Report 97-004

Cessna 185F

ZK-PRM

wake turbulence encounter

Wellington International Aerodrome

3 March 1997

Abstract

On Monday 3 March 1997 at 1014 hours, Cessna 185F ZK-PRM became airborne from runway 16 at Wellington International Aerodrome, behind a Boeing 727 which had departed directly ahead. The Cessna encountered wake turbulence which caused the pilot to lose control of the aircraft at a height from which recovery was not possible. Neither of the two occupants was injured but the aircraft was substantially damaged. The pilot took-off from a mid-point runway position and had requested and been granted a waiver of the wake turbulence separation standards. The pilot misjudged the likely region of wake turbulence in his take-off path. The error resulted from a lapse in concentration, partly due to the routine nature of the flight and partly because of his preoccupation with his personal concerns. Safety issues discussed include the appropriateness of allowing waivers of the wake turbulence separation standards. Safety recommendations were made on the safety issues.

Transport accident investigation commission

Aircraft Accident Report 97-004

Aircraft type, serial number and registration:	Cessna 185F, 18504414, ZK-PRM
Number and type of engines:	One Continental IO-520-D
Year of manufacture:	1983
Date and time:	3 March 1997, 1014 hours[1]
Location:	Wellington International Aerodrome Latitude: 41° 19' S Longitude: 174° 48' E
Type of flight:	Private
Persons on board:	Crew: 1 Passengers: 1
Injuries:	None
Nature of damage:	Substantial
Pilot-in-Command's Licence:	Airline Transport Pilot Licence (Aeroplane)
Pilot-in-Command's age:	44
Pilot-in-Command's total flying experience:	14 402 hours Approximately 2 000 hours on type
Investigator in Charge:	K A Mathews

[1] All times in this report are NZDT (UTC + 13 hours)

1. Factual Information

1.1 On Monday 3 March 1997, at about 1008 hours, the pilot of Cessna 185 ZK-PRM began taxiing for runway 16, the runway in use, at Wellington International Airport. The aircraft had been parked at Gate 4 on the eastern apron. On board was the pilot and his wife and a small amount of personal cargo. The pilot intended to fly to his home 55 km to the north-west in the Marlborough Sounds, and return to Wellington later that day. The aircraft had sufficient fuel on board for some 2 hours and 30 minutes of flying.

1.2 The pilot made radio contact initially with Wellington Ground and was transferred to Wellington Tower about one minute later. Tower gave the pilot his departure instructions and the pilot acknowledged them. A short time later Tower advised another taxiing aircraft that its take-off would be delayed for two minutes because of wake turbulence behind a Boeing 727 which was ready to begin its take-off roll from the beginning of the runway. A Bandeirante was on a three mile final approach, and the other aircraft was instructed to line up on the runway after the Bandeirante had landed.

1.3 ZK-PRM taxied along the eastern apron, and stopped opposite stub taxiway 5 situated approximately half way along the 1996 m runway. The pilot's usual practice, when taking off to the south, was to take-off from this runway mid-point position.

1.4 Shortly after the Boeing 727 began to roll down the runway Tower told the pilot there would be a three minute delay for his departure due to wake turbulence from the departing aircraft, and that the surface wind was 150 degrees at 14 knots.

1.5 The pilot acknowledged this and, after determining he should outclimb the wake from the Boeing 727, advised Tower he would accept his own wake turbulence separation behind the Boeing. Tower agreed to this (pilot initiated) request and after reviewing the traffic situation instructed the pilot to line up on the runway behind the departing aircraft and to be ready for an immediate departure. The pilot accepted this instruction.

1.6 Tower advised the Bandeirante on final approach that it would get a late landing clearance due to the mid-point departure of the Cessna 185, and that the surface wind was 150 degrees at 12 knots. Tower cautioned the pilot of ZK-PRM about the wake turbulence behind the Boeing 727 and cleared him for immediate take-off.

1.7 The pilot acknowledged the instructions and commenced his take-off. He noted that the Boeing had rotated sooner than he expected, so he set two notches of flap and carried out a short take-off with the intention of staying above the departure path of the Boeing 727 and its wake turbulence. ZK-PRM took off normally, but at a height of about 70 feet and 70 knots airspeed the Cessna involuntarily rolled violently to the right. The pilot applied full opposite aileron and rudder control to recover, but the aircraft kept rolling. Ground witnesses said the aircraft appeared to roll more than 90 degrees to the right before it began to slowly recover. The aircraft sank quickly, striking the right side of the runway with its right wing-tip and in a shallow nose down attitude. Maximum power had been used for the take-off and was maintained throughout by the pilot.

1.8 The main undercarriage struck the ground shortly after the wing-tip and collapsed. A cargo pod attached to the belly of the aircraft was torn away. The aircraft yawed some 90 degrees to the left and slid on its belly, tail first, to the aerodrome boundary fence, coming to rest upright. The propeller was destroyed. The right wing was badly distorted and bent upwards near its tip. No fire occurred.

1.9 The Bandeirante on final approach was instructed to go around.

1.10 Neither the pilot nor his wife was injured. The pilot informed Tower they were not hurt, and secured the aircraft. Two airport service vehicles were first on the scene of the accident followed by the rescue services.

1.11 The pilot of ZK-PRM was well experienced having flown some several thousand hours in light aircraft. The balance of his flying experience was as an airline pilot and he was employed as an international airline captain. He had owned and operated a Cessna 185 for the past 19 years and had flown about 2000 hours on that aircraft type. He was in current flying practice and flew ZK-PRM, on average, about two times each week between his home and Wellington.

1.12 The pilot was knowledgeable about wake turbulence, its effects and how to avoid it. He had requested his own wake turbulence separation many times before and intended to climb out above the departure path of the Boeing 727 to avoid its wake. The Boeing however rotated sooner than the pilot expected; some 200 m past where ZK-PRM had lined up on the runway. A witness believed ZK-PRM became airborne at or past the rotation point of the Boeing and within one minute after the Boeing rotated. The cross wind at the time was calculated to have been 2.4 knots from the left, and the head wind 13.7 knots.

1.13 The Manual of Air Traffic Services (MATS) requires an aerodrome controller to apply a standard three minute separation between a departing medium weight aircraft, such as the Boeing 727, and a light aircraft departing from an intermediate point on the same runway. However, a pilot is permitted to request and be granted a waiver of the separation standards, if he determines he can nullify the effects of wake turbulence by ensuring the flight profiles of his aircraft and the one taking off do not cross. Should the pilot make such a request and be granted a waiver, the controller is required to caution the pilot about wake turbulence when issuing the take-off clearance.

1.14 Runway separation standards for wake turbulence are published in the New Zealand Aeronautical Information Publication (AIP) - Planning Manual, Rules of the Air and Air Traffic Services (RAC) section. This section includes a discussion on the effects of wake turbulence, the aircraft weight categories for assessing wake turbulence separation and the separation standards that will be applied by aerodrome controllers. It allows a pilot to request and be granted a waiver of the separation standards, as detailed in the MATS. The only restriction on the granting of such requests was that the controller is not to offer a waiver, the request must be initiated by the pilot.

1.15 The AIP and MATS note that the occurrence of wake turbulence hazards cannot be accurately predicted, and aerodrome controllers cannot assume responsibility for issuing advice of such hazards at all times, nor for its accuracy. Whenever practicable controllers will advise pilots of the expected occurrence of the hazards.

1.16 When departing behind a larger aircraft, and using the same runway, a following aircraft should start its take-off from a position where it can rotate prior to the rotation point of the preceding larger aircraft, and then establish a climb above its flight path until a turn can safely be made clear of the wake. If this is not possible the take-off should be delayed.

1.17 Much research has been carried out, and numerous flight safety articles have been published world wide, on wing-tip vortices and wake turbulence. It is not an unknown phenomenon. Wing-tip vortices generated by medium to large aircraft can be severe, especially after the generating aircraft rotates during take-off. Aircraft configuration can modify the vortex pattern and persistence. The vortices, one trailing behind each wing-tip, are violent spiralling air masses and rotate in opposite directions. The left wing-tip vortex, when viewed from behind the aircraft, will rotate clockwise and the right wing-tip vortex will rotate counterclockwise. Vortices descend behind the generating aircraft. At low altitude they approach the ground, and at a height usually about 15 m (50 feet) they curve outward and spread laterally away from the track of the aircraft. The vertical and lateral movement of the vortices will be affected by and move with the encompassing air mass. A cross wind will displace the vortices from the vertical in their downward travel and affect the lateral rate of travel. A crosswind component up to five knots is sufficient to cause one vortex to stay within the flight path, over the runway. The other vortex will travel at its own lateral rate plus that of the crosswind away from the flight path. Stronger crosswinds blow the wake across the flight path and quickly break it up. (See figure 1).

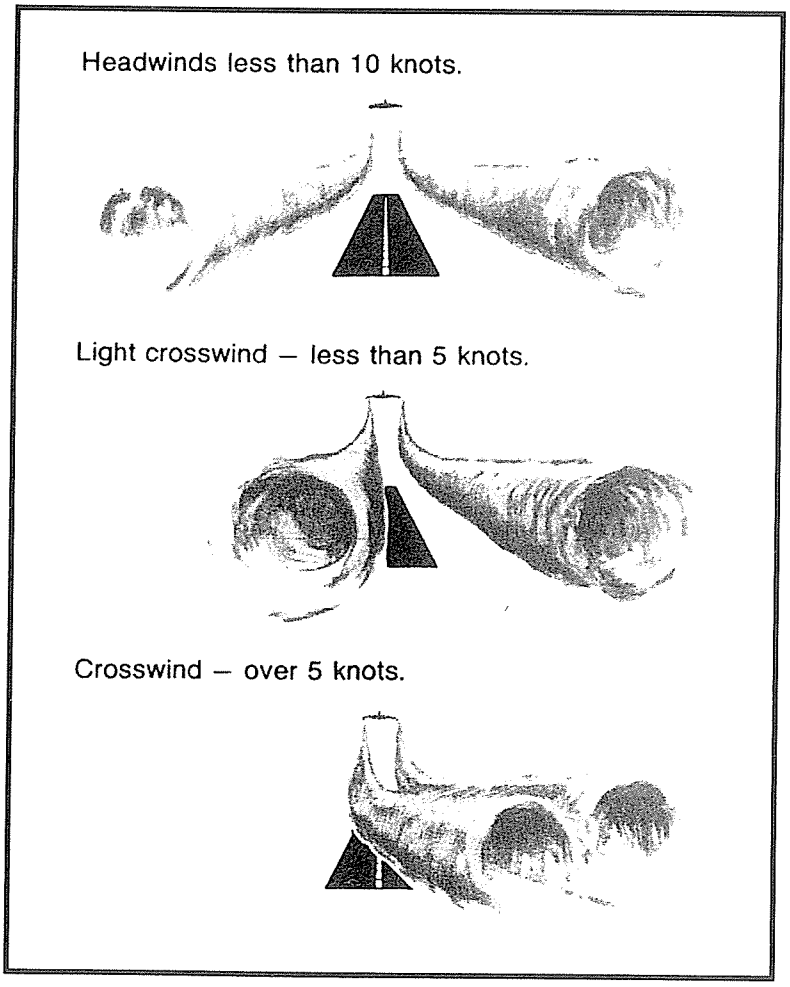

Figure 1
Wing-tip vortex patterns

1.18 The usual hazard for aircraft encountering wake turbulence is a violent induced roll which can exceed the capability of the aircraft to counter the roll. Counter control is usually more effective where the wing span and ailerons of the aircraft extend beyond the field of the vortex. Aircraft with short wing spans will have more difficulty countering an imposed roll induced by a vortex.

1.19 The pilot was a joint owner and chief executive of a small airline which had recently had its operating licence suspended following an audit check of the airline. During the week before the accident the pilot had been involved in lengthy negotiations to get the operating licence reinstated. He had not been flying as an airline pilot during that period.

1.20 On Sunday 2 March he flew his Cessna from his home to Wellington where he had been involved in further negotiations during the morning and until about 1800 hours that evening. He returned to his airline offices afterwards and remained there for several hours before retiring to his accommodation in Wellington around midnight. He slept for about six hours and returned to the airline the next morning at 0800 hours.

1.21 The pilot was under abnormal emotional stress as a result of the suspension of the operating licence for his airline and the negotiations to have it reinstated. At the time of the accident the negotiations had been unsuccessful, and the pilot said he was very frustrated and upset at not being able to resolve various issues necessary for the licence to be revalidated. He could not recall experiencing similar pressure and stress before.

1.22 Both the pilot and his wife were confident about his ability to fly ZK-PRM safely back to their home, despite the stress he was under. The flight was routine, one they had made many times before. Following the accident however, the pilot believed his thoughts were distracted by the events surrounding his airline as he was taxiing and during the take-off. He consequently misjudged or overlooked the likely region of wake turbulence in his take-off path.

2. Analysis

2.1 ZK-PRM encountered wake turbulence shortly after it became airborne, and the encounter resulted in an involuntary loss of control of the aircraft at a height from which recovery was not possible. A Boeing 727 generated the wake turbulence, having departed directly ahead of the aircraft.

2.2 ZK-PRM rolled violently to the right indicating it was probably the left wing-tip vortex from the Boeing that it encountered. The pilot applied full opposite aileron and rudder in an attempt to recover, but the roll exceeded the capability of the aircraft to overcome it. The relatively short wing span of the Cessna 185 would have contributed to its inability to recover.

2.3 The cross wind component at the time of the encounter was less than five knots from the left, and the head wind component was some 13 knots. As a result the left wing-tip vortex would have remained within the flight path of the Boeing, over the runway, and drifted back towards ZK-PRM.

2.4 The pilot's intention had been to climb above the departure path of the Boeing and therefore avoid the possibility of flying into the vortices generated by it. The pilot however miscalculated, or did not fully consider, where the vortices would be in relation to the flight path of his aircraft, or the effect the wind would have on the movement of the vortices and the time necessary to dissipate them.

2.5 The aerodrome controller on duty in Wellington Tower gave the pilot adequate warning about the possibility of wake turbulence behind the Boeing and accordingly advised the pilot there would be a standard three minute delay for his take-off clearance. The pilot however exercised his right to be responsible for his own wake turbulence separation and requested a waiver of the standard separation requirements. The controller granted the request and asked the pilot to line up on the runway and be ready for an immediate departure. The pilot did not have to accept this instruction if he considered it was inappropriate or unsafe, and he had the opportunity to reject it. The pilot accepted the instruction and took off a short time later.

2.6 The pilot was well experienced and was employed as an international airline captain. He had flown several thousand hours in light aircraft and was experienced and familiar with the Cessna 185. He was knowledgeable about wake turbulence and how to avoid it.

2.7 Wing-tip vortices have an unpredictable nature and it is not possible to accurately determine their path. Sufficient time should be allowed for the vortices to break up before commencing a take-off behind a departing aircraft, especially when a following aircraft will become airborne close to the rotation point of a heavier aircraft.

2.8 A departure from an intermediate runway position has a greater potential to place a following lighter aircraft into the wake of a preceding heavier aircraft. If the pilot had been required to wait the standard three minutes before taking off the accident would probably have been avoided. The controller however was entitled to grant the pilot's request.

2.9 The decision by the pilot to take-off shortly after the Boeing, close to its departure point, and to ignore the apparent danger and clear warnings of wake turbulence seem out of character for a pilot of his experience and background. The pilot's actions therefore require some explanation.

2.10 During the week before the accident the pilot had been subject to a high level of emotional stress due to the suspension of the operating licence for his airline. He had not been accustomed to so much stress before. Not only did he perceive the future of his airline to be at risk but also the employment of its staff. He had been frustrated in his attempts to resolve many of the issues which led to the suspension.

2.11 ZK-PRM was the pilot's personal aircraft which he used to commute between his home and Wellington. The purpose of the accident flight was to return with his wife to their home and to refresh himself before returning to Wellington later that day. As he taxied the aircraft and began his take-off he was carrying out a task he had performed many times before. The flight was routine.

2.12 The high level of emotional stress the pilot was under and the events of the previous week probably combined to divert the pilot's conscious attention away from the task of flying his aircraft safely. He was performing routine tasks as he taxied and prepared for his take-off; tasks that required little thought. The warnings about the likely existence of wake turbulence were not unusual, and he was accustomed to hearing them and requesting his own wake turbulence separation. Although the pilot heard the warnings about wake turbulence and was aware of the potential for it to affect his flight he made an error in judging, or overlooked, the likely region of wake turbulence in his take-off path. This error of judgement resulted from a lapse of concentration, partly because of the routine nature of the flight and partly because of his preoccupation with his personal concerns.

3. Findings

3.1 The pilot was well experienced and familiar with the Cessna 185, having owned and flown one successfully for about 19 years.

3.2 The pilot was undertaking a routine private flight to his home.

3.3 The pilot was knowledgeable about wake turbulence and the adverse effects it can have on an aircraft encountering it.

3.4 The aerodrome controller acted correctly by giving the pilot adequate warning about the likely existence of wake turbulence and by applying the standard separation for the pilot's take-off clearance.

3.5 The pilot was entitled to formulate his own wake turbulence separation and request a waiver of the wake turbulence separation standards.

3.6 There were no restrictions on the granting of waivers for departures from intermediate runway positions.

3.7 The aerodrome controller was entitled to grant the pilot's request for a waiver.

3.8 The pilot should have allowed more time or distance between his aircraft and the departing Boeing 727.

3.9 The existing wind conditions were sufficient to cause the left wing-tip vortex from the generating aircraft to remain over the runway and drift toward ZK-PRM.

3.10 The pilot was under unusual emotional stress following the recent suspension of the operating licence for his airline and the unsuccessful negotiations to have the licence revalidated.

3.11 ZK-PRM flew into wake turbulence when it became airborne directly after a departing Boeing 727, close to its rotation point.

3.12 The wake turbulence encounter caused an involuntary loss of control at a height from which recovery was not possible.

3.13 The pilot misjudged or overlooked the likely region of wake turbulence in his take-off path.

3.14 The pilot's error of judgement resulted from a lapse of concentration, partly because of the routine nature of the flight and partly because of his preoccupation with personnel concerns rather than the task of flying the aircraft safely, due to the high level of emotional stress he was experiencing.

4. Safety Recommendations

4.1 This accident highlights the potential problems that can exist for an aircraft that takes off from a mid-point (intermediate) runway position behind a larger aircraft, when the wake turbulence separation standard is waived.

4.1.1 Standard separation criteria have been implemented world wide with good reason due to the viciousness and somewhat unpredictable nature of wing-tip vortices. Aerodrome controllers have an appropriate responsibility for only issuing advice and warnings about the potential for wake turbulence and for applying standard separations when they consider that wake turbulence is likely to exist. Pilots must accept the responsibility for avoiding wake turbulence, and use sound judgement when any warnings about its existence are given. Aerodrome controllers however should have clear guidelines to follow when granting a waiver of the separation standards. Some countries do not allow waivers to be granted in certain circumstances.

4.1.2 Some commercial operators allow their pilots to request waivers. The potential therefore exists for a similar occurrence at a busy aerodrome with more disastrous results should an aircraft, for example, collide with a terminal building or strike a taxiing aircraft.

4.2 The Commission therefore recommends to the Director of Civil Aviation that he:

4.2.1 Ensure that waivers of the wake turbulence separation standards are:

i) restricted to VMC, by day only; and

ii) specifically acknowledged by pilots with words such as "ACCEPT WAIVER"; and

iii) not permitted under certain circumstances, for example:

when a light aircraft:

(a) will take-off behind a heavy or medium aircraft from a point on the runway more than 150 m beyond where the heavy or medium aircraft started its take-off roll; or

(b) will take-off in the opposite direction to a heavy or medium aircraft that has just taken-off from, or carried out a missed approach to, the same runway; or

when a medium aircraft:

(c) will take-off behind a heavy aircraft from a point on the runway more than 150 m beyond where the heavy aircraft started its take-off roll; or

(d) will take-off in the opposite direction to a heavy aircraft that has just taken-off from, or carried out a missed approach to, the same runway.

(This is similar to the Australian restrictions on granting waivers.), (027/97) and:

4.2.2 Publish another article on wing-tip vortices, in the Vector magazine, to alert pilots and operators to wake turbulence concerns. This article should highlight the dangers of encountering wake turbulence and explain how it can be avoided, (028/97).

4.3 The Director of Civil Aviation responded as follows:

4.3.1 In regard to Recommendation 027/97, the first two points of the recommendation are adopted to the extent that the proposals will be forwarded to the Assistant Director Rules and Standards for processing as a petition for rulemaking as an amendment to the appropriate Rule or Advisory Circular, probably Part 91 or its associated ACs.

4.3.2 The third point is not adopted on the basis that:

(i) it does not impose any specific requirements on any person. It would be inappropriate to place the responsibility for determination of what was safe and what was not on the air traffic controller. Such persons would be unlikely to have sufficient knowledge to carry out such a function;

(ii) it is too specific in quoting distances which may be appropriate on some occasions and inappropriate on others; and

(iii) the ultimate responsibility for the safe operation of the aircraft rests upon the pilot-in-command.

4.3.3 The recommendation 028/97 is adopted and has been passed to the Editor of *Vector* for action in 1997.

11 June 1997

Hon. W P Jeffries
Chief Commissioner

Glossary of aviation abbreviations

AD	Airworthiness Directive
ADF	automatic direction-finding equipment
agl	above ground level
AI	attitude indicator
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
amsl	above mean sea level
AOD	aft of datum
ASI	airspeed indicator
ATA	actual time of arrival
ATC	Air Traffic Control
ATD	actual time of departure
ATPL (A *or* H)	Airline Transport Pilot Licence (Aeroplane *or* Helicopter)
AUW	all-up weight
°C	degrees Celsius
CAA	Civil Aviation Authority
CASO	Civil Aviation Safety Order
CDI	course deviation indicator
CFI	Chief Flying Instructor
C of A	Certificate of Airworthiness
C of G (*or* CG)	centre of gravity
CPL (A *or* H)	Commercial Pilot Licence (Aeroplane *or* Helicopter)
DME	distance measuring equipment
E	east
ELT	emergency location transmitter
ERC	Enroute Chart
ETA	estimated time of arrival
ETD	estimated time of departure
°F	degrees Fahrenheit
FAA	Federal Aviation Administration (United States)
FL	flight level
ft	foot/feet
g	acceleration due to gravity
GPS	Global Positioning System
h	hour
HF	high frequency
hPa	hectopascals
hrs	hours
HSI	horizontal situation indicator
HT	high tension
IAS	indicated airspeed
IFR	Instrument Flight Rules
IGE	in ground effect
ILS	instrument landing system

IMC	instrument meteorological conditions
in	inch(es)
ins Hg	inches of mercury
kg	kilogram(s)
kHz	kilohertz
KIAS	knots indicated airspeed
km	kilometre(s)
kt	knot(s)
LAME	Licensed Aircraft Maintenance Engineer
lb	pound(s)
LF	low frequency
LLZ	localiser
Ltd	Limited
m	metre(s)
M	Mach number (e.g. M1.2)
°M	degrees Magnetic
MAANZ	Microlight Aircraft Association of New Zealand
MAP	manifold absolute pressure (measured in inches of mercury)
MAUW	maximum all-up weight
METAR	aviation routine weather report (in aeronautical meteorological code)
MF	medium frequency
MHz	megahertz
mm	millimetre(s)
mph	miles per hour
N	north
NDB	non-directional radio beacon
nm	nautical mile
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board (United States)
NZAACA	New Zealand Amateur Aircraft Constructors Association
NZDT	New Zealand Daylight Time (UTC + 13 hours)
NZGA	New Zealand Gliding Association
NZHGPA	New Zealand Hang Gliding and Paragliding Association
NZMS	New Zealand Mapping Service map series number
NZST	New Zealand Standard Time (UTC + 12 hours)
OGE	out of ground effect
okta	eighths of sky cloud cover (e.g. 4 oktas = 4/8 of cloud cover)
PAR	precision approach radar
PIC	pilot in command
PPL (A *or* H)	Private Pilot Licence (Aeroplane *or* Helicopter)
psi	pounds per square inch
QFE	an altimeter subscale setting to obtain height above aerodrome
QNH	an altimeter subscale setting to obtain elevation above mean sea level
RNZAC	Royal New Zealand Aero Club
RNZAF	Royal New Zealand Air Force
r.p.m.	revolutions per minute
RTF	radio telephone or radio telephony

s	second(s)
S	south
SAR	Search and Rescue
SSR	secondary surveillance radar
^{o}T	degrees true
TACAN	Tactical Air Navigation aid
TAF	aerodrome forecast
TAS	true airspeed
UHF	ultra high frequency
UTC	Coordinated Universal Time
VASIS	visual approach slope indicator system
VFG	Visual Flight Guide
VFR	visual flight rules
VHF	very high frequency
VMC	visual meteorological conditions
VOR	VHF omnidirectional radio range
VORTAC	VOR and TACAN combined
VTC	Visual Terminal Chart
W	west