights are operated in accordance with visual flight rules.

**VERTICAL VISIBILITY**

When the sky is obscured and the vertical visibility is forecast to improve, or deteriorate and change to or pass through one or more of the following values:
100, 200, 500 or 1000 ft.
Or.
Any other criteria based on local aerodrome operating minima, as agreed between the meteorological authority and the operators.

**TAF EXAMPLES**

Example at No Such International Airport.
TAF NONE 130900Z 131212 240010KT 7000 SCT025 FEW030CB BKN070 TEMPO 1220 18015G25KT 2000 TSRA BKN005 SCT020CB BKN070 BECMG 2224 BKN015 TEMPO 0306 2000 BR BKN003 PROB40 0406 0500 FG OVC000 FM0815 03007KT 9999 SCT020 TX23/12ZTNM01/03Z=

**METEOROLOGICAL AERONAUTICAL REPORT (METAR)**

**METAR CCCC DDHHmmZ (AUTO) DDDSSGSSKT VVVV(D) (RD/VVVVi) WW NNNhhh (VVhhh) TT/TdTd QPPPP REWW WS RWYDRDR
TTTTT (RMK)=**

**METAR**

May be followed by **AMD** (Amended) **COR** (Corrected)

**CCCC**

Location or Place. Four letter ICAO designator is used. Example: FADN.

**DDHHmmZ**
Time of origin. DD - Day, HH - Hour, mm – Minutes Z (Zulu time, Z). Note, all times in TAFs are Z time. Example: 261200Z.
**(AUTO)**
Automatic weather station (AWS)
**DDDSSGSSKT**
Direction in degrees true followed by the average wind speed.
KT = knots, KMH = kilometres per hour, MPS = metres per second, G = gusts. Example 24015G27KT. Calm = 00000KT, Variable wind = VRB EG: VRB02KT. > 3 kt and the direction is varying by 60 degrees or more: EG: 31015G27KT 280V360
**VVVV(D)**
Visibility is recorded as a four figure group in metres (2000 metres is roughly 1 nm).
If 0000 is shown it would indicate that the visibility is less than 50 metres.
9999 is shown it indicates that the visibility is 10 km or more.
If local conditions vary greatly then two groups may be displayed showing the visibility variation in different sectors. Example, 1000NW 6000S = visibility to the north-west is only 1000 metres but is 6 km to the south.
D – Direction. When the horizontal visibility is not the same in all directions, a minimum and maximum visibility may be given followed the direction. Values for D are: N – North, NE – North-east, E - East, SE – South-east, S – South, SW – South-west, W – West and NW – North-west
**(RD/VVVVi)**
Runway visual range. At airports where instruments are used to measure visibility this group will be included in the METAR when significant. RVR observed when the visibility decreases below 1500 metres
RD/ - Runway designator/point where the visibility is measured. VVVV – Visibility as in the TAF code.
RD/VVVVvVVVV - This format is used when the visibility fluctuates at a runway point. The fluctuation is considered significant when the visibility during the last 5 seconds changes by 50m or 20% of the mean visibility of the previous 10 minutes.
v - tendency for the visibility to change by 100m or more from the mean, terms used are: U - upward, D - downward, N - no tendency. P – exceeds 1500 metre, measuring capability. Some RVR equipment can go go up to 2000 metres. M - less than 50 metres
**WW**

| **WEATHER SYMBOLS AND GROUPS** | | | | |
|---|---|---|---|---|
| **Qualifier** | | **Weather Phenomena** | | |
| **Intensity 1** | **Descriptor 2** | **Precipitation 3** | **Obscuration 4** | **Other 5** |
| **-** Light<br><br><br>**Moderate** (no qualifier) | **MI** Shallow<br>**BC** Patches<br>**PR** Partial (Covering part of the aerodrome)<br>**DR** Low Drifting<br>**BL** Blowing | **DZ** Drizzle<br>**RA** Rain<br>**SN** Snow<br>**SG** Snow Grains<br>**IC** Ice crystal (diamond dust)<br>**PE** Pellets<br>**GR** Hail | **BR** Mist<br>**FG** Fog<br>**FU** Smoke<br>**VA** Volcanic ash<br>**DU** Widespread dust | **PO** Dust/sand whirls<br>**SQ** Squalls<br>**FC** Funnel Clouds (tornado or waterspout)<br>**SS** Sand storm |

| | | | | |
|---|---|---|---|---|
| + Heavy<br><br>**VC** Vicinity | **SH** Showers)<br>**TS** Thunderstorm<br>**FZ** Freezing (super-cooled) | **GS** Small hail and/or snow pellets | **SA** Sand<br>**HZ** Haze | **DS** Dust storm |

GR - hail diameter of the largest hailstones is ≥5 mm or more.
GS - hail diameter <5 mm.
FU, HZ DU, SA (except DRSA) - visibility 5000 metres or less.
BR – visibility at least 1 000 metres but not more than 5 000 metres.
FG (without the qualifiers MI, BC, PR or VC,) - visibility less than 1 000 metres.
MIFG - visibility at two metres above ground level shall be 1 000 metres or more and the apparent visibility in the fog layer shall be less than 1 000 metres.
VCFG - used to report any type of fog observed in the vicinity of the aerodrome. BCFG - used to report fog patches
BCFG should be used only when the visibility in parts of the aerodrome is 1 000 metres or more although, when the fog is close to the observing point, the minimum visibility reported by VVVVDv will be less than 1 000 metres.
PRFG - used to report fog covering part of the aerodrome; the apparent visibility in the fog patch or bank shall be less than 1 000 metres, the fog extending to at least two metres above ground level.
SQ - used to report squalls when a sudden increase in wind speed is observed of at least 16 knots (32 KPH, 8 m/s), the speed rising to 22 knots (44 KPH, 11 m/s) or more and lasting for at least one minute.

**NNNhhh**

Cloud height is above airfield level.
NNN cloud amount is given as: FEW = Few. This indicates 1 or 2 oktas of cloud, SCT = Scattered. This indicates 3 or 4 oktas of cloud, BKN = Broken. This indicates 5 to 7 oktas of cloud, OVC = Overcast. This indicates 8 oktas (solid cloud cover).
hhh cloud height show the altitude in hundreds of feet. i.e. 040 is 4000 ft, 004 is 400 feet, 200 is 20,000 ft. Examples: SCT020 - Scattered at 2000 ft, BKN005 - Broken cloud at 500 feet, OVC250 - Overcast at 25,000 feet.

**(VVhhh)**

Reported when it is not possible to determine NNNhhh. Usually during fog. VV vertical visibility indicator. hhh is the vertical visibility in units of 30 metres (hundreds of feet). When information on vertical visibility is not available, the group shall read VV///.

**TT/TdTd**

Temperature and dew point temperature. Temperature and Dew Point are both measured in Centigrade. A minus value is preceded by the letter M. Examples: 25/12 = Temp 25°C, Dew Point 12°C. 00/M02 = Temp 0°C, Dew Point -2°C.

**QPPPP**

QNH (Barometric Pressure) reduced to sea level. QNH is rounded down to the next whole hectoPascal (hPa). Examples: Q0996 = 996hPa, Q1030 = 1030hPa

**REWW**

Recent Weather. This may be included if appropriate using the weather codes above, prefixed with RE (for recent). Example: RERA for recent rain.

**WS RWYDRDR (or WS ALL RWY)**

Information on the existence of wind shear along the take-off or approach path between runway level and 500 metres (1 600 ft) when significant. DRDR is the runway direction. The group can be repeated when necessary. If all runways are affected WS ALL RWY shall be used. Example: WS LDG RWY28L or WS TKOF RWY08.

**TTTTT**

Trend forecast. Indicates significant changes of weather valid for two hours after the observation. TEMPO = a temporary change. BECMG = a permanent change. Examples: TEMPO 3000 SHRA = temporary visibility 3000 metres with rain showers. BECMG 33035KT = wind becoming 330°T 35 kts. NOSIG = no significant change in weather. Also, FM – from Z time, TL – until Z time, AT – Z time