VH-MDX
Part 1:
An Initial Overview

Version: 2nd Edition (2nd July 2015)

Glenn Strkalj

August 2014

© Glenn Strkalj 2014

Distribution: Public

Copyright and distribution of this document

Document Purpose

This document was drafted to support VH-MDX related operations of the author, Bushwalkers Wilderness Rescue Squad (BWRS) search operations and NSW Police Force Rescue and Bomb Disposal Unit (NSWPRBDU) Strike Force Wittenoom.

The contents of this document are purely intended to clarify accident events to the best of the author's ability to offer a solid base in determining the location of VH-MDX.

This document must not be used for any purpose other than to provide guidance in locating VH-MDX.

The information and data presented in this document must not be used for any legal purposes as the content may be inaccurate or subject to interpretation errors of the author.

This document is to be read in conjunction with other background and area development documents published by the author.

This reference paper will be subject to change as new information and data is found or errors corrected; it is a 'living' document.

Amendments:

2nd Edition:

- Grammatical errors fixed
- End of daylight graphs 1981 added
- VFR requirements 1981 added
- FIS-5 FIA 1972 marked on chart
- Radar propagation analysis updated
- Probable type of audio recorder added
- Better quality charts
- Expansion on search aircraft post accident
- SSR gating line on Sydney Northern Mosaic explained
- Addition of possible radar recording equipment
- Williamtown ATCO quiz choices included
- Icing section expanded. Great C-210 wing ice photo.
- Likely speed range flown expanded to include more backing information
- Inclusion of a possible final track
- Point form Executive summary removed and added to Annex (a good summary is now in Annex A).

Abbreviations

AACC	Area Approach Control Centre
ALERFA	Alert Phase (SAR)
AMSL	Above Mean Sea Level
AH	Artificial Horizon
ARFOR	Area Forecast
ASIB	Air Safety Investigation Branch
ATA	Actual Time of Arrival
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATS	Air Traffic Services
BASI	Bureau of Air Safety
DETRESFA	Distress Phase (SAR)
DI	Direction Indicator
DoT	Department of Transport
ELT	Electronic Locator Transmitter
FIA	Flight Information Area
FIS	Flight Information Service
GS	Ground Speed
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
INCERFA	Uncertainty phase (SAR)
ISA	International Standard Atmosphere
KTAS	Knots True Air Speed
kts	Knots
LSALT	Lowest Safe Altitude
ºM	Degrees Magnetic
Navaid	Navigation Aid

NDB	Non-Directional Beacon
NOTAM	Notice to Airmen
NVFR	Night Visual Flight Rules
OCTA	Outside Controlled Airspace
MHz	Megahertz
NM	Nautical Mile
NOTAM	Notice to Airman
PE	Permanent Echoes
PPI	Plan Position Indicator
PSR	Primary Surveillance Radar
RAAF	Royal Australian Air Force
RCC	Rescue Coordination Centre
RSR	Route Surveillance Radar
SAR	Search and Rescue
SIGMET	Significant Meteorology
SOC	Senior Operations Controller
SPI	Special Position Identification
SSR	Secondary Surveillance Radar
ºT	Degrees True
TAR	Terminal Approach Radar
TAS	True Air Speed
TC	Turn Coordinator
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VHF	Very High Frequency
WGS	World Geodetic System
°	Degrees Celsius

Table of Contents

Executive Summary

This paper offers an initial and non-exhaustive overview of the VH-MDX accident as researched by the author so far. Not all research aspects are covered. This paper forms part one of a series of documents covering specific areas.

VH-MDX departed Coolangatta on the 9th August 1981 for Bankstown and was last seen on radar in the greater vicinity of the main ranges of the Barrington and Gloucester Tops approximately 95km north-north-west of Newcastle. Five people were on board and no trace of the aircraft has been found.

Night Visual Flight Rules (NVFR) were nominated for the flight despite the aircraft and pilot being Instrument Flight Rules (IFR) certified and being a Private category flight.

Contrary to proliferated beliefs, the weather along the route flown from Coolangatta was generally *clear skies* and generally pleasant flying conditions. A very dark night was reported and strong westerly to south-westerly winds were forecast and reported. A cold front passed through the area about nine hours previous and a thunderstorm well out to sea associated with this front reportedly caused fluctuations of radio navigation aid indications.

Cloud was forecast and reported as being limited to the western mountain tops as a result of orographic uplifting from the westerly to south-westerly flow. Turbulence was forecast and reported over the eastern sections of mountain tops and coast. This was due to these areas being downwind of the flow disturbed by the roughly north-south oriented Great Dividing Range.

After Taree, VH-MDX flew well west of planned track being identified by Sydney Air Traffic Control (ATC) operated Route Surveillance Radar (RSR) approximately 36NM north of Singleton. Enroute to this position the pilot reported penetration of cloud and almost at the same time primary attitude and heading instrumentation was reported as having failed.

From this initial radar position VH-MDX turned approximately south then was radar observed in a slow turn to the east. RAAF Williamtown radar observed VH-MDX at a position 320˚M/45NM, +4˚/-2˚, +2NM/-0NM approximately three and one half minutes before the final received radio call from VH-MDX.

Approximately two minutes later, it is likely VH-MDX was observed on a bearing of 330˚M +/-5˚ from Williamtown. Sydney ATC deposed a final radar position of VH-MDX approximately 5NM west to north-west of Craven waypoint with no time of fade reported. Williamtown ATC did *not* observe radar fade of VH-MDX.

It was found that of the two RSR's operated by Sydney ATC in the northern sectors, only The Round Mountain RSR was capable of interrogating VH-MDX below 10000'AMSL. This finding was important for radio propagation analysis that suggested the radar *fade* position reported by either the Air Safety Investigation Branch (ASIB) or the Sydney Rescue Coordination Centre (RCC) did not align with *communications transcripts* based altitude reports and radar fade.

Williamtown ATC had one Air Traffic Control Officer (ATCO) on duty with procedural (non-radar) control in-force. The Williamtown ATC radar was turned on to offer increased situational awareness this in the author's view proved to be a prudent decision.

VH-MDX was Outside Controlled Airspace (OCTA) from Taree onwards and the only agency to communicate directly with the aircraft from Taree onwards was Sydney Flight Service 5 (FIS-5). FIS-5 was not ATC and did not have radar information presented in front of the Flight Service Officer (FSO).

An Electronic Locator Transmitter (ELT) was fitted to VH-MDX however no signals were detected by airborne aircraft soon after the final received transmission.

A stepped approach to search area development was explained. It was discussed how drawing *certain* conclusions as to VH-MDX's flight path after the 320˚M/45NM radar position was challenging. One could argue either loss of direction and altitude control (e.g. spin/ spiral dive) or maintenance of rough track control with loss of altitude due to icing and/or downdrafts. The latter was viewed as more likely.

Defensibly predicting a single, fixed impact area with the information currently at hand is viewed as highly challenging. Multiple areas of interest potentially with significant distances between them are likely to result. Such large distances in the Barrington Tops area significantly increase search resources as a result of the considerable terrain and vegetation.

Despite this, given the information at hand it is *currently* viewed by the author that an easterly track towards the deposed Sydney final radar position was the most likely flight path. Secondary impact areas should also be synthesized.

Annex A contains a key point summary of this document for quick reference to facts.

Further parts will be published as new information and data is found, existing information and data is corrected or when understanding has changed.

It must be noted that information is being continuously sourced and methodically interpreted leading to lengthy document release times and also multiple document iterations.

 © Glenn Strkalj 2014

1. Introduction

1.1. Why was this document drafted?

Many searches for VH-MDX have been conducted over the years, some in areas that can be justified valid from a critical point of view with the information and data at hand whilst others are based on skewed interpretation of such information and data and are clearly invalid.

Many theories that have been circulating regarding VH-MDX's final resting place tend not to offer sufficiently balanced arguments. In many cases authors have selected particular items of information whilst ignoring other key items with little or even without, solid justification. This lack of balance only pushes locating VH-MDX further away.

Additionally, much information and analysis has been 'lost' over the years leading to repetitive overviews and superficial analysis. As a result, it was viewed beneficial to collate, overview and formally record information and data that would provide a solid base for current and future VH-MDX analysis.

This has commenced through various focus documents that have been drafted by the author in key areas such as Williamtown Air Traffic Control (ATC) and radar, Sydney ATC and radar, communications and meteorology. Despite this, an overview of such information found thus far is required to position interested parties 'in the loop'.

The purpose of this paper is to overview events leading to the accident of VH-MDX and present findings from discussions and interviews with Air traffic Control Officers (ATCO's), Technical Officers and Air Safety Investigation Branch (ASIB) officers.

Defensible, relevant suggestions will also be offered that critical overview of information and data will allow *at this stage*. Suggestions offered are not terminal or all encompassing but rather the first stage in stimulating further ideas and refinement.

The overview will form a useful reference for emergency services whilst key issues will be identified that will explain why at this stage a *single* small area of interest regarding VH-MDX's final resting place is difficult to defensibly propose.

1.2. Aim

The aim of this paper is to provide a reasonably detailed initial overview of the VH-MDX accident based on the author's research *to date*, highlighting challenges whilst also offering robust suggestions for further analysis.

1.3. Note on recent interviews and discussions

Interviewing key personnel over thirty years from an event can result in changed views compared to what was apparent at the time. The author has proceeded as carefully as possible to ensure capture of the most true-to form views of the event however, caution must be applied in using such information.

<u>The findings from interviews and discussions must not be used in any legal sense as the findings may not be indicative of actual events given the significant time frame and interpreting ability of the author.</u>

1.4. Acknowledgement

Hearty thanks are due to the key personnel involved in the VH-MDX accident and to the numerous Air Traffic Controllers, radar technicians and others who have assisted the author with research. Special thanks to the Airways Museum and Civil Aviation Historical Society and the National Archives of Australia are also due.

For many involved there has been over thirty years of repetitive discussion and questioning of this event and to go over events yet again can be a burden. Your efforts are truly appreciated.

2. Overview

2.1. Introduction

Section 2 will provide an overview and offer overall insight into the VH-MDX accident. Later sections will provide more in-depth views.

Sources of information regarding the VH-MDX accident currently include:

- One BASI (Bureau of Air Safety Investigation) VH-MDX Accident Investigation folio archive, believed to be that of the *Sydney Field Office*
- Coronial Inquest
- Media articles (Newspaper etc.)
- Various other publications
- Current (2014) interviews and discussions with:
    - Key personnel involved in accident
    - Subject matter experts not involved in the accident (Air Traffic Controllers, Technical Officers, Air Safety Investigators)
    - People who discussed the accident event with personnel involved in the accident

2.2. Aircraft type

VH-MDX was a single piston engine Cessna 210M Centurion model light aircraft[1] with a maximum take off weight of 1724kg[2]. The aircraft was of aluminum semi-monocoque construction with a high mounted, cantilever (strutless) wing[2]. 342L of fuel could be stored in integral wing tanks. Approximately 180L of fuel would have been in the tanks during impact. The aircraft had retractable undercarriage[2].

Figure 1: Cessna 210. (Not VH-MDX). This particular aircraft was an L or M version (Photo: Glenn Strkalj 2002).

There was seating for six occupants including the pilot whilst a small baggage area was located behind the last row of seats[2]. *Five* people (including the pilot) were on board VH-MDX during the accident[1]. The aircraft was cream and green in color[1].

VH-MDX was certified for operations at night and in accordance with the Instrument Flight Rules (IFR) but not in known icing conditions[1].

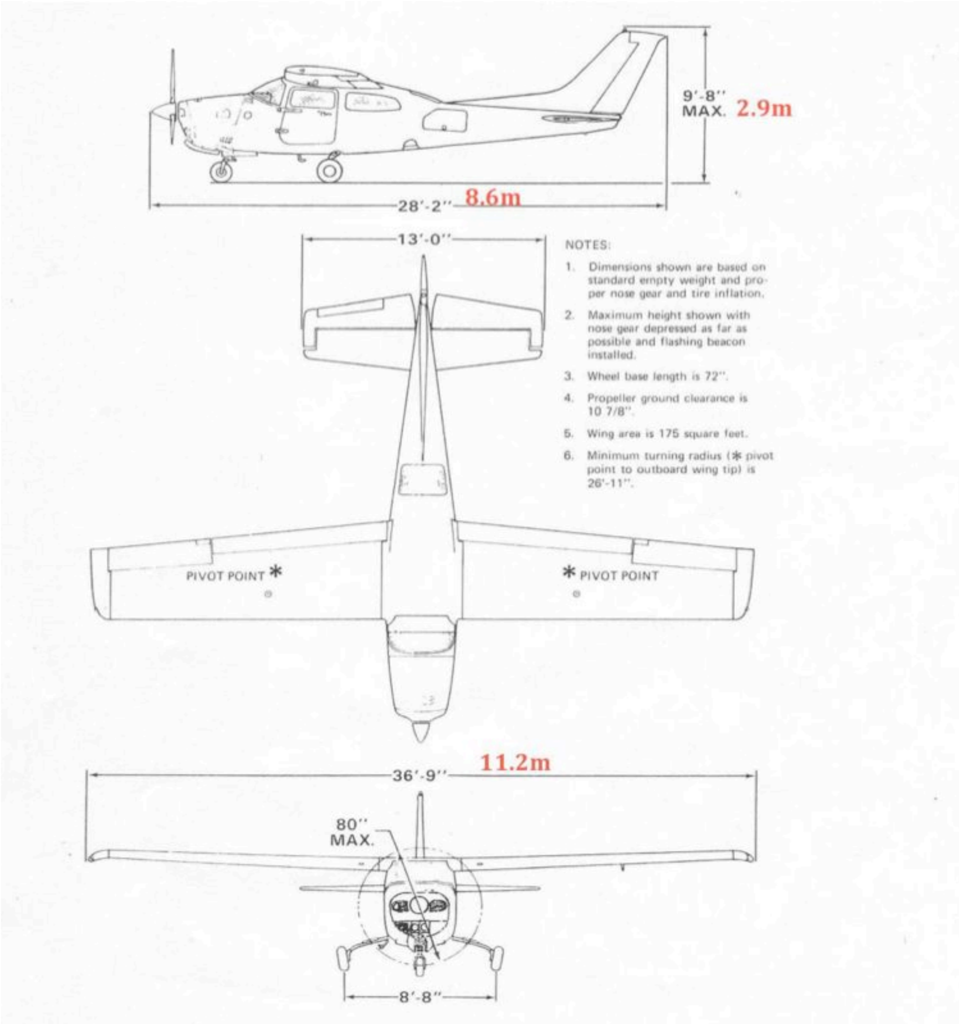


Figure 2: Cessna 210 dimensions (Image: Cessna Aircraft Company, 1976).

2.3. Pilot qualifications

The pilot held a Senior Commercial Pilot's Licence and a Class 3 Instrument Rating with appropriate currency[1]. Experience included[1]:

- 3412 hours total fixed wing
- 2187 hours of Pilot in Command
- 4400 hours as a Navigator.

34 hours of flying were conducted by the pilot in the last 30 days leading up to he accident[1]. The pilot had experience with a variety of light aircraft and also with larger types of aircraft such as the DC-3[1].

Appropriate qualifications and currency appear to have been held by the pilot during the accident flight.

2.4. Aircraft equipment

Confirmation of equipment on board VH-MDX is generally limited to snippets of information that reflect the equipment fit-out during sale of the aircraft when new in 1977 although some information was confirmed by engineers post accident. The flight plan also lists the avionics equipment installed and useable.

Accordingly, some of the equipment discussed cannot be absolutely verified as being fitted during the time of the accident in 1981. Where required an assumption is made that equipment referred to in 1977 remained the same up to the time of the accident in 1981.

VH-MDX was fitted with a *vacuum* powered Artificial Horizon (AH) and Directional Indicator (DI)[1][3]. An *electrically* driven Turn Co-coordinator (TC) was also fitted[1]. The following avionics equipment was found to be fitted during sale in 1977 or verified through other means so, was likely on board *during* the accident.

Equipment	Model	Features	Indicated on Flight Plan[1]
Autopilot	ARC 300A Navomatic[3]	Roll axis only[4]. Primary info source was heading info from DI bug[4] in 'heading select' mode. Another mode was 'turn rate select' which sourced info from the TC[4].	No
VHF Comm	ARC 328T[1]	No standby frequency Class 2, ≈6-8W carrier[5][6] power, 25W PEP[5]	Yes
HF Comm	Sunair ASB-125[1]	10 Channel[7] SSB/AM[7] 2-18MHz[7] 125W PEP (SSB)[7]	No
VOR/Nav	ARC 328T with IN-525B indicator[1]	Same unit as VHF Comm No standby frequency[5] No ILS[5]	Yes
ADF	ARC R546E[1] likely with IN-346A indicator	Fixed Card ADF	Yes
Transponder	ARC RT-359A[1]	Mode C is generally installed on this unit[8] but the pilot indicated only Mode A in the flight plan[1].	Yes
ELT	Leigh Systems SHARC 7J[1]	121.5MHz[9] Switch position has manual 'on' and 'auto'[9]. Auto function is 'G' switch (longitudinal G) triggered[9].	Yes

Figure 3: VH-MDX avionics equipment.

© Glenn Strkalj 2014

2.5. Intended plan

On Sunday the 9th August 1981, the pilot of VH-MDX intended to fly from Proserpine to Coolangatta to Bankstown generally coastal and predominantly at night[1].

End of daylight appears to have occurred just south of Yamba, about 20 minutes prior to Coffs Harbour. End of daylight was annotated in the flight plan as figure 4 below shows.

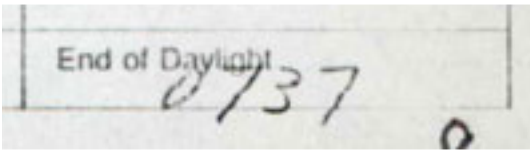


Figure 4: VH-MDX Flight plan extract: End of daylight. End of daylight was annoted in the VH-MDX flight plan as 0737UTC. This would mean VH-MDX was just south of Yamba during last light. Accordingly, most of the flight was conducted at night. A very dark night was reported (Image: Australian Government (Department of Transport) 1981).

End of daylight calculated for Taree airport from Visual Flight Guide (VFG) tables of September 1981 yield 0734UTC/ 1734EST. Annex B refers. This corroborates with the flight plan value and confirms VH-MDX was operating at night from well before Taree.

At Coolangatta, the pilot obtained a briefing of weather and NOTAM's (Notices to Airmen) and the aircraft was refueled to full capacity[1]. The flight-planned route from Coolangatta was[1]:

Coolangatta (ABCG/ CG) Tucki (TWK) – The Lake (TKE) – Coffs Harbour (CH) – Port Macquarie (PMQ) – Taree (TRE) – Craven (CRV) – Singleton (SGT) – Mount McQuoid (MQD) – Bankstown (ASBK/ BK).

The route was predominantly *coastal* or *just inland* of the coast.

The nominated flight rules were Night Visual Flight Rules (NVFR)[1] requiring flight *clear of cloud*. A heavy reliance on flight instruments and radio navigation aids would have been required to conduct the flight and to regularly and reliably obtain position fixes during the dark night. VFR requirements are shown in Annex C.

A private category flight was being conducted. Of interest is that IFR category appears to have been circled then scrubbed out for NVFR. Figure 5 below presents this.

Figure 5: VH-MDX Flight plan extract: Nominated flight rules. The flight had every reason to proceed IFR as both pilot and aircraft appear to have been certified and current for IFR and the flight was *private* category allowing single-engine IFR. The pilot displayed some confusion regarding the true meanings of the flight rule categories (Image: Australian Government (Department of Transport) 1981).

The flight had every abiltiy to proceed IFR at night as both pilot and aircraft appear to have been certified and current for IFR[1] and the flight was *private* category allowing single-engine IFR.

The Briefing Officer clarified the difference between NVFR (NVMC) and IFR categories leading to a correction as described in figure 6.

(b) The pilot had circled both the "I" and "NV" boxes of the flight plan, apparently being under the impression that NGT VMC was in fact IFR. However, after discussing this aspect with KNIGHT, the pilot decided to make the flight NGT VMC;

Figure 6: Coolangatta Briefing Office/ flight rules selection. (Australian Government (Image: Air Safety Investigation Branch) 1981).

2.6. Notes on Craven intersection/waypoint

There has been much confusion regarding this position in VH-MDX related research over the years. It should be noted that the position Craven (CRV) is a waypoint/ radio navigation aid (navaid) *intersection* and does not refer to the *township* of same name in the area.

No navaid was located at Craven waypoint during the VH-MDX accident nor is there one located there presently[10][11][12]. ‘Craven waypoint’ will be the term used to differentiate this position from the township.

Craven waypoint is important in the VH-MDX conundrum as it was the last flight planned waypoint the pilot ‘passed’ and is the reference for Sydney ATC’s deposed final radar observed position of ‘*approximately 5NM west of Craven*’[13].

Many false assumptions have been made of this position with searches even based on a position 5 NM west of Craven *township,* with the township located some 10NM to the east of the waypoint.

The Craven waypoint position is defined by what the pilot sees with radio-navigation instruments through the intersection of two bearings from ground-based navaids located some distance away.

Contrary to one suggestion[14], there is no significant physical ground feature below the waypoint that the pilot of a night is able to confidently reference from.

Craven waypoint is approximately 1NM south of Mount Berrico, not directly over Mount Berrico as is stated[14] in one VH-MDX analysis. Accordingly, Mt Berrico transceiver station does not offer an exact position reference for Craven waypoint as was suggested[14].

Figure 7: Craven intersection/waypoint. Craven waypoint is defined by bearings taken from at least two navaids; not visual features. Magnetic bearings from Craven waypoint are included on the track lines to various navaids. Taree NDB is on a bearing 059˚M from Craven waypoint whilst West Maitland VOR is on a bearing 186˚M from Craven waypoint. When these bearings are observed on each navaid receiver then the aircraft is at Craven waypoint (Base image: Australian Government (Department of Transport) c.1981).

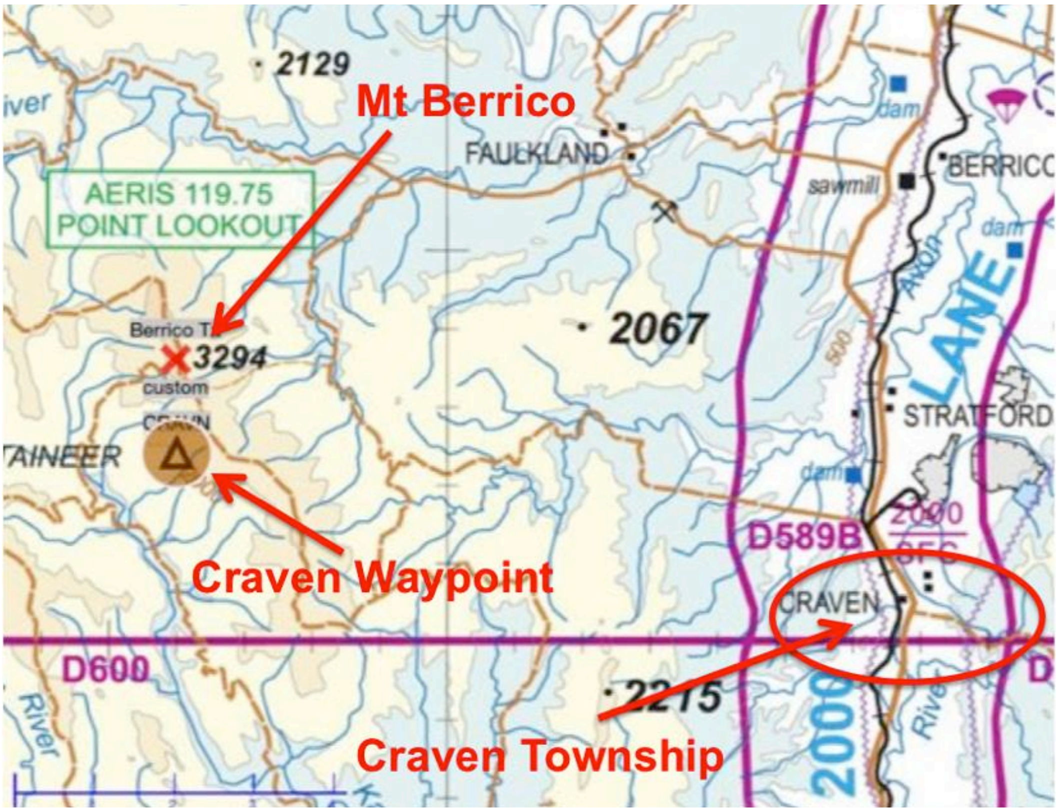


Figure 8: Craven waypoint, Mt Berrico, Craven township. Berrico transceiver station (red cross), Craven waypoint (brown triangle) and Craven township (red oval). Immediately obvious is the distance between Craven waypoint and township (about 9NM-10NM). Mt Berrico transceiver station is located approximately 1NM north of Craven waypoint (Base image: OzRunways 2014).

It is suggested in *Operation Phoenix*[14] the pilot of VH-MDX descended to altitudes below LSALT (Lowest Safe Altitude) to identify the Mt Berrico transceiver station *visually* using aircraft landing lights.

Operating intentionally below LSALT in this manner is also an unreasonable suggestion. One would be hard pressed to locate a pilot with a NVFR or Instrument rating that would perform or even propose such a maneuver.

Also, landing lights generally illuminate objects within a few hundred meters. It is so unlikely that these lights were capable of illuminating the Mount Berrico transceiver station at a safe distance from the aircraft.

In summary, Craven waypoint was not and currently is not a visual geographic position, nor was there a navaid located there in 1981[10][11][12]. Craven waypoint is defined by *crossing bearings from at least two navaids*.

Airservices Australia currently specifies a position of WGS84: S32° 07.6', E151° 46.0'[12] for Craven waypoint and this agrees with a 1993 position from the Civil Aviation Authority[15].

> Craven waypoint is not associated with Craven township: they are separated by approximately 10NM

> Craven waypoint is defined by the intersection of two radio-navigation aid bearings not by visual reference to features on the ground.

2.7. Weather conditions

Contrary perhaps to popular opinion, weather conditions were generally rather *good* within Area's 20 and 40 (north of Sydney to Brisbane) with *clear skies* being the predominate forecast and *reported* visual condition[1][17].

A dark night with strong southwesterly to westerly winds was forecast and reported[1].

Only localised orographic cloud around the western mountain tops was forecast and reported[1].These orographic clouds would have remained 'fixed' over the western to south-western ridgelines.

The appearance of the clouds forming would have been impressive with significant vertical motion obvious and precipitation in various forms including snow beneath.

Figures 9, 10 and 12 present evidence of generally clear skies and only localised cloud from the perspective of pilots airborne in the area over or near the Barrington ranges and of one ASIB inspector.

Pawnchee Hamid, pilot of commuter C.402 VH-ESV reported that on his descent from 9000 feet into Williamtown (commenced at 1913 EST. 5 minutes before MDX's ETA Craven)

he could see the glow of Sydney, the lights of Newcastle and towns in the Hunter Valley. He said that there was no cloud on his track or to the coast but there was a thunderstorm out to sea. (Page 27 refers.)

Barbara Roberts, instructor of NASA, Cessnock reported that there was no cloud on track Cessnock/Singleton/West Maitland/Aeropelican/The Entrance. Her observation confirms that of Pawnchee Hamid. (Page 29 refers.)

Figure 9: Pilot reports of clear skies. It can be seen clear conditions were apparent along the NSW coast north of Sydney. The thunderstorm out to sea was associated with a cold front well out to sea. VH-ESV's track approached Craven from the north (Australian Government (Image: Bureau of Air Safety Investigation) 1983).

The pilot-in-command of an F.27 aircraft transitting the Newcastle area a short time before reported that the conditions were 'Sky clear on the coast and this situation extended for at least 30 nm. inland'. (Report not included.)

Robert Catto, pilot of Cessna 206 VH-AZC about ten minutes ahead of MDX southbound reported: 'There was no cloud at all on the track south and in fact, I doubt if there was any cloud anywhere east of the Barrington Tops. There was a thunderstorm well out to sea from Point Stephens' (ie. near Nelson Bay). (Report not included.)

Figure 10: Pilot reports of clear skies. Further pilot reports of clear conditions along the coast and inland. (Image: Australian Government (Bureau of Air Safety Investigation) 1983).

Formation of the clouds was due to forced lifting by the high terrain (orographic uplifting). Cloud formation on the lee side of the ranges is limited or prevented by the cessation of uplift coupled with the precipitation on the windward side significantly drying the air mass out[19][41]. The image in figure 11 on the following page depicts this.

The author has on a number of occasions observed localised cloud on the southern and western tops of the Barrington ranges with associated rain and even snow but with the greater surrounding areas free of or substantially free of cloud.

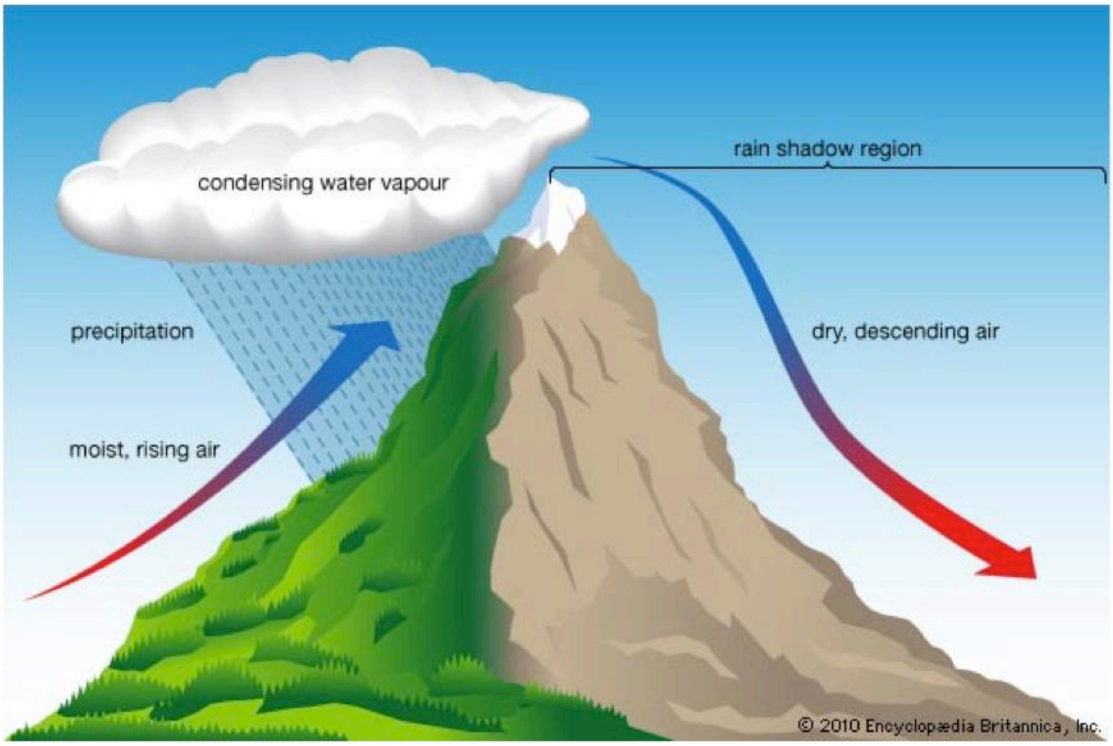
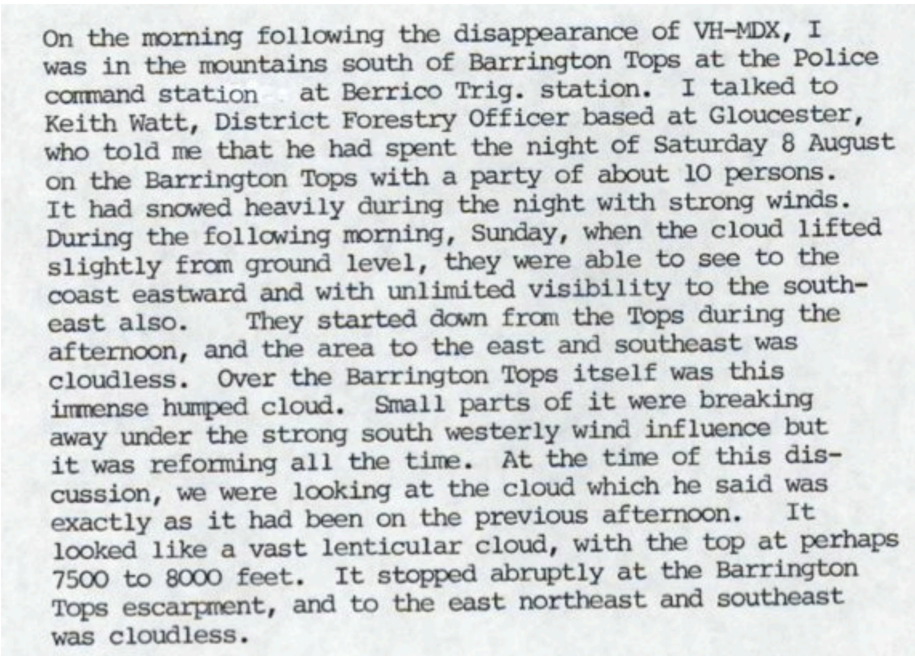


Figure 11: Orographic cloud formation. Orographic cloud stays 'stationary' on the windward side of and on, mountain tops. The lee side is generally clear of cloud or small roll type clouds may be apparent. VH-MDX flew into such cloud over the Barrington Tops area, this being some of the only cloud in the general area (Image: Encyclopedia Britannica 2010).



On the morning following the disappearance of VH-MDX, I was in the mountains south of Barrington Tops at the Police command station at Berrico Trig. station. I talked to Keith Watt, District Forestry Officer based at Gloucester, who told me that he had spent the night of Saturday 8 August on the Barrington Tops with a party of about 10 persons. It had snowed heavily during the night with strong winds. During the following morning, Sunday, when the cloud lifted slightly from ground level, they were able to see to the coast eastward and with unlimited visibility to the south-east also. They started down from the Tops during the afternoon, and the area to the east and southeast was cloudless. Over the Barrington Tops itself was this immense humped cloud. Small parts of it were breaking away under the strong south westerly wind influence but it was reforming all the time. At the time of this discussion, we were looking at the cloud which he said was exactly as it had been on the previous afternoon. It looked like a vast lenticular cloud, with the top at perhaps 7500 to 8000 feet. It stopped abruptly at the Barrington Tops escarpment, and to the east northeast and southeast was cloudless.

Figure 12: Cloud in the Barrington Tops area. This report the day after the accident clearly suggests orographic localised cloud in the Barrington Tops ranges and clear skies in surrounding areas (Image: Australian Government (Bureau of Air Safety Investigation) 1983).

A cold front moving east and aligned roughly north-north-west/ south-south-east passed through the Barrington Tops area about 9 hours *prior* to the accident[1][18].

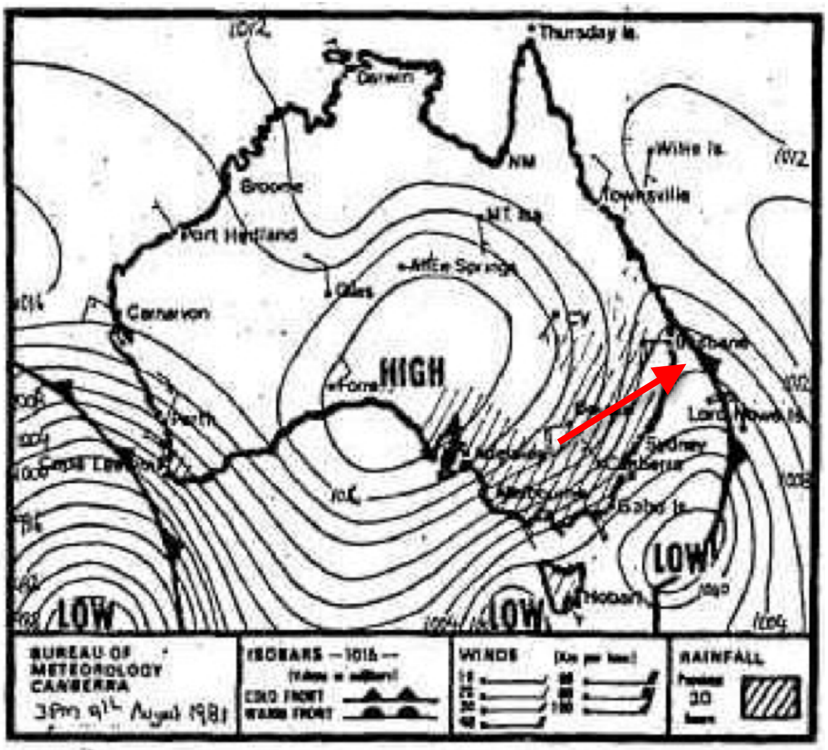


Figure 13: Synoptic MSL chart 1500EST (0500UTC) 9th August 1981. VH-MDX entered the Barrington Tops area approximately four and a half hours after 1500EST (1930EST/0930UTC). The author has included the red arrow to indicate very approximately the aloft wind direction in the Barrington Tops region. A south-west flow is indicated. Reasonably close isobars suggest strong winds. The cold front had well and truly passed by the time of the accident resulting in winds backing and generally clear skies. Although rain is depicted, *specific* area and location forecasts in addition to actual reports show that rain seemed only to be associated with localized orgographic uplift. It must be remembered clear skies were predominate (Australian Government (Bureau of Meteorology) 1981).

Figure 13 shows the weather synoptic situation approximately four and one half hours before the accident. The cold front is clearly out to sea in the mid to northern NSW area. By the accident time, the cold front would have moved further east seaward.

During the time of the accident, contrary to some suggestions of a '*giant storm front*'[16] and '*incoming bad weather*'[16] there was *no* such *frontal* weather like a line of squall or similar over the Barrington Tops; the frontal weather was long gone out to sea as described and generally clear skies with localised orographic cloud was apparent[1][17][18].

An aircraft just ahead of VH-MDX at the same altitude flying almost the same route stated the weather was '*so pleasant*' and visibility '*so good*' but did report moderate turbulence prior to Coffs Harbour[1]. Accordingly, conditions were generally suitable for NVFR procedures.

Turbulence would be expected and was forecast[1] along the NSW east coast resulting from a strong south-westerly to westerly wind blowing across the Great Dividing Range. This would have generated significantly disturbed airflow downstream of the Great Divide along the coast.

Specifically, *severe* turbulence was forecast below 12000'AMSL over the eastern sections of mountain tops with mountain waves also indicated in a SIGMET (significant meteorological information advisory concerning safety of aircraft)[1]. Figure 14 on the next page depicts how mountain waves are generated.

A south-westerly to westerly wind of 30-50 knots, not inclusive of gusts, has been found as the likely wind VH-MDX was subject to around the Barrington Tops area[17].

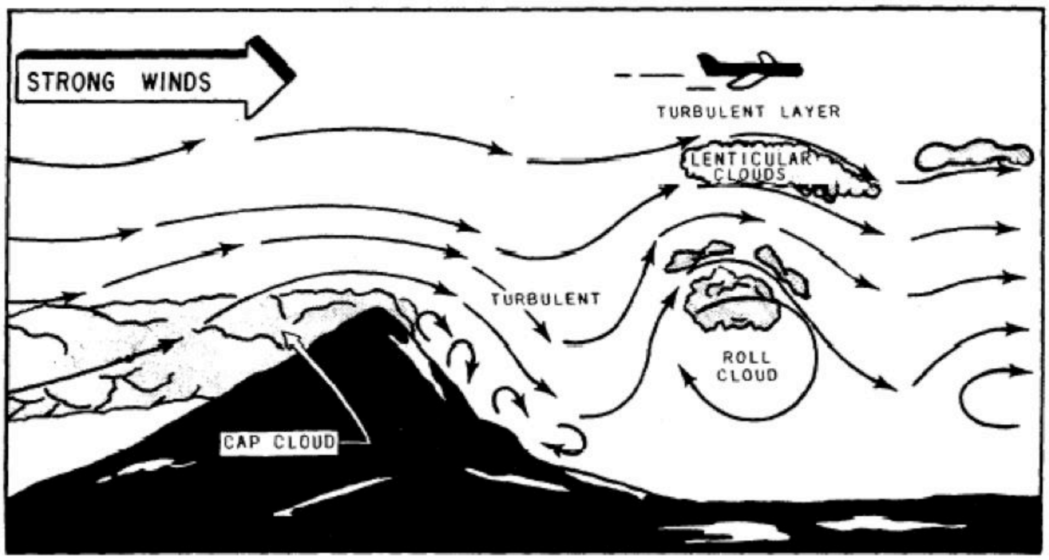


Figure 14: Mountain wave generation. Strong winds are disrupted by significant vertical terrain. Orographic cloud is formed on the windward side of the ranges. On the lee side, rotor and 'wave' type wind flows may be formed generating turbulence by the nature of their varying flow directions and at times highly localised clouds (Roll and Lenticular Clouds). Even if true rotors are not formed, the terrain disruption will likely cause turbulence (Image: http://www.tpub.com/weather2/3-25.htm).

Temperature deviation was forecast to be around ISA-4°[1] and based on the statement of one pilot near Williamtown, was calculated as ISA-1°[1].

A thunderstorm was reported as being located well offshore Port Stephens[1]. This would have been associated with the cold front that was at sea.

Any suggestion of *widespread* poor weather and conditions generally unsuitable for visual flight should be ignored.

2.8. Air Traffic Services (ATS) involved

There were three main ATS units involved in the VH-MDX accident during the final leg from Taree[1][20][21]:

- Sydney Flight Information Service 5 (FIS-5)
- Sydney Sector 1 (Area Control Service, radar)
- RAAF Williamtown ATC

Sydney FIS-5 was the sole ATS agency in communications with VH-MDX throughout this period[1]. FIS provides *advice* and *information* to assist achievement of safe and efficient flight rather than the *direct* control of aircraft as ATC does[22]. There was no radar display at the FIS-5 position[20].

Figure 15 presents relevant Flight Information Area (FIA) and controlled airspace boundaries. FIS-5 was responsible for an area Sydney- Bankstown – Quirindi – Crowdy Head (near Taree) – Sydney in 1972 and it is assumed the same for 1981[50].

Sydney Sector 1 was responsible for lower altitude airspace (generally below 10000'AMSL) outside of 30NM Sydney to the north bounded approximately by Calga, Singleton, West Maitland and Aeropelican[20]. At times, Sectors were amalgamated depending on workload[20].

Normal manning for Sector 1 was two ATCO's: a Procedural Controller and a Radar Controller[20]. The Procedural Controller was in charge of the Sector[20][23]. Both controllers sat next to each other[20][23].

The Procedural Controller co-coordinated aircraft within the sector and worked at the procedural desk[20][23] whilst also observing the radar display[20]. The Radar Controller sat in front of the radar display monitoring radar information[20]. At times, the two positions were consolidated into one [20].

Multiple ATCO's were present at the Sector 1 position after the pilot of VH-MDX reported entering cloud without primary attitude and heading instrumentation[20].

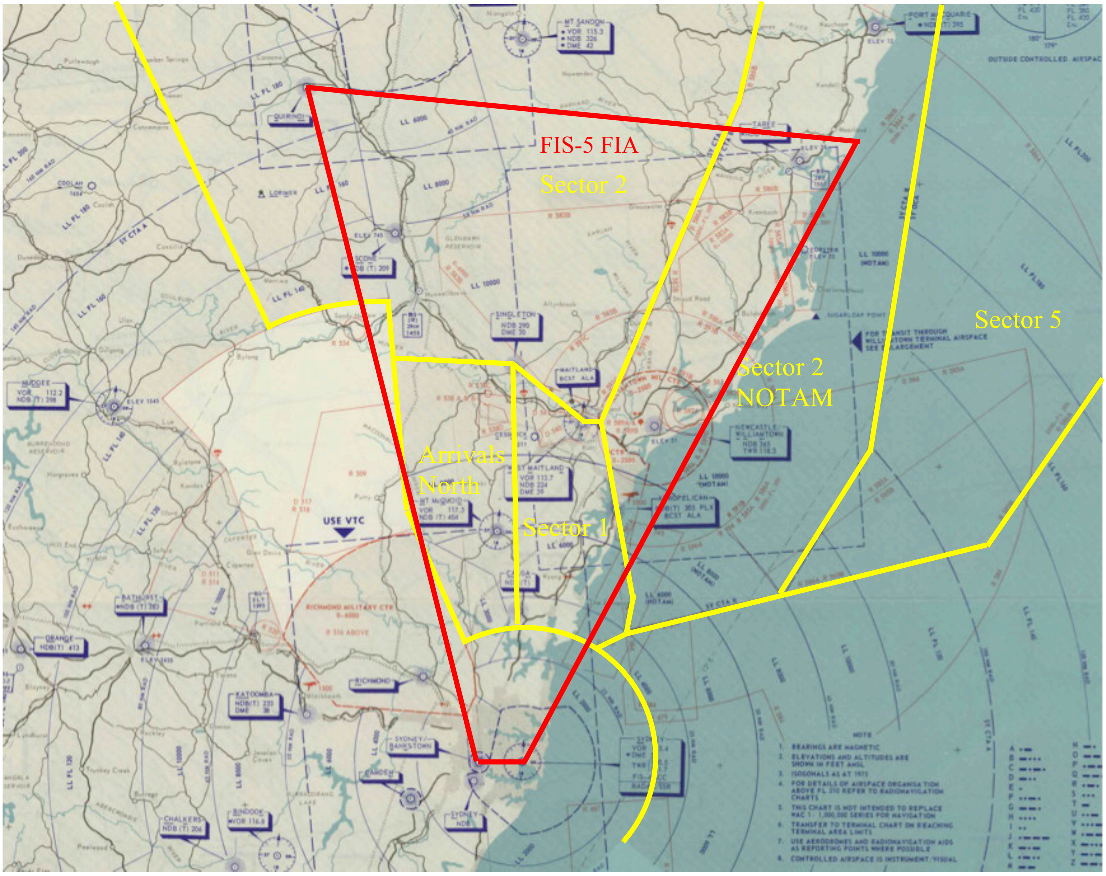


Figure 15: Sydney Area control boundaries 1981 (yellow) and Sydney FIS-5 Flight Information Area (FIA) boundary 1972 (red). From Taree, VH-MDX was OCTA beneath Sydney Sector 2 airspace and to the north of Sydney Sector 1 (Base chart: Australian Government (Department of Transport) 1981, additions: Glenn Strkalj 2015).

Williamtown ATC had one ATCO on duty during the night of the VH-MDX accident located in the control tower[21]. Procedural (non-radar) control was being used however, the ATCO asked for the radar to be switched on for better situational awareness[21]. A radar display was available to the Williamtown ATCO in the control tower[21].

After Taree, Sydney FIS-5 was the only ATS agency to communicate with VH-MDX.

VH-MDX was OCTA from Taree onwards. Sydney controlled airspace was above (10,000') and to the south (Singleton) of VH-MDX.

Procedural (non-radar) control was in-force at Williamtown: monitoring the radar display was <u>not</u> a requirement.

2.9. Radars involved

Three radars of interest have been identified that may have contributed to positional information of VH-MDX in the final 15 minutes of flight[20][21].

The exact geographical locations of all three radar heads have been confirmed or determined with high confidence[20][21]. Radar system and read-off tolerances have been determined to a *reasonable* level of confidence[20] [21].

All three radars had Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR) capability[20][21]. The radar heads were[20][21]:

- Sydney Route Surveillance Radar (RSR)
- The Round Mountain RSR (remote head operated by Sydney ATC)
- RAAF Williamtown SURAD (Surveillance Radar) Terminal Approach Radar (TAR).

The first two were operated by Sydney ATC[20]. Figure 16 on the next page presents a map with the positions of the three radars.

The confirmed *display* 'program' used by Sydney Sector 1 during the accident was the *Northern Mosaic* shown in figure 17[20]. This program combined the information from both Sydney and The Round Mountain RSR's to be displayed on one display[20].

RSR's have a relatively *slow* sweep rate of 12 seconds[20][23] (per 360˚ rotation of the antenna) and are used for enroute (between major airports) work[20][23]. This would have made tracking VH-MDX somewhat more challenging than using a TAR.

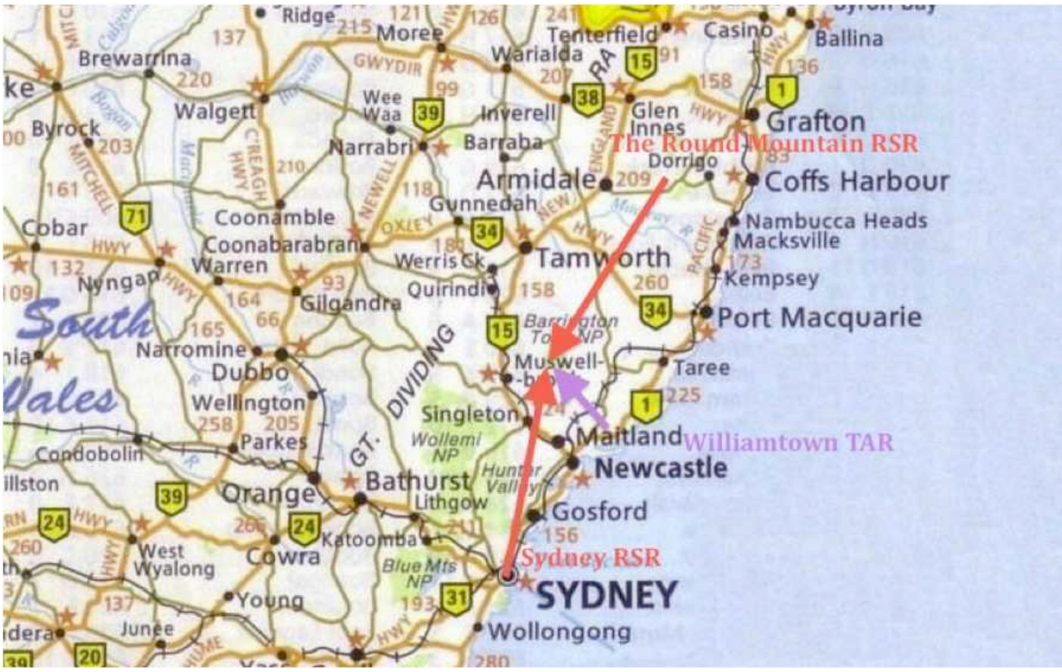


Figure 16: Relevant radar head locations. The Round Mountain RSR and Sydney RSR were operated by Sydney ATC (red arrows). Immediately obvious is how much closer to VH-MDX Williamtown TAR was. Despite this, as will be discussed only a single *complete* radar fix was obtained by Williamtown TAR (Base Map: Melway Publishing Pty Ltd 2014, additions: Glenn Strkalj 2014).

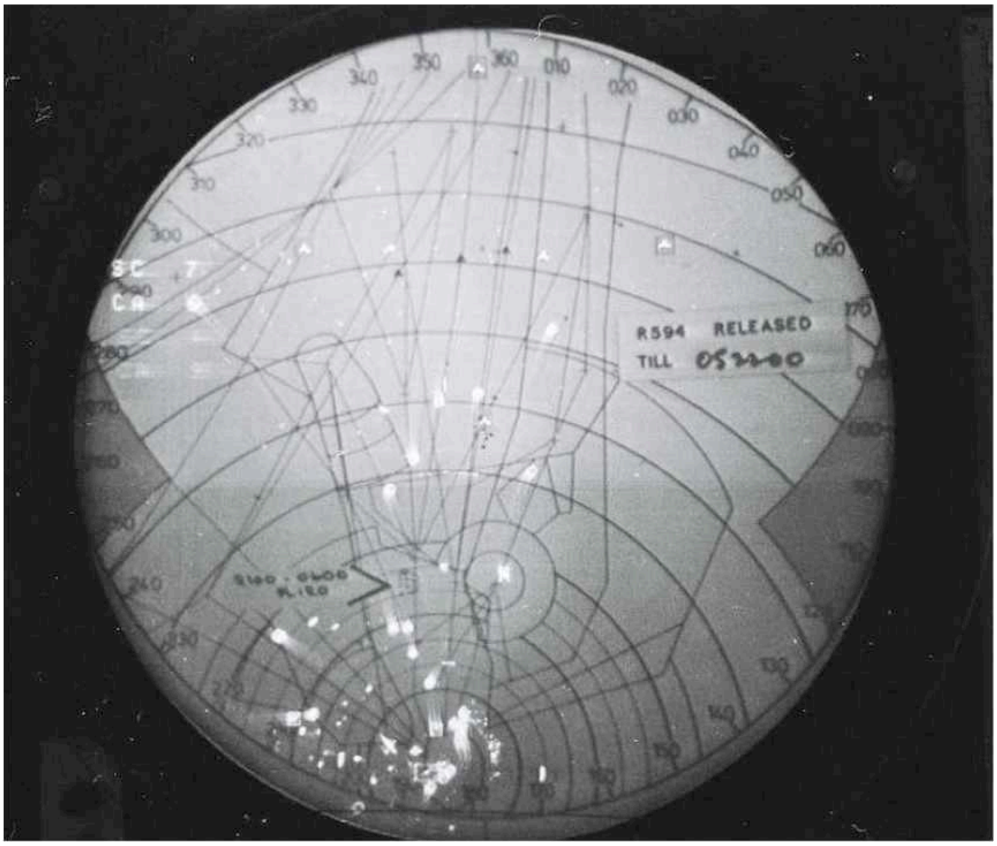


Figure 17: Northern Mosaic display program. Both the Sydney RSR and The Round Mountain RSR were used to ‘feed’ this particular display program although, if both radar heads painted a single target, only one radar head was selected to provide display information at any *single time.* Range rings from Sydney are displayed at 10NM increments to 90NM. 30NM rings are displayed throughout. Control area boundaries are also displayed (Photo: M. Price c.1983).

Both The Round Mountain and Sydney RSR's had a maximum certified range of 160NM[20][23] at high altitudes (above 20000'AMSL)[20]. Aircraft at lower altitudes would be subject to shorter radar range as a result of Earth curvature or terrain masking.

It was shown how the Sydney RSR was highly unlikely to contribute to VH-MDX radar positions as a result of terrain masking and Earth curvature[20]. The Round Mountain RSR was shown able to interrogate VH-MDX at altitudes below 10000'AMSL at various VH-MDX radar fix positions[20].

Even though VH-MDX was at a similar range from either Sydney RSR or The Round Mountain RSR, the latter had an advantage in that it was mounted atop a mountain almost 5200'AMSL in elevation offering excellent line-of-sight ability[20]. Comparatively, the base of the Sydney RSR tower was almost at sea level[20].

Williamtown SURAD was configured as a TAR with a 4 second sweep and was used for terminal work (within about 30NM of the aerodrome)[21]. SURAD had a maximum range of 96NM although the 48NM range display was selected during the accident[21].

The Williamtown radar display shown in figure 18 was a simple Plan Position Indicator (PPI) rather than the more complex map and scan converter display at Sydney ATC[21].

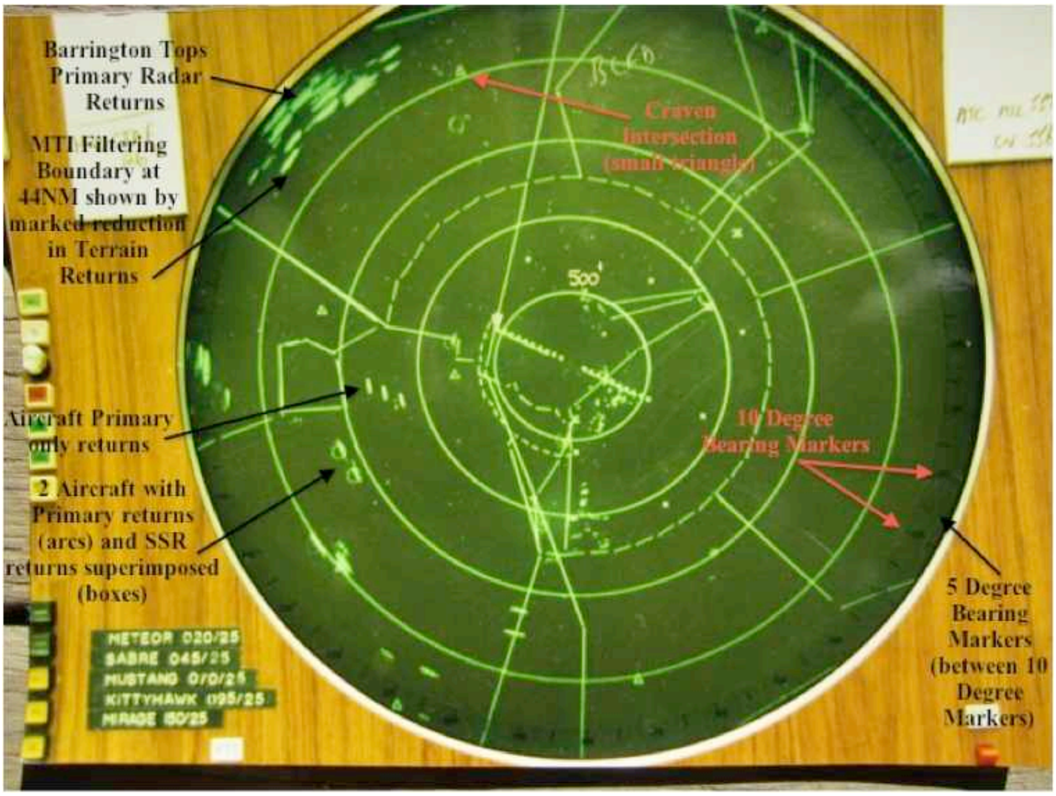


Figure 18: RAAF Williamtown *Approach* room SURAD PPI. North is at the top of the PPI. The compass rose on the circumference displays bearing in 10º increments with 5º markings in between. 10NM spaced rings are displayed to determine target range whilst airspace boundary markings and reporting points (small triangles) are also displayed. To the north-west from around 43NM are the permanent echo terrain returns of the Barrington Tops (Photo: H. Howard c.1983).

Three radar heads were *potentially* involved in the VH-MDX accident: two used by Sydney, one by Williamtown.

Only <u>one</u> Sydney ATC radar could interrogate VH-MDX below 10000'AMSL in the known radar fix positions: The Round Mountain RSR.

2.10. Recording of radar tracks

Unlike contemporary systems, it has been stated neither the Sydney Bright display system nor the Williamtown SURAD TAR system had radar track recording capability[20][21].

Despite this, the author has located a radar data recorder of early 1970's vintage apparently associated with the Thompson CSF/ Bright display system. Research is on going and the recorder may have been associated only with approach/departures and terminal area displays or being trialed at the time of accident.

Alternatively, radar data other than *track information* may have been recorded.

'*Equipment to record digitised radar data*' was installed in Sydney, Perth and Melbourne by mid 1983[52] however, the exact date has not been confirmed yet.

As the radar recorder located had a 'Department of Transport, Air Transport Group' label riveted to it and considering this department only existed between November 1973 and February 1977[53], this indicates the radar recorder existed from at least this period. Figure 19 below presents the label and figure 20 on the next page shows the recording unit.

It cannot be confirmed which airport this recorder was removed from however it is likely to be Melbourne. Regardless of the airport, the information above suggests existence of radar track recording equipment from the 1970's.

Figure 19: Radar Recorder Label. 'Air Transport Group' existed between 1973 and 1977 thus, suggesting this recorder was in the department's inventories at least by this period. This does not necessarily mean the recorder was in operational use (Image: Glenn Strkalj, 2015).

Figure 20: Radar Recorder unit. The unit is a SE7000 data recorder labeled 'Radar Recorder' (Image: Glenn Strkalj 2015).

2.11. Final radar fade of VH-MDX

It was stated by an ATCO that he was informed that the *Sydney* radar ATCO's made a clear observation of the VH-MDX radar fade position[20]. Although not completely sure, the ATCO seems to recall being informed that the paints of VH-MDX were observed to gradually slow down in the final leg[20].

The *Williamtown* ATCO did not observe final fade of VH-MDX as he was conducting procedural control duties away from the radar display[21]. Procedural control did not require observation of the radar display by the Williamtown ATCO[21].

2.12. Communications

From section 2.8, Sydney FIS-5 on 121.6MHz, was the only Air Traffic Service (ATS) agency to communicate with VH-MDX after Taree[1][24]. FIS-5 received the final recorded transmission from VH-MDX at 0939:26UTC being '*Five thousand*'[1].

The ground transceiver station for FIS-5 was located on Mt Berrico[24] approximately 1NM north of Craven waypoint. 121.6MHz lies in the Very High Frequency (VHF) band that is generally line-of-sight reliant but also has excellent diffraction propagation modes around terrain[24].

Following acknowledgement of the '*Five thousand*' call, FIS-5 next attempted communications with VH-MDX at 0940:38UTC (approximately one minute after the final received call from VH-MDX) then again at 0941:39UTC[1][24].

QF26 was the first airborne aircraft to attempt communications with VH-MDX[24] at 0951:32UTC[1] approximately twelve minutes after the final received call from VH-MDX.

An internal ATS communications line not unlike a normal telephone system with conference call ability, connected the various ATS agencies together[20][21]. This enabled co-ordination of aircraft clearances, discussion of weather and liaison in times of emergency.

Both radio and ATS internal communications lines were recorded as is evident in ASIB communications transcripts[1]. Multi-channel reel-to-reel recorders most probably of the Magnasync brand were used.

The first attempt to communicate with VH-MDX following the final received call of 'five thousand' was just over a minute later at 0940:38UTC.

2.13. Communications transcripts and recordings

Communications transcripts drafted by ASIB transcribe communications between:

- FIS-5 and VH-MDX
- FIS-5 and Sector 1
- Sector 1 and RAAF Williamtown
- Various other Sydney ATC positions between each other and also between RAAF Williamtown
- Various enroute Flight Service stations and VH-MDX

These exist in a variety of forms in the BASI (Bureau of Air Safety) archives including typed and freehand. There are also slightly differing timings or words for the same transcript at times.

In this document, the source that is perceived to be most precise will be chosen and used. This means using different transcripts for different tasks as each transcript has peculiarities.

For instance, *written* transcripts have been found to contain fewer wording errors in many cases than those that are typed. The ASIB Spectrographic Unit's transcript is viewed as specifying the most precise timings although this transcript does not contain all ATS agencies (e.g. Williamtown).

Actual audio recordings have only been found so far to exist in compact cassette or digital audio file format. It is believed the magnetic recording media that stored the original audio was erased and returned to service.

Audio recordings found by the author so far have all been of the same stations; FIS-5, Sector 1, VH-MDX and RAAF Williamtown. Interestingly, key conversations such as:

- 320˚M/45NM radar fix
- 330˚M bearing call
- Sydney radar fade
- Williamtown check on radar for VH-MDX with no paints;

Are <u>not</u> apparent on these audio recordings.

2.14. Communication time stamps

There has been no method found so far to independently and absolutely verify timings of ATS recordings. Nolan in *Operation Wittenoom VH-MDX Research*[25] does present a reasonable case suggesting the timings of recordings should be taken as accurate.

Chessor[26] on the other hand exposes the problems associated with using compact cassette versions of audio recordings in determining timings of calls highlighting the timing variability possible.

As there are no recordings available on the *original medium* used, nor are there *quality* and verifiable compact cassette recordings of the audio available to the author, a critical assessment of timing has not been carried out.

It is assumed the ASIB reported timings in *transcripts* are correct based on the expectation that appropriate standards, procedures and equipment were in place to ensure accuracy of recording timings.

A +/- 30 second tolerance based on the aviation industry standard for pilot time-keeping[27] is assumed as an <u>absolute maximum</u>. It is expected that communications recordings were required to conform too *much, much smaller* tolerances likely in the order of seconds. +/-5 seconds is accepted as the maximum expected recording deviation.

It is assumed ASIB transcripts reflect actual times within at least 5 seconds. The transcripts prepared by the ASIB's *Spectrographic Unit* have obviously been refined in terms of timings associated to specific calls down to the second and are viewed as the most accurate.

2.15. Electronic Locator Transmitter (ELT)

VH-MDX was fitted with an ELT capable of automatically transmitting an emergency signal on 121.5MHz following sensing of a certain 'G' value in the longitudinal axis[1][9]: provided the unit was armed and serviced correctly.

ELT transmissions were *not* detected by aircraft overhead the Barrington Tops area when flying over shortly after the final received communications transmission from VH-MDX[1].

2.16. Flight path: Taree to Williamtown 320˚M/45NM radar fix

Flight progress prior to Taree appeared *normal* then, after Taree accident events started to unfold.

From Taree, VH-MDX likely tracked south towards Williamtown for a short interval then in a generally westerly direction towards the Moonan Brook area located approximately 10km to the north of Mount Barrington.

It was in the area around Moonan Brook that VH-MDX was first identified by Sydney ATC radar at approximately 36NM north of Singleton NDB (Non-Directional Beacon) just west of the Singleton NDB to Mount Sandon NDB track[1][20]. This was fix was made around 0928:45UTC[1][20].

From this position, VH-MDX was observed on Sydney radar to track in a generally southerly direction[1][20]. This was followed by a radar observed *slow* turn to a generally easterly track[20].

As VH-MDX was tracking toward an area of suspect radar coverage and towards the Williamtown area in any case, Sydney requested Williamtown ATC to locate VH-MDX on the nearer located Williamtown ATC radar[1][20].

VH-MDX was observed on the Williamtown ATC radar at approximately 0936:00UTC at a position of 320˚M/45NM (+4˚/-2˚, +2NM/0NM) from Williamtown[1][21].

This was the only *complete* and *confirmed* radar fix obtained by Williamtown ATC[21] and was approximately three and one half minutes before the final received radio call from VH-MDX[1]. Following this, the *exact* direction VH-MDX tracked in is open to opinion.

> Only one *confirmed, complete* radar fix from Williamtown ATC currently exists: The 320˚M/45NM fix at 0936:00UTC

2.17. Conundrum after the 320˚M/45NM fix

An ATS call recorded in transcripts implying VH-MDX was on a bearing of 330˚M from Williamtown at 0938:30UTC and a heading suggestion at around 0939:00UTC of 150˚M from Williamtown (to track VH-MDX to Williamtown)[1] were both not remembered by the Williamtown ATCO in 2014 thus, not allowing any refinement of these positions[21].

Additionally, two ‘final’ radar positions are recorded in archives some 10NM apart and this is considered significantly outside of radar tolerances if it assumed both radar positions are representing the same position of VH-MDX in terms of time[21].

A Sydney Air Traffic Control Officer (ATCO) deposed that the final observed *Sydney* ATC radar position of VH-MDX was approximately 5NM west to north-west of Craven waypoint[13].

BASI archives on the other hand reveal a ‘final’ radar position located in the Upper Williams River Valley based on *Williamtown* radar[1].

Unlike the *initial* Sydney radar fix and the 320˚M/45NM Williamtown fix neither of the ‘final’ radar fixes of the previous paragraph are *completely* defensible in terms of origin and likeliness although the Sydney final radar position has many more positives[20][21].

A Sydney ATCO and the Williamtown ATCO both ‘feel’ VH-MDX was tracking generally *easterly* but were not completely certain given the thirty plus years from the accident[20][21]. The Williamtown ATCO made a statement shortly after the accident stating he got the impression that VH-MDX was tracking towards the east[21].

Intermittent radar coverage would have been experienced by Sydney ATC from the initial fix to end of flight[1][20] that, coupled with a slow sweeping enroute radar and possible weather clutter, would have made *accurate* track determination difficult[20].

2.18. Importance of final track

The 320˚M/45NM Williamtown fix has been found to be the most reliable, latest, radar position obtainable of VH-MDX[21]. Consequently, it is the approximate three and one half minute period from this position to the last radio call from VH-MDX where the tracking of VH-MDX is of high interest.

Determining aircraft tracking trends in this period will narrow down search areas *significantly* and this is of high importance given the substantial terrain and vegetation of the Barrington Tops area.

2.19. Research

Assumptions are an important and necessary component of VH-MDX analysis. Despite this, it is the role of researchers to minimise the number and depth of assumptions whilst ensuring that the assumptions remaining are as relevant as possible.

More often than not, the author has found that VH-MDX research appears to have been conducted to a level where the incumbent is satisfied with the outcome based on limited knowledge. This outcome then remains as the base level to support assumptions leading to flawed conclusions.

Even whilst searches are being conducted in areas of high probability, research should be on-going pushing in different directions until the aircraft is found.

Proliferation of correctly documented research will likely catalyse the interest of subject matter experts or people with alternative approaches to fill in gaps of missing information or data or, at the very least, minimise the depth of assumptions. It is through this approach that VH-MDX will be found.

3. Flight path breakdown

3.1. Introduction

This section will take a closer look at various stages of VH-MDX’s flight path from Coolangatta to the final received radio call. Known information will be presented and some suggestions will be made as to what may have occurred at various times.
The suggestions will hopefully stimulate some thought that may then result in more defensible conclusions.

Figures 21 and 22 on this and the following page graphically show VH-MDX's intended and predicted flight paths. Actual Time of Arrivals (ATA's) at the various fixes enroute are also presented.

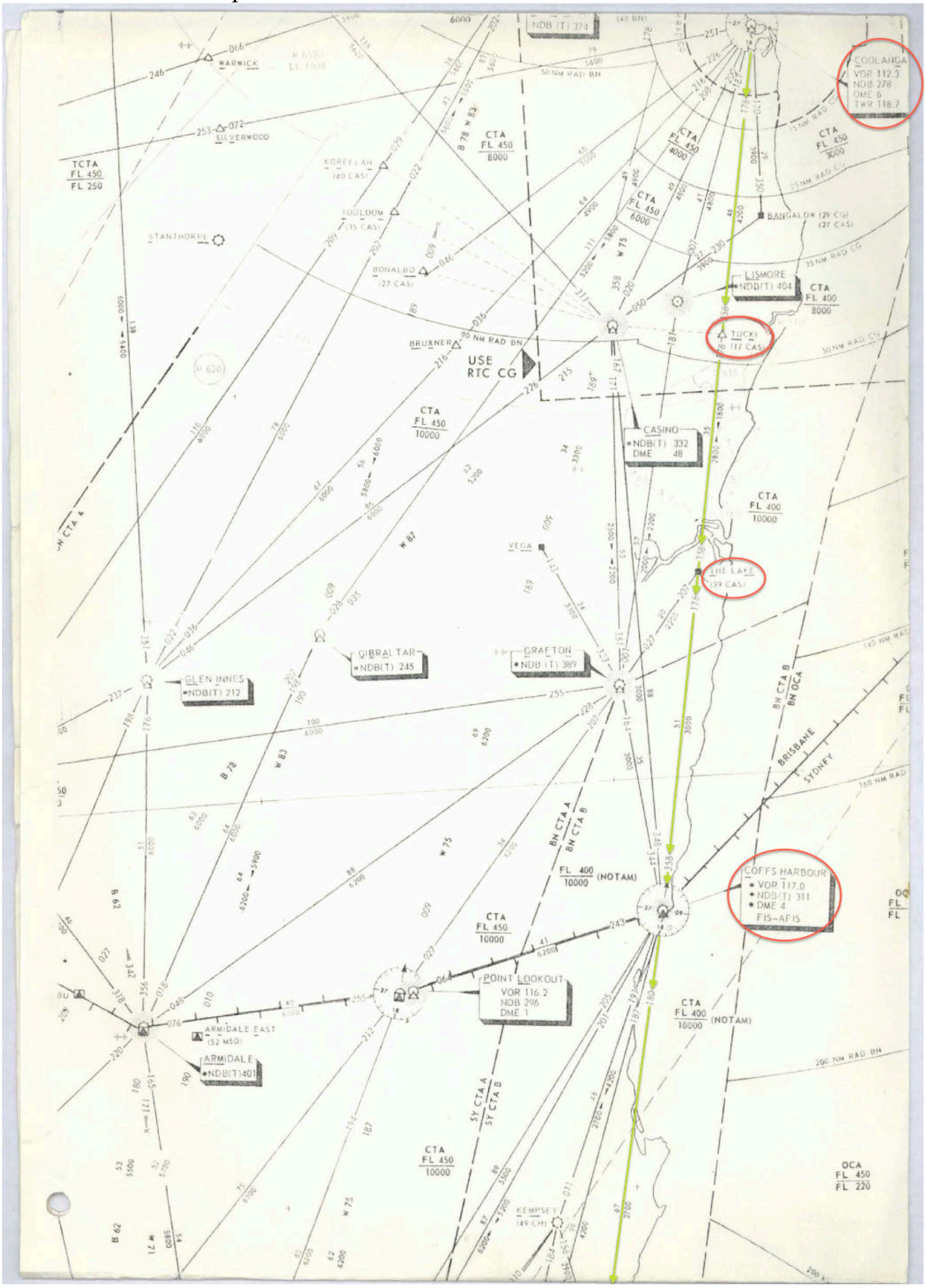
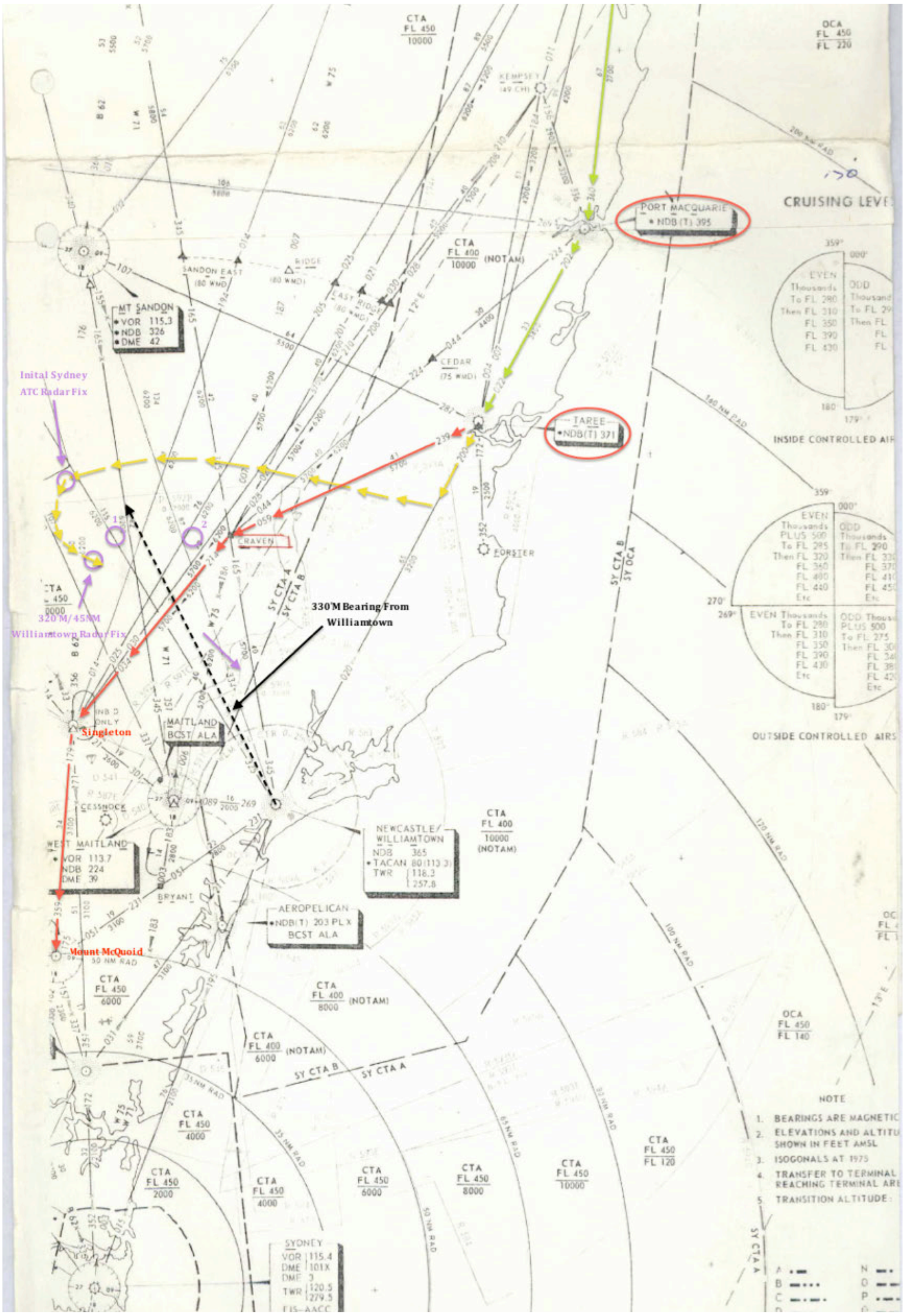


Figure 21: Flight progress Coolangatta-Coffs Harbour. Green arrows represent VH-MDX's track. VH-MDX appeared to progress normally between Coolangatta and Coffs Harbour. Tracks and distances are marked on the chart from each waypoint/navaid. Tracks marked are in degrees *magnetic* whilst distances are in Nautical Miles (NM) (Base image: Australian Government (Department of Transport Australia) c.1981).



Scone NDB

Figure 22: Flight progress Coffs Harbour onwards. Green arrows represent actual flight path, yellow one possible flight path and red the original flight plan route from Taree. Radar positions are represented with purple circles with circle '1' being the ASIB/RCC final radar position, circle '2' being the Sydney ATC deposed final radar position. The 330˚M bearing from Williamtown is also shown. The position of Scone NDB is indicated off the chart with a black star (Base image: Australian Government, (Department of Transport Australia) c.1981).

3.2. Coolangatta to Taree: (0701:00UTC-0850:00UTC)

3.2.1. Overview

Normal operations were apparent between Coolangatta and Taree. VH-MDX climbed to 7500’ and cruised at this altitude until Coffs Harbour where the aircraft climbed to 8000’ to meet quadrantal cruising altitude requirements.

FIS-5 asked VH-MDX at Taree if the pilot preferred a clearance through Williamtown airspace to which the pilot of VH-MDX agreed. ATS agencies commenced processing the airways clearance.

3.2.2. Coolangatta to Coffs Harbour

VH-MDX appeared to have proceeded normally from Coolangatta to Taree. Departure from Coolangatta was reported as 0701UTC and an estimate for Tucki given of 0725UTC[1]. Coolangatta ATC shortly after directed a transfer to Brisbane Control on 123.0MHz[1].

VH-MDX was climbing to 7500’ and was radar identified by SPI (Special Position Identification) ident at 0708UTC[1]. A report of VH-MDX maintaining 7500’ was received by Brisbane Area Approach Control Centre (AACC) at 0713UTC[1].

A frequency change occurred at position Tucki at 0724UTC when the pilot of VH-MDX contacted Brisbane Flight Service Unit (FS-4) on 120.7MHz[1]. Actual time of Arrival (ATA) at Tucki was given as 0724UTC (1 minute early) and an Estimated Time of Arrival (ETA) for The Lake was given as 0740UTC[1].

VH-MDX transferred to Coffs Harbour Flight Service-1 (FS-1) on 122.1 or 124.6MHz at The Lake[1].

3.2.3. Coffs Harbour to Taree

On the Coffs Harbour FS-1 frequency, VH-MDX reported an ATA for The Lake at 0740UTC (on time) and was at 7500’ estimating Coffs Harbour at 0803UTC[1].

The pilot of VH-MDX discusses a Sydney SIGMET (Significant Weather) regarding occasional severe turbulence below 12000’ and mountain wave activity followed by cruising altitude options after Coffs Harbour of 6000’ or 8000’AMSL[1].

Such conditions would be expected on the coast after the strong west to southwesterly winds were disturbed by blowing over the Great Dividing Range as described in section 2.7.

Unlike today where *hemispheres* and *whole* thousand foot altitudes are used for all cases, in 1981 cruising heights for VFR (Visual Flight Rules) aircraft Outside Controlled Airspace (OCTA) were determined by *quadrants* of planned magnetic track and were odd or even whole thousand foot altitudes or odd/even thousand foot altitudes plus 500 feet[11][22]. Figure 23 and Annex D presents this information.

VH-MDX was OCTA for most of the flight[1][10]. The track from Coolangatta to Coffs Harbour was 178˚M[10] therefore requiring *odd* thousands *plus* 500’ (with VH-MDX using 7500’). From Coffs Harbour to Singleton the tracks were south to south-west[10] therefore requiring an *even whole* altitude (with VH-MDX using 8000’).

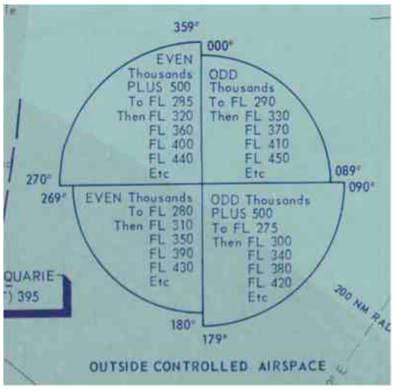


Figure 23: OCTA cruising quadrants. (Base image: Australian Government, (Department of Transport Australia) 1980).

VH-MDX arrived at Coffs Harbour 2 minutes early at 0801UTC, maintaining 7500' estimating Port Macquarie at 0828UTC[1]. Coffs FS-1 advise there is no traffic at 8000' and VH-MDX climbs to this new cruising altitude by 0803UTC[1].

At 0828UTC VH-MDX advises a Revised ETA (RETA) for Port Macquarie of 0832UTC (+4 minutes)[1]. VH-MDX reports an ATA Port Macquarie of 0832UTC whilst also advising an altitude of 8000' and a Taree ETA of 0848UTC[1].

Just after 0850:30UTC, VH-MDX transfers to Sydney Flight Information Service-5 (FIS-5) on 121.6MHz and reported an ATA at Taree of 0850UTC (+2 minutes) and estimating Singleton (SGT) at 0930UTC[1]. FIS-5 is the final ATS agency that VH-MDX would remain in communications with[1][24].

3.2.4. Derived winds

The figure below presents information for the relevant legs flown to Taree excluding the climb (initial) leg. Ground speeds are derived from the pilot's ATA's and rough wind velocities suggested.

Attempts are made to reflect the Area Forecast (ARFOR) winds in either direction or speed from base data to enable simple comparison. The winds found approximate ARFOR winds reasonably well.

Leg	Time Interval	Distance	Course	Ground Speed	Special Conditions	Wind Suggestions
TUK-TKE	16 min	35NM	178˚M	131kts	-	240˚M/55kts 180˚M/30kts
TKE-CH	21min	51NM	178˚M	146kts	-	240˚M/40kts
CH-PMQ	31min	67NM	180˚M	130kts	500' climb	240˚M/50kts or: 225˚M/40kts
PMQ-TRE	18min	33NM	202˚M	110kts	-	240˚M/60kts or: 200˚M/55kts

Figure 24: Ground Speed and wind suggested from communication transcript timings. It should be noted that delays in reporting ATA's and/or rounding ATA's would result in noticeable changes to ground speed and therefore calculated wind. The derived winds are coarsely indicative of forecast winds.

3.2.5. Williamtown airspace clearance

Just prior to 0951:00UTC, FIS-5 asked if VH-MDX would prefer a clearance via Williamtown rather than proceeding via the planned inland dogleg over Craven waypoint and Singleton NDB[1].

The pilot of VH-MDX answered that he would prefer to proceed via Williamtown and gave an estimate of 0920UTC overhead Williamtown[1].

Williamtown ATC *immediately* offered a clearance to VH-MDX (via FIS-5) to track via Williamtown however, the clearance was rightfully held up by Sydney ATC who were unsure of the weather conditions within Sydney's airspace through which VH-MDX would exit into from Williamtown[1]. This is shown below in an ASIB communications transcript extract in figure 25.

TIME (GMT)	FROM	TO	TEXT
	FIS 5	WM	Mike Delta Xray a Cessna 210 night VMC was Taree at five sero eight thousand would prefer "clearance via Willie" estimating overhead Willie at two sero he's bound Bankstown, I'll check with Sector one, can he expect a clearance through your areas.
0852.22	WM	FIS 5	Why not. Two sero overhead Williamtown at two sero confirm.

Figure 25: Williamtown response to clearance request. It is immediately obvious there is no delay or impedance from Williamtown ATC regarding a clearance for VH-MDX through Williamtown airspace. This is contrary to the recent claim (2014) by Dick Smith that it was Williamtown ATC that held up VH-MDX (Australian Government (Air Safety Investigation Branch) 1981).

The question arises then, why VH-AZC less than ten minutes ahead of VH-MDX obtained a fast clearance and tracked through Williamtown and Sydney airspace with relative ease. The answer lays in the flight rules the pilot's nominated for their respective flights.

VH-AZC was operating to the IFR (Instrument Flight Rules), which signifies that the pilot and aircraft are both certified and current in terms of experience and equipment serviceability to operate the flight *into cloud*.

VH-MDX was operating to NVFR (Night Visual Flight Rules) allowing flight only in *visual* conditions, clear of cloud and in sight of ground or water when below a certain altitude. It can then be seen why VH-AZC appeared to 'sail through' Williamtown and Sydney controlled airspace whilst VH-MDX was subject to delays as ATS agencies ensured the flight *could progress safely* in accordance with NVFR requirements.

Section 2.5 also identified that both VH-MDX and it's pilot appeared to have had the *ability* to operate IFR but NVFR was chosen.

A point that must be made here is that ultimately it is the pilot's responsibility to ensure the appropriate flight rules are adhere to however in controlled airspace there is a shared responsibility to some degree.

It was suggested on one Network 7 VH-MDX television documentary that the RAAF delayed VH-MDX: '*…the fault of the RAAF which delayed the flight causing the pilot to fly inland into a storm*'[16]. A basic overview of communications transcripts and recordings easily yields information to *invalidate* this suggestion.

Interestingly, Network 7[16] plays only snippets of audio recordings in isolation and excludes key responses that actually would refute their claim.

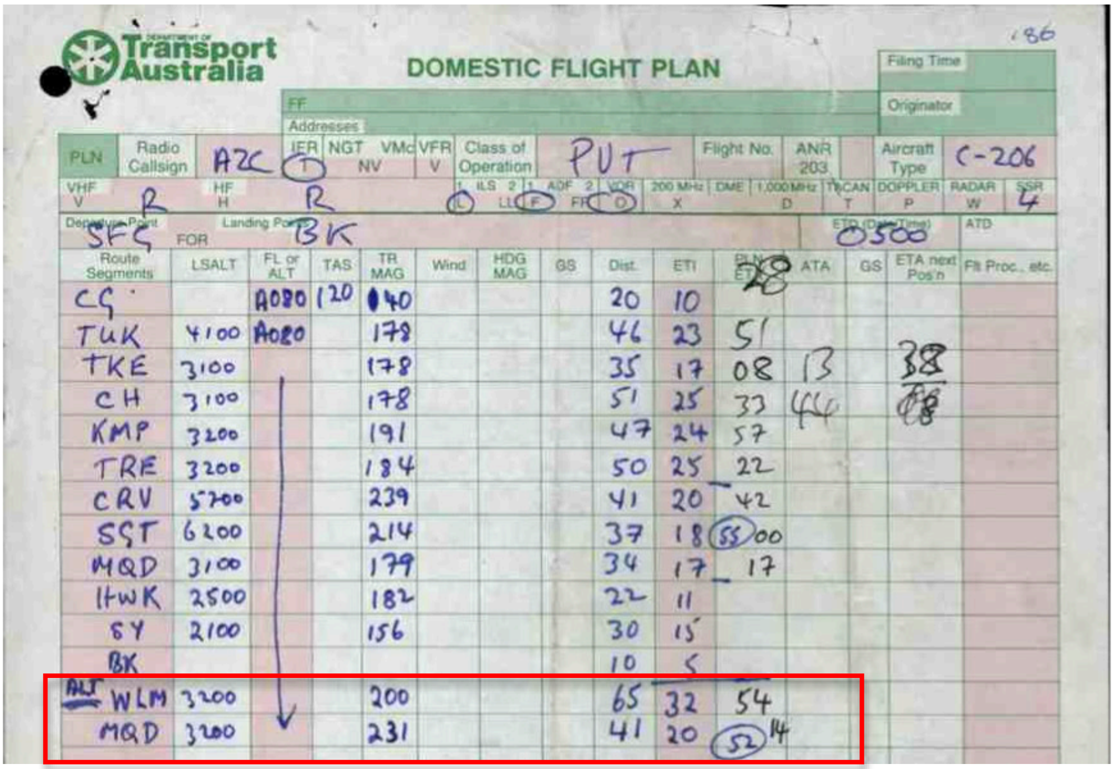
Regardless of the inability to *flight plan* through Williamtown airspace, the pilot of VH-MDX could have pro-actively requested a clearance through Williamtown airspace *some time before* Taree. This would have given all agencies time to assess and prepare the clearance without pressure. Such a timely request is a normal and a rational process used in aviation.

Additionally, the Williamtown ATCO on duty during the night of the VH-MDX accident suggested the pilot of VH-MDX could have attempted direct contact with Williamtown ATC to obtain a clearance through Williamtown airspace[21]. The ATCO stated many pilots did this and in the case of VH-MDX a clearance would have been given[21].

The pilot of VH-AZC at Taree proactively requested a clearance to track via '*preferred route to Williamtown*' also offering an ETA for Williamtown. FIS-5 had all the information needed to efficiently request a clearance from Williamtown.

Also, even though the pilot of VH-AZC had *flight planned* a route clear of active Williamtown airspace via Taree NDB-Craven waypoint-Singleton NDB-Mount McQuoid VOR, the pilot also planned an alternate route from Taree NDB to Williamtown then Mount McQuoid VOR.

This is evidenced in the VH-AZC flight plan presented in figure 26 below.



Transport Australia

DOMESTIC FLIGHT PLAN

PLN Radio Callsign: AZC — Class of Operation: PVT — Aircraft Type: C-206

Departure Point: SFC — Landing Point: BK — ETD: 0500

Route Segments	LSALT	FL or ALT	TAS	TR MAG	Wind	HDG MAG	GS	Dist	ETI	PLN EST	ATA	GS	ETA next Pos'n	Flt Proc. etc.
CG		A080	120	040				20	10	28				
TUK	4100	A080		178				46	23	51				
TKE	3100			178				35	17	08	13		38	
CH	3100			178				51	25	33	44		08	
KMP	3200			191				47	24	57				
TRE	3200			184				50	25	22				
CRV	5700			239				41	20	42				
SGT	6200			214				37	18	55 00				
MQD	3100			179				34	17	17				
HWK	2500			182				22	11					
SY	2100			156				30	15					
BK								10	5					
ALT WLM	3200			200				65	32	54				
MQD	3200			231				41	20	52 14				

Figure 26: VH-AZC Flight plan. The pilot of VH-AZC proactively requested a clearance through Williamtown airspace when at Taree NDB. An alternate route through Williamtown was also included in the flight plan (red box). The latter gives the pilot quick access to relevant information for flying through Williamtown airspace (Australian Government (Air Safety Investigation Branch) 1981).

Accordingly, the pilot of VH-AZC 'drove' the clearance request and was ready for a possible clearance through Williamtown airspace with tracking information readily available.

A Williamtown transit was discussed at the Coolangatta briefing office by the pilot of VH-MDX as shown below in figure 28[1] but there appears to be no *clear* preparation for such a transit.

> (e) When the pilot had first come in to the Briefing Office, he had asked KNIGHT if Williamtown CTR was active. KNIGHT told him that Coolangatta Briefing were not told of this, but said he understood that pilots normally seemed to "get through OK on weekends no worries." However, the pilot did not plan that way, "he wanted to plan via Singleton for some reason."

Figure 27: Discussion of Williamtown airspace transit. (Image: Australian Government (Air safety Investigation Branch) 1981).

What also must be remembered is that many flights operated over the Barrington Tops area the night of the VH-MDX accident without incident. Aircraft intentionally operated at lowest safe altitudes in the area of the accident not long after VH-MDX's final received radio transmission and all aircraft appeared to return normally[1].

Making a statement to the effect that the RAAF forced VH-MDX into a geographical area of certain death can be viewed as flippant with communications transcripts *clearly* suggesting otherwise.

It is readily evident that all ATS agencies were conducting their duties as required and that apportioning blame to any agency, organisation or individual for unnecessarily delaying or forcing VH-MDX to track along the original flight plan track is indefensible and unreasonable.

3.3. Taree to diversion decision point (0850:00UTC-0856:00UTC)

3.3.1. Overview

After reporting overhead Taree at 0850:00UTC at 8000'[1], VH-MDX likely tracked an initial course towards Craven waypoint for a very short period then generally southbound from Taree NDB towards Williamtown as an airways clearance was expected forthcoming to track via Williamtown. Eventually the pilot of VH-MDX made a decision to track via Craven waypoint as originally flight planned.

3.3.2. Pending clearance/remain OCTA: 0854:20UTC

At around 0854:20UTC FIS-5 advises VH-MDX that *Sydney's* airspace was classified as not-suitable for VFR flight at 'higher levels' but that a coastal clearance at a lower level may be available[1].

The pilot of VH-MDX confirmed that he would rather proceed coastal than via Craven waypoint so, FIS-5 continued the pursuit of a clearance from Sydney ATS[1].

Just before 0855UTC, FIS-5 reminded VH-MDX that the Williamtown Control Zone and Restricted Areas 589 and 591B were active to 10000' and that he should remain Outside Controlled Airspace (OCTA) whilst an airways clearance was negotiated[1].

Offering advice such as this is FIS's core role; FIS-5 was ensuring VH-MDX was aware of the situation at hand that is, suspect weather in Sydney's airspace, a possible requirement to descend and track coastal and a reminder not to accidentally track into controlled airspace without a clearance.

There was no obvious suggestion from FIS-5 that this restricted airspace was about to be infringed.

3.3.3. Proximity to airspace boundary: 0855:09UTC

Shortly after the FIS-5 advice above, at 0855:09UTC the pilot of VH-MDX advised that '*we're coming up to it pretty shortly*'[1], referring to the Williamtown controlled airspace boundary.

During the delay of less than six minutes throughout which Sydney ATS agencies were ensuring the weather was suitable to confirm a clearance, the pilot of VH-MDX made the decision to track via his original flight planned track via Craven waypoint and Singleton. This intention was advised by the pilot of VH-MDX at 0856:00UTC[1].

VH-MDX was cruising at 8000' for six minutes after Taree to this decision point, most likely on a track direct to Williamtown although this cannot be confirmed. This leg would be 200˚M at 65NM from Taree NDB.

A cruise TAS of around 164 KTAS would be expected at 8000' in ISA conditions and coupled with a ARFOR wind of 250˚T/40 knots (238˚M/40 knots) would give a Ground Speed (GS) of 131 knots or 2.2 NM per minute.

This cruise TAS figure is Pilot's Operating Handbook (POH) derived so, would be a more optimistic figure than a near fully laden C-210 would achieve. 155-160 KTAS is viewed as a more realistic speed. However, using the POH value is conservative in this case.

This yields an approximate distance along track to Williamtown of 13NM south of Taree NDB, being near the town of Nabiac. A similar turn position was suggested by the ASIB/BASI[1], Chessor[26], Donovan & Readford[14] and Nolan[25].

The furthest reaching active Williamtown controlled airspace boundary towards Taree was R591B and this was 25NM from Williamtown or 40NM (65NM-25NM) from Taree NDB[11].

Accordingly, the pilot of VH-MDX was approximately 27NM or 12 minutes away from the controlled airspace boundary. Figure 28 on the next page depicts the situation. The red arrows represent a likely track that VH-MDX may have took.

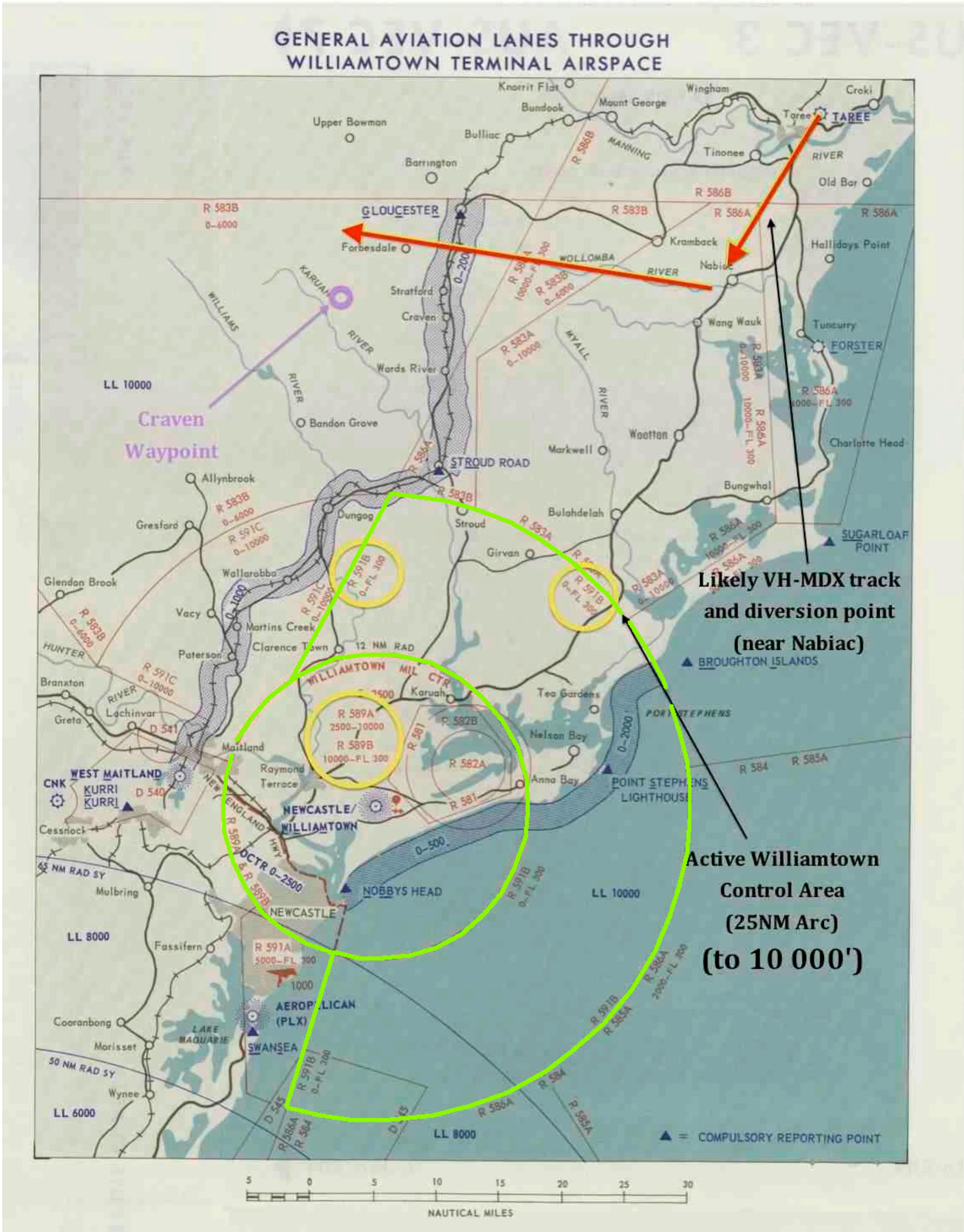


Figure 28: Williamtown airspace and surrounds. Active Restricted areas are marked with lime lines. The Restricted Area numbers are marked with yellow circles. Both active Restricted Areas were active to 10000'. The red arrows depict the approximate flight path up to a possible turn point. Immediately obvious is the distance from where VH-MDX likely turned for Craven waypoint to the Williamtown control area boundary. Although there was probably sufficient time to obtain a clearance before having to hold, re-intercepting the Craven waypoint would have involved coarse intercept angles and possibly backtracking. Picking up an inbound bearing direct to Singleton NDB would perhaps have been the simplest approach. It can be seen an early turn to Craven waypoint could possibly simplify navigation (Base chart: Australian Government (Department of Transport Australia) 27 November 1980).

It can be seen that being such a distance away from the controlled area boundary does suggest VH-MDX was not as close as the pilot insinuates. Indeed Don Chessor[26] expresses his lack of understanding why there was an immediate '*preoccupation with entering controlled airspace*'.

Despite this, for the purposes of efficiency and simplicity of navigation it can be seen that the longer a turn towards Craven waypoint was left, the coarser the intercept angle was required. This potentially could lead even to backtracking somewhat if the pilot had made the turn in a further 4NM/≈2 minutes onwards from where he is assumed to have turned.

Another alternative would be to bypass Craven waypoint altogether and track the Craven waypoint-Singleton NDB track with a sensible track to intercept that would avoid controlled airspace.

Despite all of the above, VH-MDX may have been established on the flight plan track (or what the pilot perceived to be the flight plan track) from Taree NDB to Craven waypoint all along during the clearance negotiation although from a dead reckoning point of view to the initial Sydney radar position, the initial track to Williamtown seems more likely.

<u>What is clear from this part of the flight is that all parties involved were conducting their roles as expected.</u> ATS parties were ensuring the safe progress of flight whilst the pilot of VH-MDX obviously set out to make an early decision regarding diversion to avoid last minute changes.

Attempting to apportion blame on any party involved in the airways clearance process is unjustified.

VH-MDX was flight planned to track Craven waypoint-Singleton NDB-Mount McQuoid VOR. Sydney controlled airspace just north of Mount McQuoid had a lower limit of 8000' and from around Mount McQuoid and south was a 6000' lower limit. VH-MDX was at 8000' at Taree and planned to fly at 5000'AMSL at Mount McQuoid. Figure 29 on the following page shows the control area steps.

Section 3.2.5 identified that a clearance through Williamtown airspace was likely to have been given. If VH-MDX had secured such a clearance and waited for the Sydney airspace clearance, the perceived immediate issue of infringing the Williamtown restricted areas would have been removed

Whilst comfortably tracking through Williamtown airspace the pilot could wait for Sydney ATS to check weather conditions in Sydney controlled airspace. From this position, VH-MDX could have proceeded through Sydney controlled airspace if a clearance was possible or OCTA if not.

If weather conditions were unsuitable, VH-MDX could exit Williamtown airspace and possibly descend to a lower altitude to fly beneath the Sydney control area steps coastal or inland so removing the requirement for a Sydney ATS clearance.

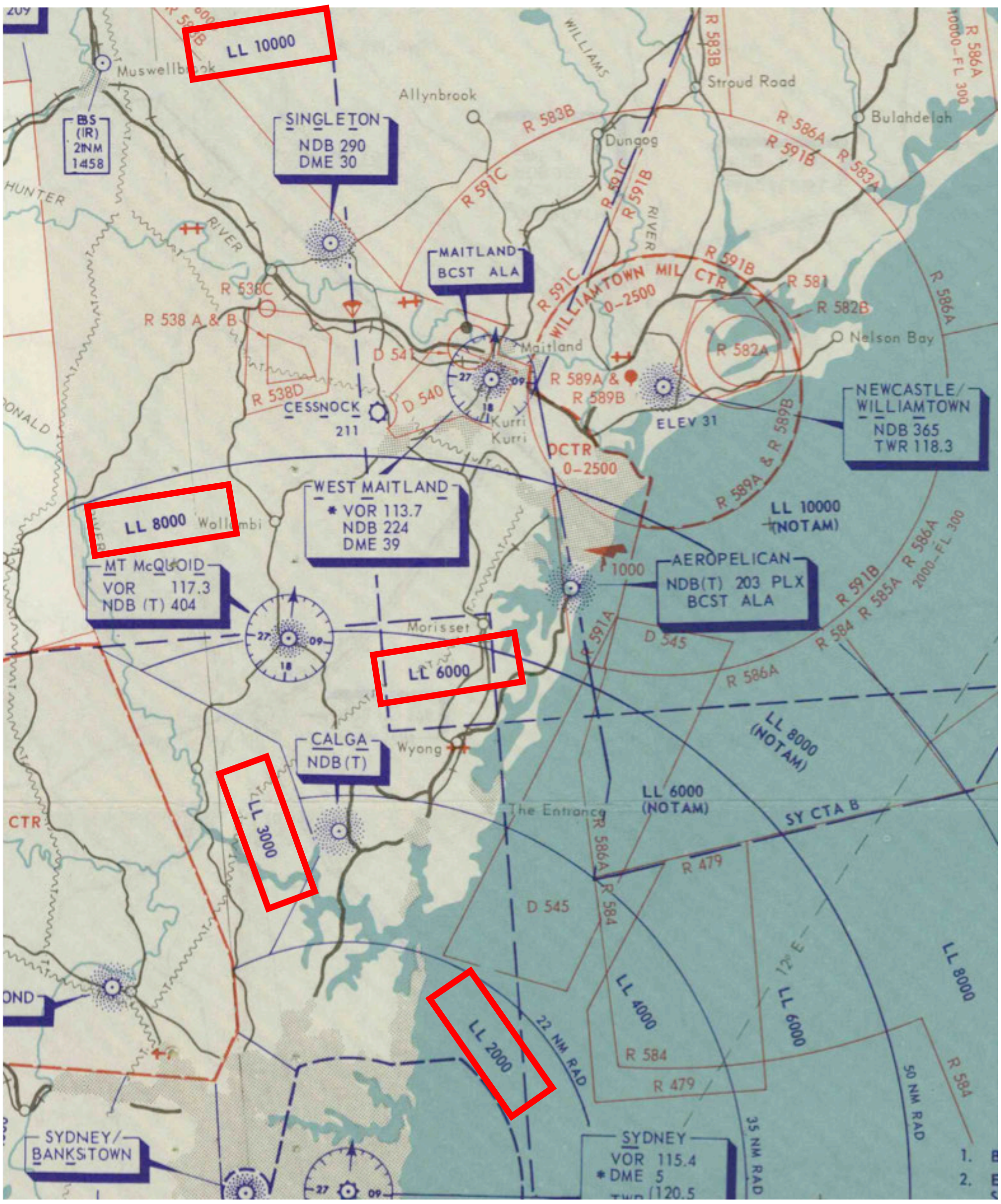


Figure 29: Sydney controlled airspace lower limits. (Blue arcs, with lower altitude limits boxed in red) (Base image: Australian Government (Department of Transport) 1980, additions: Glenn Strkalj 2015).

3.3.4. Navigation aids (Navaids): A quick overview

VH-MDX was believed at the time of accident to be fitted with one fixed card ADF (Automatic Direction Finder) and one VOR (VHF Omni Directional Range) receiver[1][24]. No DME (Distance measuring Equipment) was fitted[1].

Both of these navaid systems receive signals from ground-based radio beacons and then present the pilot with bearing information to/from these beacons in a relative or magnetic north oriented form[30].

Pilots can track from one beacon to the other or use bearing lines from two beacons and fly to the intersection of these bearing lines. Consequently, a pilot can navigate the aircraft without reference to visual features on the ground allowing safe flight in cloud or on dark nights.

3.3.5. ADF/NDB

ADF’s are used to tune into aviation radio beacons known as Non-Directional Beacons (NDB’s)[30] located in strategic positions on the ground. A simple pointer needle turns to point towards the tuned NDB.

NDB’s transmit in the Low Frequency (LF) and Medium Frequency (MF) bands that are susceptible to atmospheric, weather and terrain effects[30]. Received signals are therefore subject to significant errors and instability in indication.

The fixed card ADF display system likely to be fitted to VH-MDX displayed only *relative* bearing information to the pilot: that is the signal direction relative to the aircraft’s nose.

The pilot then has to mentally transpose magnetic bearing information from the *compass* over the fixed card indicator to allow tracking of magnetic bearings indicated on aviation charts (i.e. to turn the *aircraft relative* bearing into a *magnetic* bearing). This procedure increases pilot workload.

As the Directional Indicator (DI) was reported as unserviceable[1], the direct reading compass had to have been used.

Figure 30 presents photos of the ADF receiver and ADF indicator models likely to be on board VH-MDX during the accident.

Figure 30: IN-346A fixed card ADF indicator and ARC R546E ADF receiver. These particular units were likely onboard VH-MDX during the accident. ‘Fixed card’ refers to the fact that the compass rose is not continually slaved to magnetic north as in some indicators. Despite this, the pilot is still able to manually rotate the card to any position. This is handy when transposing compass headings to the fixed card indicator in order to convert the displayed *relative* bearings to *magnetic* bearings.

 © Glenn Strkalj 2014

3.3.6. VOR

VOR's on the other hand transmit in the Very High Frequency (VHF) band and are effectively free from weather interference[31]. VOR's transmit signals representing bearings around the station like spokes on a wheel[31].

Unlike the NDB that transmits the same signal in all directions[30], the VOR transmits a signal that defines every bearing with a particular phase difference characteristic[31]: basically every transmitted bearing signal around the station has a unique signal characteristic. These are known as 'radials'[31] and are depicted in figure 31.

Airborne VOR displays present *magnetic* bearing to or from a VOR station meaning the magnetic bearing of the aircraft to or from these stations is displayed *immediately* to the pilot[31]. The pilot does not have to mentally transpose compass information as in the fixed card ADF case.

Additionally, the type of display VH-MDX likely had for the VOR[1] also offered much better bearing *read-off* resolution than the ADF system. Overall it can be seen that VOR systems are simpler to use and offer more reliable bearing information than the ADF/NDB combination.

The catch is VOR ground stations are more *expensive* so are not as prolific as NDB's.

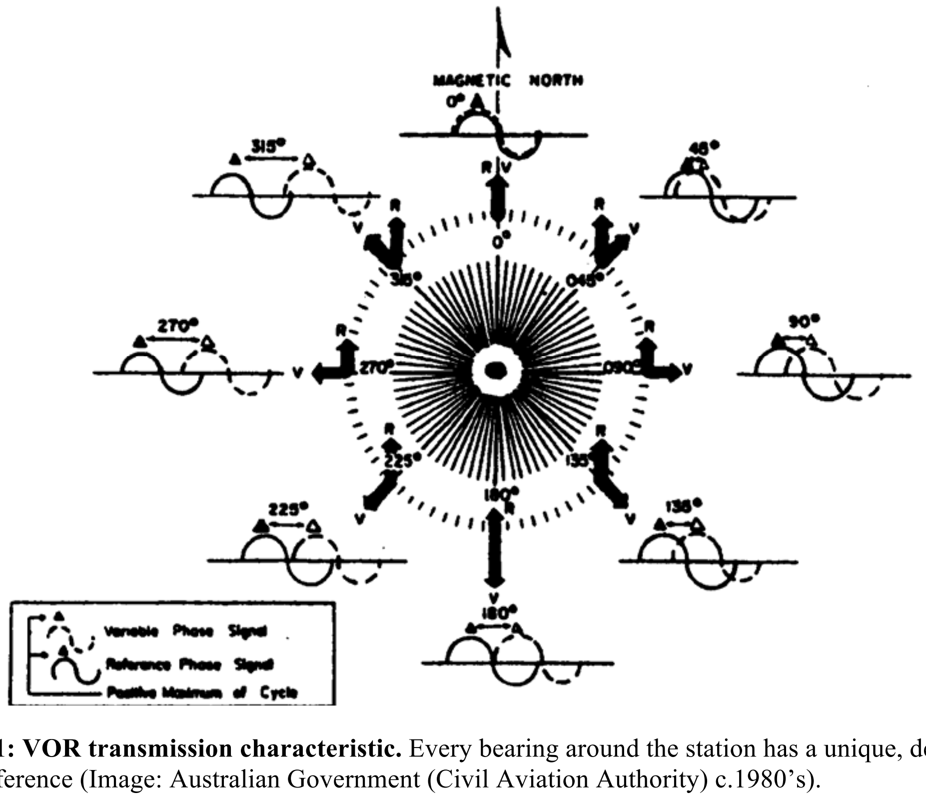


Figure 31: VOR transmission characteristic. Every bearing around the station has a unique, defining phase difference (Image: Australian Government (Civil Aviation Authority) c.1980's).

The VOR indicator likely to have been on board VH-MDX during the accident is shown in figure 32 on the following page.

Figure 32: IN-525R VOR Omni Bearing Indicator (OBI). This indicator was listed in BASI archives as being fitted on board VH-MDX when delivered to Australia in 1977. Unlike the fixed card ADF, the OBI presents *magnetic* bearing information to the pilot. This simplifies obtaining magnetic bearing information to the pilot compared to the ADF. The knob on the bottom left is turned until the vertical needle is centered. The magnetic bearing is simply read off the top scale; in this case 000˚M. A small 'to/from' indicator (not visible in the photo) indicates if the aircraft is positioned on the hemisphere that is going 'to' the indicated bearing (selected bearing is on the other side of the VOR ground station) or 'from' the selected bearing (selected bearing is on same side as the aircraft relative to the ground station). (Photo: Bennett Avionics 2001-2014).

3.3.7. Navaid selection

Navaid choices by the pilot of VH-MDX can only be speculated however, there is a limit in choices given distances from and limitations of surrounding navaid's. Notwithstanding specific navaid limitations, pilots generally use the *closest* applicable aid as this normally results in the most accurate track guidance.

Each individual NDB has a *unique* certified range outside which the pilot must not use the NDB even if the beacon can be received which, in many cases it can be. To do so would likely result in significant navigational errors.

VOR's on the other hand have a generic maximum useable range applicable to all VOR ground stations unless otherwise noted, based on aircraft height above the VOR station.

Applicable VOR station rated (useable) ranges to the VH-MDX event are[32]:

- <5000' = 60NM
- 5000' <10000' = 90NM

Facility and site variations may result in ranges less than those specified above. Such variations are specified in the Enroute Supplement Australia (ERSA).

Navaid choices to the pilot of VH-MDX are shown on the chart in figure 33 overleaf.

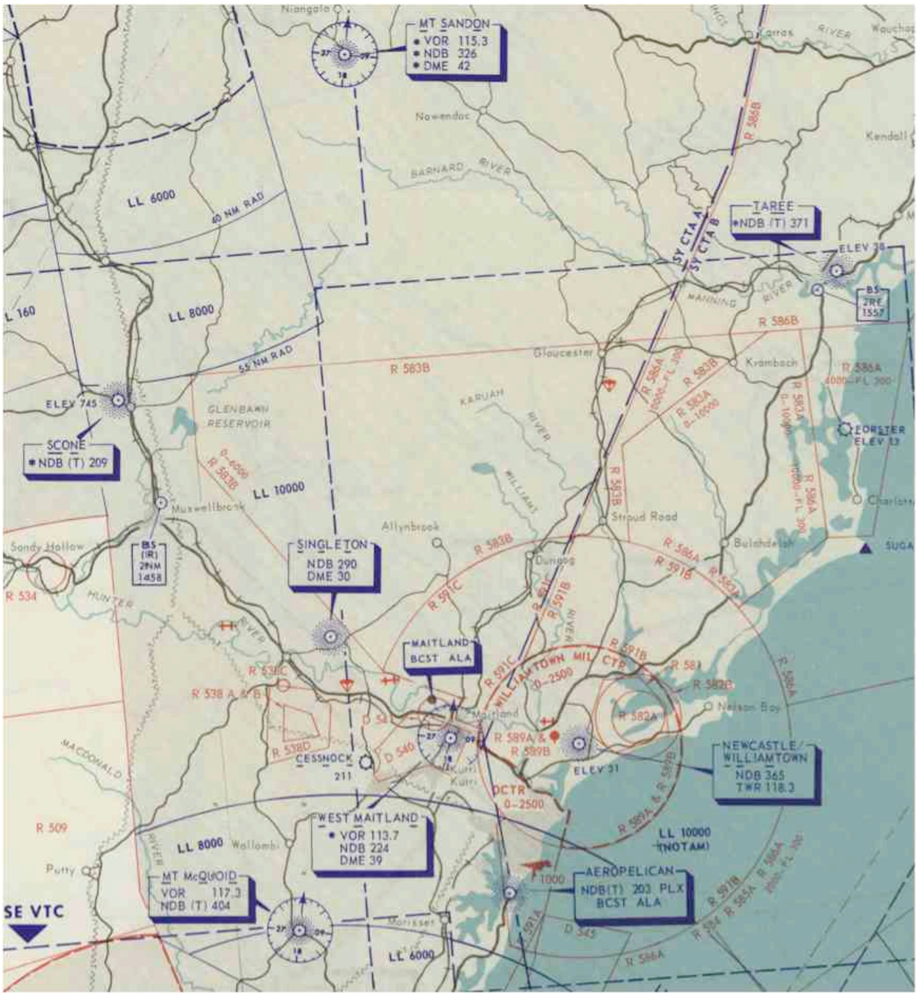


Figure 33: Available Navaid's. Three VOR's were within usable range for the pilot around the Barrington Tops: Mount Sandon, West Maitland and Mount McQouid. VOR's provide a stable, weather free bearing indication. NDB's in the area were limited in range and subject to bearing fluctuations from weather and terrain. Note the similarities in abbreviation and frequency between Scone and Singleton NDB's. It has been suggested by many that the pilot of VH-MDX miss-tuned the Scone NDB over the Singleton NDB that took the aircraft well north of intended track. (Base image: Australian Government, (Department of Transport Australia) 1980).

To track Taree to Williamtown it would be likely the pilot of VH-MDX either:

- Initially used the Taree NDB for greater tracking accuracy (closer NDB) or;
- Tuned in the Williamtown NDB as that was the next intended reporting point (subject to clearance), and used this NDB for tracking.

The Williamtown NDB had a range advantage (90NM in 1993)[15] over Taree NDB (70NM in 2005)[28] at night over land but either could be legally used over the *entire* 65NM leg from Taree to Williamtown assuming these ranges were valid for 1981.

The VOR may have been tuned to Mount Sandon to provide proximity awareness to Williamtown control area boundaries although no published tracks of significance to VH-MDX existed on the Enroute Chart.

Equally likely, West Maitland or Mount McQuoid being 'downrange' navaids may have been tuned as they would provide tracking assistance *onwards* of Williamtown whilst published tracks of interest to the pilot of VH-MDX existed.

3.4. Diversion decision point to initial radar identification (0856:00UTC-0928:45UTC)

3.4.1. Overview

Ultimately, VH-MDX tracked from Taree NDB at 0850UTC to a radar confirmed position approximately 36NM north of Singleton NDB just after 0928:30UTC[1]. This track is well to the north and west of what was intended.

Along the way, VH-MDX reported entering cloud, experiencing turbulence and downdraft[1]. The pilot reported failure of the AH and DI whilst also indicating the ADF indication was unstable[1].

An Uncertainly Phase (INCERFA) was declared by FIS-5 at 0926UTC based on VFR flight in Instrument Meteorological Conditions (IMC) and the SOC (Senior Operations Controller) was advised[1].

3.4.2. Definition of Craven waypoint

The most immediately useful VOR station to intercept and define Craven waypoint would have been *West Maitland* as a result of:

- Distance to Craven waypoint 40NM
- Reasonable geometry of bearing intersection with Taree or Singleton NDB's
- VH-MDX was tracking towards the general direction of West Maitland
- A course line with bearing and distance from West Maitland VOR through Craven waypoint was marked on the Enroute Chart (information readily available).

Mount Sandon VOR would provide perhaps a better cut geometry through Craven waypoint with either the Singleton or Taree NDB's but as it appears that there were no published tracks from Mount Sandon to Craven waypoint published, the pilot would have to plot the bearing from this station through Craven waypoint to determine required bearings (unlikely due workload).

To overfly the Craven waypoint from a position *abeam* the Taree NDB-Craven waypoint track would have been more challenging than an 'along track' case directly from Taree NDB.

Firstly intercepting and maintaining the Taree NDB-Craven track of 239˚M using the Taree NDB would have made things easy as the pilot would then only have to wait until the 006˚M West Maitland VOR radial was also achieved to define Craven waypoint.

But, if the pilot had initially tracked toward Williamtown from Taree for the ≈13NM mentioned in section 3.3.3, then a reasonably coarse intercept angle was required to intercept Craven waypoint. This leads to higher workloads and increased chances of errors or flying out of tolerances. It must be remembered there is no navaid at Craven waypoint from which to 'start again' in terms of tracking.

Alternatively, as mentioned in section 3.3.3, Craven waypoint may have been 'ditched' and an intercept of an inbound bearing to Singleton NDB may have occurred.

Figure 34 presents some examples of how Craven waypoint would be defined.

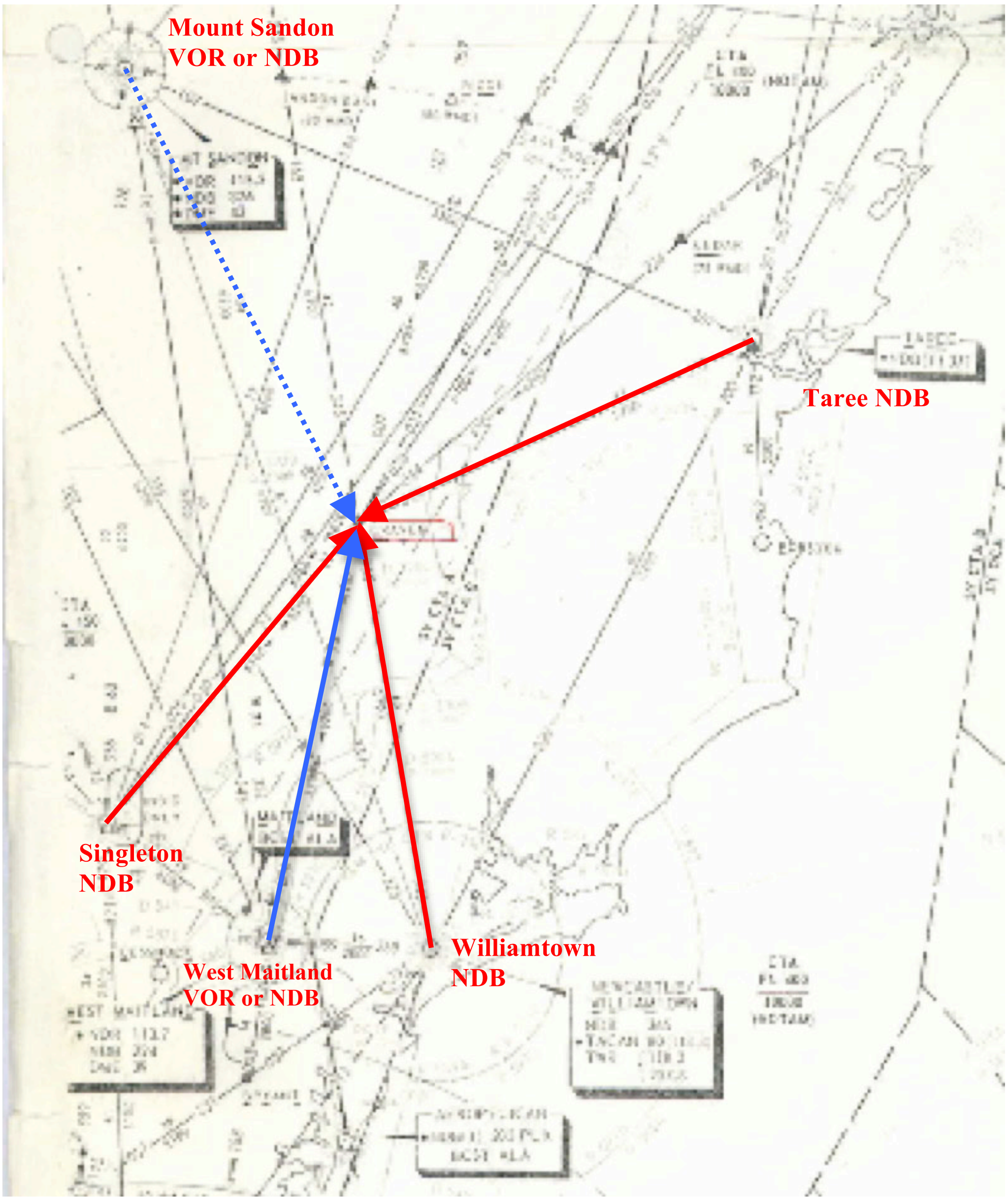


Figure 34: Definition of Craven waypoint. Intersections between likely navaids are used to define Craven waypoint. Blue are VOR radials, red NDB bearings. West Maitland was the most likely VOR used given close proximity, being 'downrange' of intended track and having a published bearing to/from Craven waypoint. The *intended* NDB used was likely to be Taree or Singleton. Singleton being the next waypoint after Craven would be a highly likely choice. Mount Sandon VOR whilst offering good intersect geometry with Singleton or Taree NDB's has no published track. Many of the navaids discussed had restrictions on use in 1981 (Base image: Australian Government, (Department of Transport Australia) c.1981).

Many including Don Chessor[26] and John Watson[42] have suggested that the Scone NDB was mistakenly tuned instead of the Singleton NDB given the similarities in frequency and ident (209kHz vs. 290kHz).

If the ADF was mistakenly tuned to Scone NDB instead of Singleton NDB and the Scone NDB 'homed' (needle on nose), it can be seen in figure 35 how VH-MDX arrived at the initial Sydney radar position. Additionally, VH-MDX would likely pass a few NM north of Craven waypoint. More of this will be discussed later.

Even if the Singleton NDB was tuned, defining the Craven intersection would be challenging given the coarse flight intercept angle stated and the mountain and thunderstorm errors likely that night which would have made the ADF indicator unstable in bearing.

Indeed unstable ADF indications were reported in the Barrington Tops area by the pilots of VH-ESV and VH-MDX[1].

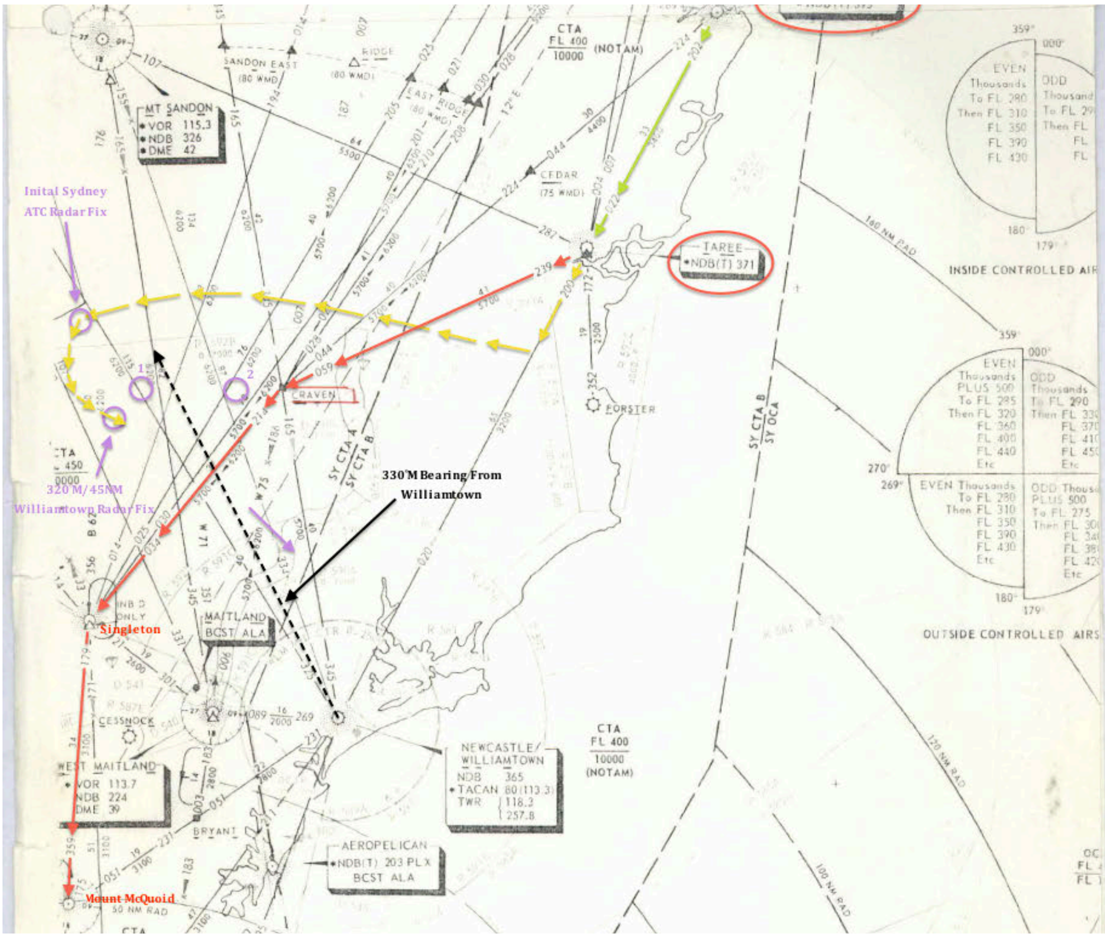


Figure 35: Scone NDB theory. Readily obvious on this chart is the co-incident alignment of Scone NDB when considering tracking between just south of Taree NDB to the initial Sydney radar position. If this NDB were homed, a track north of the direct course (black dashed horizontal line) would be expected (Base image: Australian Government, (Department of Transport Australia) c.1981).

Mount Sandon VOR, West Maitland VOR, Taree NDB and Scone NDB had navigation aid *limitations* specified in 1981. Such limitations are specified when the navaid has restrictions beyond what is specified as normal.

This could be related to disregarding bearings in certain sectors or above/below certain altitudes or may relate to fluctuations in radial/bearing information. It has not been confirmed yet what restrictions these navaids had during the time of the VH-MDX accident.

Additionally, Singleton NDB had restrictions on use during 1993 with possible excessive needle fluctuations between 20 and 40 NM above mountains[33] (effectively being over the Barrington Tops). Although it appears a new NDB was installed between 1981 and 1993, given the site location and simplicity of the NDB transmission the same restrictions were likely apparent in 1981.

Assuming the pilot of VH-MDX used West Maitland VOR, then it can be seen that this more accurate and stable navaid (in pragmatic application) would be relied upon perhaps *more* to define Craven waypoint than the ADF/NDB combination.

Consequently, it is feasible that when the pilot of VH-MDX noted the applicable VOR radial being achieved to define Craven waypoint (e.g. 006˚M if West Maitland VOR was used) a position call may have been given for Craven and perhaps the ADF indications ignored to some extent.

3.4.3. Craven position: 0918:00UTC

Just before reporting at Craven waypoint, VH-MDX reports experiencing moderate turbulence at 0918:06UTC[1].

At 0919:32UTC the pilot of VH-MDX reports an ATA at Craven waypoint of 0918UTC whilst also reporting considerable turbulence and '*quite a lot of downdraft*'[1]. This ATA was four minutes *later* than initially estimated.

3.4.4. In cloud: 0923:54UTC

At 0923:54UTC VH-MDX reports: '*...Mike delta x-ray is in the clag, in turbulence and would request a clearance to ah 10,000 from 8000*[1].

The ADF was reported by the pilot as '*...going all over the place*'[1] and this may have been a result of the thunderstorm off-shore Port Stephens interfering with ADF reception and/or mountain effect particularly if the Singleton NDB was being used (given its 1993 stated bearing fluctuations limitation over mountains).

VOR signals would not have been weather affected and would have offered the pilot a reliable bearing line from West Maitland, Mount McQuoid or Mount Sandon VOR's.

FIS-5 queries VH-MDX if a rate of climb can be maintained without an Artificial Horizon to which the pilot confirms that he can[1].

Accepting the time of the pilot's radio call stating the failure as indicating the time of detection then, the simple assumption is that the vacuum system failed as VH-MDX entered cloud.

Although this is possible, the timing of occurrence is *highly coincidental*. It is most *unlikely* the vacuum system was affected by icing given the design with the ASIB[1] also suggesting this. It is suggested that one of the following is more likely:

- The vacuum system failed prior to entering cloud but was not detected
- The vacuum system failed prior to entering cloud and was detected but was not of major relevance to the pilot when in clear skies
- The vacuum system was unserviceable prior to take off in Coolangatta.

There is some evidence[1] although circumstantial, suggesting the last option may have occurred. A witness in Coolangatta did state that the pilot of VH-MDX commented to him that '*there was some problem with the gyros or electrics*'[1]. No hard conclusions as to the timing of the failure can ever be made.

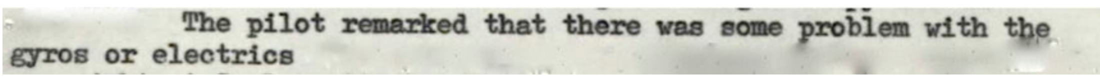

The pilot remarked that there was some problem with the gyros or electrics

Figure 36: ASIB extract: Possible gyro issues. (Base image: Australian Government (Air Safety Investigation Branch) 1981).

3.4.5. Single axis (roll) autopilot

Despite the loss of primary attitude and heading instrumentation, the pilot did have at his disposal[3] (assuming serviceability) a very important item that would be fundamental in allowing him to maintain control of the aircraft: a single axis roll channel autopilot.

Having the ability to stabilise the roll axis frees much of the pilot's resources to concentrate on the all important pitch axis.

The 300A autopilot was a basic single-axis, roll channel, wing-leveler; i.e. the autopilot controlled the aircraft in roll *only*[4]. The *primary* source of turn rate and heading information for the autopilot was from the *vacuum* driven Directional Indicator (DI) (or Directional Gyro (DG))[4].

Although the *vacuum* driven primary attitude and heading references were stated as unserviceable by the pilot of VH-MDX[1], the aircraft was equipped with an *electrically* driven Turn Coordinator (TC)[1] that the ARC 300A Navomatic autopilot[3] could use to fly turn *rates*[4]. VH-MDX electrics are assumed as functioning normally given:

- Transponder returns detected by ground surveillance radar[1]
- Communications with ground ATS station[1]
- A robust eyewitness report at Mt Mooney Station[14][16] that was highly likely VH-MDX with aircraft external lighting clearly visible.

Turn-rate information could still be sourced from the *electrically* driven TC and from this, the pilot of VH-MDX could use the autopilot to potentially hold a steady *heading* (zero turn-rate) or constant *turn-rate*, to maintain a *constant turn rate* up to an approximate maximum limit of 3º per second[4].

Thus, a basic 'turn-rate hold' type mode was still available to the pilot of VH-MDX[4].

Additionally, despite the DI being unserviceable, the compass card could have been rotated *manually* to align with compass derived headings. The heading bug could then be used to select headings for the autopilot to fly.

A Cessna 210 instrument panel is shown on the next page in figure 37 with red circles highlighting relevant unserviceable gyro instruments and a green circle highlighting the serviceable TC. The autopilot control panel is also indicated.

Despite the ability of the 300A autopilot to hold a *steady heading* (zero turn rate), given the reported moderate to severe turbulence and lack of primary directional information, it would be challenging to maintain a perfectly *constant* heading. Specifically, such an outcome would be due to:

- The pilot having to reference headings from the direct reading compass that would be bouncing around thus, not offering a steady heading reference
- The author's experience with such autopilots has shown they rarely result in a straight course (zero rate) with the turn rate selector set to zero-rate (no turn) (although the autopilots were decades old in the author's case rather than around four years in VH-MDX's case)

- Turbulence causing continuous error signals in the Turn Co-Coordinator (TC) that would likely cause the autopilot to 'hunt' (the TC is highly sensitive to *bank* as well as turn rates[29])
- Turbulence causing the DI compass card to deviate
- Aircraft motion from turbulence may have exceeded the autopilot's control ability resulting in the autopilot disconnecting.

It can be seen that a more likely result is to end up with *residual* turn rates rather than a constant heading (zero rate) particularly in turbulence and without a primary heading reference.

Consequently, a weaving track may have been the way a 'constant' course was maintained: if the pilot had sufficient situational awareness to continually be aware of his position and track direction.

From these points, it is assumed that the pilot of VH-MDX had an ability to hold a roughly steady *course*. Indeed as will be seen, radar observed tracking of VH-MDX suggests an ability to maintain a *reasonably* steady course.

Figure 37: Cessna 210 instrument panel. Red = unserviceable, green = serviceable *gyroscopic* instruments. The AH and DG/DI were vacuum operated and were reported as unserviceable by the pilot of VH-MDX. The TC is electrically driven thus would have been serviceable. Autopilot roll error detection can be sourced from the DI for a 'heading select' type mode via the right knob on the DI or, from the TC for a 'turn-rate hold' type mode. Consequently, the pilot of VH-MDX had the ability to set a turn-rate and thus maintain a steady turn-rate or heading. Heading select was also still possible if the pilot continually, manually adjusted the DI for current compass heading. The autopilot shown is not the exact same model fitted to VH-MDX but, the 'pull-roll' knob is effectively the same (Photo: Glenn Strkalj 2002).

3.4.6. Ground witness: ≈0900UTC-0920UTC

Enroute to the Moonan Brook area where VH-MDX was first identified by Sydney radar, it is probable that VH-MDX was observed by a witness entering Mount Mooney Station around 0900UTC to 0920UTC[14][16]. Mount Mooney Station is located approximately 14NM north-west of Gloucester township.

 © Glenn Strkalj 2014

This ground witness is one of the very few that appears to offer a defensible sighting in that the direction and position of the aircraft agreed with what would be expected whilst the time of sighting appears to be confidently determined.

It is the latter point that throws most other witness reports out of consideration as the timing was either way out, inaccurately determined or the methodology of determination was questionable.

3.4.7. A caution on ground witnesses

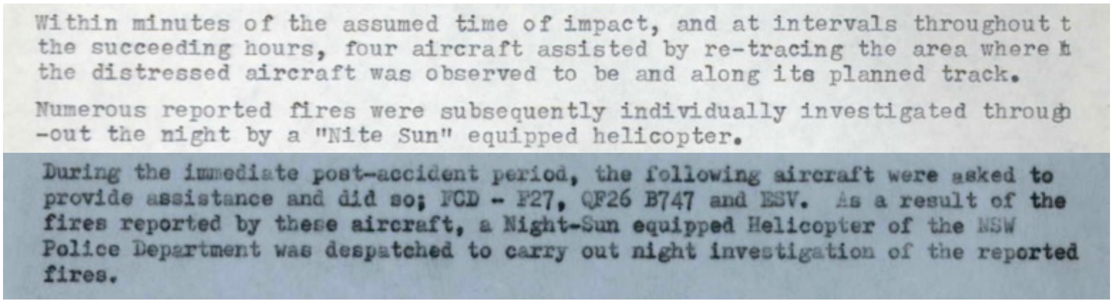
Regarding ground witness reports, it should be noted that within 5-10 minutes of the final received call from VH-MDX at least three aircraft were overhead searching for VH-MDX[1][3].

One aircraft was a 747 that descended to a Lowest Safe Altitude (LSALT) of around 7000' whilst a Fokker 27 also descended to a similar height[1][3].

Needless to say these large sized aircraft flying around at such relatively low levels would have captured peoples attention in the area.

Additionally, it was reported a NSW Police helicopter operating a 'Night Sun' searchlight was flying over the area assisting the search later that night[1]. This too would not go unnoticed. A light aircraft also joined the search in the 5-10 minutes after final transmission[1].

Figures 38 and 39 below display BASI archives extracts of search aircraft activities during the night of the accident.

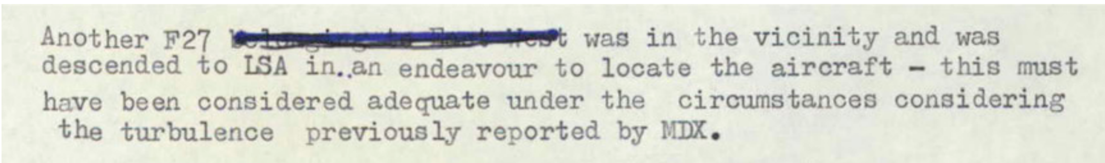


Within minutes of the assumed time of impact, and at intervals throughout t the succeeding hours, four aircraft assisted by re-tracing the area where t the distressed aircraft was observed to be and along its planned track.

Numerous reported fires were subsequently individually investigated through -out the night by a "Nite Sun" equipped helicopter.

During the immediate post-accident period, the following aircraft were asked to provide assistance and did so; FCD - F27, QF26 B747 and ESV. As a result of the fires reported by these aircraft, a Night-Sun equipped Helicopter of the NSW Police Department was despatched to carry out night investigation of the reported fires.

Figure 38: BASI Archive extract: search aircraft within minutes of lost communications. (Image: Australian Government (Air Safety Investigation Branch/ Bureau of Air Safety Investigation) 1981-1983).



Another F27 [redacted] was in the vicinity and was descended to LSA in an endeavour to locate the aircraft - this must have been considered adequate under the circumstances considering the turbulence previously reported by MDX.

Figure 39: BASI Archive extract: search aircraft descending to Lowest Safe Altitude (LSA). A Fokker 27 at around 7000' would be a noticeable site to a ground observer (Image: Australian Government (Air Safety Investigation Branch/ Bureau of Air Safety Investigation) 1981-1983).

The author urges readers of theories heavily based on ground witness reports to critically overview the validity of the information.

How was the time of sighting verified? How would an observer identify an aircraft as a light *single-engine* aircraft over a twin in the dark conditions apparent? How did the observer know the aircraft was not one of the search aircraft?

A good example is the ground witness report of Bette May Diver who observed a white light *'...stay up in the sky then slowly drop..'* over the mountains to the north-west of Dungog[38]. The key information here is the sighting time of 10pm (if one considers the time as accurate)[38]; almost two and one half-hours after the final received transmission from VH-MDX.

It can reasonably be concluded the observation was of search aircraft, quite possibly the 'Night Sun' equipped Police helicopter. Little in current theories and in on-line forums makes such connections or is even aware of or, considers the search aircraft operations.

Also, there are different versions of the same sighting that opens up questions as to the accuracy of the proliferated reports.

It must be remembered, most observers on the ground inherently cannot discriminate what aircraft they observed thus every aircraft sighted becomes VH-MDX. It can be seen that a heavy reliance on ground witnesses in flight path determination is imprudent.

Nolan in *Operation Wittenoom Research* highlights some significant deficiencies with ground witness reports used in one VH-MDX theory[25].

> There does not appear to many witness statements obtainable that can be classified as *reliable* or *robustly determined*.

3.4.8. Incorrect NDB tuned?

When the decision to track via Craven waypoint was made, the ADF would likely be tuned to either:

- Taree NDB to define the Craven intersection
- Williamtown NDB to define the Craven intersection (although with a shallow intersect angle)
- Singleton NDB (although likely outside of certified range) to define Craven waypoint and to continue tracking towards Singleton after Craven waypoint
- Scone NDB mistakenly instead of Singleton NDB due to similar frequencies (209kHz vs. 290kHz) and similar ident abbreviations (SCN vs. SGT).

The last option has been proposed by a number of people and perhaps does explain why VH-MDX tracked to a position 36NM north of Singleton NDB particularly if the pilot simply 'homed' on the NDB or applied the drift correction for the Craven - Singleton leg to a Scone NDB relative bearing. This was discussed in section 3.4.2.

A pilot is required to identify the navaid being used and during 1981 (and predominately now) this was done by monitoring the audio transmission of the navaid tuned and confirming the two or three letter Morse code identification of the navaid[34]. The Morse code ident was/is transmitted by the navaid at regular intervals[30].

It is likely the pilot of VH-MDX was experiencing high workload at the time of tuning navaids from the turn towards Craven waypoint as a result of diversion planning and quite possibly inoperative primary attitude and heading instruments.

Additionally, it will be shown in the ensuing sections that the pilot had not jotted down the frequency for Singleton NDB as he had with other enroute navaids (not a requirement but simplifies processes airborne). As a result, misidentification of navaids or even no attempt to identify may have occurred.

If the pilot of VH-MDX simply used 'homing' techniques (needle on nose) to track to the NDB then it can be seen in figure 40 that combined with the force of the prevailing south-westerly to westerly wind, VH-MDX could easily end up at the position of initial radar identification (approximately 36NM north of Singleton).

Why the pilot may not have detected the incorrect tracking will be explained in the following sub-sections.

If indeed the pilot of VH-MDX were *homing* on Scone NDB then constant heading adjustment towards the left (south) would have been required to maintain the needle approximately on the nose.

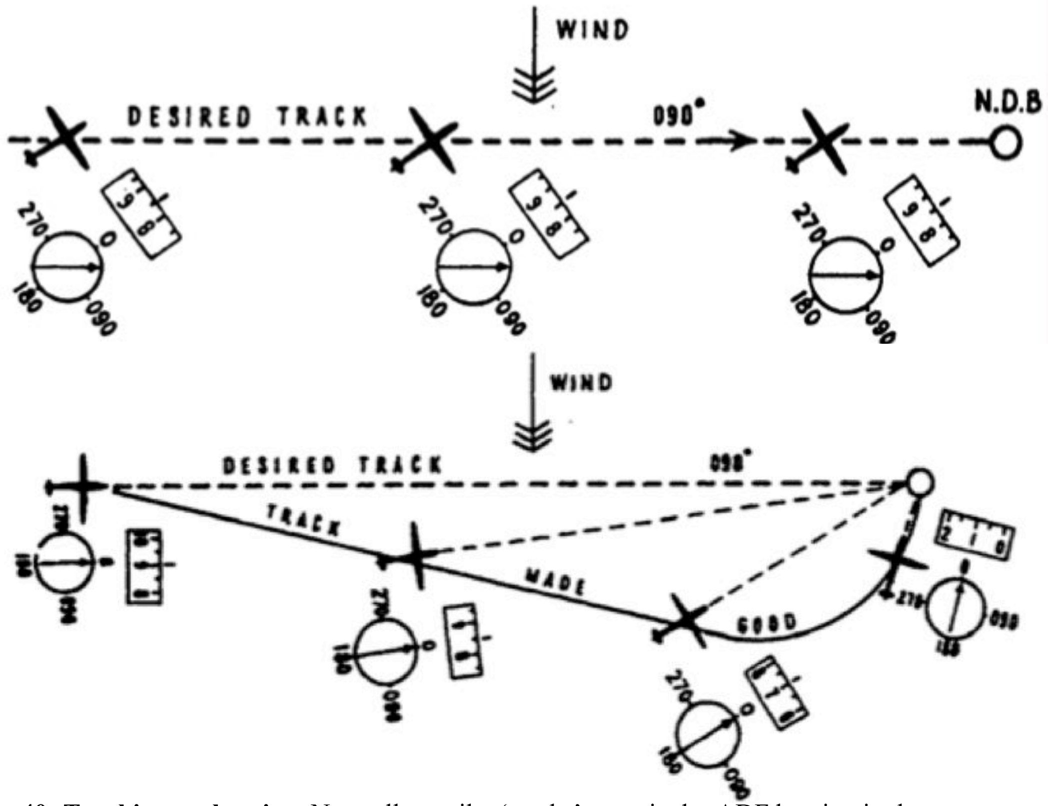


Figure 40: Tracking vs. homing. Normally, a pilot 'tracks' a particular ADF bearing in that appropriate drift correction for wind is held achieving a constant track (top image). The aim is to continually maintain a *particular* bearing inbound or outbound relative to the NDB (top image) rather than drift onto other bearing lines (bottom image). A less tidy way of tracking to an NDB is by *homing*. Basically the pilot adjusts the aircraft heading continually to keep the ADF needle on the nose (0˚ *relative* bearing). The prevalent wind will push the aircraft downwind and as the pilot adjusts the heading for zero *relative* bearing it can be seen the aircraft passes through a multitude of *magnetic* bearings to arrive at the NDB. Not only is this an inefficient way to arrive overhead an NDB but aviation charts specify particular tracks between navaids with information such as Lowest Safe Altitudes (LSALT) and leg distance. Such information is invalidated by not maintaining a *particular* track (Images: Australian Government (Civil Aviation Authority) c.1980's).

3.4.9. Maintenance of incorrect track: why?

About 40 seconds after reporting in cloud, the pilot of VH-MDX advises that he had lost his AH and DI. These are both vacuum powered gyroscopic instruments crucial for flight in instrument conditions such as cloud[1]. Both gyro's operated on a single vacuum pump source[1][2].

This failure would have made tracking accurate bearings with the ADF rather difficult as the pilot would have to scan the small sized *direct indicating compass* located near the roof for a heading and transpose this on the ADF rose that was displaying *relative* bearings: *regularly*. Figure 41 shows the distance involved in scanning the direct reading compass.

Adding the effects of turbulence bouncing the compass around and the darkness of night, it can be seen that maintenance of *accurate* bearings would have been highly challenging.

Additionally, understanding that keeping the aircraft flying in a safe attitude was a more important duty than navigating, one can see that simply homing on the NDB or maintaining planned relative drift would have relieved some load off the pilot to focus on flying.

Figure 41: Bearing transposition onto the ADF. VH-MDX was likely fitted with a *fixed card* type ADF (located at the *heads* of the two arrows above) that displayed only *relative* bearings of the NDB to the aircraft. Pilots are required to mentally transpose heading information onto the relative bearing card of the ADF to yield *magnetic* bearings that are then useable for navigation. This is normally done by reference of the Direction Indicator (DI) positioned two instruments to the left of the ADF indicated by the origin of the red arrow. With the DI unserviceable, the pilot is forced to include the direct reading compass located at the top of the windscreen (indicated at origin of yellow arrow) into the scan that forces the pilot away from 'flying' the aircraft. Throw in the additional challenges of attempting to read the compass bouncing around in turbulence at night and it can be seen that maintenance of accurate NDB bearings is very challenging (Photo: Glenn Strkalj 2002).

© Glenn Strkalj 2014

Incorrectly tracking to the Scone NDB would result in a roughly westerly track thus exposing VH-MDX to a cross wind that would push the aircraft north in a ‘bow’ shaped track and to the initial Sydney radar position.

Alternatively (to homing), initially applying and holding the planned drift correction (tracking) with Scone NDB tuned followed by homing would have resulted in a similar outcome.

3.4.10. Navaid planning

Of interest regarding the Scone NDB suggestion is that the pilot of VH-MDX jotted down the frequencies of the first three enroute navaids on the flight plan log presumably to give him a quick reference to the frequency required for tuning as the flight progressed.

The final three navaid frequencies were not jotted down. Figure 42 presents a VH-MDX flight plan extract showing this.

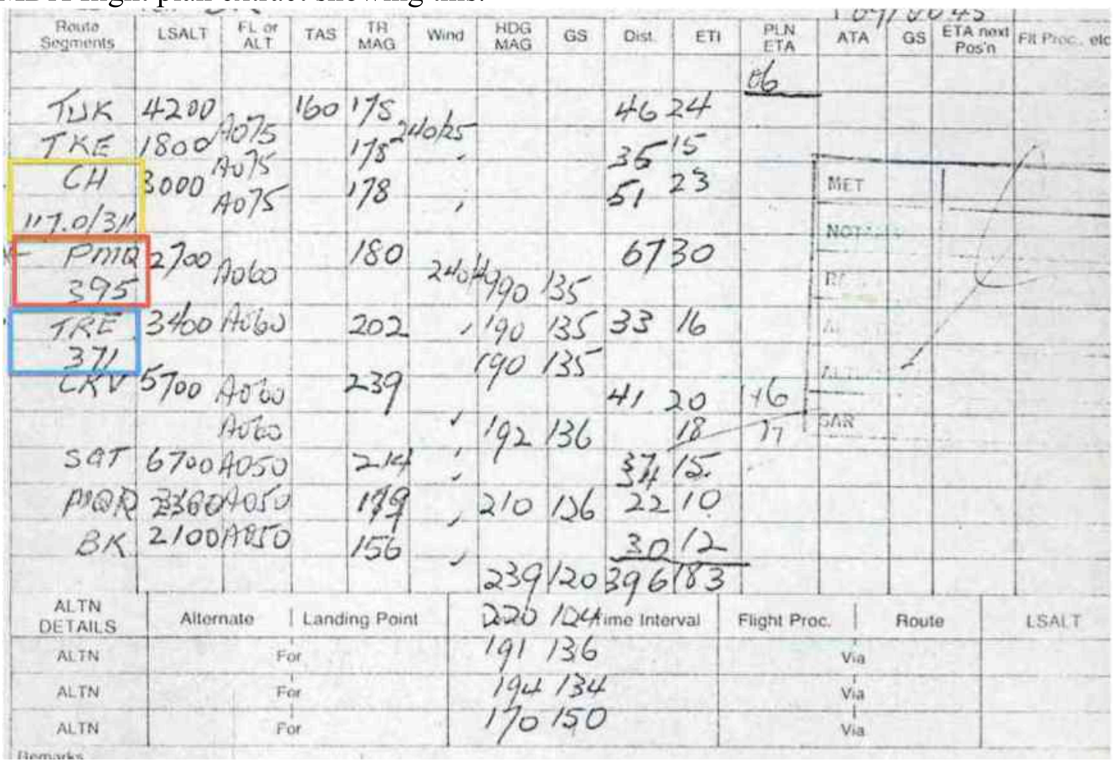


Figure 42: VH-MDX flight plan/navigation log. The pilot has noted navaid frequencies up until Taree (TRE). Such an action would reduce workload in-flight as the pilot did not have to look at charts with small writing in turbulence to find a navaid frequency. This was not done for Singleton, possibly raising the chances of selecting the incorrect NDB (Scone). There was no legal or other requirement to jot down navaid frequencies (Base image: Australian Government (Air Safety Investigation Branch) 1981: additions: Glenn Strkalj 2014).

Tucki (TUK) and The Lake (LKE) are both intersection-derived waypoints so do not have (or need) frequencies jotted next to them. Coffs Harbour (CH), Port Macquarie (PMQ) and Taree (TRE) all have navaids and the pilot of VH-MDX has jotted the appropriate frequencies below the relevant navaid abbreviations[1]:

CH VOR: 117.0 MHz / CH NDB: 311 kHz (yellow box)

PMQ NDB: 395 kHz (red box)

TRE NDB: 371 kHz (blue box)

Interestingly, the pilot did not jot down the frequencies for Singleton, Mount McQuoid or Bankstown. This does potentially increase the chances of tuning the incorrect NDB after Taree because:

- Scone and Singleton NDB's have similar numbers for their transmission frequencies: 209kHz vs. 290kHz
- Both audio Morse idents start with 'S' and have similar starting Morse for the remaining two letters
- A very high workload of flying in cloud with failed primary attitude and heading instrumentation (assuming the instruments failed by the intended turn towards Craven waypoint).

Such jottings of navaid frequencies were *not* a requirement legally or otherwise but assist by minimising in-flight workload.

3.4.11. Initial Sydney radar position: 0928:45UTC

VH-MDX was identified by Sydney ATC radar at approximately 36NM north of Singleton NDB, just west of the Singleton NDB to Mount Sandon NDB track[1] (the latter marked in red in the figure 43).

This fix lies in the Moonan Brook area[20]. This initial radar identification is depicted in figure 44 as position '1'[35] and was made around 0928:45UTC (specifically the 36NM call)[1].

This position was passed to VH-MDX at around 0929:00UTC[1]. VH-MDX was identified with Secondary Surveillance Radar (SSR) SPI (Special Position Identification) ident[13] so, was positively identified.

Accordingly, it is unlikely that VH-MDX was miss-identified.

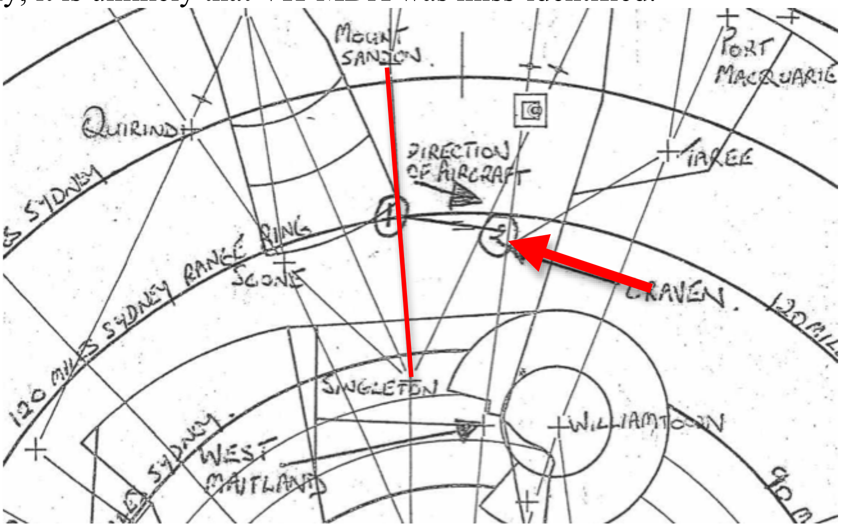


Figure 43: Sydney radar positions of VH-MDX. '1' is the initial Sydney radar position, '2' is the final observed radar position. The red line depicts the Singleton NDB-Mount Sandon NDB track. Craven intersection/waypoint is at the tip of the red arrow (Base image: Australian Government (Department of Transport Australia) 1981, additions: Glenn Strkalj 2014).

A Sydney ATCO indicated that this initial radar fix was easily remembered as the radar paints were boxed-in by the Tamworth 55 DME Control Area Step, 120NM Sydney arc and the Singleton NDB-Mount Sandon NDB track line[20].

In a letter to lawyers a little less than two months after the accident, Department of Transport Australia/ASIB described VH-MDX as '*heading in an easterly direction*' at the initial Sydney radar position[1].

One ATCO (after many years) recalls a generally *southerly* course from the initial radar position[20] and indeed according to communication transcripts VH-MDX was later radar observed to track in a generally southerly direction[1].

Assuming a bowed Scone NDB homing track from south of Taree, then VH-MDX by this radar position would be expected to be tracking around 245˚M. The pilot of VH-MDX had requested radar vectors to Bankstown[1] located well to the south and would shortly ask for vectors to West Maitland[1].

Consequently, a southerly track was expected at this stage from pilot intent. The ATCO's suggestion of a southerly track appears correct as the suggestion is based on a primary witness at the radar display whilst communication transcripts suggest the same.

It is believed the reference described above of a generally easterly track from the initial Sydney radar fix is describing the *general overall* progress from this radar position to the final observed radar position rather than the preliminary track.

The track may have been southeast which would explain why the Sector 1 ATCO gave a '*maintain present heading*' in response to the pilot's request for a vector to West Maitland (located to the southeast) but this is viewed as unlikely.

As the RSR had a relatively slow sweep rate, the Mosaic display was large in scale and VH-MDX was only recently identified, it is viewed that the ATCO simply required more radar paints to develop a *track trend* before assigning headings[20].

With VH-MDX tracking somewhere from south-west to south-east the aircraft's groundspeed would have been relatively low (roughly into wind), leading to closely grouped radar paints. Such closely grouped paints could also lead to difficulties in track determination for the ATCO.

Also, knowing that the pilot had failed primary flight instrumentation, issuing an instruction to '*maintain present heading*' can be seen to be a very appropriate instruction to minimise risky maneuvering whilst determining a radar observed track direction.

3.4.12. Radar technical details

The radar display program in use during the VH-MDX accident at the Sector 1 position was the Sydney Northern Mosaic display[20].

It was found through basic propagation analysis that The Round Mountain Route Surveillance Radar (RSR) was the only Sydney ATC radar likely to interrogate VH-MDX from 0928:45UTC onwards[20]. Sydney RSR was found highly unlikely in contributing to VH-MDX positional information given terrain obstructions and Earth curvature[20].

So far, the calibration of the radar on the night of the accident has not been verified however the radar display system was calibrated three times a day[20].

Although every procedure performed during the calibration cannot be confirmed, scan converter (radar information) and map information was continually adjusted and monitored to ensure co-incidence. To do this, the ATCO had calibration markers in front of him on the display with which to monitor the calibration.

Figure 44 gives an example of the remote RSR alignment markers. There were other calibration marks to check azimuth and range sourced from the scan converter was aligned with the map display.

A DoT Officer involved in the accident investigation did recall that the radar system at Sydney for the Sector 1 position was verified as being well within tolerance and that aircraft during the night of the accident where radar observed over positions they were calling in over the radio[20].

Until further clarification is found regarding actual calibration during the accident, Sydney's radars are assumed to be within tolerance given the reportedly robust monitoring and maintenance of tolerances.

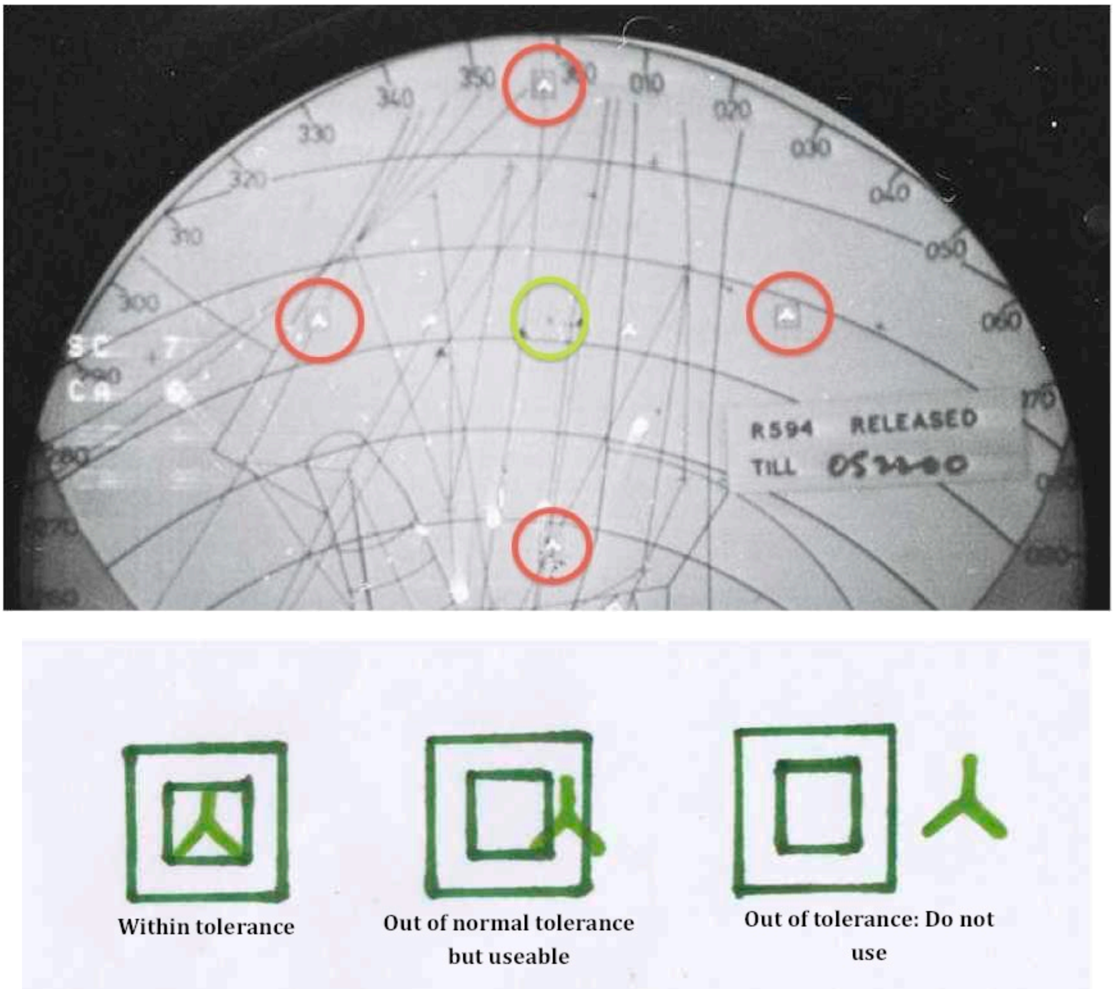


Figure 44: Northern Mosaic alignment markers (red circles). The ATCO would check if the illuminated inverted 'Y' was located within inner and outer boxes. Various levels of tolerance determined serviceability: This was only one of many calibration checks performed. Equipment was reportedly calibrated to very tight tolerances and there is no reason to suspect equipment was significantly out of tolerance during the VH-MDX accident. Despite this, it would be prudent to confirm calibration if applicable information ever presents. (Photo: M. Price c.1983, tolerance box drawing: Glenn Strkalj 2015).

A further question arises as to what 'in tolerance' means in terms of actual angular and range displacement limits. Such displacement would include:

- '*Technical errors'*: deviations attributable to technical limitations of the radar system, alignment errors between map and radar information, alignment of radar heads to magnetic north, and;
- '*Read-off errors'*: deviations arising from the process of assessment by the ATCO when determining ('reading-off') target positions.

3.4.13. Radar technical errors

Most air surveillance radars tend to be more accurate in range than in azimuth[47][51]. Azimuth accuracy is determined by a number of variables including beam width[47] and signal processing.

The Thomson/CSF RSR primary radar units operated by Sydney ATC had a specified *azimuth* accuracy of 1.5˚ when using the basic Plan Position Indicator (PPI) display[51]. Figures for use with the Bright display have not been obtained yet but would probably be between 1.0˚ - 1.5˚.

Accuracy data for the SSR units of the time has not been located but are being actively pursued. ICAO SSR standards of 2004 give typical standard deviations of SSR systems as a result of technical type errors with these typically being 250m in range and 0.15˚ azimuth[39].

The same standard also states the importance of carefully aligning radar north to geographical north when overlapping multiple radar sites (such as in the Northern Mosaic used during the VH-MDX accident) suggesting such alignment should be within 0.1˚[39].

Azimuth accuracy of two *primary* air surveillance radars of the 2000's has been stated to be 0.2˚[47]. This is similar to the 2004 SSR azimuth accuracy (0.15˚).

Considering that primary and secondary returns were rarely observed separated on the Bright display, a reasonable conclusion can be made that primary and secondary radars had very similar azimuth and range accuracy.

Accordingly, in the 1981 RSR case 1.5˚ is the accepted azimuth accuracy for both the PSR and SSR until actual specifications are obtained.

At the ranges VH-MDX was from The Round Mountain RSR around 1.5˚ manifests into approximately 2.6 - 2.8NM.

Range error for the primary RSR in 1977 was specified as being 1% of the target range when using the PPI[51]. This results in 1.0 - 1.1NM range accuracy at the distances VH-MDX was at from The Round Mountain RSR[20].

SSR accuracy of the 1981 RSR will be determined but in the meantime the 2004 example given provides a fair insight into likely tolerances of 1981 as described. As the SSR accuracy would have likely been better than the PSR accuracy, this approach is also conservative. Two DoT ATCO's of the 1980's agree with this suggestion[36][37].

The Bright display had a displayed radar information to map accuracy of +/-0.5% of the 20” display diameter[51]. This roughly equates to 1.7 NM[20].

It must be clarified that the accuracy values discussed in this section represent *maximum* deviations and actual accuracy values experienced would have been much lower for the vast majority of the time.

3.4.14. Radar read-off errors

Read-off errors in the VH-MDX case are limited to some degree as a result of the boxing in of the radar paints by radar map display depicted airspace boundaries, range arcs and tracks.

Even still, discussions with ATCO’s who used Mosaic Bright displays reveal how a tolerance of around 2NM for paints within 10NM of a map reference or, 5NM when outside 10NM can be realised[20].

Communications transcripts pragmatically show the effects of a quick range assessment with that of a precise approach.

VH-MDX was initially stated as being 40NM north of Singleton NDB but was seconds after refined to 36NM when the ATCO assessed ‘*…it accurately….*’[1]. This is a difference of 4NM.

Discussions with ATCO’s who had used the Bright display revealed that up to +/-10˚ of bearing and +/-5NM of range error could be experienced when *determining the bearing/range* of radar paints (read-off errors)[20].

With care +/5˚ and +/-1NM to 2NM could have been achieved[20]. Deviations appeared to be dependent on distance *measured* with the following determined[20]:

- >10NM distance resulted in +/-5NM deviation
- <10NM distance resulted in +/-2NM deviation

3.4.15. Mosaic radar information

3.4.15.1. Mosaic SSR paints

Only one SSR source was displayed for each aircraft at a time[20]. SSR source selection logic on the Mosaic Bright display has been determined to a strong level of confidence[20].

It was stated that SSR paints from each RSR were only ever displayed on their own respective sides of the gating line[20]. Reference to this electronic gating line has been found in an official DoT manual of the time.

The electronic gating line was a simple straight line that connected the intersections of the two 160NM range arcs from each RSR[20]. Figure 45 on the next page presents this. The line was not visible on the display[20].

It is almost certain that the position of the gating line on the Sydney Northern Mosaic was as described and that SSR information from only the Sydney RSR was displayed south of the line and only The Round Mountain RSR SSR radar information was displayed north of the line[20].

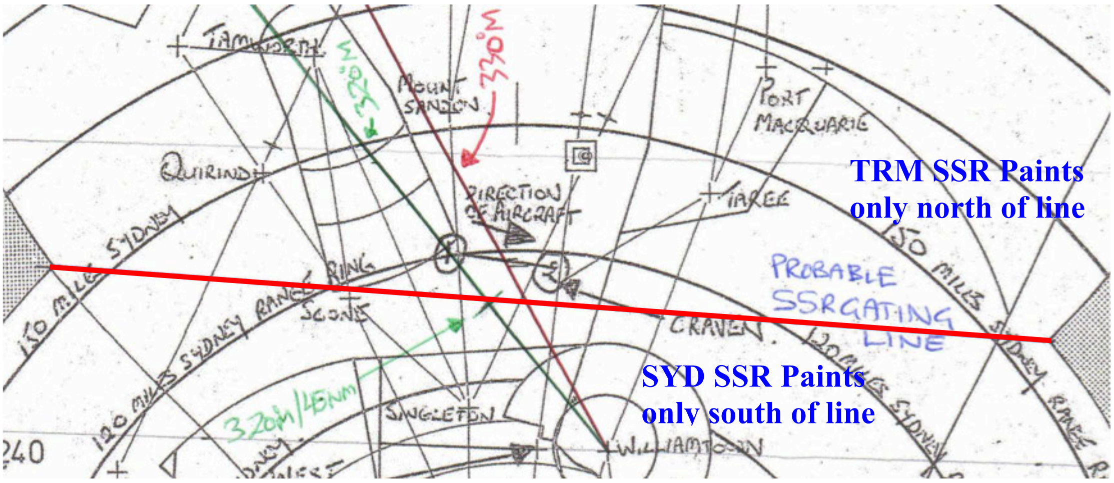


Figure 45: SSR gating line. The electronic gating line was not visible on the display and formed a hard barrier determining the RSR SSR source that would be displayed. North of the gating line only The Round Mountain RSR SSR information was displayed, south of the gating line only Sydney RSR SSR information was displayed. (Image: Australian Government (Department of Transport) 1981, additions: Glenn Strkalj 2015).

As VH-MDX was highly unlikely able to be interrogated by the Sydney RSR, this means that if VH-MDX tracked south of the gating line the aircraft's SSR paints would likely disappear from the Bright display. Accordingly, this knowledge can be applied to flight path analysis.

In particular, this reveals that the 320˚M/45NM radar fix was more likely north in azimuth of 320˚M (i.e. ≈321˚M-324˚). This confirms other findings suggesting a more northerly azimuth than 320˚M.

3.4.15.2. Mosaic PSR paints

Conflicting information exists to Mosaic PSR paints. One suggestion is that *remote* radar heads at the time (in this instance The Round Mountain RSR) reportedly displayed small solid squares to represent Primary Surveillance Radar (PSR) returns whilst the Airport based head (in this case Sydney RSR) displayed raw 'slashes'[20].

Many other Radio Technical Officers suggest PSR paints from both RSR's were displayed for the one aircraft as slashes[20]. Such a logic would not cause confusion as two SSR symbols for the same aircraft would and additionally would offer the ATCO a check of RSR alignment[20].

It cannot be confirmed at this stage through *discussions with ATCO's* if the Remote PSR 'small squares' or Airport RSR PSR 'slashes' returns were observed during the VH-MDX event although as stated earlier it was found highly unlikely through propagation analysis that Sydney RSR was able to interrogate VH-MDX.

Knowing which PSR and indeed which SSR returns were observed can give clues to read-off tolerances and the likely altitude of VH-MDX at radar fade.

It is viewed probable that there was no gating logic for PSR paints on the Mosaic display and that PSR returns were presented as slashes from both the remote and airport RSR's.

3.5. Initial Sydney radar fix to Williamtown 320˚M/45NM radar fix (0928:45UTC-0936:00UTC)

3.5.1. Overview

Following the initial Sydney radar fix, VH-MDX turned generally south then conducted a gradual turn to the east being identified by Williamtown TAR at a reported position of 320˚M/45NM at 0936:00UTC.

In terms of accuracy and precision this radar fix is the best radar derived position obtainable so far. It is also the least ambiguous radar position farthest down the recorded communications time line.

3.5.2. Climb difficulties: 0928:10UTC

VH-MDX appears not to have achieved the climb to 10000' as the pilot reports that he was '*struggling to get 85* (8500')' at 0929:10UTC[1]. Considering the climb was probably started some 4 minutes previously from 8000', it can be seen a very low climb rate of around 100fpm (feet per minute) was apparent.

This outcome may have been the result of airframe and propeller icing and/or significant downdraft/rotor activity from terrain (mountain) induced weather. Indeed the latter was likely given VH-MDX's position over and to the lee of some significant ranges around this time.

3.5.3. First West Maitland vector: ≈0929:40UTC

VH-MDX requests a vector to West Maitland at 0929:32UTC with Sector 1 advising FIS-5 around 0929:40UTC for VH-MDX to maintain present heading. FIS-5 advises VH-MDX at 0929:53UTC to maintain *present heading* for West Maitland based on the Sector 1 radar controller's advice[1].

As discussed in section 3.4.11, it cannot be confirmed if the present heading instruction was:

- Intended to develop a radar track history
- To avoid unnecessary maneuvering of VH-MDX
- Because VH-MDX was already roughly tracking to West Maitland.

It was viewed the more likely that the ATCO was developing a track history. Track history would not be required to issue a heading for West Maitland as all that was necessary was to have an identified paint but, obviously the ATCO needed to see where VH-MDX was tracking.

A little after 0928:30UTC, FIS-5 asks Sector 1 for a present heading of VH-MDX to which Sector 1 responds: *Oh...* its *a bit hard to tell*' and that Sector 1 would: '*I'll let you know in about two or three*'[1].

This does hint at difficultly in determining VH-MDX's track from the slow sweeping RSR approximately 1 minute prior to the West Maitland vector request. It is also suggested VH-MDX's slow speed at this stage (flying into wind and likely at climb speed) generating small length paint histories combined with weather clutter could also have added to the difficulties[20].

 © Glenn Strkalj 2014

If the pilot of VH-MDX were tracking towards the Scone NDB, a *very approximate* course of 245˚M would have been required to track direct to the NDB with drift correction. If homing on the NDB an approximate heading of 245˚M would also result in a track *close* 245˚M given the accepted wind.

The initial Sydney radar fix was determined around 0928:45UTC, passed to VH-MDX at 0929:03UTC and a request for vector to West Maitland was made by the pilot of VH-MDX at 0929:32UTC[1].

Accordingly, if VH-MDX was radar observed at this stage to be tracking towards West Maitland, the pilot of VH-MDX had approximately 30 seconds to absorb the radar position given to him, develop a picture then react by steering the aircraft to track towards the desired location (West Maitland). Such an outcome was completely possible given:

- Simplicity of the radar fix being located almost along a track leading to one of the pilot's originally intended enroute navaids (Singleton NDB)
- To have turned from a heading of around 245˚M to around 150˚M (95˚ total) would have taken a little over 30 seconds at standard rate (3˚/sec) (Agrees with transcript based timing) (heading not corrected for wind)
- The full turn would not need to be complete to reveal on radar a generally southerly to southeasterly track
- The RSR having a sweep rate of 12 seconds in this time frame would have probably displayed two paints that were displaced towards the south to southeast of the initial radar position.

Considering the likely intention of VH-MDX to turn south towards destination, one cannot conclude that VH-MDX was tracking to West Maitland at this stage but it is probable VH-MDX commenced tracking generally to the south[20].

VH-MDX was positioned very close to the 150˚M radial *to* West Maitland VOR at and shortly after the initial Sydney radar position.

The SOC upgraded the SAR phase to an Alert Phase (ALERFA) at 0931UTC[1].

3.5.4. Turn southbound: 0931:16UTC

Sector 1 reports observing VH-MDX having turned southbound at 0931:16UTC and requests (via FIS-5) the present heading of VH-MDX to which the pilot replies *'…is averaging somewhere around two-two-zero'*[1].

Such a heading considering the Area Forecast (ARFOR) winds would yield a track of *approximately* between 205˚M to 215˚M at either cruise or normal climb speeds.

The southbound observation ties in *generally* well in order for VH-MDX to achieve the 320˚M/45NM Williamtown radar fix: i.e. VH-MDX had to turn southeast from its probable southwesterly course (possibly around 245˚M if tracking the Scone NDB) at the initial radar fix[20]. It must be remembered southbound may indicate any course in the southern cardinal hemisphere[20].

As the aircraft heading was advised to be unstable in indication or maintenance, tracking could be easily either side of 205˚M-215˚M.

Given the turbulence it is suggested more likely that the direct indicating compass upon which the pilot would be relying upon for primary heading information was unstable as a result of the inherent inertial errors of such an instrument in rough flight conditions (rather than the compass indication moving as result of unstable pilot control inputs).

The roll axis autopilot would have greatly assisted in maintaining control of heading.

Given the relatively short time frame (about 1.5 minutes) from the initial radar fix, it is expected that VH-MDX would have turned somewhere towards the south after the initial radar position was given (to head towards intended plan and/or destination) by this time[20].

3.5.5. Second West Maitland vector: 0931:47UTC

An exchange of information occurs between FIS-5 and Sector 1 from just after 0931:28UTC during which the FIS-5 FSO explains that VH-MDX has lost the Artificial Horizon (AH) and ADF.

At 0931:47UTC Sector 1 advises a heading of '*…about 150 from his present position*' to track to West Maitland[1] and this was passed to VH-MDX by FIS-5 approximately 10 seconds later.

This alludes to a position from West Maitland on the reciprocal bearing, 330°. A similar suggestion was also described in *Operation Wittenoom VH-MDX Research*[25].

A position within 10˚ of the West Maitland 330˚M bearing was suggested based on read-off ability from the Northern Mosaic display[20].

Overviewing actual audio recordings reveals that FIS-5 although stating '…..*required to turn onto a heading of one-five-zero by radar*' the 'required' sounds very much like 'right' A right turn would lead VH-MDX away from West Maitland. The pilot seems to be aware of this by strongly questioning the FIS-5 FSO if the directed turn was to the right to which the FSO clarifies that a *left* turn is required.

Given the pilot's confident questioning of a perceived inappropriate turn direction, it can be seen that the pilot had a reasonable mental picture at the time of where he was and where he had to go to.

This is important to confirm as such situational awareness would easily be lost in a 'partial panel' (primary instruments failure) environment in cloud. Retaining situational awareness on position may give clues to the pilot's intent therefore probable tracking. It also alludes to the successful use of the roll axis autopilot.

3.5.6. Sydney passes position to Williamtown: 0934:00UTC

Just after 0934:00UTC Sydney Sector 1 contacts Williamtown and asks if the Williamtown radar is on to which the Williamtown ATCO responds '*affirmative*'[1]. Sydney Sector 1 passes a position of 320˚(M) at 45NM from Williamtown and also advises that VH-MDX is squawking mode A code 4000[1].

The Williamtown ATCO does not observe any SSR paints but does state a '*…primary paint about 45 miles*'.[1]

The Williamtown ATCO has clarified with the author that this was not referring to a PSR paint likely of an aircraft but was referring to the Permanent Echoes (PE's) of the Barrington and Gloucester Tops where the 45NM paint was located[21].

Indeed the Williamtown ATCO did mention in discussions with the author that PE's of the Barrington Tops were a permanent feature outside 44NM where stationary targets were not filtered by the Moving Target Indicator (MTI) filter[21].

It has been suggested by a number of Williamtown ATCO's who used the SURAD TAR that it was effectively impossible to discern *primary* paints from aircraft in the permanent echoes of the Barrington and Gloucester Tops[21].

It is noteworthy to mention the Williamtown ATCO can be seen to have a methodical approach in verbalising the stages of the processes he was carrying out mentally.

A good example is when checking for VH-MDX radar returns at around 0941:20UTC where he sequentially verbalises every possible avenue for detection.

A request to change VH-MDX's mode A SSR code from 4000 to 3000 and to squawk SPI ident was given around 0935:41UTC[1]. The former action was perceived as required to interrogate VH-MDX on the Williamtown radar.

Contrary to Nolan's suggestion[25] or what may be insinuated by reading communications transcripts, such a mode A code change was *not* required as either the Sydney or Williamtown radars could interrogate and display *all* SSR codes possible and could do so *almost* simultaneously[21].

VH-MDX squawking ident was essential for the Williamtown ATCO to positively identify VH-MDX.

On the Williamtown ATC Radar, *particular* display symbols could be allocated through thumbwheel switches to *particular* SSR codes ('dialed up') but of importance is that <u>all</u> received SSR codes could be displayed by a synthetic symbol regardless of these thumbwheel settings[21].

Non 'dialed up' codes were represented by a symbol allocated to all *non-preselected* codes most likely being an inverted 'Y'[21] this being the same symbol allocation as Sydney ATC radar[21].

As described in the previous paragraphs, VH-MDX was squawking a mode A code and was within line of sight of the Williamtown SSR ground station out to at least 48NM[20] so, there was no reason VH-MDX would not be displayed *unless VH-MDX was not within 48NM of Williamtown*.

A refinement of position is given by Sydney Sector 1 at 0934:30UTC to assist Williamtown in locating the paints on his display[1]. This is in the form of a distance amendment of 46NM however no VH-MDX paints were detected by Williamtown[1].

It was suggested by ATCO's experienced with the Bright display radar that 2NM read-off resolution could be achieved when referencing the returns from fixed references such as waypoints etc <u>within 10NM of the return</u>[20]. No such references exist in the vicinity of this particular position.

Furthermore, as the position had to be defined in reference to Williamtown, a simple reference to the closest waypoint was not applicable. There were no range rings from Williamtown in the vicinity of the position so, the Sector 1 ATCO had to extrapolate. It can be seen that errors in range are almost assured.

It was also shown that range deviations of around 5NM all-round were applicable to paints that could *not* be referenced to map features within 10NM and this is applicable to this 320˚M/45NM position[20].

From this it is clearly seen that although VH-MDX was stated to be at 46NM from Williamtown by Sydney radar, the aircraft could in fact have been as far as 51NM away. Considering:

- The Williamtown radar could *detect* and *display* all mode A codes possible[21]
- The Williamtown ATCO describes to the author a high level of detail in searching for radar returns amongst and away from the Barrington Tops PE's
- That the primary paint referred to at 45NM was unlikely to be VH-MDX as the ATCO was referring to the PE's whilst an SSR symbol would have been associated with it and visually detectable if an aircraft
- VH-MDX was squawking a mode A code at the time[1]
- Propagation analysis suggests VH-MDX was within line of sight of Williamtown ATC radar during the times in question out to 50NM along the 320˚M bearing to altitudes well below 7000'[21]
- The outer limits of the Plan Position Indicator (PPI) (radar scope) was set to 48NM during the accident[21]
- A read-off tolerance of around 5NM;

It is concluded likely that VH-MDX was outside of 48NM from Williamtown just after 0934:00UTC and possibly up to 0935:00UTC although it cannot be confirmed when the ATCO ceased observing the PPI.

Of note is although the Williamtown PPI could be set to a 96NM maximum range, changing maximum range would result in the PPI going blank for a significant time[21] that is obviously an undesirable state when experiencing high workloads.

3.5.7. Turning easterly: ≈0934:20UTC

During the process of passing VH-MDX's position to Williamtown, the Sydney Sector 1 ATCO advises at around 0934:20UTC: '*He's just turned onto an easterly heading looks like about 120*'[1]. The immediacy of the 120˚ turn as recorded in the communications transcripts can insinuate a turn was 'just made' to 120˚M track at a fast rate[20].

But, considering the situation at a big picture level, one can see how VH-MDX may have been observed at a *certain instant* of a *continuous* turn towards the east. i.e., VH-MDX may have been observed for the last number of radar paints to be turning to a track of 120˚M but this may have simply been one portion of a slow turn to the east[20].

It was stated that a *slow* turn to the east was radar observed of VH-MDX[20]. From the author's understanding, it appears this slow turn commenced roughly from where the 150˚M heading advice to West Maitland was given to VH-MDX at around 0932:00UTC[20] (basically, just after the southerly observed radar track from the initial Sydney radar position).

To have turned from approximately south at 0932:00UTC to a track of 120˚M at around 0934:20UTC suggests a slow turn rate: 60˚ in 2 minutes 20 seconds = 0.4˚/sec which is a relatively slow turn rate). This somewhat backs the suggestion of a slow turn to the east.

3.5.8. Icing, downdrafts, lights on the coast: 0934:20UTC

During the period where Williamtown ATC was attempting to identify VH-MDX by radar, at 0934:20UTC the pilot reports having picked up '*a fair amount of ice*' and that '*I can just make out a few towns on the coast*'. Also reported was a significant downdraft of about 1000fpm (feet per minute)[1].

These reports do suggest flying in at least *partial* visual conditions and that VH-MDX had flown through precipitation and/or significant cloud to accumulate ice. Such conditions also allude to flying somewhat away from the range tops or being located in a section of the ranges away from the west or south.

It is likely VH-MDX was located on the south or western sections of the upper to middle slopes and this was where most of the weather was. Despite this, scattered to broken cloud was forecast[1] which would allow opportunities for visual sightings of townships.

Furthermore, most cloud was forecast with tops of 4000'-7000'AMSL with occasional tops to 12000'AMSL[1]. As section 3.6.1 will reveal, VH-MDX was likely to have been between 7500'AMSL and 8500'AMSL at this time so, being above *most* of the cloud. This would result in at least partial visual conditions if not fairly consistent visual conditions. Why then the pilot elected not to turn south visually is unknown.

How the pilot determined ice accumulation can only be suggested however, poor aircraft performance and possibly ice on the windscreen or inboard leading edges that could be sighted (in the dark night) are plausible. Section 3.7.6 will discuss icing further.

3.5.9. Intention to continue flight plan: 0934:40UTC

At 0934:40UTC *communication transcripts* state the pilot of VH-MDX responds to a question of whether VH-MDX was equipped with pitot heating from FIS-5 with: '*It's a single…and we'll try to continue our flight plan*'[1].

A DoT officer did describe to the author how some phrases from the audio recordings took some time to determine whilst also leading to *different conclusions* later. '*It's a single*' was an example given by the DoT officer suggesting that after the transcripts were typed it was thought that 'Singleton' was actually said by the pilot rather than '*It's a single*'[36].

Overview of the audio recordings does support this suggestion whilst the context of using 'Singleton' within the sentence '*and we'll try to continue our flight plan*' does make much more sense than 'single'.

Also of note is that FIS-5 seems to have clipped the transmission from VH-MDX as the VH-MDX transmission flows on immediately after the FIS-5 transmission with no gaps. Additionally, the reply from VH-MDX does not align in *context* with FIS-5's query thus also supporting the proposition of a clipped transmission.

What relevance is all of this? An idea of the pilot's intentions can be gained that may then offer clues to the final flight path. The flight plan legs were Craven-Singleton-Mount McQuoid -Bankstown. A *very* approximate position at the time of the call was in the vicinity of the Mt Royal Range at approximately 25NM – 30NM north of Singleton NDB.

If VH-MDX was continuing flight plan then a track immediately south to Singleton would be expected but an easterly track was radar observed. One consideration was that the ADF was reported as '*…going all over the place*'. The only azimuth aid at Singleton was an NDB so, it is possible the pilot elected to use VOR's only.

Directly south approximately 60-65NM was Mount McQuoid VOR which was a navaid originally flight planned after Singleton. A turn to the south tracking the current Mount McQuoid VOR radial would have taken VH-MDX easily and efficiently to Mount McQouid and away from the Barrington area.

Despite this, the weather was passed on as suspect in this area by Sydney ATS as this is what held up VH-MDX's Williamtown clearance. Sydney ATS also eluded to VH-MDX that coastal weather was VMC.

Sighting of coastal towns may have also spurred the idea to track towards West Maitland or other towns although, it cannot be verified if the pilot actually sighted *coastal* towns or other townships in the Hunter Valley.

Indeed after flying through the weather that the pilot did, a 'moth' mentality (fly towards the light) would develop rather easily following the sighting of townships.

With this in the pilot's mind and considering the pilot reported seeing coastal towns, the pilot may have intended over flight of the West Maitland VOR to the south-east followed by a visual coastal route.

Tracking to West Maitland VOR was also suggested by Watson[46].

Interestingly, if one considers the approximate track from the 320˚M/45NM position to the Sydney final radar position, extending the track ahead reveals that the town of Gloucester and the coastal towns of Taree and Forster (depending on which tolerance value is used for the 320˚M/45NM fix) are almost directly ahead.

Despite the above, there was a good chance that significant cloud existed on the Gloucester range tops between VH-MDX and the towns of Taree or Forster. Such cloud could possibly block sight to these townships.

It is also worth noting that the larger *coastal* towns of the area would have glowed more brightly than smaller townships inland. The pilot of VH-MDX may have sighted coastal towns and proceeded to track towards them visually but he does not report doing so.

It appears despite his icing and turbulence encounter, the pilot of VH-MDX was happy to continue on normally. Indeed throughout the whole flight the pilot of VH-MDX does not declare an urgency or emergency to ATS.

3.5.10. Cockpit fire, West Maitland airport lights: 0935:00UTC

FIS-5 advises VH-MDX at 0935:00UTC that the airport lights are switched on at West Maitland if the pilot wished to make a diversion there. The pilot replies five seconds later: '*Mike delta x-ray, no, we thought we had a cockpit fire but ah we seem to have resolved that little problem………………West Maitland, but would appreciate if you'd leave the lights on for a while*'[1].

The transmission regarding resolution of the cockpit fire was stated somewhat sarcastically (from audio recordings) ('*….we seem to have resolved that little problem*'). ATS immediately declares a Distress Phase (DETRESFA) upon receiving the advice of a cockpit fire at around 0935UTC[1].

It is suggested that an actual fire was *unlikely,* nor is it viewed probable to be cockpit dust floating around the cockpit from the turbulence as suggested by some. A possible explanation could be one of the passengers lighting up and partaking in a cigarette as it can be seen given the turbulence how such an action may have been soothing.

What is of interest is the reference to West Maitland that was clipped. The pilot originally requests radar steer to Bankstown at 0924:37UTC then to West Maitland at 0929:32UTC. At 0934:40UTC the pilot advises that he is trying to continue his flight plan. The cockpit 'fire' may have been the impetus to ask for vectors to West Maitland.

The reference to West Maitland may have been associated with tracking to West Maitland VOR followed by a coastal route as described in the previous section. What was said in the clipped section cannot be discerned.

3.5.11. Change of squawk code

At 0935:00UTC the Williamtown ATCO informs Sydney of VH-MDX: '*He's right in the Barrington Tops at the moment*' and that the Williamtown PPI displays permanent echoes from terrain beyond about 44NM[1]. With the latter comment, the Williamtown ATCO is suggesting to Sydney that detection of paints is difficult in this terrain clutter.

As described in section 3.5.6, it has been found the SURAD TAR would have displayed *any* code detected with an SSR symbol on the PPI *regardless* of code pre-selection[21]. Pre-selection was simply a feature used to allocate *specific* symbols to *specific* codes but *not a requirement* to display SSR returns[21].

At 0935:20UTC the Williamtown ATCO asks Sydney Sector 1 if VH-MDX could squawk mode A code 3000 to which the latter agrees[1]. At 0935:26UTC Sector 1 directs the FIS-5 Assist to advise VH-MDX to squawk mode A 3000 with ident and that Sector 1 is attempting to obtain a radar fix from Williamtown[1].

FIS-5 directs VH-MDX to squawk mode A code 3000 and ident at 0935:41UTC[1]. The pilot of VH-MDX confirms squawking mode A 3000 and ident at 0936:07UTC.

An SSR symbol is detected at 0936:00UTC by the Williamtown ATCO '*Just in the Barrington Tops'* and: '*just about 320* (˚M) *Williamtown 45*(NM)'[1]. An SPI ident symbol was also viewed over the same return shortly after[1][21].

Procedural control was in force, which meant the Williamtown ATCO was located away from the PPI[21]. There was no requirement to monitor the PPI[21]. The ATCO stepped across from the procedural work area to observe the PPI for VH-MDX[21].

Figure 46 presents a photo of Williamtown Tower during the 1970's. The SURAD PPI is visible and the likely procedural control position is marked.

Figure 46: Williamtown control tower. As procedural control was in force, there was no permanent manning of the PPI nor was there a requirement to even have the radar on. The ATCO had to step between the procedural work area and the PPI (Photo: H. Howard c.1970's).

3.5.12. Williamtown 320˚M/45NM fix: 0936:07UTC

3.5.12.1. Overview

VH-MDX was positively identified around 0936:00UTC at 320˚M/45NM from Williamtown (just west of Mt Ally) using Williamtown TAR with the following observations[21]:

- SSR mode A 3000 SSR symbol (likely to be a circle)
- Ident (SPI) triangle;

Superimposed on each other with the centroid of the images easily determined[21]. Figure 47 depicts the SSR symbols that would have been observed.

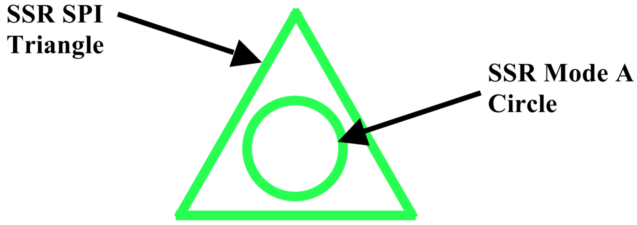


Figure 47: Observed VH-MDX returns at 0936:00UTC. The ATCO cannot recall with *complete* certainty the *type* of SSR mode A symbol that was displayed but was absolutely certain it was observed along with the SPI triangle. The ATCO recalls a circle. The SPI triangle was observed as being unclipped by the outer edge of the PPI and *not* hanging over the 44NM MTI boundary. Primary paints from VH-MDX were not discernable in the terrain clutter (Image: Glenn Strkalj 2014).

PSR returns were classed as 'impossible' to discern in the PE's of the Barrington and Gloucester Tops by two ex-Williamtown ATCO's[21]. SSR returns on the other hand were described as being easy to detect in such clutter as a result of the transverse nature of the symbology across the unidirectional (tangential) clutter[21].

Offset controls used to move the origin (centre) location of the PPI were confirmed to be centralised thus, the PPI origin was centered on the physical radar head position[21]. The offset control panel is shown below in figure 48.

Figure 48: PPI offset controls. The displayed area on the PPI could be offset away from the radar head at origin position. This obviously changes the reference point for any bearing/range given so, the setting needs to be known in order to *geographically* plot radar fixes. Two controls were available to move the PPI origin position in both the X and Y-axis. The offset was then activated or cancelled by pressing the 'Select/Reset' button. Offset was confirmed as <u>not</u> being used during the VH-MDX accident thus, radar bearing/ range positions after modification for 1981 magnetic variation, can be directly plotted on charts. (Photo: Glenn Strkalj 2014, access to SURAD PPI courtesy of The Australian Aviation Heritage Centre).

The exact radar head position has been confirmed by the author through aerial photography archives[21].

It was *very roughly* estimated that the returns of VH-MDX were observed for at least two sweeps of the radar but in any case there was *no prolonged* period of observation of these returns[21].

Radar calibration has not been confirmed yet but is assumed with reasonable confidence to be within applicable standards.

Figure 49 is a photo of the Williamtown approach room PPI and offers good examples of primary and secondary aircraft paints whilst also clearly showing the Barrington/Gloucester Tops permanent terrain clutter.

Figure 49: Williamtown SURAD PPI. Although this photo is of an *approach* PPI rather than the *tower* PPI used during the VH-MDX accident, almost everything except for the size was the same. The tower PPI was a little smaller (17”) than the approach PPI (Photo: H. Howard c.1983).

3.5.12.2. Position tolerances

The Williamtown radar position has been suggested with confidence by the Williamtown ATCO to be observed within +/-2˚ and +2NM/-0NM of 320˚M/45NM based on recent (2014) interviews with the ATCO[21].

Such accuracy was attributed to the close position of the VH-MDX SSR returns (around 45NM) compared to the PPI outer edge (48NM) where the compass rose was located to read off the bearing[21].

An alternative position of 324˚M was suggested by a person who informally discussed the fix with the Williamtown ATCO within weeks of the accident[43]. Many finer points of this discussion cannot be refined. As this information was obtained close to the incident date and the memory of the witness regarding the ≈324˚ azimuth was very clear, an azimuth value of around 324˚ is viewed as a likely azimuth.

Indeed the position of 320˚M/45NM compared to the SSR gating line suggests a position further north to avoid loss of SSR paint and 324˚M would satisfy this requirement.

It was also shown how a maximum bearing tolerance of +/-10˚ was applicable as a worst case 'quick visual assessment' when using SURAD[21]. This is a possible deviation given procedural workload and movement to and away from the PPI.

Whether +4˚ or +2˚ is accepted, the 320˚M/45NM fix remains a reasonably precise and defensible radar fix[21]. The position is the most reliable and precise radar fix furthest down the accident time-line.

3.5.12.3. Azimuth determination

Such was the proximity of the paints that a simple visual assessment was enough to determine the bearing accurately with high confidence[21]. 5˚ and 10˚ marks were provided on the compass rose with actual numeric bearings marked for each 10˚ value of bearing[21].

Figure 50 is a photo of the Williamtown *Approach* SURAD PPI that shows the 5˚ and 10˚ bearing markings and annotations as discussed. The tower PPI in use during the VH-MDX accident was smaller in size but had the same rose markings[21].

Figure 50: Williamtown SURAD approach PPI rose. This photo shows the compass rose with 5˚ and 10˚ marks and numeric values for each 10˚ value. 10NM range rings are also visible. (Photo: H. Howard c.1983).

3.5.12.4. Range determination

VH-MDX range was easily determined as the returns were located between the last 10NM range ring (40NM) and the PPI outer edge (48NM) but more importantly between the 44NM MTI boundary outside which terrain clutter (PE's) of the Barrington and Gloucester Tops was prominent and the PPI outer edge (48NM)[21].

The ATCO observed the *full*, *unclipped*, shape of the SPI triangle and mode A symbol, likely a circle, confirming the returns were *easily* and *definitely* inside the 48NM outer scale of the PPI rather than being right on the edge[21].

The returns were also confirmed to have not 'hung' over the 44NM MTI boundary (terrain clutter PE's)[21]. SSR symbology was variable in size as set by technicians on the day but it appears to the author the *smallest* possible useable size is in the order of 1NM[21].

The Williamtown PPI photo of figure 49 shows SSR circle symbols 2NM in diameter[21]. The SPI triangle would have been larger than the SSR circle.

It can be seen then that these pieces of evidence together suggest that the VH-MDX returns were not closer than 45NM (otherwise the SSR symbols would hang over the 44NM MTI boundary) and not more than 47NM (otherwise the SSR symbols would be clipped) from Williamtown[21]. 46NM was suggested as the most likely range VH-MDX was observed at[21].

It is viewed that range determination was more precise than azimuth. This is because of the proximity of VH-MDX paints to the 48NM outer edge, brightly lit 44NM MTI boundary and range rings compared to the non-illuminated compass rose.

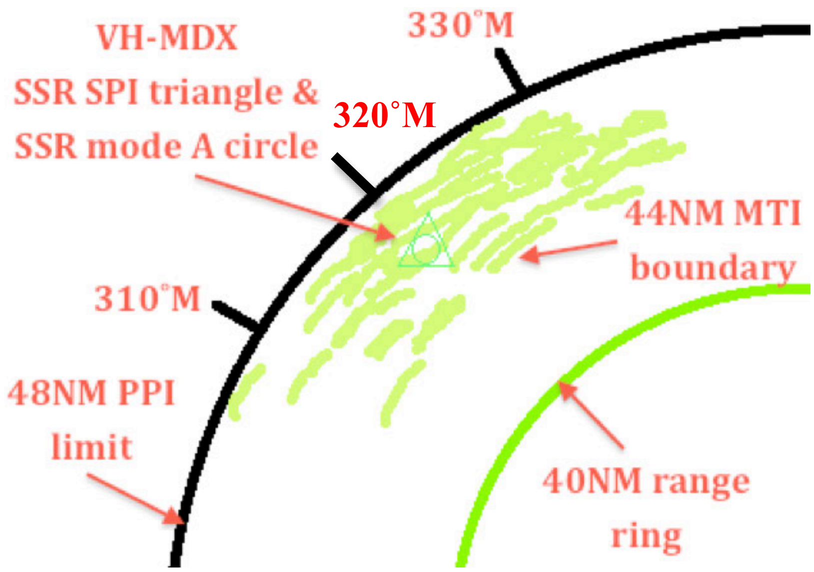


Figure 51: Reported position of the 320˚M/45NM fix. SSR returns are purposely dulled down in the picture to show the effect of terrain clutter on the ability to discern returns. Regardless, the Williamtown ATCO did state that the SPI triangle and mode A squawk (circle) were 'clearly visible' despite the clutter due to the *shape* of the symbols cutting across the permanent echoes. 5˚ bearing checks are also included on the real PPI compass rose (Image: Glenn Strkalj 2014).

3.5.12.5. Appearance of VH-MDX returns

The SSR returns were *not* observed to 'bloom' (appear) in position nor were they observed to have transited from the outer edge of the PPI to the fix position[21]. What the ATCO recalls quite clearly is that he looked at the PPI and the SSR returns as described were apparent[21].

Consequently the ATCO suggests he must have been attending to procedural control tasks away from the PPI during some time period between 0934:00UTC (the initial check for VH-MDX) and 0936:00UTC when he observed the 320˚M/45NM fix[21].

Indeed a person discussing this fix within weeks of the accident suggested the Williamtown ATCO discussed how he was about two meters away from the PPI conducting procedural duties and leaned/stepped over to observe the PPI[43].

This is deemed highly probable given the significant procedural control workload at the time resulting in necessary movement away from the PPI to attend to strips, the printer, other screens and visually scanning for inbound traffic whilst handling the ATC communications 'party line' with multiple agencies on line.

In fact it must be remembered that observation of the PPI was *secondary* to performing procedural duties and that a highly finessed radar position was neither required nor likely to be at the forefront of the ATCO's objectives.

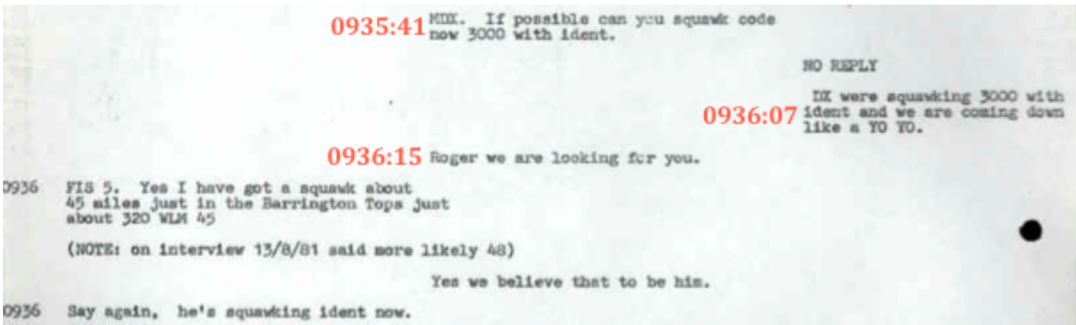
To perform these tasks the ATCO approximates at least one full side step away from the PPI was required[21]. The ATCO stated there were many different agencies on the one party line and that there was no way of telling who was who unless verbal confirmation was used for each agency[21]. It was suggested up to around six agencies could be on the same line at the same time[21].

ASIB communications transcripts reveal confusion at times on the party line as a result of the number of agencies participating[21].

3.5.12.6. Exact timing of fix

Cross-referencing transcripts suggests that the 320˚M/45NM Williamtown fix occurred around 0936:15UTC.

This was found by cross-referencing common FIS-5 and VH-MDX calls from the more accurate transcript made by ASIB's Spectrographic Unit with those of the Williamtown/Sydney transcript as shown below in figure 52.


0935:41 MDX. If possible can you squawk code now 3000 with ident.

NO REPLY

0936:07 DX were squawking 3000 with ident and we are coming down like a YO YO.

0936:15 Roger we are looking for you.

0936 FIS 5. Yes I have got a squawk about 45 miles just in the Barrington Tops just about 320 WLM 45

(NOTE: on interview 13/8/81 said more likely 48)

Yes we believe that to be him.

0936 Say again, he's squawking ident now.

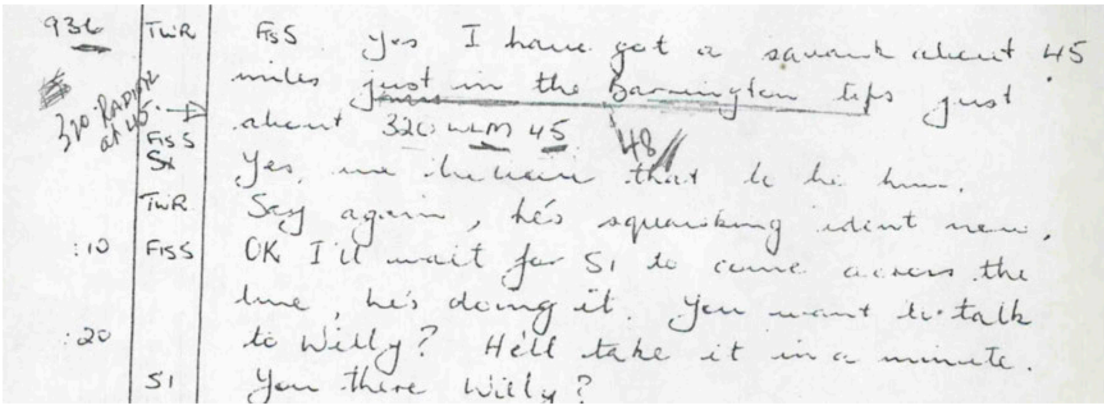
Figure 52: Time of 320˚M/45NM Williamtown radar fix. Cross-referencing communications transcripts reveals the fix was verbalised at some time after 0936:15UTC (Image: Australian Government (Air Safety Investigation Branch) 1981).

This suggestion is contingent on the ASIB recording the correct sequence of communications.

The written transcripts suggest that ≈0936:00UTC is the time of the fix as the following call ('*Say again he's squawking ident now*') is shown to have occurred just prior to 0936:10UTC. Figure 53 on the next page depicts this.

As the author has not located an audio recording of this radar position being verbalised, it is difficult to clarify the exact timing.

The written transcript is viewed as the original and most accurate version. Typed transcripts may be subject to transposing errors. Accordingly, 0936:00UTC is accepted as the Williamtown 320˚/45NM radar position time subject to a +/-10 second deviation representing the 10 second resolution of these transcripts.



936 | TWR | FSS Yes I have got a squawk about 45 miles just in the Barrington tips just about 320 WLM 45. 48

320 RADIAL at 46.

FSS S1 | Yes, we believe that to be him.

TWR | Say again, he's squawking ident now.

:10 | FSS | OK I'll wait for S1 to come across the line, he's doing it. You want to talk

:20 | to Willy? He'll take it in a minute.

S1 | You there Willy?

Figure 53: Written transcript: 320˚M/45NM Williamtown position. This transcript suggests an approximate 0936:00UTC time for the 320˚M/45NM position based on the next call being associated with 0936:10UTC (Image: Australian Government (Air Safety Investigation Branch) 1981).

3.5.12.7. Effects of SSR gating

Section 3.4.15.1 described how The Round Mountain RSR SSR paints would be suppressed when an aircraft passed south of the electronic gating line.

Section 2.9 revealed that Sydney RSR was highly unlikely able to interrogate VH-MDX. From these findings, it is then seen how VH-MDX SSR paints would not be presented on the Mosaic display if the aircraft proceeded south of the gating line.

Depending upon the precise position that VH-MDX was at during the 320˚M/45NM Williamtown radar fix, VH-MDX could have been just south or just north of the gating line.

Figure 54 on the next page presents the situation. The magenta line is the electronic gating line, the brown arcs represent range rings from Williamtown TAR between 44NM and 48NM at 1NM intervals whilst various bearing/range combinations are shown.

Immediately obvious is that the pure 320˚M/45NM position is south of the gating line thus SSR paints would unlikely be displayed in this position. The 320˚/46NM position is right on the gating line so, may or may not have been displayed. North of the gating line are the 324˚M positions that likely would have been displayed.

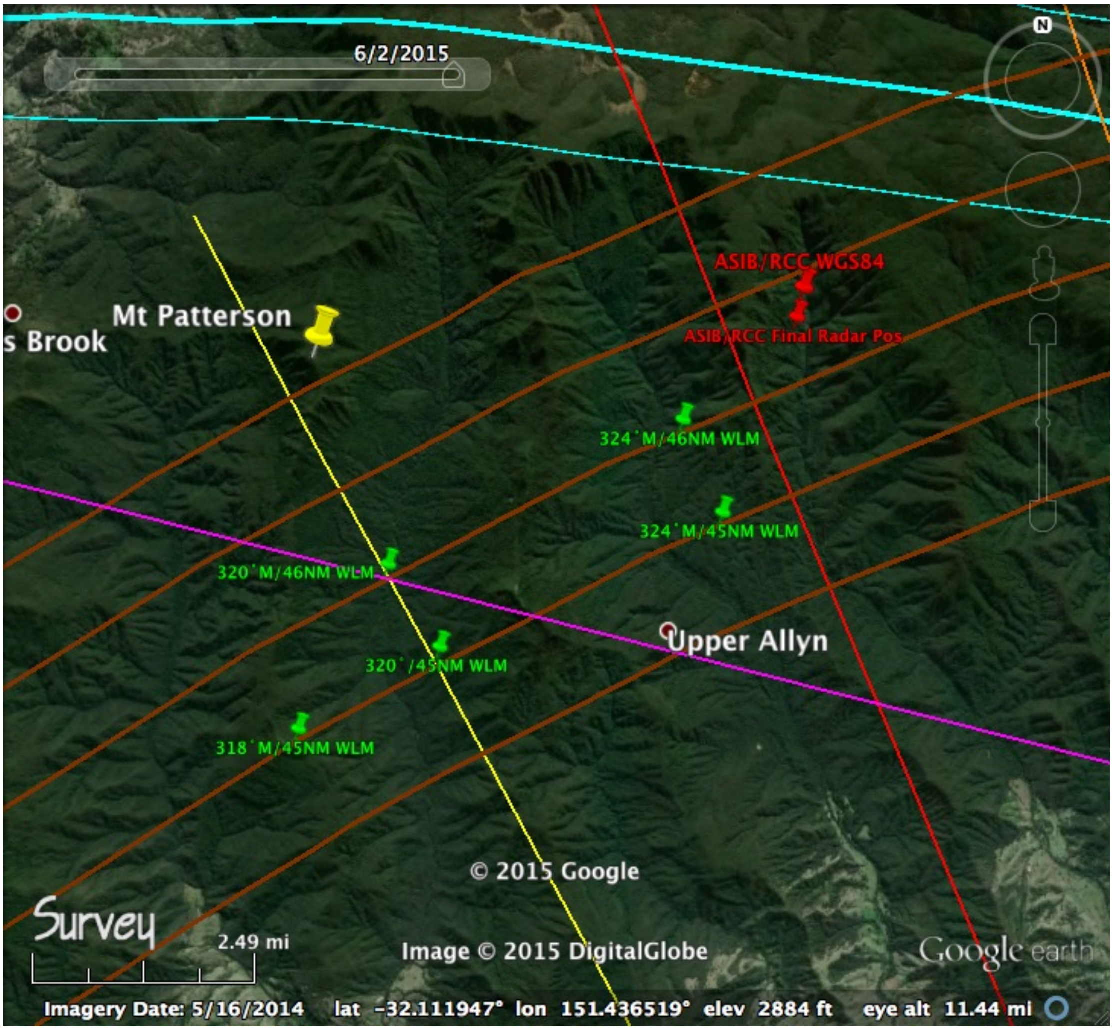


Figure 54: Gating line position and 320˚M/45NM fix. Assuming reliance on SSR paints, it is unlikely VH-MDX was at the pure 320˚M/45NM position considering this image. An angular position further north of 320˚M and a range more than 45NM can be seen to be more probable. This supports various findings indicating the same (Image: Google Earth 2015, additions: Glenn Strkalj 2015).

Assuming reliance on SSR paints for identification, what can be suggested of the 320˚M/45NM fix is that:

- The fix was unlikely to be a pure 320˚M/45NM position
- Azimuth values less than 320˚M are highly unlikely for the fix
- An angular position further north of 320˚M and a range more than 45NM can be seen to be more probable.

Section 3.5.12.4 found that 46NM was the most likely range VH-MDX was at during the fix. Likely azimuth during the fix was described in section 3.5.12.2 to be around 324˚M. It can be seen these values align with the suggestions of this section.

3.6. Most reliable radar fix: 320˚M/45NM

The 320˚M/45NM radar fix obtained by Williamtown ATC at around 0936:00UTC is classed as being *highly reliable* and of good accuracy and precision[4].

This is because:

- Williamtown radar was located at less than half the distance to VH-MDX than the Sydney ATC northern RSR's were[21]
- Williamtown ATC radar was configured as a TAR thus having a sweep rate much faster than the Sydney RSR's (faster display update)[21]
- VH-MDX was positively identified by squawk ident (SPI) (triangle) and mode A SSR symbol (likely a circle) superimposed over each other[21]
- VH-MDX at 45NM was in very close proximity to the 48NM outer edge of the radar display (PPI) where the compass rose was located thus, bearing read-off and range determination can be regarded as simple and precise[21]
- Permanent clutter of the Barrington and Gloucester Tops was displayed unsuppressed, *outside* of 44NM in the northwest sector and was a notable, *continuous* feature on the PPI[21]. VH-MDX was identified within this clutter thus, a gross error check of position exists (VH-MDX must have been between 44NM and 48NM in the northwest sector between 310˚M and 330˚M)[21]
- The maximum range can be further refined as the ATCO observed *full* and *unclipped* SSR symbology[21]; so, VH-MDX was not more than a maximum distance of approximately 47NM to preserve SSR symbol integrity[21]
- The minimum range can be further refined as the ATCO did not observe the SSR symbols hanging over the clutter transition at 44NM thus, VH-MDX was at least 45NM but probably closer to 46NM when considering possible SSR symbol sizes[21]
- Sydney Radar passed on a position of 320˚M/46NM approximately 1.5 minutes previous that grossly aligns with the Williamtown ATCO's position[21]
- The ATCO reported (in 2014) unequivocally that VH-MDX was observed on the 320˚ bearing and that he would have said 318˚ or 322˚ if such a bearing was observed
- An individual who talked to the Williamtown ATCO within weeks of the accident stated a bearing of 324˚M was suggested
- Offset feature confirmed as not being used
- Exact radar head position has been verified

This fix is the sole *complete* (bearing and range) radar fix made of VH-MDX by RAAF Williamtown ATC radar[21]. This and the initial Sydney radar fix around Moonan Brook are the only *completely confirmed* (during 2014) radar fixes of VH-MDX[21].

Considering the points above and in section 2, the 320˚M/45NM Williamtown ATC radar fix is clearly the most reliable, accurate and precise *latest* radar position of VH-MDX available.

A sample of the questionnaire given to the Williamtown ATCO is shown as figure 55 on the next page.

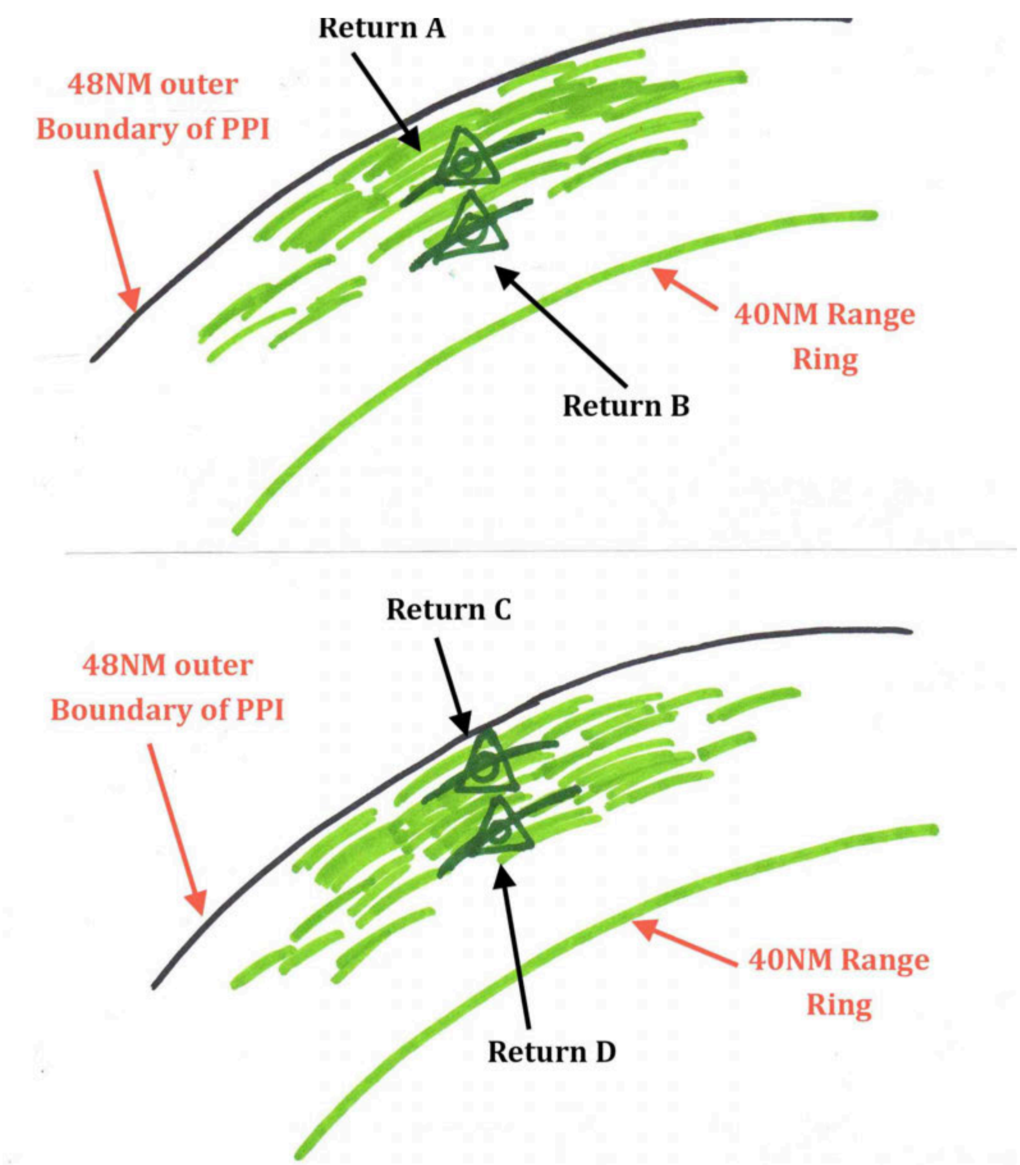


Figure 55: Multi choice options considering *range* for the 320˚M/45NM fix. A gross error check of reported VH-MDX paints was carried out by asking the ATCO to select the most appropriate positioned paint separately for range and bearing (2014). Only terrain clutter was displayed for reference. Terrain clutter was a known quantity on the Williamtown TAR. Despite the permanent terrain clutter, the SSR symbology of the returns were readily apparent to the Williamtown ATCO due to their shape cutting across the clutter direction. A 44NM MTI filter boundary and 48NM outer edge brackets the range of the returns. The ATCO was quite confident that the SPI triangle was not clipped by the outer edge of the PPI (48NM) nor was it hanging over the 44NM MTI clutter boundary (return B). The ATCO 'feels' there was a gap between the SPI triangle and the PPI outer edge rather than the paints touching the outer edge as in return C. Return A was chosen to represent what the ATCO observed. Considering the distance between outer edge and MTI boundary and probable SSR symbol sizes, VH-MDX was likely around 46NM when using this rough method. Referencing VH-MDX paints to the clutter only gives a *gross error check* to the reported position. 320˚/45NM, +4˚/-2˚, +2NM/-0NM is still viewed as the fix position. (Image: Glenn Strkalj 2014).

3.6.1. Altitude between initial Sydney and 320˚M/45NM fixes

VH-MDX seems to have maintained around 7500’-8500’ to the 320˚M/45NM fix. There is no *direct* evidence to back this claim however, VH-MDX reports an altitude of 7500’ at 0937:40UTC[1], approximately 1 minute 40 seconds after the 320˚M/45NM fix. Considering the situation, there would have been little benefit in descending below this altitude intentionally.

The pilot of VH-MDX reports that he was struggling to achieve 8500’ less than one minute after the initial Sydney radar fix (0929:11UTC).

Initial radar propagation analysis shows that VH-MDX had to be above approximately 8300’AMSL from the initial Sydney radar position to the 320˚M/45NM radar fix to ensure *continuous* radar coverage by Sydney ATC. Indeed radar contact with VH-MDX may not have been continuous.

As VH-MDX progressed south and east, various lowest interrogation altitudes of approximately 6000’-8300’AMSL were found in initial radar propagation analysis.

Transcripts suggest Sydney radar fade occurred by 0939:00UTC and this coupled with:

- The initial radar propagation findings
- A reported altitude close to 8500’ just after the initial Sydney radar fix
- Reasonable radar contact being maintained as communications transcripts suggest;

Loosely allude to VH-MDX maintaining an altitude from 7500’ to 8500’ between the initial Sydney radar identification around 0928:28UTC and the 320˚M/45NM fix at 0936:00UTC.

Section 3.7.7 will explain that this was the correct quadrantal cruising altitude for a southeast track and how the pilot may have intentionally decided to cruise at 7500’.

3.7. The final leg: 320˚M/45NM to ‘Five thousand’ (0936:00UTC-0939:26UTC)

3.7.1. Overview

Onwards of the 320˚M/45NM position from Williamtown (within radar tolerances stated), VH-MDX was observed by Sector 1 on radar to have a track initially of 150˚M but also stating that VH-MDX was ‘*all over the place*’[1]. A call on the ATS internal communications line of ‘*330*’’ (Magnetic bearing from Williamtown) at 0938:30UTC was attributed by ASIB to Williamtown ATC [1].

30 seconds later, a heading advice from Williamtown of 150˚ was given to track VH-MDX to Williamtown[1]. The Williamtown ATCO does not remember making the 330 or 150 calls when interviewed in 2014[21].

The only radar position verified as occurring by the Williamtown ATCO (during 2014 interview) was the 320˚M/45NM fix[21]. The ATCO stated this was so as he was preoccupied with procedural duties away from the PPI as would be expected[21].

ASIB communication transcripts suggest Sydney radar contact of VH-MDX faded by 0939:00UTC[1]. Considering radar propagation analysis, aircraft rates of descent and radar sweep time, it was found likely that Sydney radar contact faded *just before* 0939:00UTC[20].

One Sydney ATCO deposed a final radar position of approximately 5NM west to north-west of Craven[13] whilst the ASIB specifies a possible Rescue Coordination Centre (RCC) derived final radar position by *Williamtown* radar located in the Upper Williams Valley[1] some 10NM west of the Sydney position.

The Williamtown ATCO states confidently he did not participate in determining the RCC's final Williamtown position nor does he recall being interviewed by the ASIB[21].

It was confirmed with *certainty* that <u>no</u> observation of VH-MDX *radar fade* was made by the Williamtown ATCO thus quashing the suggestion of a Williamtown *fade* position in the Upper Williams River [21].

No ATCO can state the tracking direction of VH-MDX in the last few minutes with *certainty*. It is very obvious that the final, critical three and one half minutes of recorded (communications) flight has many loose ends.

<u>This perhaps more than the terrain and vegetation of the area explains why VH-MDX has not been located.</u>

3.7.2. Up and down like a yo-yo: 0936:07UTC

Shortly after the 320˚M/45NM fix at 0936:07UTC, the pilot of VH-MDX confirms squawking mode A code 3000 with ident whilst also stating '*we're up and down like a yo-yo*[1].

As VH-MDX was located around the upper southern slopes of the main Barrington range at this time, the aircraft would be subject to the effects of orographic uplifting. Significant turbulence would be expected in this position and this is reflected by the pilot's radio transmission.

3.7.3. Tracking 150˚: ≈ 0936:50UTC

At around 0936:50UTC, the Sydney Sector 1 ATCO informs the Williamtown ATCO that: '*Well he's on a heading of 150 mate he's all over the place*'[1]. Note that 'heading' in this case refers to track as it is the latter being observed by radar. This implies a radar observed track at this time of 150˚M.

Of interest is the Sector 1 ATCO's comments leading up to and then after the 150˚M track observation. VH-MDX was (as previously stated) observed to track in a *slow* easterly turn from around the 150˚M West Maitland heading advice.

120˚M track was observed about two and one half minutes prior to the 150˚M track observation. It would be expected that a turn in an easterly direction would result in a track of less than 120˚M rather than 150˚M at 0936:53UTC.

Despite this, 'easterly' can as mentioned previously refer to tracking anywhere in the eastern hemisphere of tracks. The observed 150˚ track may have been the result of:

- A short error in tracking by the pilot in the challenging situation (turbulence/ no primary attitude or heading instrumentation)
- Loss of heading control (spiral dive or spin)
- The limitations of a radar observation using an RSR with intermittent coverage, possible weather clutter and large scale map
- A *general* observation of aircraft track from the initial Sydney radar fix.

As the 150˚ call was made at a similar time as the pilot of VH-MDX reporting a 'swinging' compass, the two will be discussed further in the next section.

3.7.4. 'Swinging' compass: 0936:53UTC

An interesting comment was made by the pilot of VH-MDX at 0936:53UTC: '*We're having a little bit of a problem in that, ah our standby compass is swinging like, like blazes*'[1]. Immediately after FIS-5 queries if the pilot can maintain a gyro heading to which the pilot replies: '*Negative, mike delta x-ray. We've lost the AH and DI. The vacuum pump's (stuffed)*'[1].

Two broad explanations are viewed as explaining the reporting of a 'swinging' compass within the context of the situation:

- Some loss of control in *heading* (e.g.: a spiral dive or autorotation (spin) type maneuver or simply an inability to maintain constant heading)
- Turbulence induced movement/rocking of the direct reading compass.

The pilot's voice was *not* showing signs of panic or *immediate* concern; the calls were more advisory in nature and at a normal tempo. This was highlighted by John Watson who also points out that '*there is plenty of talking…*' suggesting the pilot would not be having a prolonged conversation if loss of control was apparent[46]. This suggests that control was substantially maintained at this stage.

VH-MDX may have been weaving around a mean easterly course but assuming such control was possible, a continuous track of 150˚ at this time is unlikely given:

- Later observation of VH-MDX being further east (330ºM call, Sydney final radar fix)
- The electronic gating line would likely have suppressed VH-MDX SSR paints if the aircraft flew a continuous 150º track from the 320ºM/45NM fix position.

Despite the latter point, primary paints may have been used when SSR was gated.

The Sector 1 ATCO's comment of '*mate he's all over the place*' was made at a similar time as the pilot reported the 'swinging' compass. These two comments together may elude to loss of heading control.

Loss of heading control whilst possible is not viewed probable as:

- VH-MDX was observed further east of this position as described above
- The pilot displayed relative calmness and was chatty.

As section 3.7.2 discussed, VH-MDX was located around the upper southern mountain slopes of the main Barrington range around this time so would likely have been subject to significant turbulence.

Such turbulence would have resulted in significant direct reading compass indication instability. This occurs as a result of the design of the direct indicating compass that is subject to inertial errors.

One could successfully argue either loss or retention of control at this point in time. Regardless of opinion, it is obvious either of the described outcomes were possible.

However, considering the points raised in this section, it is viewed more probable that the reference to a 'swinging' compass is the result of turbulence induced motion to the compass.

The 150˚M track advice could very possibly be an appreciation of the overall track of VH-MDX to this point which is close to 150˚M as shown in figure 56. Such an advice can be seen as relevant considering the Sector 1 ATCO was conducting a position and situation briefing to the Williamtown ATCO[20].

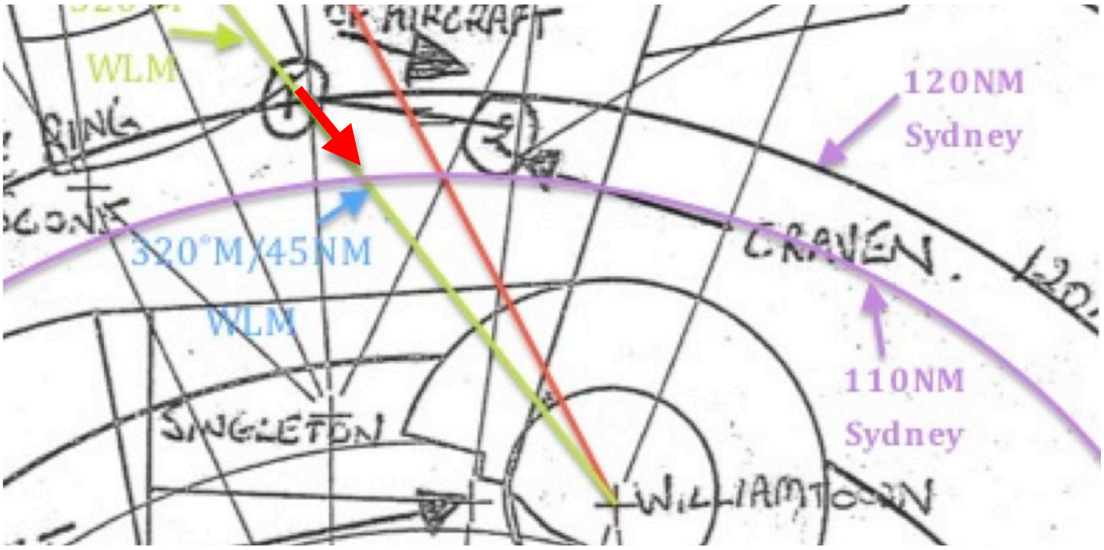


Figure 56: Overall track of 150˚M. Readily seen is the overall progress of VH-MDX from the initial Sydney radar position to 320˚M/46NM being close to 150˚ (Image: Australian Government (Department of Transport) 1981, additions Glenn Strkalj 2014).

3.7.5. Williamtown ATCO busy liaising: 0937:10UTC

From 0937:10UTC the Williamtown ATCO receives and deals with calls on the ATS internal communications line from multiple ATS agencies[1]. Initially Williamtown receives a call from FIS-3 regarding VH-AZC transitioning to Sydney airspace[1].

Communication transcripts[1] suggest Sydney Sector 1 breaks this conversation between Williamtown and FIS-3 at 0937:40UTC with a request of endurance for VH-ESV, a Cessna 402 inbound to Williamtown that may be used as an escort for VH-MDX. The Williamtown ATCO replies with the required information that he chases up from VH-ESV.

Williamtown advises VH-ESV was 7NM north of Williamtown[1]. The communications exchange regarding VH-ESV between 'Sector 1' and Williamtown concludes around 0938:10UTC[1].

What is interesting is that later on in the transcripts Williamtown is recorded as asking Sector 1 if it was him (Sector 1) querying about the VH-ESV escort to which Sector 1 replies with: '*No it wasn't me mate, might have been Flight Service*'[1].

Sector 1 does identify himself during this exchange. Accordingly it is evident that Sector 1 although *attributed* to making certain calls by *ASIB* in communications transcripts, clearly did not make these calls. Confusion on the party line with multiple agencies is clearly evident.

This finding has influence on ASIB transcribed calls and casts some doubt on who was attributed to making certain calls including radar bearings. It must be remembered from section 2.13 that original voice recordings between Williamtown and Sydney and of critical moments at the Sector 1 position (radar fade etc) have not been found available to the author.

3.7.6. Icing: 0937:32UTC

The pilot of VH-MDX reported picking up a second bout of icing at 0937:32UTC[1] suggesting flight in cloud or in precipitation beneath cloud around or just before this time.

VH-MDX was not certified for flight into known icing conditions and appeared to have no specialized anti or de-icing equipment[1].

Figure 57 on the next page shows an excellent example of a Cessna 210 with significant icing accumulation on the wing. The change in wing profile is immediately obvious.

Icing accumulation on aircraft is extremely hazardous. Some detrimental effects of ice accumulation are[48]:

- Increase in stall speed due to changing the aerodynamic shape of the wing and tail and also weight increase
- Destroy smooth airflow over the aircraft
- Reduce lift and increase drag: icing no thicker or rougher than a piece of coarse sandpaper has been demonstrated to reduce lift by 30% and increase drag by 40%
- Jammed control surfaces
- Engine failure
- Propeller vibrations
- Erroneous airspeed, vertical speed and altitude instrument indications
- Interfere with communications systems
- Reduce visibility.

Aircraft icing is categorised into three types[48]:

- *Structural*: Ice accumulation on the airframe
- *Induction*: Ice accumulation in the engine induction system
- *Instrument*: Ice accumulation on pitot/static systems and other instrument sensors.

Figure 57: Icing accumulation: Cessna 210 wing leading edge. Significant ice has accumulated on the leading edge and immediately aft and underneath. The pilot's view from the Cessna 210 cockpit does not allow inspection of the critical upper surface of the wing. The effects of the rough and jagged ice on laminar airflow of the wing is readily predictable when viewing this photo. It can be seen why stall speed and drag increases. Additionally, the extra weight of the ice can be significant further burdening performance. The pitot tube under the wing is free of ice indicating that pitot heating was probably selected during this ice encounter.

The icing level was forecast as being at 4000' and 7000'AMSL with *moderate* icing forecast for flight in cloud above the freezing level[1].

Moderate icing is defined by the following statement:

'*The rate of accumulation is such that even short encounters become potentially hazardous and the use of de-icing/anti-icing equipment or diversion is necessary*'[48].

The highest risk of icing occurs when flying in cloud between the 0˚ and -15˚ isotherms[48].

VH-AZC reported an outside air temperature of -2˚ at Taree when cruising at 8000'AMSL. This would suggest 7000'AMSL as being the altitude with the 0˚ isotherm so, the freezing level.

Cloud was *forecast* over the western mountain tops to be broken (covering 63% to 88% of the sky in that area) Cumulus between 4000' and 7000'AMSL with occasional tops to 12000'AMSL[1]. Scattered (covering 38% to 50% of the sky in that area) Stratus was also *forecast* between 2000' to 4000'AMSL[1]. Areas away from the main ranges were *reported* as being clear skies[1][17].

The pilot of VH-MDX had previously reported that he had picked up '*a fair amount of ice*'[1] at 0934:20UTC as discussed in section 3.5.8.

VH-MDX having:

- Entered cloud at 8000'AMSL
- Likely not exceeded 8500'AMSL
- Likely being at not below 7500'AMSL from the initial Sydney radar fix to 0937:40UTC;

Clearly flew into and stayed within, the highest risk weather conditions for icing.

Cloud was limited to the southern and western areas of the ranges on the windward side close to and over the tops[17]. This was because the wind was originating from the southwest, which was then orographically lifted to cause the cloud and precipitation[17].

Consequently, this suggests that VH-MDX had not left the *general area* of the range tops around 0937:32UTC.

VH-MDX was at this time tracking through perhaps the worst weather apparent in all of Area 20; a localised area of turbulence, cloud and precipitation and it is understandable why icing may have been accumulated around this time.

As pointed out in section 3.5.9 townships were observed by the pilot, however given the dark night, *maintenance* of visual conditions would be challenging and flying into cloud *again* would be rather easy.

The engine induction system design of VH-MDX was *unlikely* to develop ice to a level that would cause engine failure. But propeller icing was completely possible which could then lead to engine damage. The pilot did *not* report engine related problems.

VH-MDX would have been equipped with pitot heating and it is likely the pilot turned this on. Depending on how severe the icing was, the pitot heat may not have prevented false airspeed indicator readings.

Static ports critical to the functioning of the altimeter and the vertical speed indicator (VSI) were unlikely to be heated but an alternate source existed that sourced air from *inside* the cockpit.

The pilot does at various times report rates of descent attributed to downdrafts and different altimeter readings[1]. This suggests that a functioning static source was available for the instruments although it may have been the normal static system partially blocked. If the latter, altimeter, airspeed and vertical speed indications would be erroneous.

Why would the pilot fly through such conditions? The night of the accident was reportedly *very dark* and a Global Navigation Satellite System (GNSS) was not available to the pilot. Avoiding cloud is challenging on such dark nights unless the clouds are illuminated by lightning, which is viewed as extremely unlikely in the cloud associated with the Barrington ranges that night.

Once in icing and turbulent conditions, without the aid of a moving map type display on typical GNSS's the pilot had to determine exact position through navaid intersections.

Remembering that the ADF was reportedly unstable in indication and without Distance Measuring Equipment (DME) the pilot would have found it very difficult to accurately determine position.

In fact it is highly likely the pilot did not know where the main areas of the Barrington Ranges were.

It is clear that the beginning of the uncontrolled descent commences around this time as a result of icing and possibly combined with downdrafts.

VH-MDX flew into weather conditions of the *highest risk* for icing accumulation from the point of initially entering cloud onwards.

VH-MDX was not certified for operations in known icing conditions and appeared not to have specialized anti or de-icing equipment.

3.7.7. Pilot reports 7500': 0937:40UTC

Answering a request from FIS-5 for altitude, the pilot of VH-MDX responds: '*Mike delta x-ray seven and a half*'[1]. It was suggested by Watson that the pilot of VH-MDX up until 7500'AMSL was '*relaxed and in control*'[46] and this is evident in audio recordings.

Overview of the audio recordings does not suggest *immediate* concern by the pilot although the pilot uses non-standard brevity that does perhaps indicate higher workload (the correct terminology for altitude reports of the day was to state each digit i.e. 'seven five zero zero' instead of 'seven and a half').

This altitude call is the first *confirmation* that VH-MDX had descended from around 8000'/8500'AMSL.

From section 3.5.9 it was shown that the pilot did possibly indicate an intention to continue with flight plan, possibly by skipping Singleton and tracking via West Maitland. 7500' would have been an appropriate altitude to fly OCTA when tracking to the south-east towards West Maitland in accordance with quadrantal cruising rules.

Accordingly, the pilot of VH-MDX previously may have *intentionally* descended to 7500' to comply with cruising altitude rules for the new plan. 7500' still offered a sufficient buffer to terrain in the area.

Despite this, it is just as likely the altitude loss was *unintentional* given the situation at hand although one cannot be certain either way. A trade off of altitude to accelerate from climb speed to a cruise profile following the unsuccessful climb is also relevant.

Assuming the altitude loss was *unintentional*, the reason for loss of altitude can broadly be attributed to the following reasons:

- Loss of performance as a result of icing
- Loss of performance and control due to icing
- Loss of altitude due to downdraft
- Loss of control due to lack of primary attitude and directional information in turbulent conditions (spatial disorientation)
- Combinations of the above.

There is a question of what the *true altitude* was of VH-MDX during all of the altitude calls. Conditions were only slightly colder than ISA (standard) conditions at about ISA-1° to ISA-4°[1][17]. Such a deviation results in no more than about 100’ of altimeter over read. (colder than ISA conditions result in altimeter over-read).

Altimeter subscale setting for an area (Area QNH) had to be within +/- 5hPa which equates to about 150’ of the actual QNH of any point below 1000’AMSL within the area for the forecast area QNH[40]. So, not more than about 150’ deviation as a result of subscale setting would be expected.

If the pilot selected alternate static air for instrumentation, then air would be sourced from inside the cockpit rather than from outside. Although VH-MDX was not pressurized, differences in pressure are apparent between outside and inside the aircraft.

With the windows and fresh air vents closed (likely set closed in VH-MDX’s cases given the known cold outside air temperature) the Pilot’s Operating Handbook (POH) specifies over-reading of the airspeed indicator by 8 knots and the altimeter by 150’ at cruise speeds.

More important than these altitude deviations are the effects of mountainous terrain on local pressure sensed by the altimeter. Large changes are possible, in some cases resulting in indications varying by up to 1000’ from true[41].

Unfortunately the exact effects of terrain influence on local pressure is difficult to predict.

Additionally, as suggested by Chessor[26], a partially blocked static sense line from icing could also have been an issue contributing to the altimeter over-reading.

Hysteresis in the altimeter indication during high rates of descent may also have lead to an over-reading altimeter.

It is likely VH-MDX was at a lower true altitude than what was indicated on the altimeter but the scale of error cannot be confidently determined. The descent to 7500’AMSL cannot be confidently attributed as intentional or non-intentional.

3.7.8. Strife: 0937:54UTC

FIS-5 requests VH-MDX's endurance as part of normal procedure of the time during an emergency to which the pilot responds: '*Mike delta x-ray. We're having strife up here. Um, we've got plenty of end.*'[1].

Overview of the audio recordings reveal that although speech was still at normal tempo with long casual talk rather than brevity, concern was starting to become *immediate* given the pilot's comment of strife when answering a request for endurance whilst the tail end of the pilot's transmission was terminated early by the pilot: '*end*' vs. 'endurance'. The latter is important as it offers a clue of the pilot's workload thus, aircraft state.

It is reasonably clear that the workload was increasing significantly for the pilot. What is of question is the specific state of the aircraft given that it was reported to have accumulated significant icing. Section 3.7.7 states five broad possibilities.

As VH-MDX was probably close to or overhead the Barrington or Gloucester Range Tops, icing and possibly downdrafts (the latter particularly if located on the lee side) would very likely have been experienced.

VH-MDX was likely descending by now as the pilot reports being at 6500' in a little over 30 seconds after the 'strife' call.

Watson's suggestion that control is still being maintained due to the '*unnecessary verbalisation*'[46] is supported to a certain level. It does appear the beginning of loss of control is occurring here at least in the vertical plane, but that some control is being maintained.

3.7.9. Pilot reports 6500': 0938:29UTC

At 0938:29UTC the following transmission is received from VH-MDX: '*Mike delta x-ray. We're losing a hell of a lot of ……We're down to six and a half*'[1]. The transmission was initiated by the pilot of VH-MDX and not by request of FIS-5.

It is clear from listening to the audio recordings that the pilot's voice reflects *immediate* concern with this transmission. Inflection and rate of the pilot's voice during the '*We're down to six and a half*' is clearly louder, higher pitched and faster than previous calls thus expressing *immediate* concern. There was an obvious delay in reading the altimeter that does elude:

- Perhaps the pilot was waiting for the altimeter to actually reach 6500' and/or;
- Possibly some effort was made to determine 6500' so, confirming read-off validity to some extent.

Additionally, altimeters at high rates of altitude change do suffer from hysteresis in indication. Accordingly if VH-MDX was descending at high rate, which appears so, then altimeter indications could likely lag true altitude somewhat.

Together, the points made on altimetry errors in section 3.7.7 combined with those of this section all suggest an over-reading altimeter. This suggests that VH-MDX could have been somewhat *lower* than what the altimeter indicated thus, what the pilot reported. Despite this, other than the possible significant local pressure effects of terrain, altimeter over-reading errors seem limited to relatively small deviations.

Average rate of descent from 7500' to 6500' based on transcript timings was 1130fpm[1].

FIS-5 replied with a Lowest Safe Altitude (LSALT) for the area VH-MDX was in of 6000'AMSL whilst also advising '*....continue a heading towards the coast, towards Williamtown, sir*[1]'. No reply from VH-MDX was received regarding the latter advice possibly alluding to high pilot workload.

Also of interest with this transmission is the increase in *background noise* in an open microphone period between voice transmissions. This is obvious from listening to audio recordings whilst also being mentioned in an ASIB specialist analysis of the communications audio recordings[1].

The ASIB analysis was inconclusive with respect to whether the increased *background noise* was the result of increased aerodynamic noises or simply due to increased signal strength[1].

One ASIB conclusion that was drawn was that the overall *signal strength* of open microphone sections was stronger at 0938:29UTC ('*....six and a half*') than 0923:53UTC (north side of the Barrington ranges '*...in the clag...*')[1].

It was shown by the author how such a result was possible through different signal attenuation values resulting from reduced:

- *Distance* between VH-MDX and the FIS-5 outlet (mainly)
- Attenuating precipitation and cloud between the aircraft and FIS-5 outlet[24].

Accepting such a theory suggests VH-MDX was much closer to Mt Berrico (the location of the FIS-5 communications transceiver) at 0938:29UTC than at 0923:53UTC.

Assuming VH-MDX lost altitude as a result of icing related *performance* loss and/or downdrafts, then it can be seen how some directional control could have been maintained (i.e. no departure). Accordingly *relatively* straight, near straight or weaving flight paths can be considered.

Should *loss of control* be assumed then, departure in roll is likely leading to unstable, tight curved flight paths; it is unlikely the pilot would recover from loss of control. This would be in the form of a spin or spiral dive.

The specific flight path (e.g. spin, spiral, icing performance issues, downdraft) VH-MDX was in cannot be concluded with certainty although it is viewed less likely that VH-MDX was in a spin or spiral dive at this stage.

It is suggested both possibilities be considered in search area generation.

3.7.10. 330 Bearing: 0938:30UTC

Just following the exchange between Williamtown and Sydney Sector 1 as described in section 3.7.3, an unknown agency (as indicated by *written* communications transcripts) asks on the ATS internal communications line: '*Who's on the Willy line please?*'[1]. At a similar time the Williamtown ATCO responds to a call from VH-ESV[1].

Sector 1 at 0938:20UTC is transcribed as asking Williamtown: '*Roger, do you have mike delta x-ray on the Willy radar?*' to which Williamtown was transcribed as responding: '*affirmative*'[1].

Sector 1 is then stated as asking: '*What's his position on the radar?*' to which Williamtown is stated as replying at 0938:30UTC: '*330*____' with the line indicating an over-transmission of his call[1].

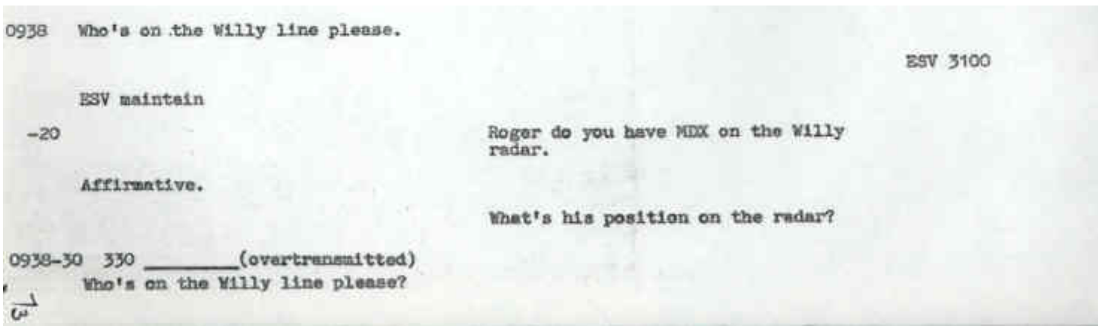
Immediately after the '330__' call an unknown party again asks: *Who's on the Willy line please?*' with Williamtown stating '*you there?*' followed by another '*Who's on the Willy line please?*' request shortly after[1].

At 0938:40UTC Williamtown is stated as saying '*Williamtown!*'[1]. At 0938:40UTC Sector 1 cuts in and states '*this is Sector 1 here, standby the other party…*' and goes on to explain to Williamtown that VH-MDX is suspected of having a cockpit fire and that '*we want you to keep him on your radar, we want to track him direct to Willy mate*'[1].

The confusion on the ATS communications line is readily evident and it is rather difficult without original audio recordings to verify which party was saying what. The parties that ASIB has attributed the calls to may not necessarily be correct as was shown in section 3.7.5 and this must be borne in mind.

Regarding the 330 bearing call, the Williamtown ATCO does not remember making this call nor consciously observing the PPI but suggests if he did make the call then he would have done so with an information source i.e. radar observation[21].

Even if the Williamtown ATCO did not make the 330 bearing call the important point is that someone did and they were highly likely talking of VH-MDX. It is also possible that the 330 call was made by a Sydney ATCO based on observed position on Sydney ATC radar.



0938 Who's on the Willy line please.

ESV 3100

ESV maintain

-20 Roger do you have MDX on the Willy radar.

Affirmative.

What's his position on the radar?

0938-30 330 ________(overtransmitted)

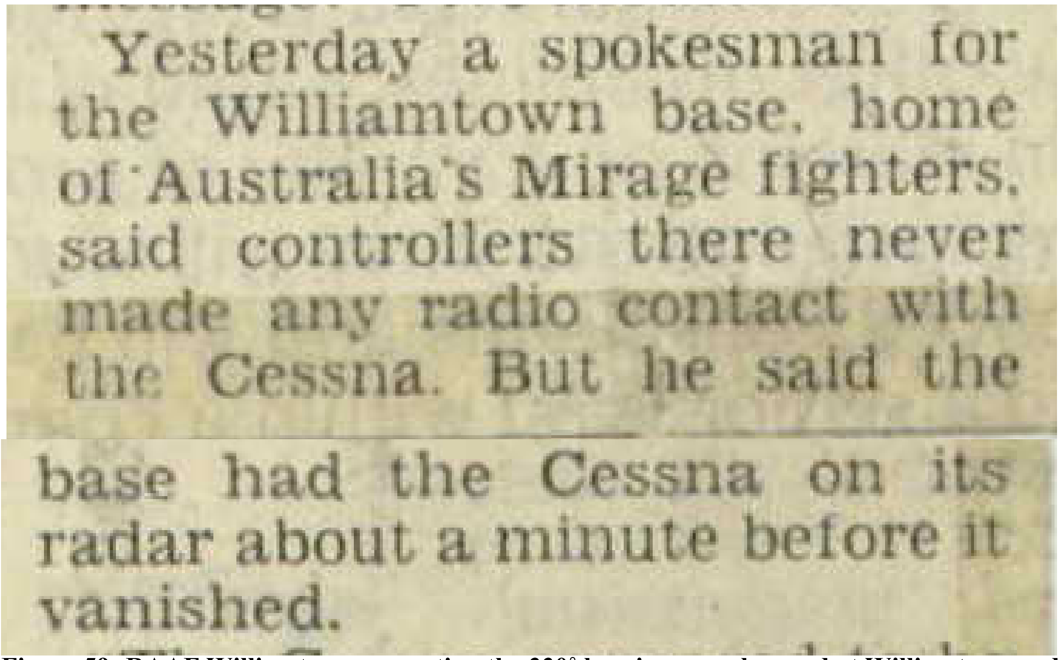
Who's on the Willy line please?

Figure 58: 330 Call ASIB transcript. The columns from left to right depict the transmitting agency and are Williamtown, Sydney and 'aircraft' respectively. What must be remembered is that the transcripts reflect what ASIB *interpreted* the recordings as. Because Williamtown ATC audio recordings around this time frame have not been located, it has been impossible to verify what was actually said and by who (Image: Australian Government (Bureau of Air Safety) 1981).

There appears to be no other *known* aircraft that the 330˚M position was relevant to other than VH-ESV. It was shown VH-ESV was unlikely to be the aircraft referred to the 330˚M bearing[21].

Furthermore, a wirds from a RAAF Williamtown spokesperson within days of the accident was quoted as stating Williamtown had VH-MDX on radar about one minute before the aircraft vanished: see below in figure 59.

As the last received radio call from VH-MDX was around 0939:30UTC, one minute prior is 0938:30UTC: the time of the 330˚M call.



Yesterday a spokesman for the Williamtown base, home of Australia's Mirage fighters, said controllers there never made any radio contact with the Cessna. But he said the base had the Cessna on its radar about a minute before it vanished.

Figure 59: RAAF Williamtown suggesting the 330˚ bearing was observed at Williamtown radar. As the last received radio call from VH-MDX was around 0939:30UTC, one minute prior is 0938:30UTC: the time of the 330˚M call. (Image: The Weekend Australian, 15th-16th August 1981).

Considering this section and the fact that the request for radar information of VH-MDX was *specific* and likely *acknowledged* by the Williamtown ATCO, it is viewed probable that the Williamtown ATCO observed and reported on the position of VH-MDX as 330˚M.

Either way it is probable that a radar position of 330˚M from Williamtown was observed by either Sydney or Williamtown ATC. Considering that the previous Williamtown and Sydney observed bearing was 320˚M, to state 330˚M some two and a half minutes later does mean that some significant change in bearing must have been observed.

The response to the position request is relatively quick possibly suggesting the ATCO was looking at the PPI prior to the request.

Accordingly, a +/-10˚ quick visual assessment tolerance although perhaps being viewed as the most applicable tolerance that may be applied given the circumstances (quick visual assessment)[21], is actually not particularly relevant given that some significant bearing change would have been observed (320˚ to 330˚ is 10˚ so, VH-MDX must have moved in the order of 5˚ to have registered a bearing difference to the ATCO).

Considering this point, +/-5˚ would better reflect the scenario described.

The 330 call occurred effectively the same time that VH-MDX was transmitting the '*six and a half*' (altitude) call.

3.7.11. 150˚M Heading for Williamtown: 0939:00 UTC

Just after 0939:00UTC Sector 1 requests a heading from Williamtown to track VH-MDX to Williamtown: '*You got a present heading, we've lost him- to track him towards yours*'[1]. This is a confirmation by Sydney ATC that radar contact has been lost but not necessarily at this time but rather, *by this time.*

Williamtown responds: '*To track him towards mine-about 150 would be good*'[1].

This is acknowledged by Sydney but is never passed to VH-MDX. Again the Williamtown ATCO does not recall making this particular call but states if he did then reference to the radar was likely[21].

It may have equally been a 'pluck' based on the reciprocal of the 330˚M bearing determined about 30 seconds previous to simply get VH-MDX heading the right way with finesse being achieved later[21].

Section 3.7.1 stated that radar propagation analysis has shown that Sydney ATC radar fade likely occurred just prior to 0939:00UTC when considering the final Sydney radar position approximately 5NM north-west of Craven waypoint, aircraft rates of descent and radar sweep time[20]. This supports the communications transcript derived fade time of 0939:00UTC.

3.7.12. Pilot reports 5000' altitude: 0939:26UTC

Another pilot initiated call was received at 0939:23UTC being '*Mike delta x-ray*' following which FIS-5 acknowledged the call with '*Mike delta x-ray, Sydney*'[1].

The pilot of VH-MDX replied at 0939:26UTC advising of an altitude of 5000'[1]. This was the last received call from VH-MDX[1].

Average rate of descent from 6500'AMSL to 5000'AMSL was 1700fpm based on communication transcript timings[1].

As VH-MDX was descending it became more probable that cloud would be flown into and with that increased chances of further ice accumulation. The lower VH-MDX descended the more tempting it would be for the pilot to raise pitch attitude in order to check the rate of descent. This would increase the chances of stall/spin.

The last received transmission from VH-MDX was brief and to the point: '*five thousand*' whilst the inflection and rate was raised even more over the '*six and a half*' call previously. It is clear from this transmission that *immediate* danger is present.

Although dire concern by the pilot is apparent, the call was still made with some thought and time: this is indicated by the pilot calling FIS-5 first with his callsign followed by the '*five thousand*' call after FIS-5 responds. (i.e. not a complete, rushed panic).

Accordingly, it is possible that VH-MDX had probably not departed controlled flight at 0939:26UTC. What is meant by this is that although the aircraft was likely descending un-commanded, the pilot still had lateral control.

Alternatively, VH-MDX may have lost control by 0939:26UTC and may have been in a spiral dive or spin. The latter may be viewed as more likely of the two considering the high probability of the pilot decreasing speed in an attempt to check the descent rate or climb.

It can be seen that once in cloud picking up icing, performance degradation leading to a descent would almost ensure increased ice accumulation that then increased the chances of loss of control.

It was also still entirely possible for VH-MDX to descend into the terrain with lateral but little vertical flight path control.

3.7.13. No Williamtown radar returns: 0941:00UTC

Just prior to 0941:00UTC during a discussion with the Williamtown ATCO about VH-MDX, the pilot of VH-ESV asks if the ATCO still has radar contact with VH-MDX: '*you're painting him?'*[1]. The Williamtown ATCO replies '*Not anymore*' indicating no radar returns of VH-MDX were observed[1].

At 0941:20UTC Sector 1 asks Williamtown: '*Sydney Sector 1, have you still got MDX radar identified mate?*'[1]. A process of elimination is verbalised by the Williamtown ATCO, systematically going through all options such as SSR returns, PSR returns and MTI filtering. The following is from transcripts:

'*No, I've lost his squawk-he's primary paint in the Barrington Tops and the MTI our MTI's not cutting it out*'[1].

Sector 1 asks: '*Does that mean you've got him or not?*' to which Williamtown replies: '*No I cant see him*'[1].

It was shown that Williamtown SURAD TAR had reasonable coverage down to low altitudes in the surrounding areas around Williamtown[21]. Radar paint persistence on the SURAD PPI was reported to be in the order of 4 to 20 seconds although in permanent echoes such as the Barrington/Gloucester Tops terrain clutter, aircraft paint persistence was not easily discernable[21].

Accordingly, even if VH-MDX were interrogated successfully by Williamtown TAR in the last seconds of flight, paint persistence would not have 'preserved' a last position for any significant time if VH-MDX were over the Barrington ranges. If inside the 44NM MTI boundary, the final paint would only display for a maximum of approximately 20 seconds.

No fading VH-MDX returns were observed on the Williamtown TAR and persistence history has been shown to be of no use in 'backtracking' to limits in flight time[21].

3.7.14. Aircraft speed during the accident phase

3.7.14.1. Overview

This is a highly contentious topic resulting in many vigorous debates. The fact is simple: we will never know *every* speed profile used by the pilot of VH-MDX at various stages throughout the flight after the initial Sydney radar position.

Why is this?

- No defined track to apply radar fix time intervals to
- Intentions of the pilot were not clear throughout the last 15 minutes of flight
- Radar inability to give speed information of aircraft
- The conundrum of icing as well as reported downdrafts and turbulence.

Donovan and Readford suggest a cruise speed for most of the flight[14]. Nolan on the other hand strongly argues that the pilot would have been attempting a climb for the last approximate 15 minutes of recorded flight[25].

Chessor explains how either a continuous climb at 90KIAS and a cruise speed of 155KIAS are both defensible but that he was biased towards the latter[26].

It is the author's strong opinion that the best solution is to set a highly likely *speed range* and utilise this range for search area development followed by assumptions of specific speeds to define specific areas of interest.

Unless otherwise stated, speeds discussed will be those at Maximum Take Off Weight (MTOW).

3.7.14.2. Slowest probable speed

The Cessna 210 Pilot's Operating Handbook[2] specifies the following climb speeds:

- Maximum angle climb 79KIAS (approx at 8000')
- Maximum rate climb 92KIAS (approx at 8000')
- Normal enroute climb 100-110KIAS

The pilot of VH-MDX reported ice accumulation[1] and this can *severely* degrade aircraft performance and aerodynamic efficiency of the aerofoil surfaces. Significant turbulence and downdrafts were also reported[1].

Whilst there was a clear attempt[1] (from communications transcripts) initially to climb after originally entering cloud to around 0929:10UTC[1], there were no further suggestions of attempts to climb.

It is rather obvious that a climb would have been on the pilot's mind in at least the final minute of recorded flight but could the pilot have actually set-up a climb profile? The pilot quite possibly was spatially disoriented by this stage and/or the aircraft may have departed controlled flight.

Slowing down an aircraft with known ice accumulation is a risky decision; pilots are readily aware that airframe ice accumulation increases stall speed of the aircraft significantly.

One particularly safe assumption that can be made is that the pilot of VH-MDX did not want to slow the aircraft down too much with the accumulated ice but to what figure was deemed 'too much' is open to debate.

Given the turbulence, it is viewed most unlikely that the pilot slowed the aircraft down below 90KIAS. The best rate and angle of climb speeds being approximately 90KIAS and 80KIAS respectively, sit rather close to the 64-68KIAS flaps up stall speed[2] when considering significant turbulence let alone *severe* turbulence, icing and no primary attitude and heading instrumentation.

64-68 KIAS is the *un-iced*, flapless stall speed; one can expect *significant* increase in stall speed with airframe ice. Buffers are required to the normal stall speed. The Cessna 210 POH specifies an *ice accumulated* approach speed of 95KIAS-105KIAS in a flapless configuration and a go-around climb speed of 95KIAS.

The author is aware of one Cessna 210 pilot that experienced icing related stall with associated roll departure (flick) at 110KIAS.

Accordingly, even if speed was reduced to below 90KIAS, it is viewed as probable that turbulence and icing would eventually result in departed flight. This would mean that sub 90KIAS speeds would not have been maintained for any *significant time* and so would have little effect on influencing the aircraft to proceed down range.

Furthermore, rather than 90KIAS, 100KIAS gives an easily identifiable airspeed indicator target and also a reasonable (although still concerning) buffer to the stall. Although it is acknowledged that a continuous speed of 90KIAS was possible, 100KIAS is viewed as probably the lowest *continually* targeted airspeed.

3.7.14.3. Highest probable speed

When considering the highest likely speed flown, the significant turbulence becomes the limiting factor in the pilot's mind. Structural failure can result in flying at too fast a speed in turbulent conditions but what exactly is too fast? This is also most certainly also open to opinion.

The Cessna 210M has the following turbulence related speeds specified as presented in figure 60. Please note that considerations are based on *current* FAR 23 requirements[49].

Speed	Term	Value (knots Indicated Air Speed)[2]	Use	Determination Criteria
Maneuvering Speed	Va	1724kg 119 1429kg 109 1134kg 96	Do not make full or abrupt control movements above this speed [2].	Set by manufacturer to determine minimum structural strength of airframe components
Maximum Recommended Turbulent Air Penetration Speed	Vb	1724kg 119 1429kg 109 1134kg 96	Can be used as a target speed when experiencing turbulent conditions	3960fpm/66fps symmetrical gust response for commuter category
Maximum Structural Cruising Speed	Vno	168	Do not exceed this speed except in smooth air, and then only with caution[2].	3000fpm/50fps symmetrical gust response

Figure 60: Cessna 210M speeds for consideration in turbulence.

<u>Maneuvering Speed (Va)</u>

This speed provides an airspeed limit for abrupt and/or full *control* use[2][49] that was used to calculate loads for structural design. Accordingly, applying full and/or abrupt control inputs below Va prevents airframe overstress if controls are applied in accordance with the manufacturer's and FAR 23 guidelines.

In most cases, only *one* single axis control input at one time with no control reversal is considered for Va. Aerobatic aircraft do consider multiple axis control inputs to ensure the empennage design is structurally sound for some simultaneous axis maneuvers[49].

Va considers maneuvering by the pilot and does not consider gust response. Va can vary with aircraft weight and is commonly specified with multiple values for multiple aircraft gross weights.

Va is chosen by the manufacturer for structural calculations[49] and in many light aircraft this speed is based off the speed where the maximum flight load factor is reached in the pitch axis but at speeds beyond which the aircraft will stall (this is Vo: Operating Maneuvering Speed), thus protecting the airframe.

In the Cessna 210M case this is not so as the +3.8g limit could be achieved at a speed of 133KIAS even though Va is 119KIAS. Accordingly there is another reason for the lower Va and this is because there are structural limitations reached when *rolling* or *yawing* the aircraft at full and/or abrupt control deflections at less than Vo.

Va is not marked on the airspeed indicator but there is usually a placard on the instrument panel with relevant Va speeds.

Maximum Recommended Turbulent Air Penetration Speed (Vb)

This is the recommended speed for turbulence penetration and gives an adequate buffer to the stall but also from overstress.

Vb these days appears to consider a 66fps/3960fpm symmetrical gust response[49]for *commuter* category light aircraft: i.e. the airframe should not experience the design load limit with such a gust.

Note that this speed does not appear to have a requirement to consider *control input* originated loads in addition to the gust criteria. Applying full and/or abrupt control input whilst experiencing significant turbulence can possibly overstress the aircraft.

In light aircraft Vb is commonly but not always, set at Va. This is so with the Cessna 210M where Vb equals Va.

Vb is not marked on the airspeed indicator but there is usually a placard on the instrument panel with relevant Vb speed(s).

Maximum Structural Cruising Speed (Vno)

This speed is not to be exceeded except in smooth air, and then only with caution Vno considers the loads on the aircraft structure resulting from a symmetrical, vertical gust of 50fps/3000fpm[49].

Vno is marked on the airspeed indicator as the beginning of the yellow arc range that is convenient for the pilot.

Vno does not consider loads from pilot maneuvering[49] so again there is a situation where structural overstress can occur with simultaneous control input and gust experience.

What would be the highest speed then?

As the aircraft was in significant turbulence the pilot would likely be loath to go too fast to minimise chances of structural overstress. Despite this, the pilot reported picking up *significant* icing.

It must be remembered Va, Vb and Vno do not provide *complete* protection from gust related overstress. Simply experiencing asymmetric gusts or gust of a strength more than the values used for the particular speed calculations can result in overstress.

Turbulence is encountered by pilots regularly and without playing down the serious implications of turbulence, icing would be viewed by many pilots as a worse experience. Icing encounters require a *rapid* exit from the icing area; ice can be accumulated very promptly and may be difficult to shed.

Icing is viewed as a more serious issue in the VH-MDX accident than turbulence although it is acknowledged that turbulence would have made flying without primary attitude and heading information very challenging.

Indeed the Cessna 210M POH states to turn back to exit the icing area rapidly and/ or to change altitude to obtain an increased outside air temperature[2].

The pilot of VH-MDX did attempt a climb with little result. It is reasonable to suggest the pilot of VH-MDX simply wanted to get out of the mess he was in by adopting a cruise profile.

The pilot of VH-MDX planned for a TAS of 160 knots[1] which represents 61% cruise power at 21”/2400RPM[2]. In the VH-MDX scenario approximately 142KIAS would result from flying at this TAS at best. Such a speed is above Va/Vb but below Vno. Accordingly, abrupt and/or full control inputs could cause structural *damage* to the aircraft but this does not necessarily mean structural *failure*.

FAR 23 would have required the Cessna 210M to demonstrate structural integrity at 150% of the design *limit* load factor i.e. 150% of the normal expected and placarded load limit. This limit is known as the *ultimate* load factor beyond which permanent damage or structural failure can occur. These requirements are well known by pilots.

The question can then be asked if the pilot would rather have prevented:

- The bending of the aircraft or;
- Extra ice accumulation and stall.

It is obvious that exiting the area of ice accumulation can easily be concluded as more important than risking damage to the airframe. This is not to say *all* pilots would conclude the same but rather that such a conclusion can easily be made by many a pilot.

Of immediate reference to the pilot is Vno at the beginning of the yellow ASI band and it is viewed that most pilots would not intentionally exceed this speed in severe turbulence. As cruise IAS’s are below Vno in the Cessna 210M, it can be seen how a cruise speed could have been intentionally flown to rapidly exit icing conditions and provide a good buffer to increased stall speed.

Figure 45: Cessna 210M Air Speed Indicator (ASI). It can bee seen that reference to *rounded off* numbers would be simpler in turbulence. The beginning of the yellow band represents the speed at which a symmetrical 3000fpm gust would induce a load factor in excess of the aircraft's design load limit: Vno (Maximum structural cruising speed). Should a pilot control input be applied at the same time as a gust is experienced below 168KIAS, overstress is still possible as Vno only considers the *gust.* Maneuvering (Va) and Turbulence Penetration (Vb) speeds are not normally marked on the ASI but are normally placarded on the instrument panel. For the C-210M Va equals Vb and varies with weight being 119KIAS at MTOW. Va considers the effects on structure from only a single control input at one time in one control axis. Any of the following or combinations thereof, of simultaneous multiple axis and/or reversing control inputs and/or gusts will invalidate the protection of Va. The C-210M normally cruises at IAS's around 145KIAS: about 25knots above MTOW Va and 15 knots below Vno (Photo: N. McGlone 2015).

3.7.14.4. Effects of weight and icing on speed

VH-MDX departed Coolangatta close to if not at or slightly above maximum take off weight (MTOW). Around the time of impact it probable VH-MDX's gross weight was around 115kg under MTOW.

Experience suggests as consequence of gross weight alone, VH-MDX was unlikely to achieve above 140KIAS in a standard cruise configuration. This is reflected in the pilot's planned cruise TAS of 160KTAS that reflects an IAS of around 138KIAS.

Additionally, as VH-MDX accumulated ice in about the last 15 minutes of flight it is viewed that 10-30 knots of IAS could easily be lost. This results in a probable cruise type profile between 110-130KIAS (high drag and weight).

3.7.14.5. Conclusions: Probable speed range during accident phase

A speed band of 90KIAS to 140KIAS is considered the *maximum speed range from climb* to *cruise*.

A speed band of 100-130KIAS is viewed as the *most probable* speed range from *climb* to *cruise.*

A dive speed considering cruise power should also be developed to account for a powered dive if such an outcome is viewed likely in analysis.

4. Final radar positions

4.1. Overview

As shown in section 3.6, the 320˚M/45NM Williamtown radar fix at 0936:00UTC currently is the most defensible, latest (time-line wise) radar position available.

As will be shown, two radar positions annotated as 'final' exist in archived VH-MDX documentation each with their own problems. As these positions are approximately 10NM apart at least one must be incorrect.

Determining which fix is invalid and also the likely tolerances of the fix position would assist in locating VH-MDX dramatically. A continual effort must be exercised in an attempt to achieve this aim.

4.2. ASIB/RCC final radar position

4.2.1. Overview

Bureau of Air Safety (BASI) Accident Investigation archives reveal a final position by Williamtown radar at 0940UTC in the Upper Williams River area[1]. Figure 61 overleaf shows the position with associated information.

This position was reportedly generated by the Sydney Rescue Coordination Centre (RCC)[36] and does not appear to be reported by either Sydney or Williamtown ATCO's[20][21].

The basis for this position is *unknown* so is of questionable defensibility[21]. This position is referred to herewith as the 'ASIB/RCC final radar position'.

Plotting the ASIB/RCC position on Google Earth and adjusting for Williamtown 1981 magnetic variation[44] and converting from AGD66 to WGS84, gives a bearing of 325.9˚M and range of 46.7NM from Williamtown TAR[21].

4.2.2. Derivation of position

Other than the references to '*Williamtown radar returns disappeared at this position at 1940 EST*'[1] and '*Last observed position by Radar*'[1] there are no explanatory notes or expansion as to how the position was derived.

If this position was determined by the information that the Williamtown ATCO gave, then a *bearing/ range definition of this position* *<u>must</u>* *have been given*. No such bearing/range definition has been found so far[21].

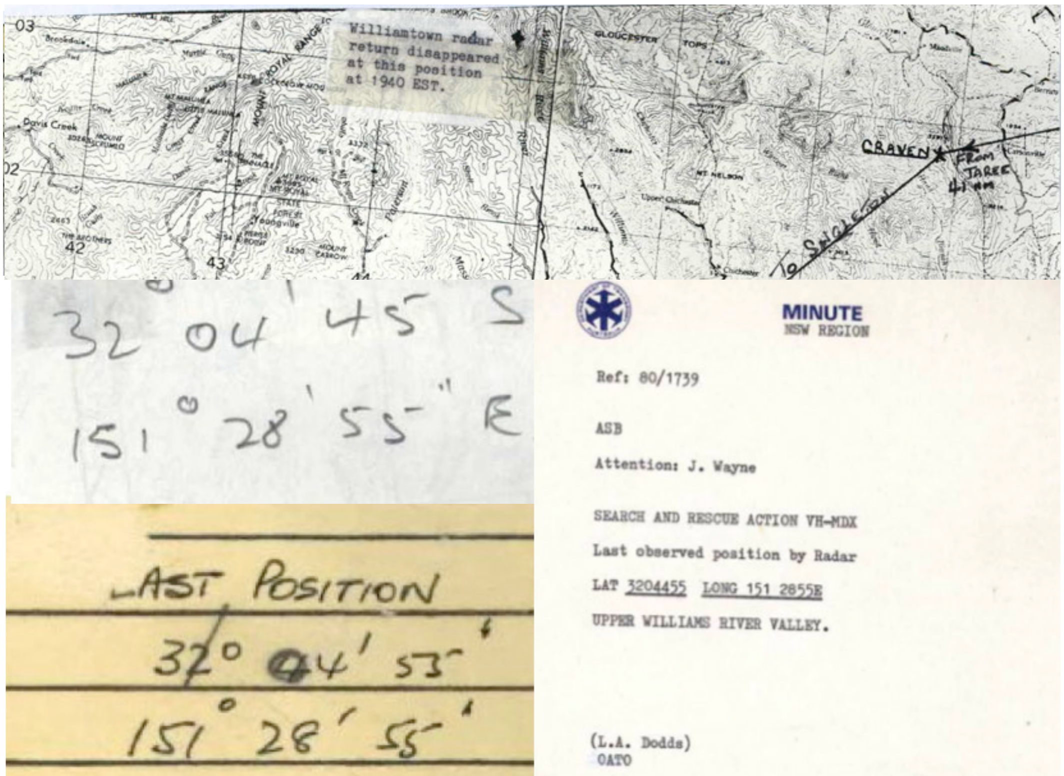


Figure 61: ASIB final Williamtown radar position references. The middle left lat/long was located on the flip side of the map displayed at top. Bottom left was located on the back of the folio cover. The Minute displays the position given from RCC to the person undersigned. The origins of these positions in terms of radar derived base data are unknown (Images: Australian Government (Air Safety Investigation Branch) 1981).

The Williamtown ATCO states with certainty that he did not contribute to this position directly nor did he view the returns of VH-MDX *fading*[21].

Observing prolonged SSR paint *fade* through persistence was stated as almost impossible in the terrain clutter that is where VH-MDX would have been apparent at the ASIB/RCC final radar position[21].

The persistence was relatively short on the Williamtown PPI and this coupled with terrain and weather clutter of the Barrington ranges where VH-MDX was located would have resulted in negligible history.

4.2.3. Radar ability

Radar propagation analysis shows that it was possible for Williamtown TAR to interrogate VH-MDX down to 3500'AMSL in this position[21]. Figure 62 on the next page presents propagation analysis results. This is approximately 500' above terrain level.

Sydney RSR had effectively no ability to interrogate VH-MDX below 10000'AMSL in this position whilst The Round Mountain RSR was able to interrogate VH-MDX down to 8200'AMSL in this position[20].

VH-MDX at 3500' AMSL Williamtown TAR

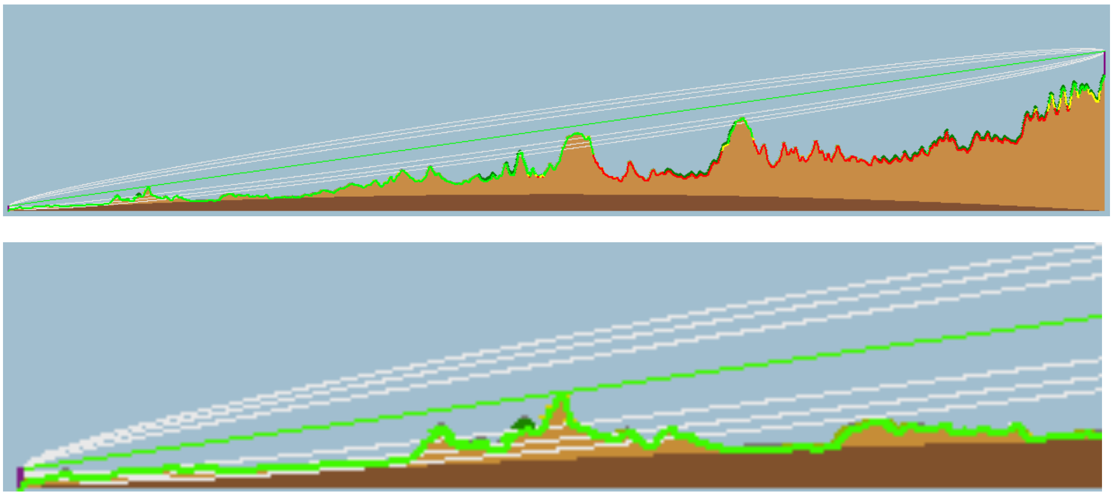


Figure 62: Williamtown TAR to ASIB/RCC final radar position prorogation at 3500'AMSL[27]. The top image zooms in on the most limiting terrain (Image: Radio Mobile Online 2014, analysis Glenn Strkalj 2014).

4.2.4. Tracking from the 320˚M/45NM position

A sharp turn from the 320˚M/45NM position would have been required to achieve the ASIB/RCC final radar position considering reported tracking towards the south-east.

From section 3.7.2, it was described how just after the 320˚M/45NM fix the pilot of VH-MDX stated '*we're up and down like a yo-yo*'[1] and then approximately 50 seconds after the 320˚M/45NM fix:

> - VH-MDX was radar observed on a track of 150˚M whilst also being (track-wise) '*..all over the place*'[1].
> - The pilot of VH-MDX stating: '*We're having a little bit of a problem in that, ah our standby compass is swinging like, like blazes*'[1].

It can be seen that the radio calls from the pilot can loosely support the suggestion of a sharp turn towards the ASIB/RCC position although the radar observed track in the wrong direction of 150˚M does somewhat discredit this suggestion.

Despite the latter it was shown in section 3.7.4 how the 150˚M track could have been the overall gross track from the initial Sydney radar fix to present position.

Sydney ATCO suggestions of a final track close to east[20] also go against VH-MDX impacting near the ASIB/RCC final radar position.

The pilot's voice was identified in section 3.7.4 as being relatively calm and it was suggested that turbulence induced compass motion was more likely.

VH-MDX could have 'achieved' the 330˚M bearing (within +/-5˚) on the way to the ASIB/RCC final radar position although the Sydney final radar position was shown to fit in much better[21].

A rough overall flight path is presented in figure 63 on the following page. As can be seen, a spiral type path is viewed as necessary.

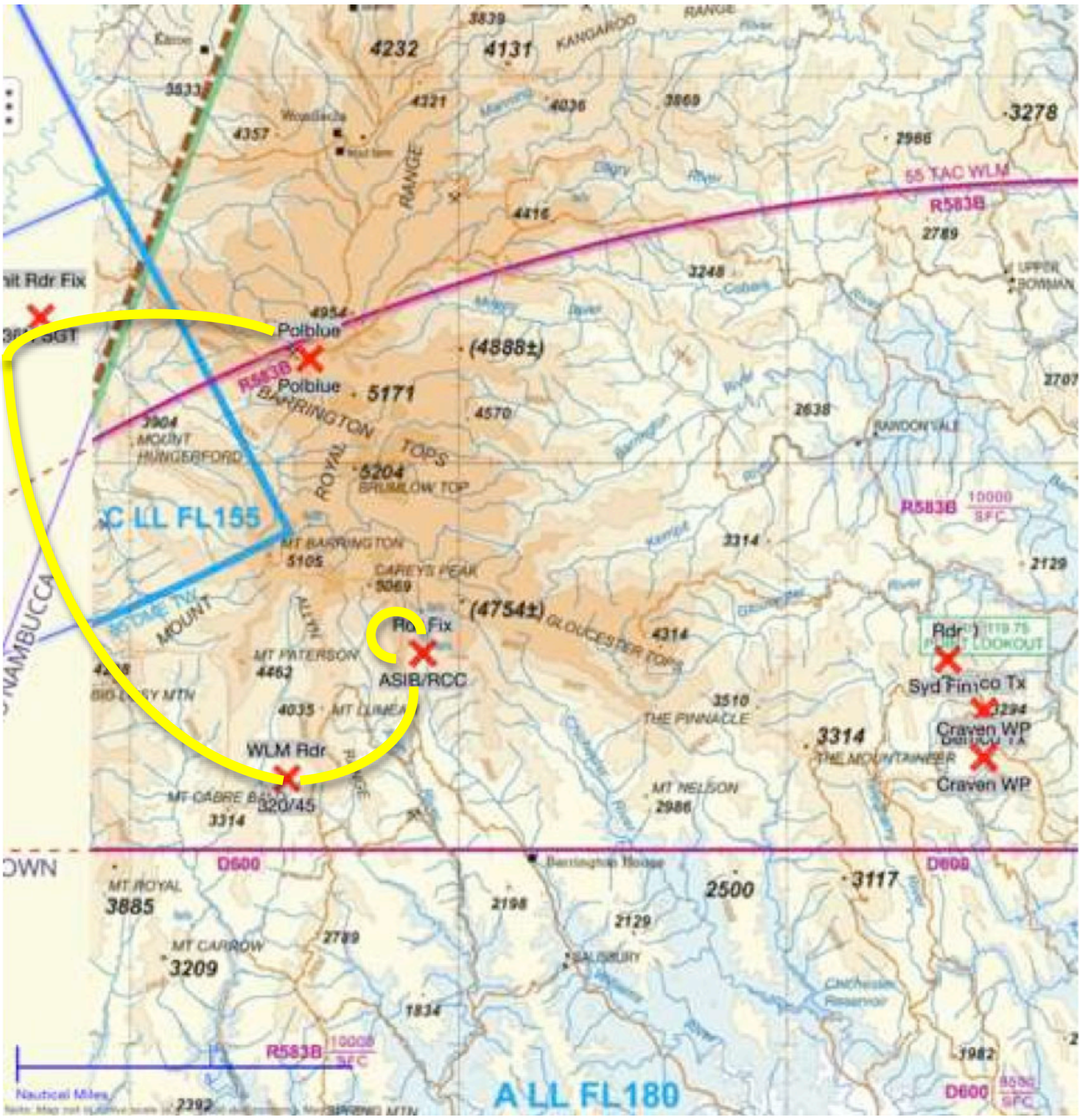


Figure 63: Possible flight path to the ASIB/RCC last radar position. The assumption made here is that a loss of directional control occurred from around 0936:00UTC resulting in a high average turn rate towards the ASIB/RCC final radar position. Communications transcripts can support this theory but they also cast doubt. A Sydney ATCO also suggests VH-MDX tracked from the initial Sydney radar position in a southerly direction followed by a slow rate turn towards the east. This observation does go against the above theory (Base image: OzRunways 2015, additions: Glenn Strkalj 2015).

4.2.5. No longer the 'final' Williamtown radar position

The Accident Investigation Summary Report of 1st September 1981 is quite explicit in stating that VH-MDX was observed to fade from the PPI at *Williamtown* at 0939:30UTC[1]. This Report was drafted approximately one month after the accident. Figure 64 below refers.

reported his altitude as 7500 feet, one minute later in an increasingly agitated voice 6500 feet, then - at 1939½ EST. - 5000 feet. At that time, the radar return disappeared from the screen at Williamtown.

Figure 64: Air Safety Investigation Report 1st September 1981 excerpt. A suggestion is made that VH-MDX was observed to have faded from radar at 0939:30UTC. The Williamtown ATCO only recalls observing VH-MDX at the 320˚M/45NM fix which occurred around 0936:00UTC whilst transcripts reveal that the ATCO thoroughly checked the PPI for VH-MDX at 0941:20UTC to no avail (Image: Australian Government (Air Safety Investigation Branch) 1981).

With time, the reference to Williamtown is removed. The Accident Investigation Summary Report of 28th September 1983 suggests loss of radar contact at 0939UTC although not specifically stating which radar VH-MDX was observed fading from[1]. This is shown below in figure 65.

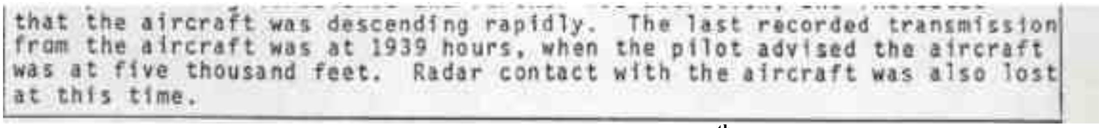

that the aircraft was descending rapidly. The last recorded transmission from the aircraft was at 1939 hours, when the pilot advised the aircraft was at five thousand feet. Radar contact with the aircraft was also lost at this time.

Figure 65: Aircraft Accident Investigation Summary Report 28th September 1983 excerpt. Unlike the 1st September 1981 report, no reference to *specific* radar is made in this report regarding the loss of radar contact at 0939UTC. Despite this communications transcripts reveal radar fade from *Sydney* ATC radars at around 0939:00UTC thus aligning with the above statement (Image: Australian Government (Bureau of Air Safety) 1983).

Additionally, the 320˚M/45NM Williamtown radar fix at 0936UTC was described in 1983 by the BASI as the *final* (not fade) *Williamtown* radar position. Figure 67 on the next page shows this. Also, figure 67 suggests that the 320˚M/45NM fix was the 'last radar fix'.

This does make sense as the 320˚M/45NM radar fix was the *only* full (bearing/range) radar position made by Williamtown and the Williamtown ATCO was adamant that he did *not* observe radar fade of VH-MDX. Thus, this fix can be viewed as the *final* Williamtown radar position but not the *fade* position.

Overview of available material and discussions with an ASIB officer involved in the accident[36] also demonstrates an over-emphasis on the range advantage of Williamtown TAR over the Sydney RSR's.

Although Williamtown TAR was located less than half the distance to VH-MDX than the Sydney RSR's, the Williamtown ATCO conducting *procedural* control duties had no obligation to continually monitor the radar display as Sydney did.

Only one and (very important) intermediate radar fix was achieved by Williamtown ATC with no radar fade observed.

There are numerous references to the Williamtown 320˚M/45NM position being referred to as a final radar fix with an example being shown in figure 66 below.


The last radar fix on the aircraft was near Mt Cockcorw in the far west of the Chichester State forest.

Figure 66: Suggestion of 320˚M/45NM being the final radar fix. (Image: The Sydney Morning Herald, Tuesday 11th August 1981).

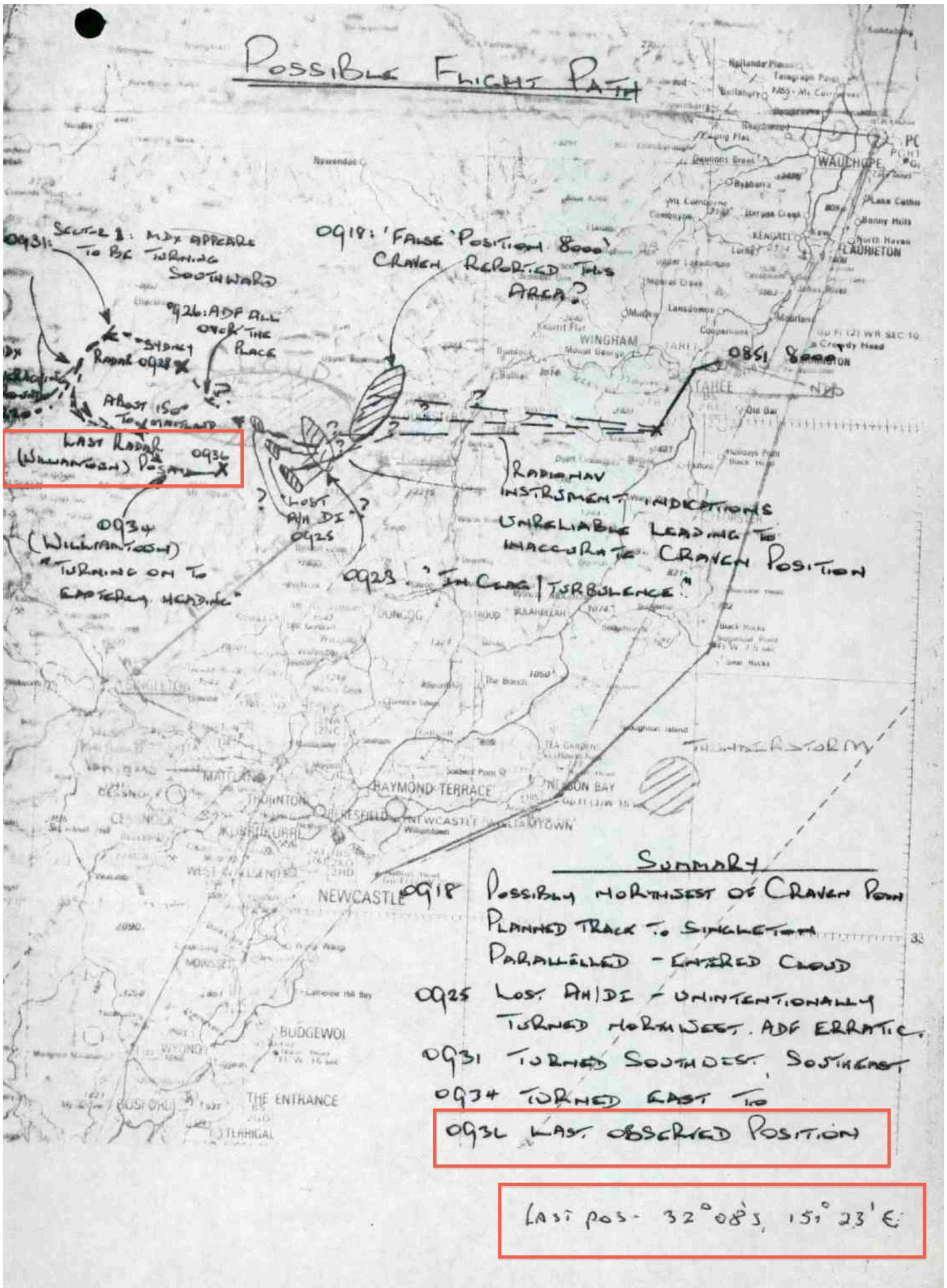


Figure 67: 1983 BASI final radar observed position. The Upper Williams River Valley ASIB/RCC final radar position is no longer classed as the final radar observed position by Williamtown in 1983; it was suggested the 320˚M/45NM fix was the final Williamtown radar fix. This does make sense considering transcripts and ATCO interviews. Interestingly, no *Sydney* ATC final radar position is mentioned (Image: Australian Government (Bureau of Air Safety Investigation) 1981, modifications, Glenn Strkalj 2015).

4.2.6. Derived by vectoring

A Department of Aviation light aircraft was reportedly vectored by Williamtown ATC within days of the accident to the final observed position of VH-MDX[21]. The Williamtown ATCO on duty during the accident could not recall the event[21].

What was classed as the final observed Williamtown position, 320˚M/45NM, 330˚M bearing or otherwise is unknown. As the ATCO on duty during the accident appears not to have been directly involved, the vectoring must have been based on communications recordings, RCC discussions with the Williamtown ATCO or third hand information from other Williamtown ATCO's who had discussed the accident with the ATCO on duty during the accident.

As there is no base bearing/range recorded and a simple cross is marked on the map, it can be seen how this position could have been derived airborne during vectoring and simply marking the map when advised by ATC of the relevant position.

4.2.7. Is the ASIB/RCC final position the 320˚M/45NM fix?

Alternatively, this position may actually be a composite (Sydney and Williamtown radars) or refined, 320˚M/45NM 0936:00UTC position if one ignores the stated time of the position (0940UTC) and reference to radar fade.

Indeed it was stated that the RCC had; '*…taken a cross vector*' between Sydney and Williamtown radars in an effort to obtain a more accurate fix and that; '*…they* (RCC) *were sure that the aircraft had come down east of Mt Allyn in the Allyn River Valley*'[3].

The exact mechanics of this statement is not expanded on however, one can clearly see if a comparison of the same radar position occurred between Sydney and Williamtown radars there was only one common position: the 320˚M/45NM position at 0936:00UTC.

The *Upper* Allyn and Williams River Valleys are adjacent to each other and in proximity to the pure 320˚M/45NM from Williamtown position located just west of Mt Allyn on the east side of the Upper Patterson River.

From section 3.5.12.2, it was described how the 320˚M/45NM fix could have been up to approximately +4˚ in deviation (324˚M). The ASIB/RCC position is approximately 325.9˚M from Williamtown (+5.9˚ from 320˚).

It is apparent that this is a relatively small angular difference (+1.9˚) to what was predicted for the Williamtown TAR alone let alone considering two radars. Considering this, the ASIB/RCC 'final' position could simply be the 320˚/45NM 0936:00UTC position mislabeled.

It was stated that there was much confusion in the RCC in the days following the accident with uncertainty in information and premature conclusions drawn[36].

There are many references in the early days following the accident of the final position by radar being in the Mt Cockrow – Mt Allyn – Upper Williams River Valley area. This is the *general* area of the 320˚M/45NM from Williamtown position.

Additionally, the Williamtown ATCO described VH-MDX's position at 0936:00UTC as being '*…just in the Barrington Tops*' and just after 0936:40UTC as: '*He's just over the top of the Barrington Tops*'[1]. These generalised descriptions broadly align with the geographical position of the ASIB/RCC 'final' radar position suggesting this could be the 0936:00UTC fix position.

Overall, it can easily be argued although not with absolute certainty that the ASIB/RCC final radar position could be the final position by Williamtown radar at 0936:00UTC rather than a final fade position at 0940UTC.

This aligns with the BASI views of 1983 as described in section 4.2.5 suggesting the 320˚M/45NM position at 0936:00UTC was the 'final' Williamtown radar position.

4.2.8. Is the ASIB/RCC fix the 330˚M Williamtown 'fix'?

As the ASIB/RCC final fix was only 4˚ away from the 330˚M bearing from Williamtown the question must be asked if the ASIB/RCC final radar fix represents the 330˚M bearing based position.

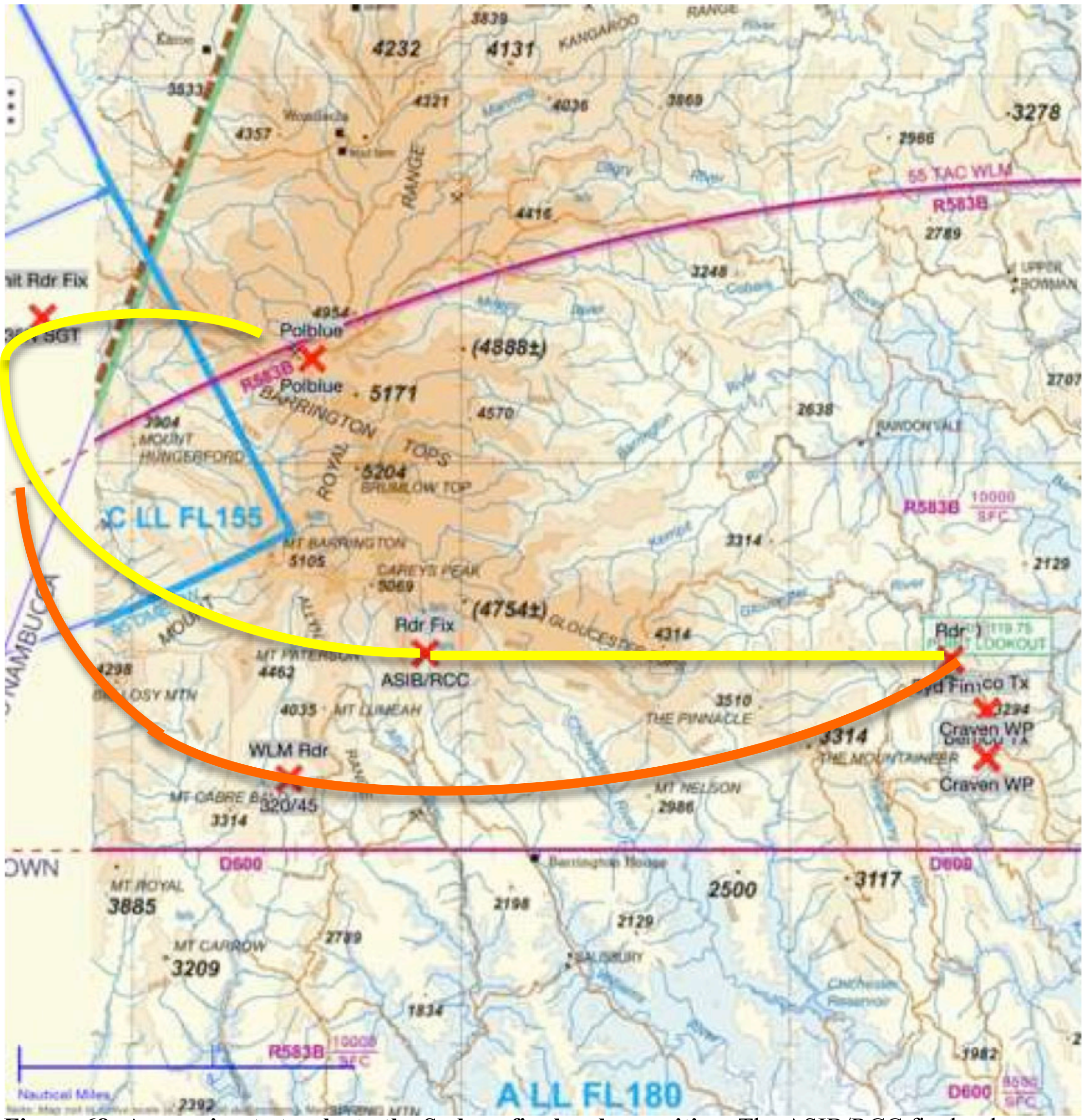


Figure 68: Approximate tracks to the Sydney final radar position. The ASIB/RCC final radar position could simply be a composite or refined version of the 0936:00UTC or 0938:30 Williamtown radar positions. There was much confusion in the RCC during the initial period following the accident and this position could simply have been miss labeled. Passing through the ASIB/RCC final position (as the fix at 0936:00UTC) would better fit the Williamtown ATCO's description of VH-MDX being '*…just over the top of the Barrington Tops*'[1] and resolve the issue of two 'final' radar positions (yellow track). Such a track would also have taken VH-MDX through the worst weather (closer to the tops). Either track fits the description by a Sydney ATCO of a slow turn towards the east observed on radar. Equally, this position could represent the 0938:30UTC 330˚M bearing position (Base chart: OzRunways 2014, additions: Glenn Strkalj 2015).

As there is no transcribed distance, of question is how such a distance would have be determined for the map position.

0938 Who's on the Willy line please.

ESV 3100

ESV maintain

-20

Roger do you have MDX on the Willy radar.

Affirmative.

What's his position on the radar?

0938-30 330 ________(overtransmitted)

Who's on the Willy line please?

Figure 69: Clipped range at 330˚M bearing call. (Image: Australian Government (Air Safety Investigation Branch) 1981).

(around time 0938 comms FIS 5 ASST - Willie - ESV
FIS 5 asks Willie if MDX on Willie radar - affirmative
position on Willie radar 330, FIS or Sector asks Willie
to keep MDX on radar for tracking to Willie
MDX to land at Willie - 150°.)

Figure 70: ASIB notes regarding the 330˚M call. (Image: Australian Government (Air Safety Investigation Branch) 1981).

4.2.9. Conclusions

The exact origin of the ASIB/RCC final radar position in terms of base data is unknown.

This position could have been derived airborne during vectoring by Williamtown ATC to a particular PPI position or during a composite of the Sydney and Williamtown radar 320˚M/45NM radar positions.

The position could represent either the 320˚M/45NM 0936:00UTC or 330˚M 0938:30UTC positions but is unlikely to represent a radar *fade* position.

If assuming this position is a radar fade location, the ASIB/RCC better fits the theory of VH-MDX losing directional control after the 320˚M/45NM position.

<u>The ASIB/RCC final radar position:</u>

- Is 10NM west of the final Sydney radar fix
- Has no base bearing/range from PPI
- Williamtown ATCO did <u>not</u> contribute to this fix
- Was 'replaced' in 1983 with the 320˚M/45NM 0936:00UTC fix as the 'final' Williamtown fix
- Is possible down to approx 3500'AMSL (500'AGL) with Williamtown TAR
- Could quite possibly be a composite/refined 320˚M/45NM 0936:00UTC fix with incorrect labeling

4.3. Final Sydney radar position

4.3.1. Overview

A Sydney ATCO deposed that the final observed position of VH-MDX by Sydney ATC radar was approximately 5NM west of Craven intersection/ waypoint[13].

The ATCO's radar plot sheet shows the final radar position of VH-MDX to be approximately 4-5NM north-west of Craven waypoint[35]. This is indicated as position '2' in figure 71 and 72 on the next page. No time is given for this specific position.

This position is approximately 10NM east of the ASIB/RCC final observed radar position described in the previous sub-section.

It was confirmed that VH-MDX could physically achieve the Sydney final radar position by the time of the final received call however, altitude requirements for radar fade may not have been met unless higher speeds were flown[21].

This could allude to the 320˚M/45 0936:00UTC Williamtown position possibly being the ASIB/RCC 'final' radar position (further north and east so, less track miles). Equally the deposed poison could be an anomalous propagation or similar.

Plotting the Sydney final radar position on Google Earth and adjusting for Williamtown 1981 magnetic variation[44] gives a bearing from Williamtown of 337˚M and range of 42.2NM for '5NM west of Craven' and 340˚M/44.9NM for '5NM north-west of Craven'[20].

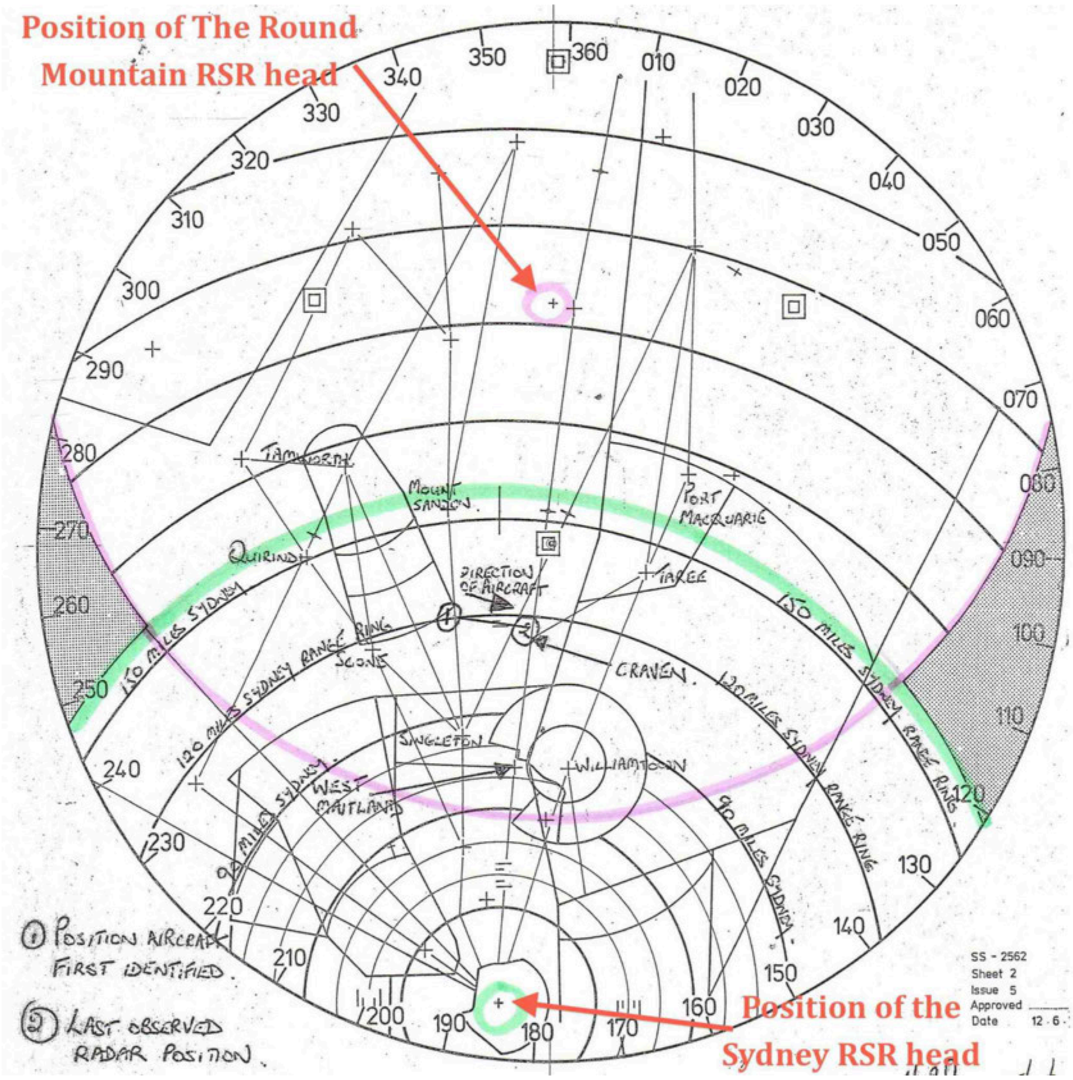


Figure 71: Sydney Northern Mosaic plot sheet. This plot sheet represents what one ATCO observed at the Sector 1 Radar position during the VH-MDX accident. Information from two radars was combined and presented for this *particular* display 'program'. The position of both radar heads is highlighted. The Round Mountain RSR certified radar range is highlighted in pink, Sydney RSR certified range is highlighted in green, both being 160NM. Obviously, terrain masking yields a practical range at lower levels less than nominal (Image: Australian Government (Department of Transport) 1981).

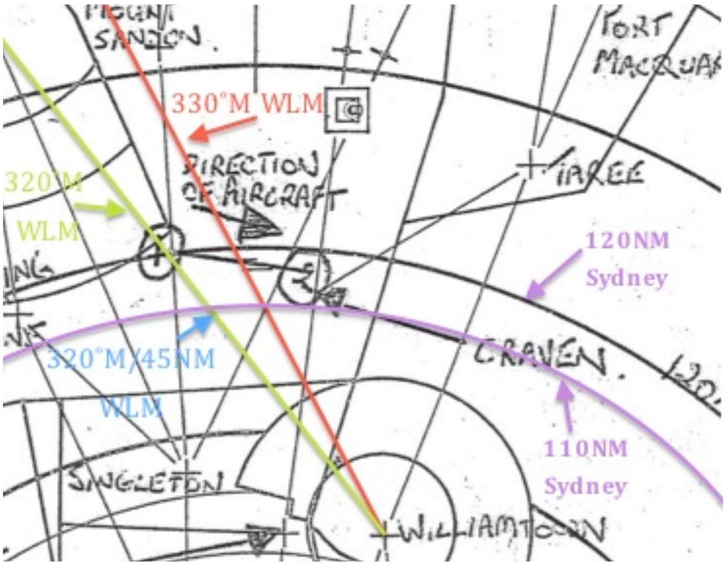


Figure 72: Sydney ATC final radar position. Position '2' was reported as the final radar position observed by one Sydney ATCO. It was deposed the position was approximately 5NM west of Craven waypoint/intersection. Of note is that the depicted straight track between both fixes was not possible given VH-MDX's track south then south-east to the 320˚M/45NM fix. The reason for the straight track appears to be because the ATCO only observed the initial few and last few paints as he was assisting the Sector 1 ATCO with other tasks. The following has been approximated by the author:
320˚M radial from Williamtown (green), 330˚M radial from Williamtown (red), 320˚M/45NM position marked at the tip of the blue arrow, 110NM arc from Sydney (purple)
(Base image: Australian Government (Department of Transport) 1981, additions: Glenn Strkalj 2014).

4.3.2. Time of radar fade

No time is specified in the deposition for this final position. Both communication transcripts of the Sydney Sector 1 ATCO[1] and ASIB/BASI Accident Investigation Summary Reports in various sections[1] indicate radar contact was lost at around 0939:00UTC.

Accordingly, it is quite *possible* that the 5NM west to north-west final observed Sydney radar position occurred at this time.

Given the findings of Williamtown ATCO interviews with the author[21], it is highly probable that the 0939UTC radar fade times discussed in Accident Investigation Summary Reports of September 1981 and September 1983 refer to fade from *Sydney* ATC radar not Williamtown radar. 0939:00UTC was the time that the Sydney Sector 1 ATCO states (referring to radar returns) '*…we've lost him..*'[1].

Communications transcripts also reveal Sydney ATC stating *'you got a present heading, we've lost him-to track towards yours'* just after 0939:00UTC[1]. As the RSR had a 12 second sweep speed coupled with the possible need to have not observed radar returns for a number of sweeps[20], VH-MDX may have fallen beneath Sydney ATC radar coverage just *before* this time.

Accounting for two sweeps without returns is realistic with this yielding an approximate radar fade time of 24 seconds prior to 0939UTC: 0938:30UTC.

Even if events occurred as described, this does not prevent subsequent pop up radar paints and consequently a later final observed radar position.

As discussed in section 4.2.5, the 1983 Accident Investigation Summary states radio and radar contact was lost at the same time; 0939UTC. *Transcripts* confirm *radio* contact was lost at 0939:26UTC with the pilot calling 5000' altitude[1].

Section 4.3.4 will discuss how Sydney ATC radar coverage was not likely below 6000'AMSL at the final observed Sydney radar position. The pilot of VH-MDX transmitted an altitude of 6500' at 0938:29UTC[1]. Considering:

- Approximate Sydney ATC (The Round Mountain RSR) radar mask height (6000'AMSL) would roughly be achieved between 0938:50UTC - 0939:00UTC time and rate of descent wise
- Last received transmission was at 0939:26UTC
- Sydney ATC transcribed fade time minus time for two sweeps approximately equals 0938:30UTC
- 0938:30UTC can be classed as 0939UTC (if rounding to nearest minute);

From these points it can reasonably be concluded that Sydney ATC radar fade likely occurred between 0938:30UTC and 0939:00UTC.

4.3.3. Paints observed

It was stated during recent discussions (2014) with one of the Sydney ATCO's that only *primary* radar returns were observed during this fix[20]. This does open up the question of anomalous propagation/returns and other considerations.

Additionally, another ATCO involved in SAR co-ordination for the VH-MDX accident also seems to recall that only primary paints were observed at the final position but is not completely sure[20].

Despite this, attempting to recall an event thirty plus years ago can yield uncertainties and given the aircraft was squawking a valid code, it is viewed likely that SSR returns *were* displayed but doubt must also be cast.

VH-MDX's initial allocated SSR code of 4000 would be represented with a diamond symbol whilst the final code of 3000 would be represented by a circle[20]. These symbols were estimated to be about 5NM in size[20].

4.3.4. Radar ability

It was found that The Round Mountain RSR was likely the sole Sydney ATC radar contributing to VH-MDX radar positions from at least around 0936:00UTC as this RSR was perched atop a 5200' high mountain[20][21].

Radar propagation analysis has shown that radar coverage by *The Round Mountain RSR* was likely at this position and indeed generally east of the Gloucester Tops down to at least 6000'AMSL. Figure 73 show this.

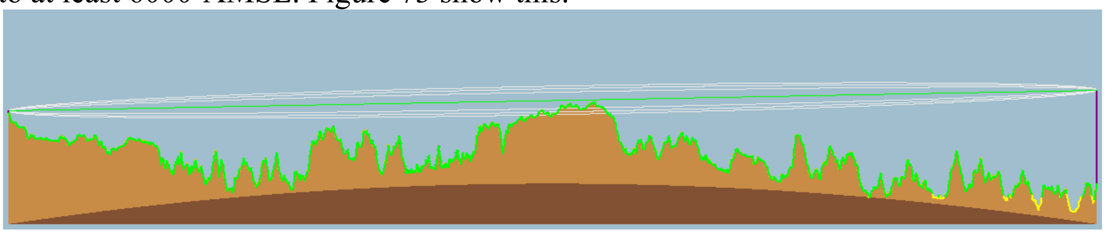


Figure 73: Radar propagation from The Round Mountain RSR to VH-MDX at 6000'AMSL located at the final Sydney radar position (centroid of deposed radar plot). Radar coverage was probably possible at altitudes slightly below 6000'AMSL (Image: Radio Mobile Online 2014, analysis Glenn Strkalj 2015).

4.3.5. Moth effect

Section 3.5.9 discussed how once seeing the lights of significant townships, the pilot of VH-MDX could have been drawn to continue tracking to this perceived safe haven. Such an action was described as being similar to a moth being attracted to light ('moth effect').

If the track from the 320˚M/45NM radar fix or the ASIB/RCC final radar position to the Sydney final radar position is plotted, it is readily evident that the track projects towards the significant coastal towns of Taree and Tuncurry/Forster (dependent on deviations used).

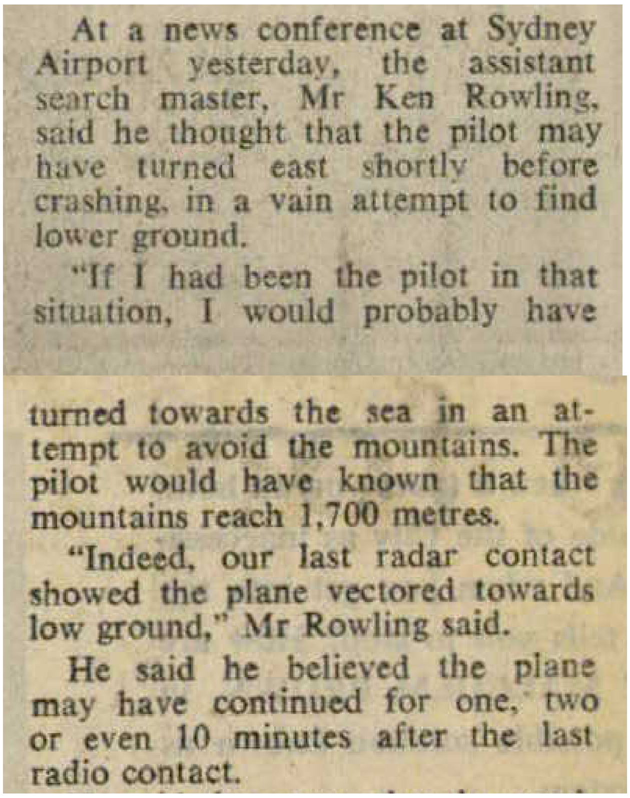
Accordingly, it is readily obvious that such a 'moth effect' with these towns or others in view could have drawn the pilot of VH-MDX to the Sydney final radar position. It is impossible to determine if cloud conditions allowed such an effect, continually or intermittently from the 0936:00UTC position.

4.3.6. Initial opinions of Assistant Searchmaster

A news conference involving the Assistant Searchmaster a few days after the accident reveals that the 'last' radar contact made with VH-MDX '*……showed the plane vectored towards low ground*'.

It was stated that the Assistant Searchmaster '*……..thought that the pilot may have turned east shrtly before crashing, in a vain attempt to find lower ground*'.

The relevant newspaper clippings are presented in figure 74.



At a news conference at Sydney Airport yesterday, the assistant search master, Mr Ken Rowling, said he thought that the pilot may have turned east shortly before crashing, in a vain attempt to find lower ground.

"If I had been the pilot in that situation, I would probably have turned towards the sea in an attempt to avoid the mountains. The pilot would have known that the mountains reach 1,700 metres.

"Indeed, our last radar contact showed the plane vectored towards low ground," Mr Rowling said.

He said he believed the plane may have continued for one, two or even 10 minutes after the last radio contact.

Figure 74: VH-MDX tracking east. The opinion of the Assistant Searchmaster is contrary to the initial high area of interest around the 320˚M/45NM Williamtown position (Image: The Sydney Morning Herald, Wednesday 12th August 1981).

4.3.7. Other media sources

An ASIB Inspector was quoted as stating the last observed radar position was near the town of Gloucester.

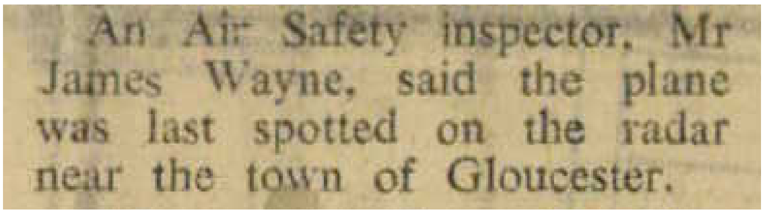

An Air Safety inspector, Mr James Wayne, said the plane was last spotted on the radar near the town of Gloucester.

Figure 75: Suggestion of easterly track from radar information (Image: The Sydney Morning Herald, 6th September 1981).

Another newspaper suggests 'radar tracking' indicates that VH-MDX impacted terrain east of the Barrington Tops and west of Craven township.


Radar tracking suggests the green and cream plane went down east of Barrington Tops and west of the small settlement of Craven.

Figure 76: Suggestion of an easterly track. (Image: The Sun, Friday 18th September 1981).

4.3.8. Final track

Information from a robust source suggests an easterly track within a highly specific range from the 320°/45NM position at 0936:00UTC.

This information is perhaps the most significant piece of information to narrow down a smaller area of interest regarding impact locations. Such information suggests impact between the Gloucester Tops and Mt Berrico.

Specific smaller areas of interest have been generated and will be refined with other information and data.

4.3.9. Discussion

Regarding tracking from the 320˚M/45NM 0936UTC fix:

- A Sydney ATCO and the Williamtown ATCO believed VH-MDX tracked easterly
- Another Sydney ATCO deposed that VH-MDX tracked east
- The pilot of VH-MDX did state sighting the coast and so would be expected to track towards the coast (east or south-east)
- From transcripts, the 330˚M bearing call and 150˚M heading advice elude to a position towards the east
- Sydney radar ATCO's were almost continually observing the radar display
- Recent interviews/discussions and communications transcripts have shown that radar fade was observed by Sydney ATCO's
- It was shown possible for VH-MDX to have tracked to the Sydney final radar position[21].

Considering the points above, the Sydney final radar position is currently considered the best *final* radar position available. Despite this, there are still significant areas that question the validity of the position, namely:

- No 'hard' time of observation of radar fade
- Radar propagation currently suggests marginal coverage below 6000'AMSL at the final Sydney radar position (VH-MDX was probably lower).
- Plotting errors have not been confidently determined yet
- This position has not been located in the BASI archives (??)
- The deposition was made months after the accident
- There is talk within ex Department of Transport members of the position being dodgy for some reason
- Dead reckoning does suggest obtaining the radar fade altitude of around 6000'AMSL at the poison was contingent on faster speeds.

4.3.10. Conclusion

The final Sydney radar position has more positives than the ASIB/RCC position but still suffers from a number of detracting traits.

This position better fits the assumption that directional control was maintained until the final radar position.

The Sydney final radar position:

- Sydney ATCO's were almost continuously observing the radar display

- 330˚M bearing and 150˚M heading advice elude to an easterly track towards Sydney final position

- Radar fade of VH-MDX was observed

- Exact time of fade is open to question

- Radar does not appear to have been able to interrogate VH-MDX at this position <6000'AMSL

- There is no record of this fix in BASI archives

- Was recorded months after the accident

- Is a reasonably reliable *final* radar position

4.4. Conclusions: Final radar positions

At this stage of research it is clear to see that the deposed Sydney final radar position has more defensible positives than the ASIB/RCC final position although has it's own issues.

Despite this, the latter position cannot be ignored and further research is required to better understand and develop theories for both positions.

5. Developing search areas/ conducting searches

5.1. Introduction

Effective search areas cannot be determined by obtaining radar or other positions and simply plotting these on a topographical map.

Position fixes radar or otherwise, must be defined in terms of what they *truly* represent. What were the expected tolerances involved? What potential factors may have lead to errors in recording? Can the position be cross-checked by alternative means? Was there a different Geodetic datum used? What was the magnetic variation at the time of recording? A fix is simply not a fix.

If all the answers were available to the VH-MDX accident the airframe would have been found by now. Accordingly, assumptions need to be made and with increase in assumption there is increased risk of VH-MDX not being found.

Given the renewed media interest in the accident, emergency service units have been inundated with reports from the general public regarding possible VH-MDX wreck sightings, impact areas and eyewitness sightings on the accident day.

Many of these reports fall *significantly outside* where VH-MDX could possibly lie however, emergency services have no way of screening such reports *with confidence*.

A system is required to allow increased risk to be taken in terms of assumption whilst retaining a safe 'fall-back' position during times of failure. The following sub-sections will discuss the author's approach to developing such a system.

5.2. Methodology: A stepped approach

A *stepped* process should be conducted to offer a variety of tools to researchers and search organisations. The idea is to limit resource allocation and prevent needless use of resources.

With a stepped approach, gradually *smaller* areas of interest are developed. As areas become smaller, *increased assumption* and therefore *risk* is experienced. (i.e. as areas become smaller there is more chance that VH-MDX could be outside the defined area).

Despite this, the stepped approach ensures some *stability* in that larger areas always exist to fall back upon. This enables effective continuation of research and reports form the public whilst allowing greater risk in terms of assumptions in the smaller areas to develop workable search areas.

 © Glenn Strkalj 2014

Differing methods should be used in generating the final area that will be recommended for search activities. Such an approach increases confidence in the recommended search area.

Three levels are suggested by the author and these will be briefly discussed in the following sub-sections.

5.2.1. Maximum Possible Extent Boundary

Such a boundary considers *highly conservative* parameters that reflect *very broad* to *maximum* expected tolerances for the situation. Such parameters and tolerances are highly unlikely to change with time. The resulting geographical boundary captures every possible area VH-MDX may be located within.

Accordingly this offers researchers and emergency services a geographical limit for intelligence and *detailed* investigative activities.

Resources have been used to follow up reports of possible VH-MDX impact areas well outside this boundary. This boundary provides a hard limit to prevent such wasteful activities.

Tersely, if it is suggested VH-MDX is located *outside* of this boundary, such a suggestion should be ignored.

5.2.2. Most Likely Extent Boundary

This *extent* boundary uses parameters and tolerances that were *most likely* to be apparent. Such parameters and tolerances are confirmed through thorough research and could possibly change with time although are not expected to do so by significant amounts.

The resulting geographical boundary encompasses the *most likely* area VH-MDX is located in based on the best information and data available to date.

This boundary offers researchers and emergency services a tool to confirm or quash specific flight path theories whilst also defining the limits to *full-scale* search areas.

This boundary can also offer an important cross-check of other reported positions such as radar fixes.

The Most Likely Extent area must lie within the Maximum Possible Extent boundary

Tersely again;

- If a flight path theory suggests VH-MDX impacted *outside* this boundary, the theory should be disregarded
- If a report of possible wreckage exists outside this boundary, it should be investigated but full-scale search operations are not justified
- Any full-scale search operation should be contained within this boundary
- This boundary offers a useful cross-check of other information

5.2.3. Specific flight path theories/ Most Probable Area

These analyses consider the *highest level* of assumptions to develop the *smallest* possible geographical areas for full-scale search operations.

As the level of assumption is significantly increased compared to the first two analyses mentioned, a change of area is likely with time thus, *multiple* areas of interest are likely to be synthesized.

The Most Probable Area must lie within the Most likely Extent boundary.

These analyses offer emergency services the most probable areas of impact based on the best contemporary information, data and understanding available, to determine search areas for *full-scale* search activities.

5.3. Change of primary search location with time

The area assessed as being the most probable location for VH-MDX should obviously be searched first. A point that must be made here is that the most probable location may move significantly based on better interpretation or more information available with time.

Accordingly, provided research is carried out *thoroughly* and *effectively*, there should be no hesitation in changing search locations even if returning to 'old' areas. The most probable area is based with significant assumption and assumptions can change with time.

Constant dissecting of information and data is required until VH-MDX is located but reasonable assumptions need to be made in the meantime.

To iterate, the research backing the decision to move the primary search area must be truly thorough and effective.

5.4. Search techniques

Small, well trained, self reliant, competent teams with clear objectives can in the author's view, achieve more than larger, resource intensive teams. Small teams are more flexible, easier to control, require less logistics for support and impact the environment much less.

The effectiveness of small teams can be multiplied by thorough and effective research and employing remote area sensing techniques if any prove viable.

Remote sensing technology should be applied within *Most Probable Areas* to offer 'hotspots'; areas of interest that can then be searched by traditional ground based techniques. Other 'hotspots' can be synthesized through flight path modeling offering more 'sub areas'.

If possible routes into and out of the most probable area should be diversified to offer varied enroute coverage of the area (increasing total area searched). This may not always be practical considering terrain, vegetation and access tracks but should be considered.

5.5. Conclusions: Developing search areas/ conducting searches

Information and data has been lost or not recorded as one would expect for an accident of this type. This leads to slower information flow during research and also increases the chance of incorrect conclusions.

The three-area approach may confuse some but, following a highly detailed overview of the VH-MDX accident and reviewing attempts to locate the aircraft, it is apparent that change in the final, smallest search area will be inevitable with time.

The three-area approach offers stability but also allows flexibility without excessively disturbing the whole system.

Figure 77 presents a flowchart representing the three-area concept.

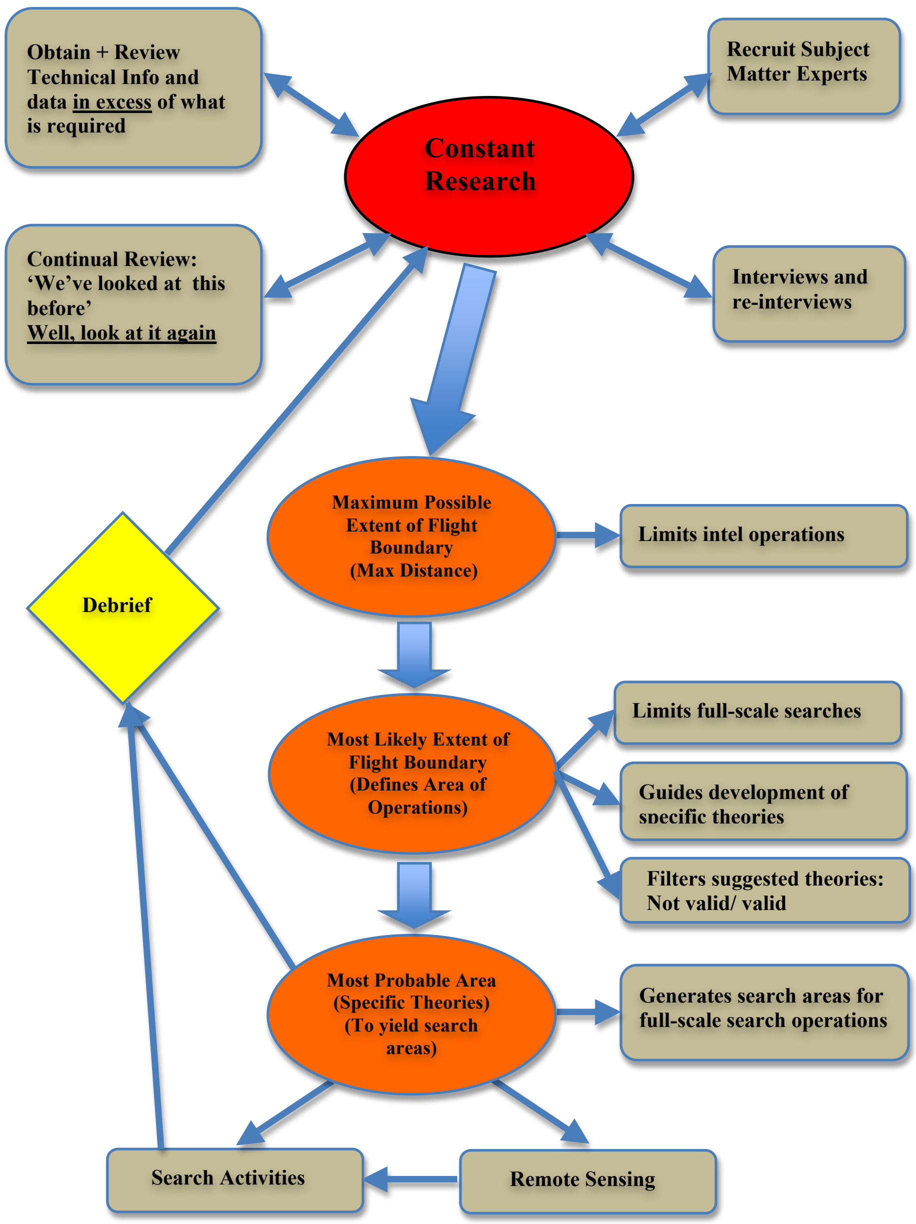


Figure 77: Locating VH-MDX: Concept of operations. (Image: Glenn Strkalj 2014).

6. Conclusion

A detailed but non-exhaustive overview of the VH-MDX accident based on the author's research to date was performed.

Numerous challenges regarding the VH-MDX accident were discussed and suggestions were offered for further investigation.

References

[1] Australian Government, 1981, Bureau of Air Safety Investigation File Number: S1, 812, 1036, Aircraft Accident, VH-MDX C-210, 75km North of Singleton 9/8/81.

[2] Cessna Aircraft Company, 1976, *Pilots Operating Handbook*, *Centurion 1977 Model 210M*, Wichita, Kansas.

[3] Statement,1982.

[4] Avionics West of Tennessee, date unknown, *The ARC Navomatic 300A Autopilot*, Savannah.

[5] Cessna Aircraft Company, 1975, Service/Parts Manual 300 NAV/COM Type RT-328T, 1 August 1975, Wichita, Kansas.

[6] Federal Aviation Agency, 1962, *Technical Standard Order, VHF Radio Communications Transmitting Equipment Operating within the Radio Frequency Range of 118-136 Megacycles*, TSO-C37b, 22 October 1962.

[7] Sunair Electronics, 1971, *Installation and Operation Manual, ASB-125, ASB-60, SSB Communications Equipment,* Fort Lauderdale, Florida.

[8] Cessna Aircraft Company, 1973, *300 Transponder Type RT-359A Service/Parts Manual*, Wichita Kansas, 15 August 1973.

[9] http://motoplaneparts.com, 2014, Photo of Leigh Systems SHARC 7 ELT, accessed 12 April 20014.

[10] Australian Government, c.1981, Aeronautical Information Publication (AIP), *Enroute Chart Low (ERC-L)*, Department of Transport Australia.

[11] Australian Government, 1980, Aeronautical Information Publication (AIP) Australia, Visual Flight Guide (VFG), *Visual Enroute Chart-3 (VEC-3)*, 27 November 1980, Department of Transport Australia.

[12] OzRunways 2014, OzRunways Version 4, Castle Hill.

[13] Australian Government, 1981, Deposition by Air Traffic Controller, Sydney Sector Radar Controller, Department of Transport Australia, 15 December 1981.

[14] Donovan. G, Readford. D.A, 2011, *'Operation Phoenix' The Theoretical Search for The Crash Site of Cessna 210 VH-MDX.*

[15] Civil Aviation Authority, 1993, Aeronautical Information Publication (AIP), *Enroute Supplement Australia (ERSA)*, 24th June 1993.

[16] 7 Network, 2014, Sunday Night, *Finding VH-MDX*, Television Program, 1st June 2014.

[17] Strkalj. G, 2014, VH-MDX *Meteorological Conditions*, Background Data, Information and Investigative Findings Volunteered in the Search of Aircraft VH-MDX, 1st Edition, May 2014.

[18] Australian Government, 1981, Mean Sea Level Synoptic Chart, 1500 EST, 9th August 1981, Bureau of Meteorology, cited in The Canberra Times 9th August 1981.

[19] Australian Government, 1990, *Manual of Aviation Meteorology*, Commonwealth Bureau of Meteorology, 1st Edition, Canberra.

[20] Strkalj. G, 2014, *Sydney Air Traffic Services and Radar 1981*, Background data, information and investigative findings aiding the search of aircraft VH-MDX, 3rd Edition July 2015, (1st Edition May 2014).

[21] Strkalj. G, 2014, *RAAF Williamtown Air Traffic Control 1981*, Background Data, Information and Investigative Findings Volunteered in the Search of Aircraft VH-MDX, 3rd Edition August 2014 (1st Edition May 2014).

[22] Australian Government, 1986, *Visual Flight Guide (VFG) Australia*, Department of Aviation, Canberra.

[23] Airways Museum and Civil Aviation Historical Society, 2014, http://www.airwaysmuseum.com, Accessed April-May 2014.

[24] Strkalj. G, 2014, *VH-MDX Communications*, Background Data, Information and Investigative Findings Volunteered in the Search of Aircraft VH-MDX, 2nd Edition, July 2014.

[25] Nolan. M, c.2013, *Operation Wittenoom VH-MDX Research*.

[26] Chessor. D, 1990, *Research into Probable Crash Sites in Barrington Tops of Cessna 210 VH-MDX*, Sunday 19:40 HRS, 9th August 1981, Draft, 25th September 1990.

[27] Airservices Australia, 2014, Aeronautical Information Publication Australia, GEN, *Time Keeping.*

[28] Airservices Australia, 2005, Enroute Supplement Australia, Canberra.

[29] Pallett. E.H.J, 1981, *Aircraft Instruments*, Second Edition, Longman Scientific & Technical, Essex.

[30] Australian Government, c.1980's, *Operational Notes on Non-Directional Beacons (NDB) and Associated Automatic Direction Finding (ADF)*, Civil Aviation Safety Authority, Canberra.

[31] Australian Government, c.1980's, *Operational Notes on VHF Omni Directional Range (VOR)*, Civil Aviation Safety Authority, Canberra.

[32] Australian Government, 1981, *Visual Flight Guide Australia*, Section 26, Navigational Requirements, Department of Transport, 3 September 1981.

[33] Australian Government, 1993, Aeronautical Publication Australia (AIP), *Enroute Supplement Australia* (ERSA), FAC-S, Singleton, Effective 24 June 1993, Civil Aviation Authority Australia.

[34] http://en.wikipedia.org/wiki/Non-directional_beacon, Accessed, July 21st 2014.

[35] Australian Government, 1981, Radar Plot Pro-Forma, by Air Traffic Controller, Sydney Sector Radar Controller, Department of Transport Australia, 15 December 1981.

[36] DoT Officer A, Former Air Traffic Control Officer, Senior Operations Controller, Searchmaster and ASIB/BASI Representative, Personal Communications, e-mail, May-November 2014.

[37] Air Traffic Controller D, Melbourne Tullamarine Radar Sector Controller early 1970's, Technical Developer-Radar Canberra, Search and Rescue, Personal Communications, Telephone, August 2014.

[38] VH-MDX Blogspot, Archive 7th November 2007 ,http://vhmdx.blogspot.com/2007_11_01_archive.html

[39] International Civil Aviation Organization, 2004, *Manual on The Secondary Surveillance Radar Systems (SSR)*, Doc 9684, Third Edition, Montreal.

[40] Australian Government, 1981, *Visual Flight Guide Australia,* 3 September 1981, Department of Transport, Canberra.

[41] Dyson-Holland. V, Dyson-Holland. J.E, 1999, *Meteorology*, 6th Edition, D-H Training Systems, Tamworth.

[42] Watson. J, *Actual MDX Winds at 8000': TRE – 355/36 SGT Radar Fix*, 19th March 2014.

[43] 2014, Discussions with Technician (non-aviation) who discussed VH-MDX accident with Williamtown ATCO within a few weeks of the accident.

[44] Horrocks. G, *VH-MDX Background Information: Magnetic Deviation,* 19 May 2014.

[45] Watson, J. 2003, *MDX Radio, Radar, C210 Performance*, Version 1.0, 18 November 2003.

[46] Watson, J. c.2003, *Search Planning Document Version 1.*

[47] Massachusetts Institute of Technology , 2001, Reynolds. T.G, Hansman. R. J, *Analysis of Aircraft Separation Minima Using a Surveillance State Vector Approach*, American Institute of Aeronautics and Astronautics, Cambridge, Massachusetts. Or cited within.

[48] Australian Government, 2015, *Hazardous Weather Phenomena, Airframe Icing*, Bureau of Meteorology.

[49] Federal Aviation Administration, 2007, *Advisory Circular, Airframe Guide for Certification of Part 23 Airplanes*, AC no: 23-19A, 30 April 2007.

[50] Australian Government, 1972, Radionavigation Chart AUS-RNC 3, 6 January 1972, Department of Civil Aviation Australia.

[51] Australian Government, 1977, *Air Traffic Control Radar Training Manual*, 14 July 1977, Department of Transport, Melbourne.

[52] Australian Government, 1983, Department of Aviation, *Annual Report 1982-1983*, Department of Transport, Canberra.

[53] Australian Government, National Archives Index, Summary Information About Series, C4288, December 1998.

Annex A: Key point summary

Aircraft

- Planned to fly Coolangatta to Bankstown
- Five people on board
- All metal construction
- Approximately 180L of AVGAS fuel on board during impact
- VH-MDX was certified for IFR operations but the aircraft was *flight planned* to conform to NVFR rules during the accident flight
- VH-MDX was fitted with a roll-axis autopilot
- The autopilot could function even though the Direction Indicator had failed
- The aircraft was likely fitted with one ADF and one VOR
- An ELT was fitted

Weather

- Contrary to many proliferated beliefs the weather along the route flown from Coolangatta was generally *clear skies* and pleasant flying conditions
- A *dark night* was apparent
- A *strong* south-westerly to westerly wind was blowing
- Isolated cloud patches existed along the western tops of mountains due to orographic lifting of air from the strong south-westerly to westerly wind
- The predominant wind generated *significant turbulence* downstream of (coastal) and close to the Great Dividing Range
- A cold front had moved through the area about nine hours before the accident and was well out to sea during the accident.
- A thunderstorm (associated with the cold front at sea) was reported off the coast of Port Stephens that may have caused unstable ADF indications

Tracking

- Mainly coastal
- VH-MDX appeared to proceed *normally* until Taree
- After Taree VH-MDX flew to the north-west of planned track at 8000'AMSL and entered orographic cloud along the Ranges north of the Barrington Tops area
- The pilot of VH-MDX reported being in cloud *without* primary attitude and heading instrumentation
- VH-MDX was identified by Sydney ATC radar near the Polblue/Moonan Brook area to the north-west of the Barrington Tops just after 0928:28UTC
- VH-MDX attempted a climb to 10000'AMSL but could hardly achieve 8500'. This was likely due to downdrafts and/or aircraft icing.
- VH-MDX turned south then was radar observed to carry out a slow turn to the *east*
- The pilot of VH-MDX reports picking up a fair amount of ice, experiencing severe turbulence and downdrafts whilst also reporting the sighting of coastal towns

- It is possible that the pilot of VH-MDX adjusted cruising altitude to 7500’ to conform with standard cruising heights outside controlled airspace somewhere after turning towards the east following the initial Sydney radar position
- Sydney ATC continued to radar observe VH-MDX until around 0939:00UTC
- Williamtown ATC made the one and only complete (bearing and range) radar fix by Williamtown radar of VH-MDX at 320˚M/45NM Williamtown (Just west of Mt Allyn) at 0936:00UTC
- An ATS agency, probably Williamtown ATC, likely radar observed VH-MDX near the 330˚M bearing from Williamtown at 0938:30UTC
- From about 0937:40UTC onwards, the pilot of VH-MDX reports ever-increasing altitude loss
- The last transmission from VH-MDX was received at 0939:26UTC being a ‘five thousand’ (feet altitude) call
- The Williamtown ATCO conducted a thorough check at 0941:20UTC confirming there were no VH-MDX radar paints
- VH-MDX almost circumnavigated the ranges in the Barrington area

<u>Air Traffic Services</u>

- VH-MDX was *outside* controlled airspace from Taree to impact
- Sydney Sector 1 was the Sydney radar sector involved with VH-MDX
- Sector 1 did <u>not</u> directly communicate with VH-MDX
  Williamtown ATC did <u>not</u> directly communicate with VH-MDX
- Sydney FIS-5 was the only unit to communicate with VH-MDX after Taree
- At least three ATCO’s *radar* observed VH-MDX at various stages at the Sydney Sector 1 position
- Williamtown airspace was active to 10000’AMSL within a 25NM arc from approximately north clockwise through to south of Williamtown. Airspace was also active to 10000’ within a 12NM circle around Williamtown.
- Williamtown ATC during the accident consisted of one ATCO conducting procedural (non-radar) control
- The Williamtown radar was turned on for extra situational awareness but there was <u>no</u> requirement for its’ use

<u>Radar</u>

- Two Sydney radars and one Williamtown ATC radar were potentially involved in the VH-MDX accident.
- All radar units incorporated both primary and secondary type radars.
- Williamtown radar was located less than half the distance to VH-MDX than Sydney ATC radars
- There was *no* radar track recording capability at any radars involved
- There was *no* mode C SSR altitude reporting available for VH-MDX
- All radars were able to interrogate <u>all</u> possible SSR codes
- Provided VH-MDX was in view, *all* radars could interrogate and display VH-MDX’s SSR code close to simultaneously
- Sydney Route Surveillance Radar (RSR) was shown to be unable to interrogate VH-MDX
- The Sydney ATC operated Round Mountain RSR was shown able to interrogate VH-MDX down to approximately 6000’ AMSL in the final Sydney radar position

- Williamtown radar could interrogate VH-MDX down to approximately 3500'AMSL in the Upper Williams River Valley area

Radar Fixes

- The 320˚M/45NM (from Williamtown) radar fix by Williamtown ATC was shown to be the *most reliabl*e, *latest* (time-line wise) radar position (≈3.5min before final received transmission)
- Two final radar positions are published; one in the Upper Williams River the other approximately 5NM west to north-west of Craven waypoint
- The origin of the former position is unknown
- The origin of the latter position is largely defensible
- The Upper Williams River Valley position has been suggested to possibly be a composite/refined 320˚M/45NM 0936:00 UTC position rather than a 'final' radar position (mistake in labeling details by ASIB and/or RCC)
- Current research points to VH-MDX being located close to the 5NM west to south-west of Craven waypoint Sydney final radar position
- Geographical definition of the final accepted radar position is required

Communications

- After Taree, Sydney FIS-5 was the only ATS agency to communicate with VH-MDX
- The FIS-5 VHF communications transceiver was located at Mt Berrico
- It was described how higher signal strength between two VH-MDX locations as discovered by ASIB, can be used in an alternative manner to allude to tracking direction
- The first attempt to contact VH-MDX after the last received transmission from VH-MDX was a little over one minute later with no response
- There was confusion on the internal ATS communications line

Developing Search Areas

- A stepped approach was recommended in developing search areas
- The generation of three geographical areas was suggested, each decreasing in area as assumptions are increased
- Such an approach allows development of higher risk, smaller areas backed with larger, lower risk areas that can be fallen back to when new information or corrections in assumptions are made
- Different methods should be used to generate and cross-check nominated search areas

0926UTC INCERFA declared by FIS-5 due reported VFR flight into IMC

0931UTC ALERFA declared by SOC

0935UTC DETRESFA declared by SOC due reported cockpit fire

Annex B: End of daylight for Taree Airport 9th August 1981

(Images: Australian Government, 1981, *Visual Flight Guide Australia*, September 1981, Department of Transport).

Approx Taree Airport lat/long: S31 53’ 24”, E152 30’ 41”

Adjustment to UTC: -1010:40 (≈1011).

LMT EOD: 1754

UTC EOD: 1745-1011= 0734UTC or 1734 EST

VFG AUSTRALIA DAYLIGHT AND DARKNESS GRAPHS 3 SEPT 1981

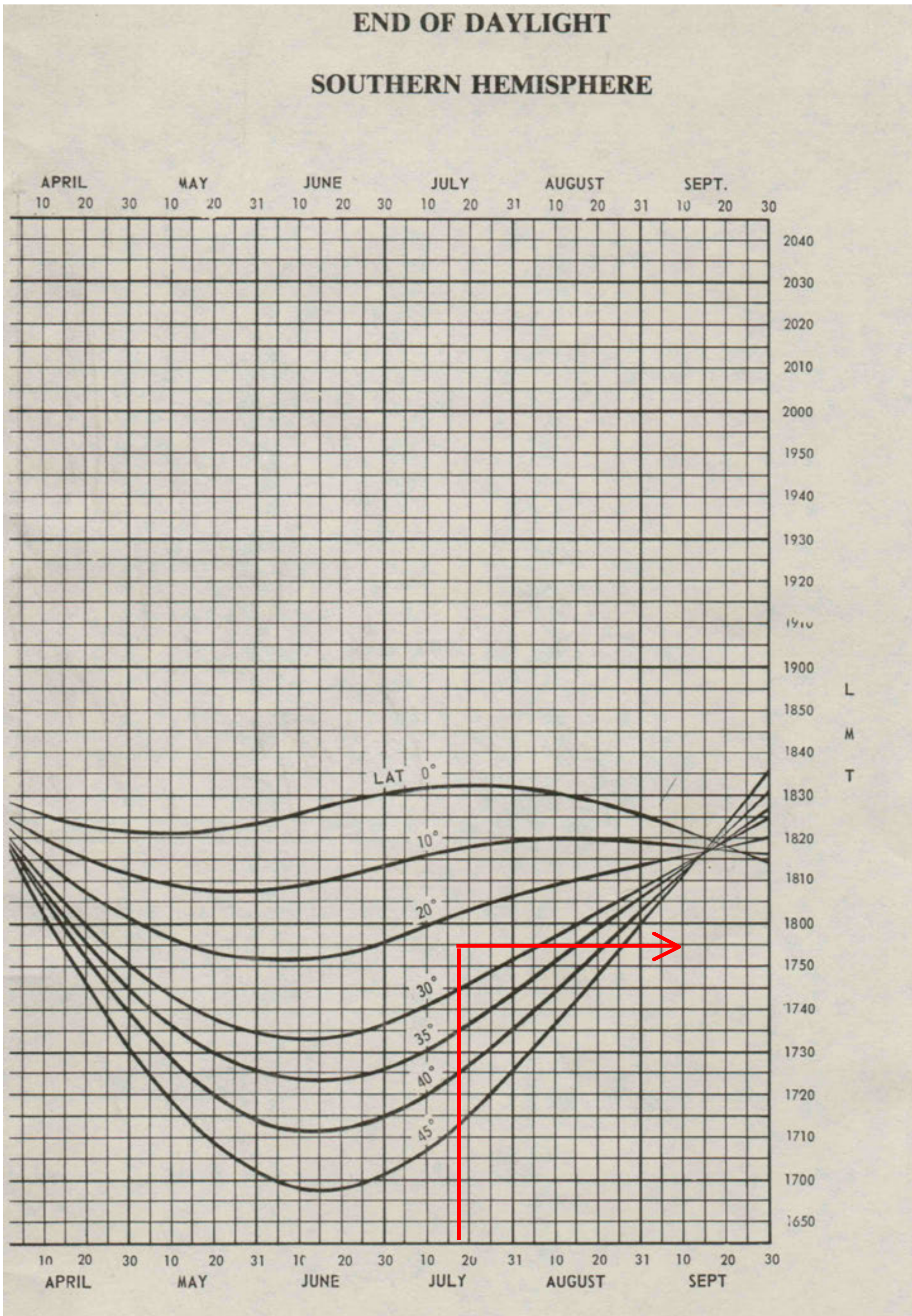
CONVERSION OF ARC TO TIME

LONGITUDE

DEGREES						MINUTES					
Long. Deg.	Time		Long. Deg.	Time		Long. Mins.	Time		Long. Mins.	Time	
	Hours	Mins.		Hours	Mins.		Mins.	Secs.		Mins.	Secs.
110	7	20	140	9	20	0	0	00	30	2	00
111	7	24	141	9	24	1	0	04	31	2	04
112	7	28	142	9	28	2	0	08	32	2	08
113	7	32	143	9	32	3	0	12	33	2	12
114	7	36	144	9	36	4	0	16	34	2	16
115	7	40	145	9	40	5	0	20	35	2	20
116	7	44	146	9	44	6	0	24	36	2	24
117	7	48	147	9	48	7	0	28	37	2	28
118	7	52	148	9	52	8	0	32	38	2	32
119	7	56	149	9	56	9	0	36	39	2	36
120	8	00	150	10	00	10	0	40	40	2	40
121	8	04	151	10	04	11	0	44	41	2	44
122	8	08	152	10	08	12	0	48	42	2	48
123	8	12	153	10	12	13	0	52	43	2	52
124	8	16	154	10	16	14	0	56	44	2	56
125	8	20	155	10	20	15	1	00	45	3	00
126	8	24	156	10	24	16	1	04	46	3	04
127	8	28	157	10	28	17	1	08	47	3	08
128	8	32	158	10	32	18	1	12	48	3	12
129	8	36	159	10	36	19	1	16	49	3	16
130	8	40				20	1	20	50	3	20
131	8	44				21	1	24	51	3	24
132	8	48				22	1	28	52	3	28
133	8	52				23	1	32	53	3	32
134	8	56				24	1	36	54	3	36
135	9	00				25	1	40	55	3	0
136	9	04				26	1	44	56	3	44
137	9	08				27	1	48	57	3	48
138	9	12				28	1	52	58	3	52
139	9	16				29	1	56	59	3	56

The above table is for converting expressions in arc to their equivalent in time; its main use is for the conversion of longitude for application to LMT (added if west, subtracted if east) to give GMT or vice versa, particularly in the case of beginning and end of daylight.

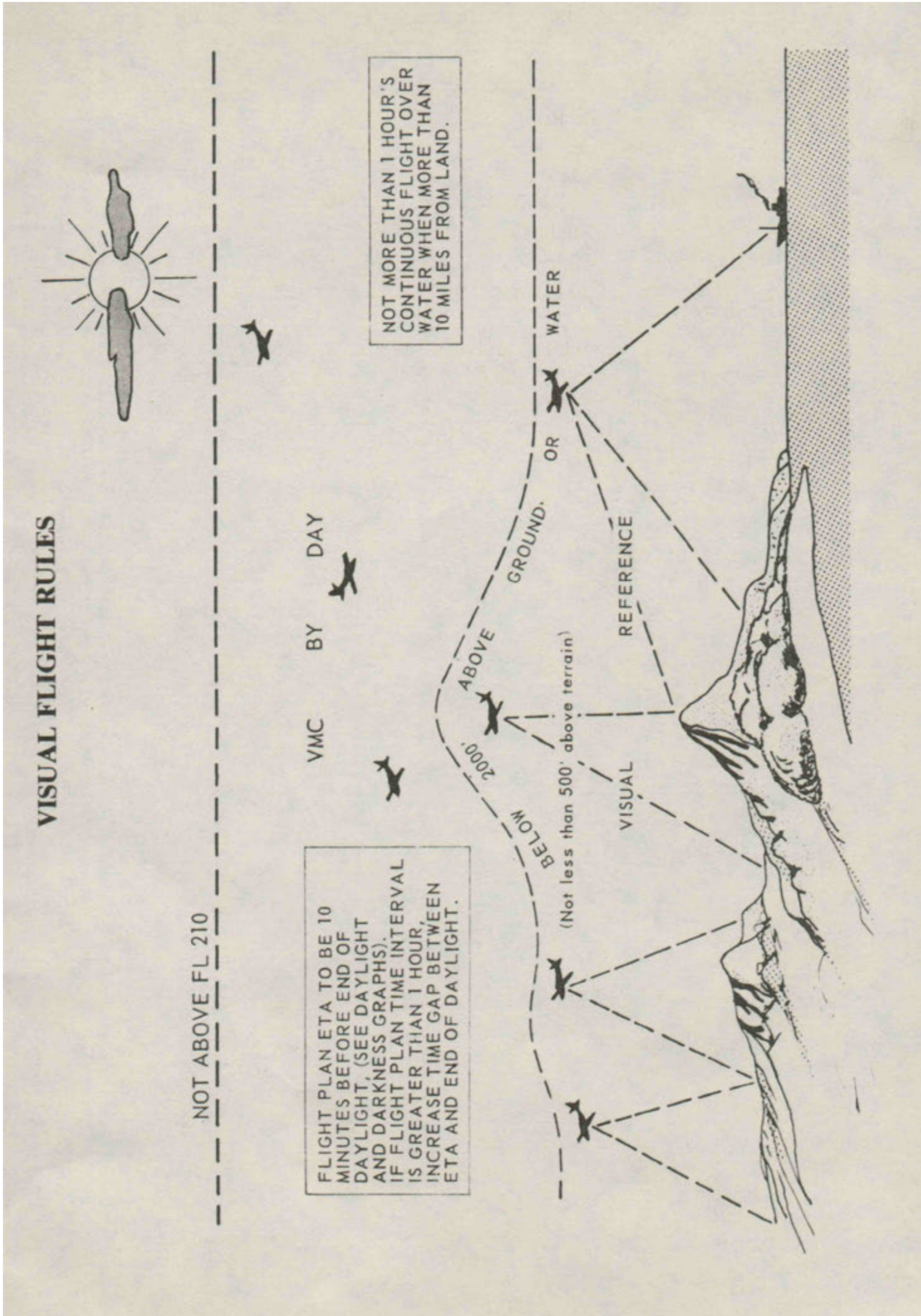
(Image: Australian Government (Department of Transport) 1981)



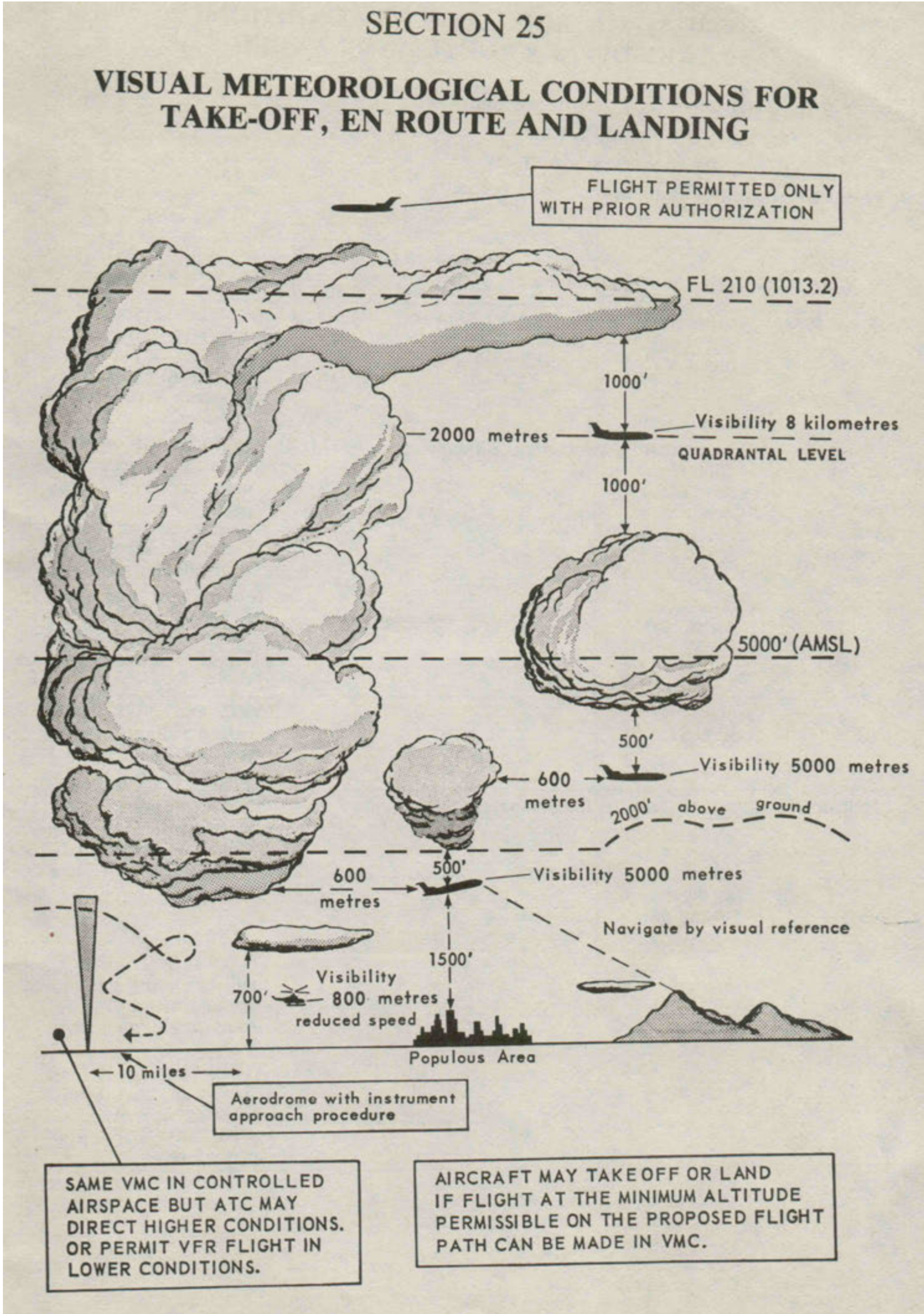
(Image: Australian Government (Department of Transport) 1981)

Annex C: Visual Flight Rules 1981

(Images: Australian Government, 1981, *Visual Flight Guide Australia*, September 1981, Department of Transport).



(Image: Australian Government (Department of Transport) 1981)



(Image: Australian Government (Department of Transport) 1981)

Annex D: Cruising levels 1981

VFG AUSTRALIA FLIGHT PLANNING 42-9
3 SEPT 1981

TABLES OF CRUISING LEVELS

TABLE A—INSIDE CONTROLLED AIRSPACE

Applicable within Australian FIRs
Compliance is required by all flights unless other levels are authorised by ATC.

Magnetic Tracks	From 000° through east to 179°		From 180° through West to 359°	
Cruising Altitudes (Area QNH)	1000 3000 5000	7000 9000	2000 4000 6000	8000 10000
Cruising Flight Levels (1013.2 millibars)	110* 130 150	170 190 210	120* 140 160	180 200 220

***Note:** *FL110 is* **not** *available for level flight when the Area QNH is less than 1013 millibars.*
FL120 is **not** *available for level flight when the Area QNH is less than 980 millibars.*

TABLE B—OUTSIDE CONTROLLED AIRSPACE

Applicable within Australia FIRs.
Compliance is required by all flights **except those operating to VFR or NGT VMC flight procedure below 5000 feet AMSL.**

Magnetic Tracks	From 000° to 089°		From 090° to 179°		From 180° to 269°		From 270° to 359°	
Cruising Altitudes (Area QNH)	1000 3000 5000 7000 9000		1500 3500 5500 7500 9500		2000 4000 6000 8000 10000		2500 4500 6500 8500	
Cruising Flight Levels (1013.2 millibars)	110* 130 150 170 190	210 230 250 270 290	115 135 155 175 195	215 235 255 275 300	120* 140 160 180 200	220 240 260 280 310	125* 145 165 185 205	225 245 265 285 320

Cruising within the transition layer is not permitted

***Note:** *FL110 is* **not** *available for level flight when the Area QNH is less than 1013 millibars.*
FL115 is **not** *available for level flight when the Area QNH is less than 997 millibars.*
FL120 is **not** *available for level flight when the Area QNH is less than 980 millibars.*
FL125 is **not** *available for level flight when the Area QNH is less than 963 millibars.*

(Image: Australian Government (Department of Transport) 1981)