1

Topics

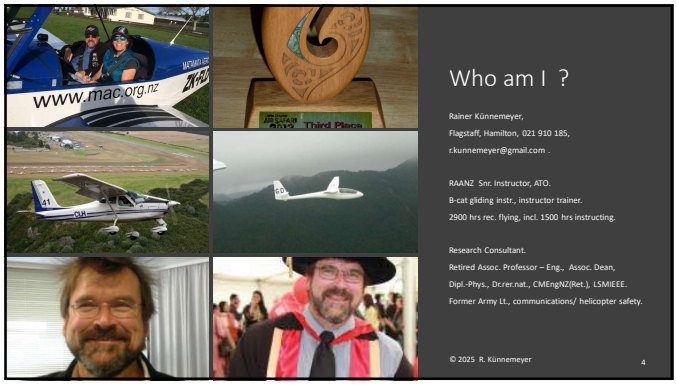
Part 1: Basics	Part 2: Flight Planning	Part 3: Navigating	Part 4: Advanced
• Coordinates • Maps • Compass • Map reading	• Measuring direction • Wind triangle, drift • Flight log • Fuel, weight • UTC, ECT	• Flying the plan • Course corrections • Getting lost	• GPS • Navigation apps (Avplan) • Windy • (Part 5 ??: Practice)

2

Part 1: Basics

Coordinates	Maps	Compass	Map reading
• Latitude/ longitude • Degrees, minutes, seconds • Great circles	• Map projection • Map grid • True north • Nautical miles	• Magnetic north • Compass rose • Magnetic Variation	• Map Legend • Scale, distances • Airspace, transponder, radio, features, height/contours, obstacles, safe altitude

3



Who am I ?

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Dipl.-Phys., Dr.rer.nat., CMEngNZ(Ret.), LSMIEEE.
Former Army Lt., communications/ helicopter safety.

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How to identify a particular location on earth (coordinates)

Earth is a, more or less, spherical body rotating around its north to south axis.

Click to proceed

5

How to identify a particular location on earth (coordinates)

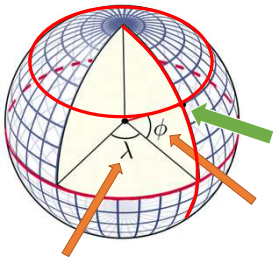
Earth is a, more or less, spherical body rotating around its north to south axis.

A point on the surface of a sphere can be identified by two angles.

For Earth these two angles are measured from its centre and the axis of rotation and the equator.

One angle, ϕ, identifies lines parallel to the equator - parallels of latitude;

the other, λ, semi circles from north to south pole - meridians of longitude.



Click to proceed

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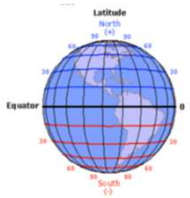
Parallels of Latitude



The reference is the equator at 0° latitude.

Latitudes are given for two hemispheres – north and south or the equator.

The north pole is at N90° or +90° latitude.

The south pole is at S90° or -90° latitude.

The equator is a great circle.
This means it is the circumference of a plane that passes through the Earth's centre bisecting the Earth's sphere.

Other parallels are only small circles.

NZ extends from about S35°00' (Kaitaia) to S47°00' (Stewart Island).

 7

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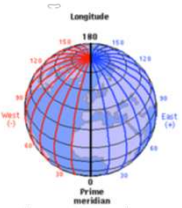
Meridians of Longitude



The reference is the 'prime' or zero meridian going through Greenwich, England .

Longitudes are given for two hemispheres east (+) or west (-) of Greenwich from 0° to 180°.

Meridians are half of a great circle perpendicular to the equator.

All meridians run between north and south pole **defining the true north direction**.

NZ extends from about E167° (Fiordland) to E178°30' (East Cape).

Note:
Traditionally, angles are measured in degrees (°), minutes (‘), and seconds (“). There are 360° in a full circle. 1° has 60’, and 1’ has 60”.

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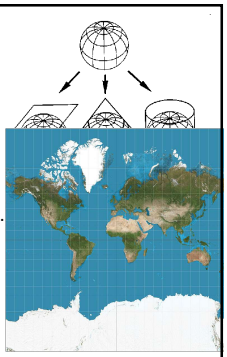
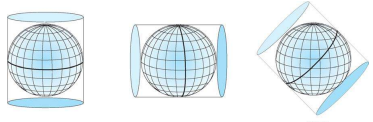
Maps

To navigate on earth's surface, we need 2-dimensional maps we can easily carry around.

This means the 3-dimensional earth surface has to be somehow projected onto a flat sheet of paper.

One of the techniques used is the Mercator projection.





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NZ aeronautical charts

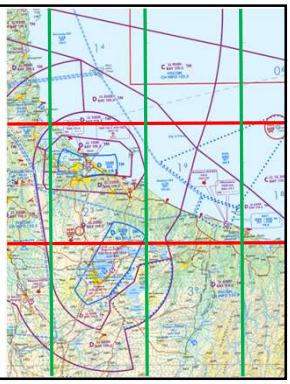
Since 2020, the 'New Zealand Transverse Mercator 2000' projection is used for our visual navigation charts.

The central (vertical) meridian is 173° E.

For all practical purposes there is:

- No significant distortion of distances,
- Distances and headings can be directly read off the chart.

The maps have a latitude and longitude grid overlayed.



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Coordinates

The coordinates of a particular location are given as a pair of latitude and longitude; each has hemisphere, degrees, minutes, and seconds:

- Latitude: N/S 0- 90° 0-59' 0-59"
- Longitude: E/W 0-180° 0-59' 0-59"

Several different formats are used. For example, Te Kowhai airfield is located at:

S37°44'42"	E175°09'31"	Traditional format used on VNC, AIP aerodrome chart
S 37 44 42	E 175 09 31	aerodrome location on AIP aerodrome chart
374442.0S	1750931.0E	Air navigation register using decimal fraction
37°44.7'S	175°9.517'E	Some mapping software (AvPlan)
-37.745	175.1586	Some GPS apps

Sometimes decimal fractions, that is divide by 10, 100, etc., are used instead of the traditional minutes, seconds – divide by 60 .

The Waikato hospital helipad is at:

374822.61S	1751651.23E	Air navigation register

This is an accuracy of 1 foot, slightly better than we need for microlight navigation.

Click here to see how to convert between formats.

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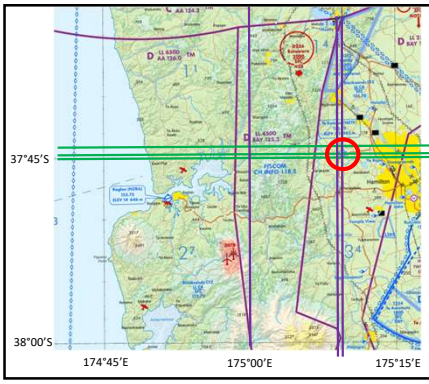

How to locate Te Kowhai airfield at S37°44'42" E175°09'31"

S37°45'
S37°44'
S37°44'42"

E175°00'
E175°09'
E175°09'31"

S37°44'42" E175°09'31"

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True Direction

True direction is given relative to a meridian of longitude which defines true north pointing to the geographic north pole.

Directions are stated using the terms of a compass rose – North, East, South, West, etc.

or an angle measured in clockwise direction relative to the north pointing meridian.

North = 0°
East = 90°
South = 180°
West = 270°

Standard maps are arranged to have true north at the top.

Clockwise 360° circle graduations

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Great and small circles

The circumference of earth is about 40,000 km. This is the length of a great circle.

All meridians of longitude follow a great circle,

parallels of latitude in general do not.

Because of its importance for navigation the surface length of one minute of arc of a great circle has received a special name: **one nautical mile = 1 NM**.

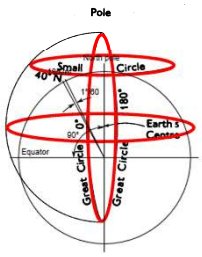
1 NM = 6076.1 ft = 1852 m

The derived unit for speed is:

1 kn = 1 NM/hr = 1.852 km/h

This now allows us to read distances directly off the VNC grid (the longitude, vertical lines) of our charts.

Click here to see some unit conversions.



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Reading distance off the latitude/ longitude grid

We first need to identity the latitude/ longitude grid and its divisions.

37°45'S

This green arrow is 15' (arc minutes of latitude) and corresponds to a surface distance of 15 NM.

This red arrow is also 15' (but arc minutes of longitude) and we cannot tell the distance.

We can use the green arrow to measure distances in any direction. For example, the distance NZRA to NZTE would be just under 15 NM.

38°00'S

 15

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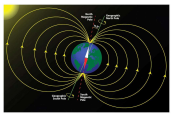
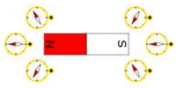
Magnetic North





Geographic or true north is difficult to determine with simple instruments, but for centuries navigators have used the Earth's magnetic field to find their way.

A compass needle aligns itself with magnetic field lines and points to magnetic north.

However, the Earth's magnetic north and south pole are not in the same location as the geographic poles, and their location changes over time.

To use a compass with our navigation charts we need to make corrections.

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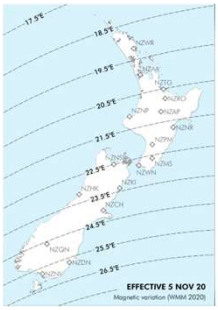
Magnetic variation / declination



… is the difference in angle between true and magnetic north.

In NZ, the magnetic variation changes by about 8° from the top to the bottom of the country.

On their front page, all paper VNCs have an indication of the variation at the centre of the map.

To convert a direction from true to magnetic, use:
Variation **East**, magnetic **least** – This means subtract the magnetic variation from the true angle to get magnetic direction);
Variation **West** – magnetic **best** - add the magnetic variation to get magnetic direction.

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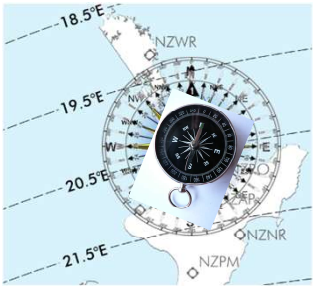
Procedure to determine magnetic direction



At a certain location, say Hamilton, determine the magnetic variation: say 20° East

True North on this map is pointing straight up.

Rotate by 20° to the East - clockwise.
True North is now least: 360° - 20°.
It is at 340° magnetic.

So, the compass North points 20° to the East (right, clockwise) of true North in this case.

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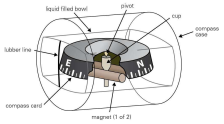
Compass deviation



All metal, wires, and electrical equipment close to a compass can cause errors in the magnetic heading shown.

This error must be considered if high accuracy is required.

A process called "swinging the compass" is used to determine the deviation (AC43-7). After that a card placed on or next to the compass tells the pilot which heading to steer for a desired magnetic heading.

Remember - Any metal or electrical object placed near the compass may cause considerable error.

Compass Deviation Card	
Heading	Steer
360	001
045	045
090	091
135	136
180	179
225	223
270	266
315	314

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Let's continue with NZ VNCs and map reading

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New Zealand VNCs

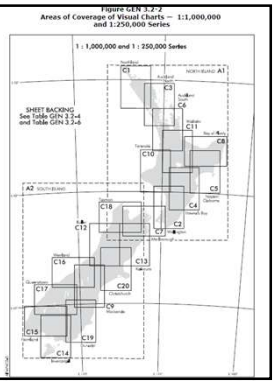
Visual Navigation Charts are available

- on paper or plastic paper,
- as the AOPA booklet,
- or in digital format.

They come in different scales with different features (pdf) .

The latest version is available at the AIP Shop .

The 'C' – 1:250,000 charts are the most useful ones for visual navigation.



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VNC - 1 :250,000 Paper map

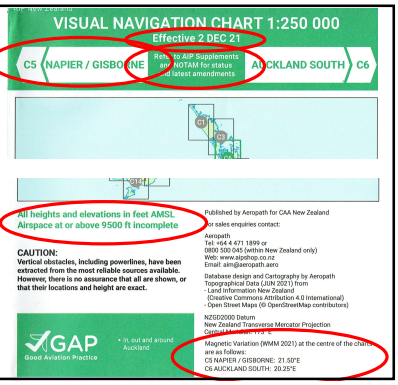
Use the appropriate map(s) for your flight.

Make sure the chart is current. VNCs are updated annually.
Amendments are published as noted.

You can find information on magnetic variation.

Note limitations.

It is essential that you familiarize yourself with the map symbols.



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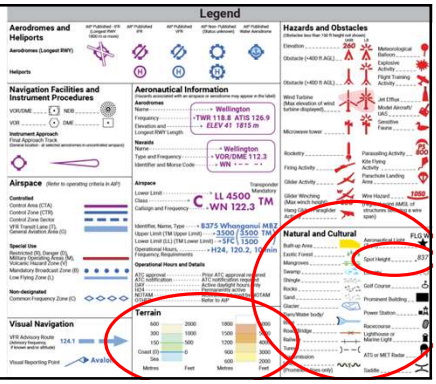
Legend

All maps have a legend that explains what each symbol means.

Aeronautical information is overlayed onto a standard topographic map that shows towns, streets, rivers, etc.,

and terrain heights are given using the a colour code or spot heights.



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Airspace

Airspace boundaries are shown by differently coloured and marked lines -

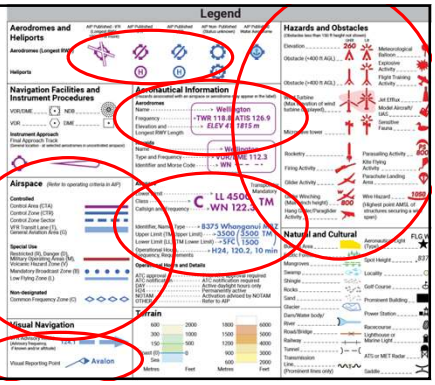
in conjunction with a coded description of that airspace.

Basic information on aerodromes is on the maps,

visual reporting points,

as well as known hazards.

Make sure you get know your maps !!



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Other info inserted into the map area

Map scale. Here 1:250,000 .

This means 1 cm on the map is 250,000 cm or 2.5 km in real life.

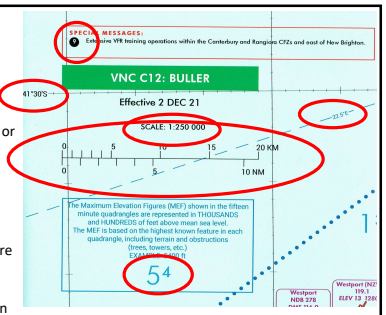
Scale ruler.

Values for the latitude/ longitude grid lines are at the edge of each paper map.

The blue dashed line gives the magnetic variation.

Maximum elevations are given for the square between the latitude/ longitude grid lines.

Some locations have a black circle with a white number. The special message associated with it is given in this information area.



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Now look at a real VNC

On the next slide some features are highlighted.

This discussion is not complete ! Get yourself a map and study it !

Click to proceed

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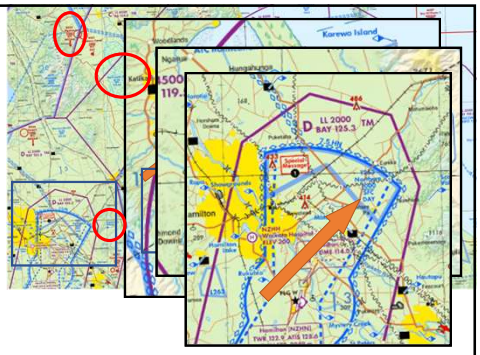
- Low flying area
- Mandatory Broadcast Zone (MBZ)
  - Blue dotted line
  - Matamata traffic
  - Surface to 4500’
  - Active 24 hours
  - Frequency 122.25 MHz
  - Reporting interval 15 minutes
- Common frequency Zone
  - Blue diamond line
  - Morrinsville traffic
  - Surface to lower level Control
  - Frequency 123.25 MHz
- Danger area
  - Red circle
  - Ngatea
  - Surface to 9500’
  - Active by NOTAM
  - Rockets
- Transit Lane
  - Wide light blue line
  - Northern
  - Surface to 1000’
  - Active during day
- Visual reporting point
  - Clear/blue diamond with leader
  - Scotsmans Valley



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NZ airspace

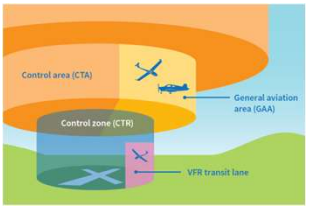
NZ has various types of airspace.

Class G is uncontrolled; Classes A, C, D are controlled. You need ATC approval before you enter or operate in any controlled airspace.

Controlled air space intersects Class G like an inverted ‘wedding cake’ around major airports. A control zone surrounds the airport and starts from the ground. Control areas are above as illustrated in the picture.

For details on operational requirements look at this poster (pdf) .

The next slide illustrates how airspace is marked on the VNCs.



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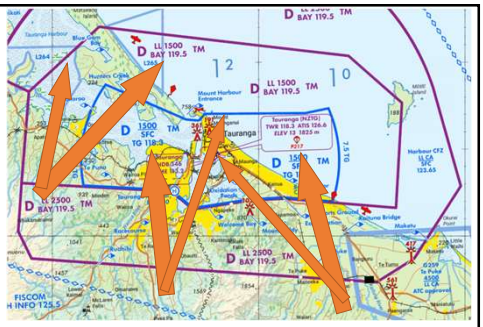
- Control Area (CTA)
  - Class D airspace
  - Purple line
  - Lower level 1500’
  - ATC unit: Bay Approach
  - Radio: 119.5 MHz
  - Transponder mandatory
- Control Zone (CTR)
  - Class D airspace
  - Thin blue line
  - Surface to 1500’
  - ATC unit: Tauranga tower
  - Radio: 118.3 MHz
  - Transponder mandatory
- Airport
  - Tauranga NZTG
  - Tower: 118.3 MHz
  - ATIS: 126.6 MHz
  - Elevation: 13’
  - Runway length: 1825 m
  - Parachute drop zone



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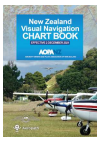
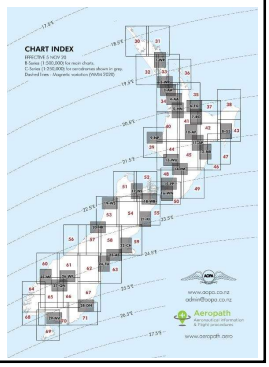
AOPA chart book

…is an A4 bound book with B series charts covering the whole country and C series charts for major airports or busy areas.





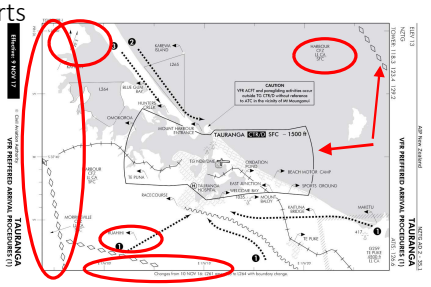
31

31

AIP (approach) charts

… show, in black and white, similar information to the VNCs for most aerodromes.

Airspace boundaries,
in conjunction with a coded description.
Scale ruler.
Magnetic variation.
Coordinates.
Visual reporting points.



Make sure you get to know your maps !!

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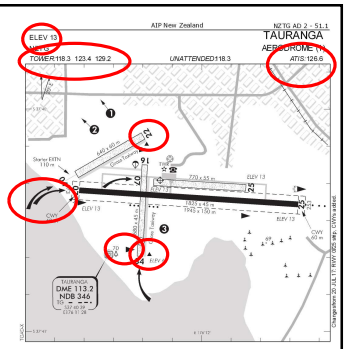
AIP aerodrome charts

… have additional symbols for

Runway numbers,
Circuit direction,
Windsock,
Holding points, etc.

… and information like
ATIS frequency
Tower radio frequencies
Aerodrome elevation, etc.

For the full chart legend read AIP GEN2.3



33

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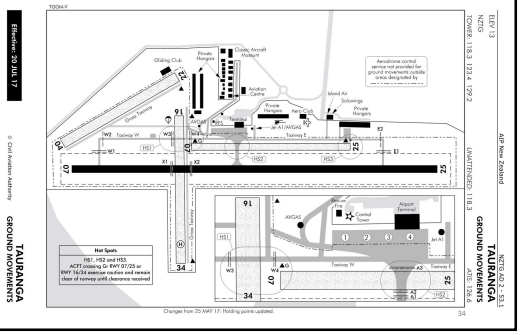
Ground movement detail



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Legal stuff

CAR 01: Cross-country flight

… more than 25 nautical miles … from the aerodrome of departure

CAR 91.221: Flying equipment

… requires current, appropriate aeronautical charts

CAR 91.525 Flights over water

… 1 life preserver for each person … if … more than gliding distance to shore…

CAR 91.529 AELS and ELT

… at least PLB is required … more than 10 nm from the aerodrome.

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That's it for Part 1. More to come in Part2.

Click to proceed

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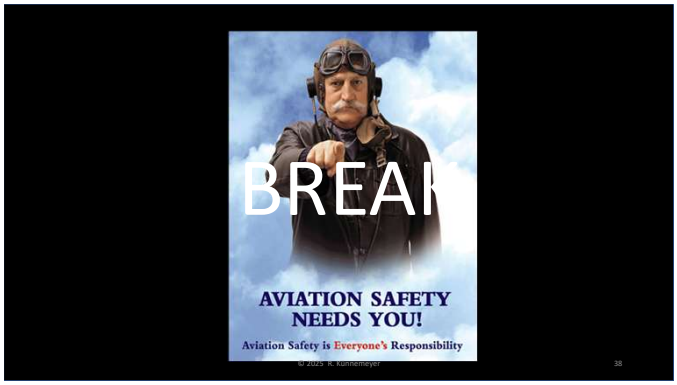

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Coordinate format transformation

Coordinates are normally given in degrees, minutes, seconds.

Remember: $1° = 60' = 3600"$

Te Kowhai airfield is at S37°44'42" E175°09'31". Some GPS apps give it as -37.745 175.1586 .

Let us convert the latitude to a decimal degree format:

$$S37°44'42" = -37°\left(44 + \frac{42}{60}\right)' = -37°(44 + 0.7)' = -37°44.7'$$
$$= \left(37 + \frac{44.7}{60}\right)° = 37.745°$$

Let us convert the decimal longitude to the standard format:

$$175.1586 = +175°(0.1586 * 60)' = \text{E}175°9.516'$$
$$= \text{E}175°9'(0.516 * 60)" = \text{E}175°9'(30.96)" \approx \text{E}175°9'31"$$

go back

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Unit conversions

Distance:

$$1\ NM = 6075.1\ ft = 1.852\ km$$

e.g.:

$$23\ NM = 1.852 * 23\ km \approx 42.6\ km$$
$$50\ km = \frac{50}{1.852}\ NM = 27\ NM$$

Speed, e.g.:

$$90\ kn = \frac{90\ NM}{1\ hr} = \frac{90\ NM}{60\ min} = 1.5\frac{NM}{min} = 1.5 \cdot \frac{6076.1\ feet}{60\ sec} = 152\ ^{ft}/_{s}$$
$$90\ kn = \frac{90\ NM}{1\ hr} = \frac{90 \cdot 1.852\ km}{1\ hr} = 167\frac{km}{hr} = 46\ ^{m}/_{s}$$

go back

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