VH-MDX Most Likely Extent (MLE) of flight

Analysis aiding the search for missing aircraft VH-MDX

5th Edition, October 2019
(1st Edition, May 2015)

Glenn Strkalj

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Document purpose

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.

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Acknowledgement

Many people have provided significant assistance to the author in producing this and other VH-MDX research documents. Many individuals have requested anonymity and the author would like to thank these people for their important input.

Special thanks go to the *National Archives of Australia* and the *Airways Museum and Civil Aviation Historical Society* for their fantastic support.

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

Amendments

2nd Edition: October 2015

- More pilot and ground reports included
- Grammatical corrections
- Inclusion of altimeter errors
- Use of ≈330˚M/45NM WLM final radar fix as analysis commencement point

3rd Edition: August 2018

- Simpler to read format, considerable reduction in document size
- Grammatical and format changes
- Analysis commencement area is an area representing a number of definitions of the Williamtown 0936:00UTC radar fix.

4th Edition: September 2018

- Simplification of 0936:00UTC Williamtown radar fix explanation
- Correction of 0936:00UTC Williamtown radar fix error
- Minor grammatical improvements.

5th Edition: October 2019

- Significant reanalysis and re-write.
- Change of radar fix for projection: use of a newly defined most probable Last Known Position (LKP) of VH-MDX. Radio propagation analysis used to bring the base 'raw' fix area into 'reality'. The resulting area is the most probable definition of this fix and the VH-MDX radar LKP.
- Speed: 100KIAS constant 5000'AMSL, ISA-5 now used
- Flight time: 1 minute 34 seconds from the LKP now used.
- Wind: 230˚T- 270˚T (218˚M- 258˚M) at 20-35 knots.

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Abbreviations

AO	Area of Operations
AMSL	Above Mean Sea Level
ARFOR	Area Forecast
ASIB	Air Safety Investigation Branch
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATS	Air Traffic Services
BASI	Bureau of Air Safety
FIS	Flight Information Service
fpm	Feet per minute
GN	Grid North
IAS	Indicated Air Speed
ISA	International Standard Atmosphere
KIAS	Knots Indicated Air Speed
KTAS	Knots True Air Speed
kts	Knots
LSALT	Lowest Safe Altitude
MCP	Maximum Continuous Power
MLE	Most Likely Extent
MPA	Most Probable Area
MPE	Maximum Possible Extent
°M	Degrees Magnetic
MN	Magnetic North
MP	Manifold Pressure
MTOW	Maximum Take Off Weight
MHz	Megahertz
NDB	Non-Directional Beacon
NM	Nautical Mile
NVFR	Night Visual Flight Rules
OAT	Outside Air Temperature
PPI	Plan Position Indicator
PSR	Primary Surveillance Radar
RAAF	Royal Australian Air Force
RCC	Rescue Coordination Centre
RPM	Revolutions Per Minute
RSC	Radar Sector Controller
RSR	Route Surveillance Radar
SPI	Special Position Identification
SSR	Secondary Surveillance Radar
SYD	Sydney
°T	Degrees True
TAF	Terminal Area Forecast
TAR	Terminal *Approach* Radar (RAAF)/ Terminal *Area* Radar (Sydney)
TAS	True Air Speed
TN	True North
UTC	Universal Time Coordinated
WGS	World Geodetic System
WLM	Williamtown

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Executive Summary

A Most Likely Extent (MLE) boundary was determined indicating the maximum area VH-MDX is *most likely* resting within and unlikely to be significantly outside of. The MLE is not a hard boundary and defines:

- The preferred sample area for *remote sensing*
- A boundary *outside* which *full-scale* searches should not normally be conducted
- A boundary that can be used to validate or quash VH-MDX *flight path theories.*

The *≈330˚M/45NM from Williamtown fix* at 0939UTC taken by Sydney ATC was found by the author to be the *most defensible* radar *fade* position available of VH-MDX[2] and because of this, was set as the Last Known Position (LKP) of VH-MDX. Although documentation recorded the time of this radar fix as 0939UTC[2], it has been shown that the most probable time was 0938:42UTC[1]

This position was plotted to yield a *base area* using likely radar read-off tolerances to represent the likely area VH-MDX could have faded from radar within based on radar read-off tolerances alone.

The base area was further developed into a *most probable* LKP/ radar fix area through the use of results from point to point radio propagation analysis to slice away portions of the base area. This process identified where it was possible for VH-MDX to be interrogated by radar at the altitude VH-MDX was predicted to be at. This most probable LKP formed the starting point of the analysis.

From the most probable LKP, tracks were projected in all directions to form an area that encompassed all flight path possibilities using parameters that are classed as being *likely* for this stage of the flight.

100KIAS (Knots Indicated Air Speed) was used as the *likely* airspeed of VH-MDX. A probable wind range of 230˚T- 270˚T (218˚M- 258˚M) at 20-35 knots was used in a manner to extract maximum extent for each track.

The total flight time was 1 minute 34 seconds from the LKP which represents a 40 second short fly on time after the final received radio call at 0939:26UTC. This time interval was chosen to represent the process of the pilot assessing and carrying out a final effort to prevent altitude loss and possibly to turn towards a well lit town (20 seconds) plus a 20 second buffer. A 10 second deviation was added to represent radio communications transcripts tolerance.

It was viewed likely that VH-MDX entered a spin or spiral type flightpath at some point after the final received radio call from VH-MDX. To account for fly on for 40 seconds followed by a spiral descent, a 0.22NM nil wind projection that was adjusted for wind was added to the first result boundary. The MLE encompasses both result areas and is treated as one area.

The MLE boundary is presented in Annex A.

The MLE is *263* square kilometres in area.

The MLE boundary described here is the best *current* interpretation of available information and is *not* a *hard* boundary: some leeway should be given at the boundary edge. As new information comes to hand this area may change. Search Coordinators should be aware of this and accept that future operations may be in a different location.

Contents

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1. Introduction

1.1. Aim
The aim of this analysis is to generate a VH-MDX Most Likely Extent (MLE) boundary to define an area that VH-MDX is *likely* to be located within to guide search and remote sensing activities.

1.2. What is a MLE Boundary?
A MLE boundary is generated using radar fix and flight path parameters that have either been *confirmed* or are viewed as being *likely* to have been apparent during the accident or, are the likely *maximum* value.

A boundary is required that provides the most likely maximum limit to VH-MDX's location. The MLE fulfils this requirement.

The resulting boundary is an *extent* boundary reflecting the *maximum likely* distance that VH-MDX flew from the selected radar fix. Accordingly, VH-MDX is unlikely to be significantly outside the MLE boundary.

The MLE is not a statistical (stochastic) prediction of impact area but rather a boundary generated from parameters that are *confirmed* or that were *likely* apparent.

1.3. Why is a MLE needed?
If more accurate information of VH-MDX's last known position (LKP) was available, VH-MDX would most probably have been located by now and multiple areas of interest would not be required.

Over the years, search and investigative resources have been applied to VH-MDX in highly dispersed geographic areas. A tool is needed to guide decision making to resource allocation to avoid ineffective or wasteful activities.

A MLE boundary provides a *maximum likely* limit to VH-MDX's potential location. The MLE can be used to determine the scale of resource allocation or indeed if any resources are applied at all in response to suggestions of VH-MDX being located in a particular location.

1.4. How is the MLE used?
The MLE defines an area that is:
- The preferred sample area for *remote sensing*
- An area *outside* which *full-scale* searches should not normally be conducted
- An area that can be used to validate or quash VH-*MDX flight path theories*.

1.5. Methodology
Information and data from VH-MDX reference papers will be used to obtain realistic parameters then develop rational assumptions and flight path scenarios.

The flight path scenarios will be plotted on Google Earth to generate a Most Likely Extent (MLE) boundary indicating the area VH-MDX is most likely located within and unlikely to be significantly outside of.

1.6. Changes to MLE Boundary
The MLE boundary may change with time. This is the result of continual information flow, changes to the way information is interpreted and inclusion of input from subject matter experts. However the MLE boundary is less likely to significantly change than the Most Most Probable Area (MPA).

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2. Parameter development

2.1. Most likely flightpath

Significant research and analysis has been performed by the author to verify or suggest locations of VH-MDX during the accident flight.

As of the time of writing, the most likely flightpath of VH-MDX is taken to be:

- Radar identified by Sydney ATC (Air Traffic Control) approximately 36NM north of Singleton NDB (Non-Directional Beacon) on the Singleton NDB/ Mount Sandon VOR (Very High Frequency Omni Directional Range) track at 0928:45UTC, had accumulated significant ice and attempting to climb[2]
- Then *initially* tracked generally southwards from the above fix at between approximately 8000'AMSL to 8500' AMSL (Above Mean Sea Level)[2]
- Was radar observed by Sydney ATC to have carried out a slow turn towards the east[2]
- Was radar observed by Sydney ATC to be on a track of around 120˚M at 0934:20UTC[2]
- Radar observed by RAAF Williamtown ATC to be around 321.34˚M - 326.98˚M (333.41˚T-339.05˚T)/ 45.82NM-47.67NM from the Williamtown ATC radar at 0936:00UTC[3]
- Commenced an un-commanded descent just after the previous radar fix either due to ice accumulation, downdrafts or spatial disorientation or all or some of these factors in combination
- Accumulated additional ice around 0937:32UTC[2]
- Descended through an altitude of around 7500'AMSL at 0937:40UTC[2][5]
- Observed on Sydney ATC radar as tracking around 060˚M to 070˚M probably after the 0936:00UTC radar fix [2]
- Descended through approximately 6500'AMSL at 0938:33UTC[2][5]
- Faded from Sydney ATC radar between approximately 6305'AMSL and 5495'AMSL[2]
- Descended through approximately 5000'AMSL at 0939:26UTC (time of last received radio call from VH-MDX[5])[2]
- Impacted terrain shortly after 0939:26UTC.

2.2. Analysis commencement area

2.2.1. Overview

A logical approach to developing a MLE is to start with the last known position (LKP) of VH-MDX then apply flight path projections from the LKP. Complicating this objective, is the finding by the author that there are *multiple* radar fixes of VH-MDX that are classed as 'final'[1][2].

Despite this, *radar derived* positional information of VH-MDX still offers the most reliable source for the development of a VH-MDX LKP[1]. This is because radio propagation analysis is able to offer increased defensibility to selecting the correct area for an LKP and that an MLE uses parameters which are *likely* rather than conservative.

The *≈330˚M/45NM from Williamtown fix* at 0939UTC taken by Sydney ATC was found by the author to be the *most defensible* radar *fade* position available of VH-MDX[2]. Therefore, this fix is the LKP of VH-MDX. This fix has been defined by radar read-off tolerances identified by the author to yield a geographical area for the fix[2]. But can this geographical area be further refined using alternative methods to yield a more probable area?

2.2.2. Making the fix 'more probable'

Redefining this fix using radio propagation analysis can potentially yield a more accurate representation of where VH-MDX was located during radar fade. This approach is highly innovative and has the potential to redefine the boundaries of nominal radar fixes in addition to validating, invalidating or providing defensible suggestions as to the confidence of transcribed final locations of VH-MDX. The fix will be developed by initially plotting a conservative base area for the Sydney ATC 0939UTC ≈330˚ M/ 45NM from Williamtown radar fix based on radar read-off errors (the largest errors) followed by slicing away portions of the base area by the use of results from point to point radio propagation analysis.

The propagation analysis will be used to find sample minimum interrogation altitudes that The Round Mountain RSR SSR (Route Surveillance Radar/ Secondary Surveillance Radar) was able to interrogate VH-MDX at within the base fix area. A defensible minimum interrogation altitude value will be selected to form the cutoff point for results.

2.2.3. Defining the base area

It was found that *read-off* error accounts for the bulk of radar related position deviations[2]. Research by the author also showed that tolerances of +/-5˚ and +/-2NM could be achieved on the Northern Mosaic (radar display program used by Sydney ATC during the accident) when care was taken in assessing paint positions and a suitable map reference was available within 10NM of the paint[2]. It was shown that these requirements were likely met during the VH-MDX accident[2].

SSR system (technical) errors were found to be significantly smaller than the radar read-off errors[2] to a value of practical irrelevance. The radar systems were accepted as being compliant with the strict standards enforced every day so, display error was not accounted for. An area was plotted using the 320˚M/45NM point with the +/-5˚ and +/-2NM read-off error applied. This area shown in Figure 1 is the base representation of the Sydney ATC ≈330˚ M/ 45NM WLM radar fix.

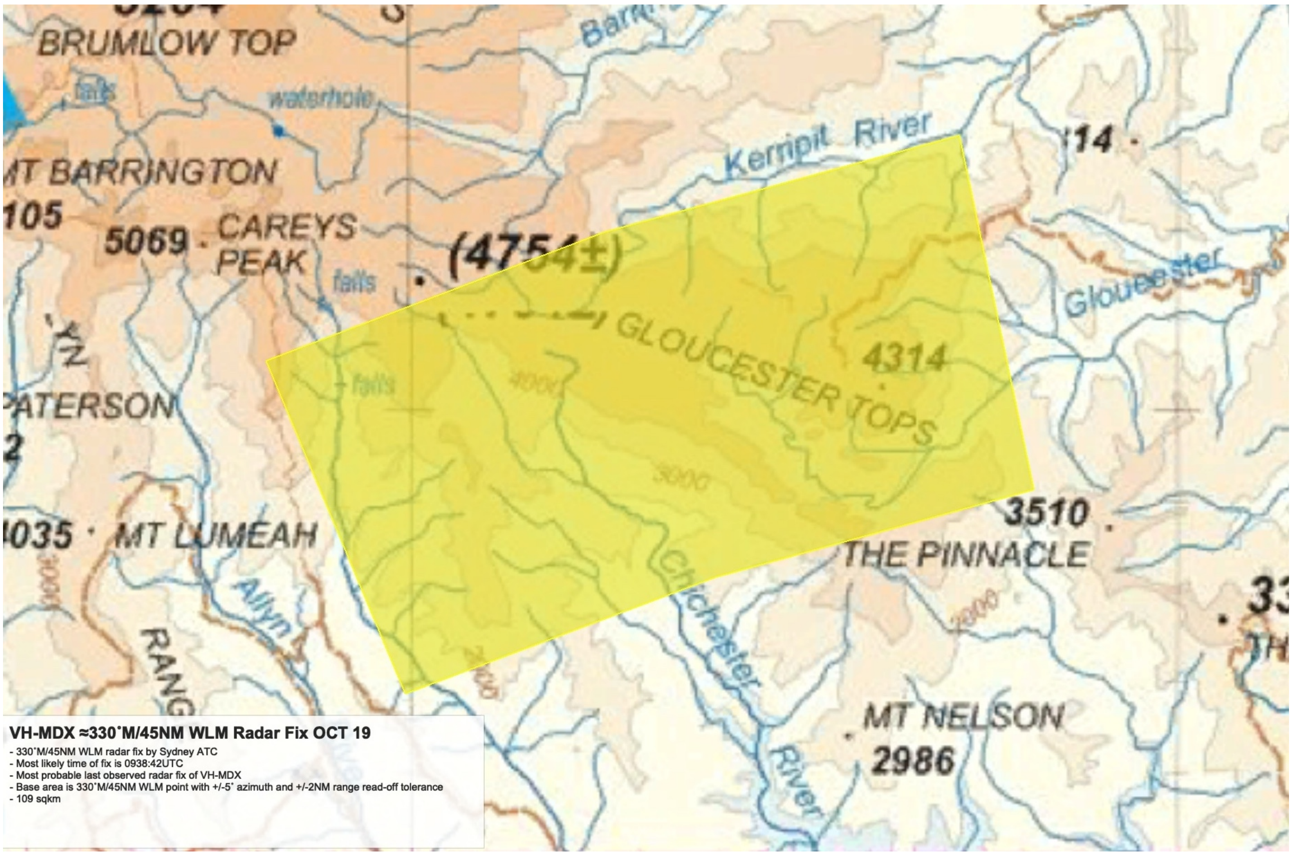

Figure 1: 'Approximately 330˚M/45NM from Williamtown' Sydney ATC radar fix: Base area. The yellow area shows the 320˚M/45NM from Williamtown location with likely radar read-off tolerances applied. This area represents the *possible* area VH-MDX could have been in during the time of the fix (Glenn Strkalj 2014).

2.2.4. Making the probable area

A range of likely VH-MDX radar fade altitudes was determined by the author based on information from communications transcripts with the highest value being 6305'AMSL[2]. The highest likely value of radar fade should be used to encompass all likely areas of radar fade. Accordingly, 6300'AMSL was suggested to be used as a screen altitude with a tolerance of +50'.

Point to point radio propagation analysis was conducted between The Round Mountain RSR and sample points within the area shown in Figure 1 to determine the *lowest* interrogation altitude at each sample point[2]. A sample of radio propagation results are shown overleaf in Figure 2.

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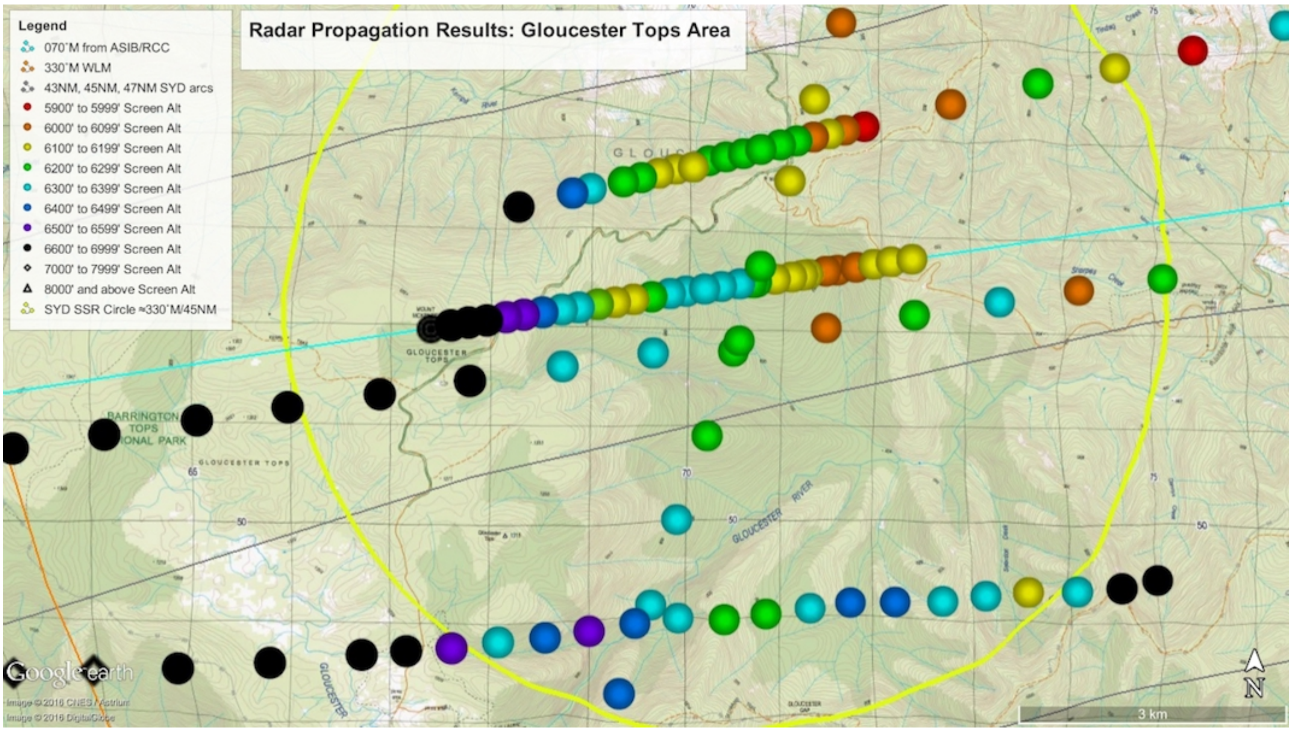

Figure 2: Point to point radio propagation result samples. Using radio propagation analysis in this manner offers an innovative and alternate method to defining radar fixes. The results from such an analysis have the potential to redefine a radar fix to a more probable area. As will be shown, this has successfully been achieved with this fix (Glenn Strkalj Analysed 2015).

Results yielding a lowest interrogation altitude of 6350' AMSL and below were used to form a new boundary for the radar fix. The end result is the most probable area of the radar fix which is the LKP of VH-MDX and is shown below in Figure 3.

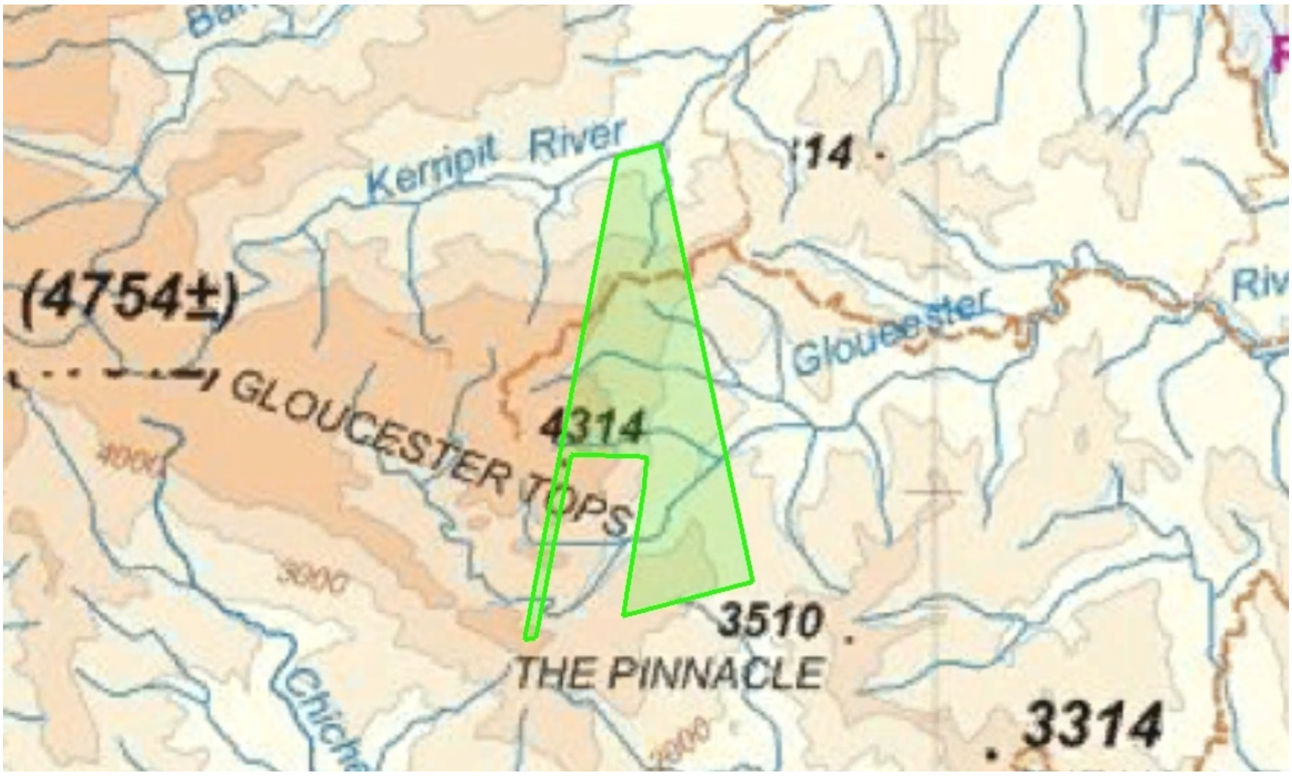

Figure 3: 'Approximately 330°M/45NM from Williamtown' Sydney ATC radar fix: Probable area. This area represents the most probable area for the ≈330°M/45NM from WLM Sydney ATC radar fix. The raw fix as defined by position point and radar read-off areas has been 'brought into reality' by assessing what actually was possible from a radar point of view. This area is the LKP of VH-MDX. (Glenn Strkalj 2015).

Flight path projections from the previous radar fix at 0936:00UTC using a likely speed range show that VH-MDX would have arrived in this area if at the fast or slow end of the speed range[2]. This is useful to further increase the defensibility of the radio propagation modified area.

2.2.5. Time of the fix

Although documentation recorded the time of this radar fix as 0939UTC[2], it has been shown that the actual time is likely in the range 0938:36UTC to 0939:00UTC and a most probable time of 0938:42UTC[1]. The Most probable time will be used in the MLE analysis.

2.2.6. Result: Most probable LKP

Research, analysis and development of this radar fix by the author suggests VH-MDX likely faded from Sydney ATC operated radar within the area presented in Figure 3 most probably at 0938:42UTC[1][2]. This fix represents the most probable LKP of VH-MDX.

Given this analysis is considering the most likely extent of flight, the LKP in Figure 3 will be used as a starting point for developing the MLE.

2.3. Timing

2.3.1. Timing deviations

It was suggested that a +/-10 second tolerance is applicable to the Sydney ATS/ Williamtown ATC radio communications transcripts[4]. Given this analysis is considering *extent*,10 seconds will be *added* to the total analysis flight time to account for this deviation.

2.3.2. Flight time

The last recorded transmission of VH-MDX was at 0939:26UTC with the pilot announcing he was at five thousand feet altitude[5]. From radio communications transcripts, it is clear that VH-MDX was in an ever-increasing descent by the time of this radio transmission and it is viewed probable that VH-MDX entered a steep, uncontrolled, spiralling descent around or shortly after the time of this radio call.

One cannot rule out the aircraft flying on for some distance and impacting terrain at a later time but this is viewed improbable given the known accumulation of significant icing, issues with the artificial horizon and the ever-increasing rate of descent of VH-MDX. This scenario is captured by the conservative Maximum Possible Extent (MPE) analysis but is not suitable for this MLE analysis.

Further discussion of the final segment of flight is warranted.

It is not defensible to suggest VH-MDX contacted terrain by the time FIS-5 attempted radio contact with VH-MDX and received no response as pilot workload would have been significant in this final stage of flight or VH-MDX may have been in an area where terrain shielded the communications link. On the other hand, a fly on case is also viewed unlikely given the ever-increasing rate of descent and accumulated ice and unreliable artificial horizon. The important point is that lack of radio communications at a particular time cannot defensibly determine the flight path.

Accordingly, for this analysis that utilises *likely* parameters and information, the time when FIS-5 or other stations attempted to contact VH-MDX and failed to receive a response should not be used as a timing limit.

Regarding radar paints at Sydney ATC, the radar coverage using Sydney ATC radars was limited in the LKP and in every direction from the LKP[2] so it was unlikely VH-MDX would re-appear on Sydney operated radars because of the ever-increasing rate of descent of the aircraft.

Williamtown ATC radar had much better coverage of the LKP area but was subject to terrain masking which was significant at lower altitudes in areas around the LKP[3].

Similarly to the radio communications case, the time when the radar display was checked again by the Williamtown ATCO should not be used as a time limit to flight in the MLE analysis.

Based on extrapolated rates of descent from radio communications transcript derived altitudes and timings, VH-MDX would be at around 4000'AMSL approximately 30 seconds after the final received radio call from VH-MDX[2]. It is viewed probable that the rate of descent was even higher and as a consequence that VH-MDX was at even lower altitude than 4000'AMSL[2]. This coupled with the terrain elevation in the vicinity of the LKP suggests it is more likely that VH-MDX contacted terrain not long after the final received radio call, perhaps within around 1 minute after.

Considering:

- There is evidence that radar paints of VH-MDX were likely observed to slow down in approximately the final minute leading to radar fade[2] which when combined with the observed direction of paint travel suggests VH-MDX slowing down
- Pilot reported issues with the artificial horizon[5]
- A dark night was apparent[1]
- The reported accumulation of significant icing on VH-MDX[5]
- That at the final radio call the pilot of VH-MDX would be well aware that he was well below the lowest safe altitude for the area
- The pilot's voice inflection during the final radio call clearly showed concern of the situation and in particular to the altitude of the aircraft (5000'AMSL)
- The likelihood of VH-MDX contacting terrain within approximately 1 minute after the final received radio call;

it is viewed likely that:

- VH-MDX did not fly on for much longer after the final radio call was made
- entered a spin or spiral type flight path shortly after the final radio call as a result of pilot awareness of being *significantly* below the lowest safe altitude and triggered by:
  - making an attempt to minimise altitude loss by pitching up and/or;
  - After breaking out of cloud just after the Gloucester Tops, saw the lights of a well-lit town on the coast or Newcastle to the south and commenced a turn towards the lights.
- This attempt was likely made by applying take off power (if not already applied) and setting a lower speed than the likely low speed VH-MDX was already at and/or commencing a turn tot he south resulting in entry into a flick and spin or spiral type flight path.

The effect of icing would have resulted in unpredictable handling characteristics particularly at low speed (e.g. higher stall speed, flick etc.) which would have increased the chances of departed flight.

it is also viewed likely that:

- a decision by the pilot to 'do something' (more/else) would have been made within approximately 10 seconds of the final radio call
- given the likely lower speeds that VH-MDX was operating at leading to the final radio call it would not have taken more than a further 10 seconds to set takeoff power (if not already set minutes before) and change the aircraft attitude in an attempt to trade speed for decreased rate of descent.

This results in a total fly-on time of 20 seconds after which departed flight in a spiral or spin type profile is considered likely. As the time interval has been 'best guessed' and the MLE is an extent analysis, this time interval will be doubled to 40 seconds as a relevant buffer.

Accordingly, an allowance of +40 seconds will be used to account for a short fly on time after the final received radio call at 0939:26UTC. As this analysis will project from the LKP which occurred at 0938:42UTC, a further 44 seconds is added to yield a time interval of 1 minute and 24 seconds.

The communications transcripts deviation of +10 seconds from section 2.3.1 will also be added.

This results in a total flight time of 1 minute and 34 seconds seconds from the LKP area.

2.4. Altitude

The pilot of VH-MDX reported altitudes of[5]:

- 'struggling to get' 8500'AMSL at 0929:10UTC
- 7500'AMSL at 0937:43UTC
- 6500'AMSL at 0938:33UTC and;
- 5000'AMSL at 0939:26UTC.

The highest altitude of VH-MDX at the LKP at 0938:42UTC was found to be 6305'AMSL[2].

From this it can be seen that VH-MDX's altitude was approximately between 6305'AMSL and 5000'AMSL between the LKP and the final received radio call. The flight time interval for this leg is 44 seconds. After the final received radio call, VH-MDX's altitude decreased rapidly and the flight time interval for the leg from the final received radio call to end of fly-on is 40 seconds.

5000'AMSL sits approximately in the middle of the analysed time line.

Altitude is used in the MLE simply to determine likely True Air Speed (TAS). Wind consideration in the MLE will be shown in section 2.7 to be simplified and not altitude related.

Accordingly, using 5000'AMSL to calculate a True Air Speed (TAS) for the scenario is appropriate and will be used in the MLE.

2.5. Speed

2.5.1. Considerations

To generate a MLE boundary, the *likely* speed *for the scenario* should be considered.

A speed band of 100-130KIAS was found to be the most probable speed range during the accident phase (≈ last 15 minutes) of the flight[1].

2.5.2. Just prior to the LKP

In the few minutes prior to the LKP, the pilot of VH-MDX reported turbulence effects, accumulation of additional icing and reducing altitude[5]. VH-MDX had lost a significant amount of altitude just prior to the LKP.

Straight after the pilot of VH-MDX reported being at 6500'AMSL, the FIS-5 Flight Service Officer advised VH-MDX that the lowest safe altitude in the area was 6000'AMSL'[5]

Given the clear situation the pilot was in coupled with advice of the lowest safe altitude being 500' below the present altitude of VH-MDX, it is viewed likely that VH-MDX would have been progressively slowed down by the pilot to trade speed for potential climb or at least reduced rate of descent. This broadly aligns with the suggestion that during approximately the final minute leading into radar fade (the LKP) VH-MDX was radar observed to be slowing down[2].

Maximum Continuous Power (MCP) or even take off power is likely to have been applied by now.

From this it can be seen that VH-MDX was likely slowed down to around 100KIAS by the LKP.

2.5.3. Post LKP

Following the LKP, it is known that VH-MDX descended at an ever-increasing rate of descent[2][5]. It is readily apparent that trading speed for a climb or reduction in rate of descent is not working.

At the 'Five thousand' radio call, the pilot would have been clearly aware of the fact that the aircraft was 1000' below the lowest safe altitude and this was represented by the inflection in the radio call.

The pilot likely attempted to further trade speed for reduction in rate of descent but it is viewed that reduction below 90KIAS was not likely to be possible given the amount of ice accumulated.

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2.5.4. Analysis speed

As this is an extent analysis the minimum speed of 100KIAS from the most probable speed range will be used as a constant speed throughout the analysis time. It was shown in section 2.4 that using 5000'AMSL to calculate a True Air Speed (TAS) for the scenario is appropriate. ISA-5 conditions likely existed over the Barrington Tops during the accident and this will be used for the TAS calculation.

2.6. Aircraft tracking

It was found that VH-MDX was likely observed on Sydney ATC radar to have tracked between 060˚M and 070˚M in the final few minutes of flight[2][6]. As this is an extent analysis, this final track range will not be used so that all possibilities of likely extent can be considered.

Accordingly, tracking in all directions from the LKP should be applied in the analysis.

Tracks in all directions (360˚) from every part of the LKP boundary will be projected. In a Most Likely Extent analysis, the tracking contributing the largest distances flown from the LKP are *straight* courses from the LKP. As a result, curved paths do not need to be considered.

As a spin/ spiral descent at some time after the final received radio call is viewed likely, an allowance of 0.22NM adjusted for wind effects will be added to the primary boundary.

2.7. Wind

As this analysis is generating the *furthest distance* VH-MDX could have flown with *likely* parameters, using the likely range of wind directions and speeds is relevant.

Previous research found that the likely wind VH-MDX was exposed to at 8000'AMSL was 230˚T-270˚T (218˚M- 258˚M) at 30-50 knots[7]. It was also found that winds just above the terrain were likely of a similar direction to those at 8000'AMSL but at around 20-30 knots.[7].

The Area Forecast for the Barrington Tops area valid for the time of the accident predicted a wind of 250˚T/35 knots at 5000'AMSL[5] whilst wind modelling conducted of the Upper Williams River area (approximately 13km west of the LKP) suggests a wind of ≈262˚T at 23 knots at 5000'AMSL[9]. These sources are evidence that reduced wind speeds were likely with reduced altitude.

As a result, the likely wind range will be modified to have a wind speed range of 20 - 35 knots whilst preserving the wind directions originally specified.

Wind flow over a mountain range may cause modifications to local and downstream wind velocities, induce turbulent flow and generate stagnant (low to no wind) zones. Such effects will *not* be accounted for in this analysis. Basic, constant velocity winds will be used.

This analysis will use the most appropriate wind direction and speed from the probable 230˚T- 270˚T (218˚M- 258˚M) at 20 -35 knots wind range to achieve the *furthest distance of flight* with the remaining parameters.

2.8. Magnetic variation

Magnetic variation adjustments are required for a number of parameters. Glenn Horrocks' Australian Geomagnetic Reference Field (AGF) Magnetic Variation / Geoscience Australia based prediction for the Barrington Tops in 1981[8] will be used.

2.9. Summary of parameters

Parameter	Value	Description
Commencement area	Sydney 330°M/ 45NM WLM radar fix refined by radio propagation	Most probable LKP defined by a shape.
Flight time	1 minute and 34 seconds seconds from the LKP area.	1 minute and 24 seconds (84 seconds) flight time +10 seconds timing deviation
Altitude	5000'AMSL	Constant value for extent analysis: used to determine likely TAS
Indicated Air Speed	100KIAS	Found likely to be apparent during the accident
ISA deviation	ISA -5	Found likely to be apparent during the accident
True Air Speed (TAS)	107KTAS	Calculated from 100KIAS at 5000'AMSL in ISA-5
Wind	230°T- 270°T (218°M- 258°M) at 20-35 knots	Apply the most appropriate wind direction and speed from this likely wind range to achieve the *furthest distance of flight*
Ground Speed (GS)	Determined from interaction of TAS value with the wind value that results in maximum extent	Plotting of all wind and TAS combinations, selection of the results with the maximum extent.
Magnetic variation	Upper Williams River: 11.732°E to TN/ 10.926°E to GN WLM SURAD: 12.066°E to TN / 11.430°E to GN	Used to convert values between MN, GN, TN.
Aircraft tracking	In all directions from all points on the LKP boundary for the specified flight time followed by addition of a 0.22NM nil wind displacement adjusted for wind effects	To account for *all possible* track directions and for a spin/ spiral descent at the end of the fly on leg
Boundary style	Convex Hull	Smoothing of the boundary to yield a practical boundary

Figure 4: Summary of Most Likely Extent of flight analysis parameters. These parameters represent deviations that have been confirmed or found likely to be apparent during the flight. Use of these parameters results in defining a geographical area that VH-MDX is likely to be located within. Further, separate analysis will be carried out to define a smaller area of interest to guide search operations and a larger area to capture all possible locations of VH-MDX.

3. Results

3.1. Resulting boundary

The resulting boundary represents the *Most Likely Extent (MLE)* of flight of VH-MDX: ie a maximum area that VH-MDX is most likely resting within and unlikely to be significantly outside of.

The MLE boundary is presented in Annex A.

3.2. MLE size

The MLE is 263 square kilometres in area.

3.3. Using the MLE

The MLE is:

- The preferred sample area for *remote sensing*
- A boundary *outside* which *full-scale* searches should not normally be conducted
- A boundary that can be used to validate or quash VH-MDX *flight path theories*
- The MLE is not a hard boundary.

4. Conclusions

A Most Likely Extent (MLE) boundary was determined indicating the maximum area VH-MDX is *most likely* resting within and unlikely to be significantly outside of.

5. Recommendations

1. Information that suggests VH-MDX is located significantly *outside* the MLE boundary depicted in <u>Annex A</u> should be regarded as *unlikely*.
2. Remote sensing operations should aim to sample the *entire* area within the MLE boundary and a limited buffer beyond the MLE
3. *Large scale* searches should *not* be conducted significantly *outside* the MLE boundary without strong supporting evidence.
4. The MLE should be reviewed in the future.

6. References

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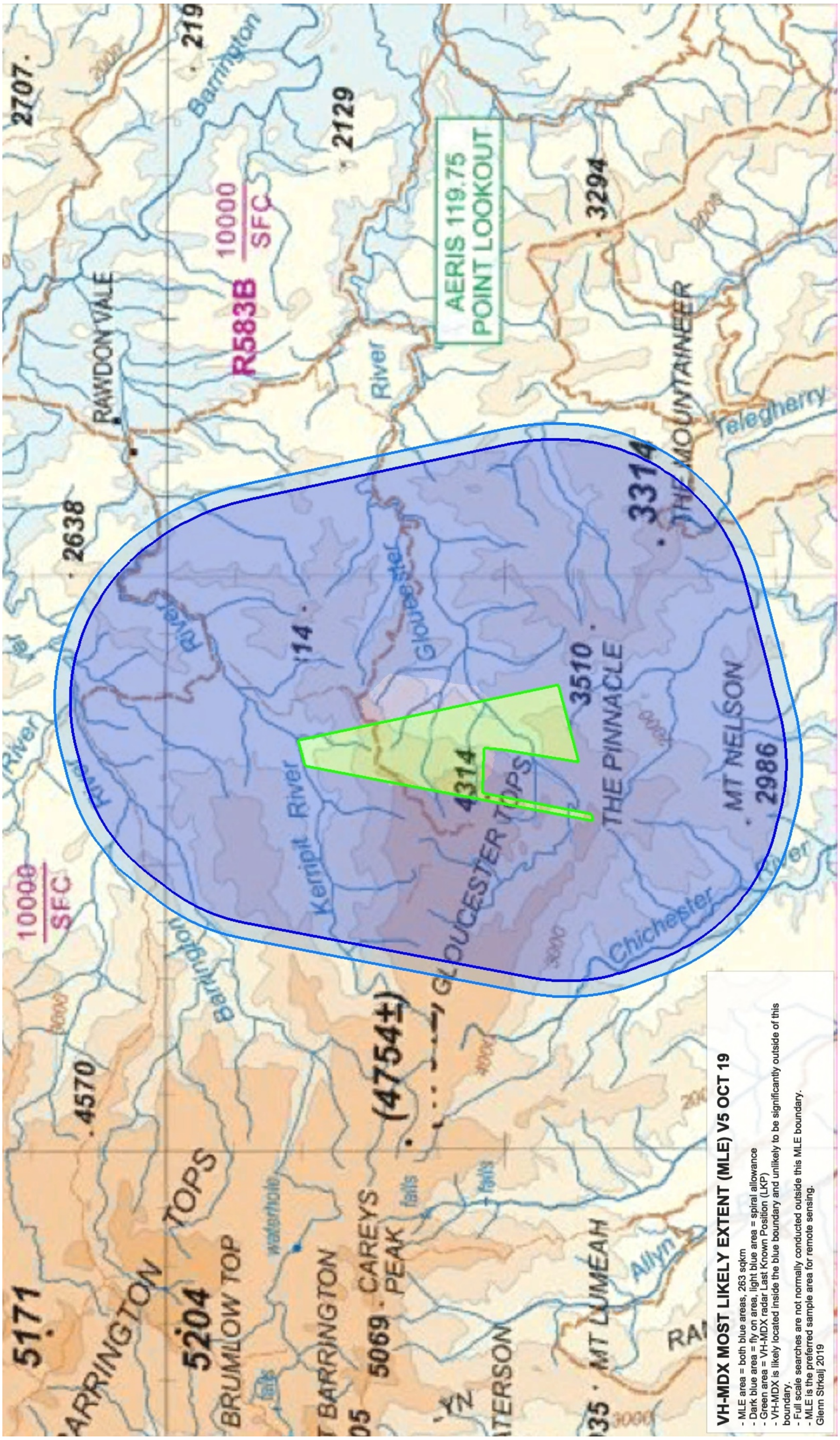
Annex A: VH-MDX Most Likely Extent (MLE) Boundary



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