



AAC CADET INSTRUCTOR'S HANDBOOK NAVIGATION

2005

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AMENDMENT CERTIFICATE

1. Proposals for amendments or additions to this document are to be made through the normal chain of command.
2. It is certified that the amendments promulgated in the under mentioned amendment list have been made to this document.

Amendment		Amended by (Print Name and Initials)	Date of Amending
Number	Date		
1	May 05	Additional information included. Reprint	May 05
2	Nov 09	SILVA 1-2-3 added	Nov 09

PREFACE

Aim

1. This pamphlet provides the correct doctrine on map reading and navigation.

Level

2. This pamphlet is for use by all cadets and is the source document for field navigation. It contains specific guidance for instructors of cadets. This document was produced by Training Cell, HQ NT AAC BN.

Scope

3. Part One, Map Reading, contains information on map craft, including the compass and the service protractor.
4. Part Two, Navigation; detail aids to navigation and information on the planning and conduct of navigation and additional information for navigation training.

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GLOSSARY

1. The terms listed below are used in this pamphlet. For convenience, the definitions are listed in the following sections:

- a. Technical Terms; and
- b. Topographical Terms.

TECHNICAL TERMS

Aeronautical Chart. A representation of a portion of the earth, its culture and relief, specifically designed to meet the requirements of air navigation.

Auxiliary Contours. Additional contours used to portray unique ground forms not adequately portrayed by the selected contour interval.

Bearing. The horizontal angle at a given point measured clockwise from a specific reference datum to a second point.

Bench Mark. A permanent mark that may be cut into a wall, but more commonly, a concrete mark recording exact height for future reference; marked BM on maps.

Cardinal Points. The directions: north, south, east and west.

Cartography. Science and art of expressing graphically, by use of maps and charts, the known physical features of the earth's surface and man's works and activities.

Compass North. The uncorrected direction indicated by the north-seeking end of a compass needle.

Contour Interval. Difference in elevation between two adjacent contour lines.

Contour Line. A line on a map or chart connecting points of equal elevation.

Control Point. A point located by ground survey with which a corresponding point on a photograph is matched.

Conventional Sign or Symbol. Symbols shown on a map or chart to denote an artificial, cultural or natural feature.

Co-ordinates. Linear or angular quantities which designate the position that a point occupies in a given reference frame or system.

Datum Point. Any reference point of known or assumed co-ordinates from which calculation or measurements may be taken.

Dead Reckoning. Finding one's position by means of a compass and calculations based on speed, time elapsed, effect of wind, and direction from a known position.

Declination. The angular distance of a star (or sun) north or south of the celestial equator.

Detail. The basic graphic representation of features.

Easting. Eastward (that is, left to right) reading of grid values.

Elevation. The vertical distance of a point or a level, on or affixed to the surface of the earth measured from means sea level.

Form Lines. Lines resembling contours, but representing no actual elevations, which have been sketched from visual observation or from inadequate or unreliable map sources, to show collectively the configuration of the terrain.

Geographic Co-ordinates. The quantities of latitude and longitude that define the position of a point on the surface of the earth with respect to the reference spheroid.

Geographic Reference System. A standard grid method of position reporting, using the earth's graticule of latitude and longitude as the grid.

Gradient. In map reading a slope is expressed as a fraction. Thus a slope of 1 in 30 represents a rise or fall of 1 metre in a distance of 30 metres.

Graphic. Any and all products of the cartographic and photogrammetric art. A graphic may be a map, chart, or mosaic or even a filmstrip that was produced using cartographic techniques.

Graphic Scale. A graduated line by means of which distances on the map, chart, or photograph may be measured in terms of ground distance.

Grid Bearing. The direction of an object from a point, expressed as a horizontal angle, measured clockwise with reference to grid north.

Grid Convergence. The horizontal angle at a point between true north and grid north.

Grid Co-ordinates. Co-ordinates of a grid co-ordinate system to which numbers and letters are assigned for use in designating a point on a grided map, photograph, or chart.

Grid Interval. The distance represented between the lines of a grid.

Grid Magnetic Angle. Angular difference in direction between grid north and magnetic north. It is measured east or west from grid north. Grid magnetic angle is some-times called 'grivation' or 'grid variation'.

Grid North. The northerly or zero direction indicated by the grid datum of directional reference.

Hachures. A conventional method of showing hill features by shading in short lines drawing the direction of the slope, thicker at the top of the slope than at the bottom.

Hill Shading. A method of representing relief on a map by depicting the shadows that would be cast by high ground if light were shining from a certain direction.

Index Contour Line. A contour line accentuated by a heavier line weight to distinguish it from intermediate contour lines. Index contours are usually shown as every fifth contour with their assigned values, to facilitate reading elevations.

Latitude. The latitude of a place is the arc of the meridian from that place to the equator, expressed in degrees.

Left (Right) Bank. That bank of a stream or river on the left (right) of the observer when he is facing in the direction of flow, or downstream.

Longitude. The longitude of a place is the angle at the pole between the meridian of that place and some standard meridian (generally that of Greenwich). A line of longitude is a line drawn through places of equal longitude.

Magnetic Bearing. The direction to an object from a point, expressed as a horizontal angle measured clockwise from magnetic north.

Magnetic Compass. An instrument containing a freely suspended magnetic element which indicates the horizontal direction of the earth's magnetic field at the place of observation.

Magnetic North. The direction indicated by the north-seeking pole of a freely suspended magnetic needle influenced only by the earth's magnetic field.

Magnetic Variation. The horizontal angle at a place between the true north and magnetic north measured in degrees and minutes, or mils, east or west according to whether magnetic north lies east or west of true north.

Map. A graphic representation, usually on a plane surface, and at an established scale, of natural or artificial features on the surface of a part or the whole of the earth or other planetary body. The features are positioned relative to a co-ordinate reference system.

Map Convergence. The angle at which one meridian is inclined to another on a map or chart.

Map Index. Graphic key primarily designed to give the relationship between sheets of a series, their coverage, availability, and further information on the series.

Map Reference. A means of identifying a point on the surface of the earth by relating it to information appears on a map, generally the graticule or grid.

Map Series. A group of maps or charts usually having the same scale and cartographic specifications and with each sheet appropriately identified by the producing agency as belonging to the same series.

Map Sheet. Individuals map or chart either complete in itself or part of a series.

Map Scale. The ratio of a distance measured on a map to the corresponding distance on the ground, classified as follows:

- a. large scale, 1:75 000 or larger;
- b. medium scale, 1:75 000 to 1:600 000; and
- c. small scale, 1:600 000 and smaller.

Meridian. A true north south line.

Military Grid. Two sets of parallel lines intersecting at right angles and forming squares; the grid is superimposed on maps, charts, and other similar representations of the surface of the earth in an accurate and consistent manner to permit identification of ground locations with respect to other locations and the computation of direction and distance to other points.

Mosaic. Assemblies of overlapping photographs that have been matched to form a continuous photographic representation of a portion of the surface of the earth.

Northing. Northward, that is from bottom to top, reading of grid values on a map.

Oblique Air Photograph. An air photograph taken with the camera axis directed between the horizontal and vertical planes. Commonly referred to as an 'oblique'.

- a. High Oblique. One in which the apparent horizon appears.
- b. Low Oblique. One in which apparent horizon does not appear.

Orientation. The turning of an instrument or map until a datum point or meridian is aligned with a datum point or a true meridian on the earth.

Overlay. A printing or drawing on a transparent or semi-transparent medium at the same scale as a map, chart, etc, to show details not appearing or requiring special emphasis on the original.

Plot. Map, chart, or graph representing data of any sort.

Projection. Representation on plane surface of earth or of celestial sphere.

Reliability Diagram. In cartography, a diagram showing the dates and quality of the source material from which a map or chart has been compiled.

Relief. Inequalities of elevation and the configuration of land features on the surface of the earth which may be represented on maps or charts by contours, hypsometric tints, shading, or spot elevations.

Representative Fraction. The ratio between map or photo distance and ground distances expressed as a fraction in the same units of measurement.

Resection. A method of fixing a position by observation and plotting of bearings from at least two previously fixed points.

Roamer. Grids constructed to common map scales used for determination of map co-ordinates.

Section. A line has drawn to represent the shape of the surface of the ground along a line between two points.

Spot Elevation. A point on a map or chart whose elevation is noted.

Traverse. A method of surveying in which lengths and directions of lines between points on the earth are obtained by or from field measurements, and used in determining positions of the points.

Trig Point. An accurately surveyed point whose co-ordinates are known.

True North. The direction of the north pole from any point.

Universal Polar Stereographic (UPS) Grid. A military grid prescribed for joint use in operations in limited areas and used for operations requiring precise position reporting. It covers areas between the 80degree parallels of latitude and the poles.

Universal Transverse Mercator (UTM) Grid. A grid co-ordinate system based on the transverse mercator projection applied to maps of the earth's surface extending to 84 o N and 80 o S latitudes.

Vertical Interval. Difference in altitude or height between two specified points or lo-cations.

TOPOGRAPHICAL TERMS

The topographical terms given below are fairly well known but are not always used correctly. Terms such as hill, mountain, river, stream and valley are in common use and need no definition.

Basin. An area of fairly level ground surrounded or nearly surrounded by hills; or the area drained by a river and its tributaries.

Col. See 'Saddle'.

Crest. The highest part of a hill or mountain range. That line on a range of hills or mountains from which the ground slopes down in opposite directions.

Defile. A natural or artificial feature that causes a body of troops to contract its front during its passage through it, for example, natural defile – gorge or mountain pass; artificial defile – bridge.

Divide. The line along a range of hills from which water flows in opposite directions, for example, the Great Dividing Range.

Dune. A mound or ridge of sand formed by the wind.

Escarpment. An extended line of cliffs or bluffs.

Estuary. The tidal mouth of a river.

False Crest. The line along which a lower steep slope changes to an upper gentle slope.

Foreshore. That portion of the shore between high and low water marks of maximum spring tides.

Gorge. A rugged and deep ravine.

Knoll. A low detached hill.

Main Features. Those important form such as ridges, drainage systems, etc, which determine the shape of the country. Sometimes called 'salient features'.

Minor Feature. An offshoot of a main feature.

Pass. A road or track over a mountain ridge or range.

Plateau. An elevated plain; an elevated region of considerable extent, generally fairly level.

Ravine. A long deep valley worn by a stream.

Re-entrant. A valley or ravine, usually between two spurs, turned inwards towards the main feature.

Ridge. The line along a hill or range of hills or mountains; sometimes the crest of a line of hills as it appears on the horizon.

Saddle. A neck or ridge of land connecting two mountains or hills, a depression between high features; also called a 'col'.

Spur. A minor feature, generally in the form of a ridge, running out from the main feature.

Undulating Ground. Ground which alternately rises and falls gently.

Watercourse. The line defining the lowest part of a valley, whether occupied by a stream or not.

Watershed. A ridge of land separating two drainage basins; the summit of land from which the water flows in two directions. A watershed does not necessarily include the highest point of a chain of mountains or range of hills.

ABBREVIATIONS

The following abbreviations are used in this publication. Their sources are as shown as follows:

GEOREF	Geographical Reference System
GMT	Greenwich Mean Time
GR	Grid Reference
IAS	Indicated Air Speed
UTM	Universal Traverse Mercator
VHF	Very High Frequency
Common Military Usage	
DEC	Declination
GHA	Greenwich Hour Angle
GN	Grid North
HD	Horizontal Distance
JNC	Jet Navigation Chart
JOG	Joint Operations Graphic
LHA	Local Hour Angle
MER	Pass Meridian Passage
MN	Magnetic North
NOE	Nap of the Earth
ONC	Operational Navigation Chart
PM	Post Meridian
RF	Representative Fraction
RMI	Remote Magnetic Indicator
SHA	Sidereal Hour Angle
TN	True North
TPC	Tactical Pilotage Chart
UPS	Universal Polar Stereographic
VD	Vertical Distance

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PART 1. MAP READING

CHAPTER ONE

THE MAP

INTRODUCTION

General

101. A map is a scaled plan of a portion of the earth's surface. As the earth's surface is curved, there is always some degree of distortion on a map, due to the type of projection used. For example, a large piece of orange peel, when flattened will tear around the edges and squash together at the centre. As long as the land area contained on the map sheet is not large, this distortion will be small and will not concern the map user.

102. In general, the term 'military map' is only used for a map that shows and features and is used for operations on the ground. Hydrographic charts and aeronautical charts are used for navigational purposes at sea and in the air respectively. This pamphlet deals primarily with military maps, but reference is made to aeronautic charts because of their use by army aviation and for joint operations.

103. A military map not only carries the required topographical detail but also possesses a superimposed grid. In Australia, exclusively the Royal Australian Survey Corps for the conduct of military operations does not necessarily produce a map used for military purposes. Most Commonwealth mapping which is produced under the auspices of the National Mapping Council of Australia serves both a civil and military purpose, irrespective of whether it is produced by a civilian or military mapping agency.

104. Such Commonwealth mapping carries a series designation number and edition number. Each State of the Commonwealth has a mapping authority under the direction of its own Surveyor General. Some States produce maps of a Commonwealth series as agents for the Commonwealth, in addition to producing their own internal series. These maps do not necessarily meet the requirements of a military map and are not designated as such. However, they do provide a valuable source of mapping intelligence for the derivation of military maps and charts of the same or smaller scale. Additionally, where no military map exists, they normally provide an acceptable alternative.

Map Craft

105. It is not sufficient for a student of map reading to be able to extract information shown on a map, give grid references, read and plot bearings and measure distances. Map craft involves being able to relate the map to the ground and the ground to the map. However much is known about the technicalities of map reading it will be largely wasted and even dangerous without a mastery of map craft. The term 'map reading' covers both aspects of the subject. Consequently, map-reading lessons should, wherever possible, be conducted out of doors.

106. The term 'map reading' covers both aspects of the subject. Consequently, map-reading lessons should, wherever possible, be conducted out of doors. The nature of modern warfare can cause extreme dispersion of troops. Any cadet can be required to navigate as part of his training or simply for his own survival. All cadets should learn map reading as part of their initial training so that, by the time they are junior leaders, they are well-practised in map craft.

THE AIMS OF MAP READING

107. The aims of map reading are to:

- a. enable the cadet to find his way about the country and recognise features on the ground and on the map;
- b. enable the cadet to understand the information given on the map so that he can picture the ground and its tactical and administrative possibilities and limitations, even though he has not seen it; and

- c. assist in the quick and accurate transmission of information and orders involving movements and dispositions.

THE CARE OF MAPS

108. Maps are valuable documents and their supply is limited. They must be treated with care to prevent damage. Most damage to maps occurs when the user opens them out fully in the open air or in moving vehicles. There is always a slight breeze to catch them and start small tears that quickly spread. To prevent tears, maps should be folded in such a way that any part can be referred to without having to open the map fully out.

109. How to fold a map. It should be first folded in half with the map detail outwards. It is then folded across the other way, concertina fashion. The number of folds will depend on the size of the map. The aim is to reduce the map to a convenient size for carrying and, at the same time, ensure that there is a reasonably large area for studying when two folds are opened like a book. Folded in this manner, any part of the map can be studied by opening the appropriate folds.

110. Once a map is folded, it should be left folded. The detail at creases is bound to deteriorate but that deterioration will be less than if the map was constantly folded and unfolded. Placing it in a map case or plastic bag should protect the folded map. The map may also be protected by the use of a map board or stick-on clear plastic.

111. If the map has to be marked, it should be done lightly in pencil so that the marks can be easily rubbed off. On operations, the marking of maps must be avoided, as they may be of great value to the enemy if they are captured.

TYPES OF MAPS

Civilian Maps

112. There are numerous types of civilian maps in existence that should not be omitted from consideration when planning military operations. These maps may have additional useful information, or may be used as substitutes when no military sheet has been published embracing the locality concerned. Examples of useful civilian maps are:

- a. atlas maps;
- b. shire/town maps;
- c. tourist maps;
- d. road maps;
- e. forestry maps;
- f. statistical maps; and
- g. geological maps.

Hydrographic Charts

113. The Hydrographic Service, Royal Australian Navy, especially for the navigation of ships, produces hydrographic charts. They are printed in four colours and are usually on individual sheet lines and at varying scales. Only those land features that will assist in the navigation of ships are shown. Soundings based on low water at springtide are shown in metres. With the exception of the polar charts and a few special charts designed for projecting great circle courses, they are almost invariably produced on the Mercator projection.

Aeronautic Charts

114. Because of the relative speeds of ground and air movement, a chart designed specifically for air use covers a much greater area than one designed for ground use. Aeronautic charts are usually produced at smaller scales than are topographic maps. As aeronautic charts are designed for special purposes, they often do not conform to the established practices employed on a topographic map. Detail is often omitted to obtain clarity, and to allow for the exaggeration or additional emphasis of certain features particularly important to the pilot or navigator of an aircraft.

115. Detail is often omitted to obtain clarity, and to allow for the exaggeration or additional emphasis of certain features particularly important to the pilot or navigator of an aircraft, (for example, those features that are of particular radar significance, as opposed to purely visual significance). Aeronautic charts of Australia currently produced by the Royal Australian Survey Corps are:

- a. Jet Navigation Chart (JNC), 1:2,000,000;
- b. Operational Navigation Chart (ONC), 1:1,000,000;
- c. Tactical Pilotage Chart (TPC), 1:500 000; and
- d. Joint Operations Graphic (JOG)(Air), 1:250,000.

Military Maps

116. Military maps are generally produced in one of the following forms:

- a. **Topographic Maps.** Topographic maps are the basic military maps which may be produced at any of the standard scales, such as 1:25000, 1:50 000, 1:100000 and 1:250000. They show both natural and man-made features, with the density of detail depending upon the map scale. In addition to horizontal position, vertical position is also depicted by means of contour lines drawn at varying intervals, depending on the scale of the map and the nature of the terrain. Topographic maps are generally produced in five or six colours and carry the Universal Transverse Mercator (UTM) grid and reference system.
- b. **Joint Operations Graphic (JOG)** is 1:250 000 scale maps produced in ground and air versions from the same base map. They are designed to provide aircraft operating in a ground attack role with map cover that is identical to that used by the ground troops that they are supporting. This facilitates liaison between ground and air.
- c. **Planimetric Maps.** Planimetric maps show the same detail as topographic maps, but do not indicate vertical position in measurable form. Hachures, shading or form lines may indicate relief, but not by contour lines.
- d. **City/Town Maps.** City/Town maps are large-scale topographic maps, usually prepared at 1:12 500, covering important or strategic urban areas. A map scaled to 1:10 000, 1:7500 or 1:5000 may be available for more detailed depiction of the area. These maps are multi-purpose, being used for tactical and administrative purposes within the city or town. In areas of flat terrain where relief is not significant, contours may be omitted.
- e. **Orthophoto maps.** An orthophoto map is made up from an assembly of photographs in which the displacements of images due to tilt and relief have been removed. Upon this, grid data, marginal data, contours, names, boundaries and other cultural features have been added. Orthophoto maps provide an interim or emergency map substitute or a routine map supplement that is especially suitable for two particular military maps:
 - (1) 1:10 000 orthophoto maps; and
 - (2) 1:25 000/1:50 000/1:100 000 topographic orthophoto maps with emphasis on remote areas.

MARGINAL INFORMATION

General

117. Around the margin of the map, information is printed which is needed to use the map. This marginal information may differ slightly in detail and layout from one map to another. On Royal Australian Survey Corps topographic survey maps, a standard layout is generally adopted and is described in this section.

Title Information

118. The title information is shown at the top of the map and consists of the following:

- a. Type of Map (top left). The Type of Map section shows the country of which the map represents a small portion, the scale of the map and type of map, (for example, AUSTRALIA 1:50 000 TOPOGRAPHIC SURVEY).
- b. Map Title (top centre and bottom right). The title maybe the name of an important town, or of an area of the map, (for example, IMBIL QUEENSLAND).
- c. Reference Box (top right and bottom left). The map series, sheet number and edition numbers is the unique reference to a map and are shown in the reference box. This information must be used when ordering maps (for example, SERIES R733, SHEET 9445-111, EDITION 1-AAS).

Production Information

119. The production information at the bottom left of the map shows when, by whom and under what authority the map was made. The method of production and an indication of the accuracy are also shown.

Universal Grid Reference

120. Located below the production information is a box that details the method of giving a universal grid reference. As any six-figure grid reference is repeated every 100 kilometres, this method is used to make the reference unique.

North Point Diagram

121. Located to the right of the universal grid reference is a diagram showing the direction of true, grid and magnetic north for a particular year. The annual change in magnetic north is also given. This diagram may not be to scale, so it should not be used to try and gauge correct angles.

Scale and Contour Information

122. The scale is located at the bottom centre of the map and consists of both a representative fraction and a graphic scale. Below the scale is information on the type of map projection and on the contour interval.

Legend

123. Below the scale is the legend, which contain the colours and symbols which make the detail on a map easy to read. These symbols are called conventional signs and are purely representative. Care should be taken when using them, as they are not always to scale (for example, buildings and the width of roads). Colours are normally used as follows:

- a. orange/brown, landforms (contours and sand);
- b. blue, water (rivers, lakes and swamps);
- c. green, vegetation (orchards and mangrove swamps);

- d. red/brown, roads and built-up areas;
- e. black, artificial features (railways and building); and
- f. purple, overprints (tactical or aeronautical information).

124. The conventional signs are typical of most maps. Aeronautical conventional signs are used on JOG maps.

Watercourse Guide

125. To the right of the scale is the watercourse guide. This small map indicates whether a watercourse is perennial, intermittent or mainly dry.

Mean Temperature/Rainfall

126. The mean temperature/rainfall graphs are located below the watercourse guide. The information is from the Bureau of Meteorology and the values are extracted from the station closest in climatic conditions to the map area. If there is considerable climatic change on opposite sides of a coastal range, two sets of temperature/rainfall graphs are produced.

Index to Adjoining Maps

127. In the bottom right corner of the map is the index to adjoining maps. This shows the relationship between this map and the eight maps that surround it.

MAP RELIABILITY

128. No matter how accurately a map was made, it is only a plan of the ground at a certain date. If it is several years since the map was made or revised, much may have changed: towns grow roads and railways are built, woods grow and are cut down. Only the main physical features should be regarded as absolutely reliable, and even these may change slowly (coastlines may erode and rivers can change their course). It is very important that the production notes be examined to note the date on which a map was produced or revised to judge its reliability.

129. Large-scale maps are sometimes made from enlargements of smaller scale maps, with more detail added. Consequently, these maps may be no more reliable than the original map. When a cadet is required to navigate, he may find that a more recently produced, smaller scale map is more useful than a map with more detail, but with dubious reliability. Whatever his decision, he should place his trust only in the natural landforms and not the man-made features.

ORDERING MAPS

130. When ordering maps, the map series, sheet number and edition number must be quoted (for example: SERIES R733, SHEET 9445-111, EDITION 1-AAS).

131. If adjoining maps or maps of larger or smaller scale is required, a map index can be consulted. This is not necessary on maps of the scale of 1:100 000, 1:500 000 and 1:25 000 as they have a common sheet numbering system.

132. The basis of the numbering is the 1:100 000-scale sheet layout, with each sheet being identified by a four-digit number. The first two digits identify the column of 1:100 000 sheets, and the last two digits identify the row of 1:100 000 sheets (Figure 3).

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CHAPTER TWO

GRID REFERENCES

MAP REFERENCE SYSTEMS

Types of Map Reference Systems

201. For the purpose of control and to enable the reporting of exact positions, various map reference systems have been devised. Many civilian maps use a system of combining letters or numbers that are marked on adjacent sides of the map. This system is useful, although the same combination of letters or numbers may define more than one position on several maps. Military operations require a map reference system where the co-ordinates are unique to each position on the ground. The following map reference systems are in use:

- a. **Geographic Co-ordinates.** When using geographic co-ordinates, the quantities of latitude (parallels) and longitude (meridians) are used to define the position on the earth's surface in terms of arc (degrees, minutes and seconds). On military maps, the geographic co-ordinates are shown in the margin. On scales of 1:1 000 000 and larger the parallels and meridians are indicated by graticule ticks at one-minute intervals.
- b. **The World Geographic Reference System (GEOREF).** GEOREF is an area designation method used for inter-service and inter-allied position reporting for air defence and strategic air operations. It provides a method of expressing position in a form suitable for reporting and plotting, and may be applied to any map or chart graduated in latitude and longitude.
- c. **UTM Grid.** The UTM grid has been adopted as a common military grid system. This grid provides comprehensive and uniform grid coverage of all but the Polar Regions of the world. It avoids the awkwardness of several grids on different projections, a situation that was encountered in the Second World War.
- d. **Universal Polar Stereographic (UPS) Grid.** The rapid convergence of the meridians near the terrestrial poles makes the UTM grid impractical for polar area. For this reason, the Polar Stereographic projection is used for areas north of 84 degrees north and south of 80 degrees South. The UPS grids, together with the UTM grid, give world grid coverage.

The Grid Reference System

202. The grid consists of two sets of equally spaced parallel lines intersecting at right angles to form squares. Maps are normally printed with north at the top of the sheet and with the superimposed grid lines running vertically and horizontally. The interval between grid lines is uniform throughout the map, and is selected in accordance with the map scale.

203. When giving grid references, the grid lines are referred to as follows:

- a. **Easting.** The vertical grid lines, which divide the map from west to east, are known as EASTINGS. They are numbered from west to east.
- b. **Northing.** The horizontal grid lines, which divide the map from south to north, are known as NORTHINGS. They are numbered from south to north.

GIVING GRID REFERENCES

204. When giving grid references, the easting (that is, the left to right reading of grid values) is always given before the northing (that is, the bottom to top reading of grid values).

Four-figure Grid Reference

205. Four-figure grid references indicate that position of one Grid Square only and are useful when identifying major features and localities. To indicate a particular grid square, the easting, which forms the left or western boundary of that square, is selected first. Next, the northing, which forms the bottom or southern boundary of the square, is selected. The two figures for the easting and the two figures for the northing, combined in that order, give the four-figure grid reference required.

206. A four-figure grid reference is given according to the following sequence:

- a. Select the easting that forms the west boundary of the selected grid square.
- b. Select the northing that forms the south boundary of the selected grid square.

Six-figure Grid Reference

207. Six-figure grid references are used to indicate positions to within 100-metre accuracy. To give a particular grid reference, imagine that each side of the square is divided into 10 equal parts and that the whole Grid Square is divided into 100 smaller squares. Estimate which small square the particular object is in. The numbering of the lines forming the small squares indicate the number of tenths of a unit there are east of easting or north of northing. Grid references are always prefixed with the letters GR to avoid confusion (for example, GR 717 137).

Eight-figure Grid Reference

208. Eight-figure grid references can normally only be given on maps with a scale of 1:50 000 or larger. The method is similar to the six-figure method explained in paragraph 207, except that each small square is again divided into 100 still smaller squares to give an accuracy to within 10 m. The result is that the easting are then calculated to four figures and the northing to four, the combination being an eight-figure grid reference. For example GR 7176 1371.

Use of a Roamer

209. A roamer is a simple device used for accurately measuring the position of a point within a grid square instead of estimating the tenths as described previously.

210. To use a roamer, place the corner against the required point on the map with the edges parallel to the grid lines. The distance east and north within the Grid Square can then be read off against the west and south grid lines of the square. Clearly, a different roamer is required for each scale of map.

211. Roamers of various scales are sometimes engraved on protractors. If a roamer is not available, one can be easily made from a piece of paper or cardboard, marking off the appropriate subdivisions of a grid square from the secondary divisions of the graphic scale on the appropriate map.

212. The eight-figure grid reference roamer is divided up into smaller squares. The third figure of the easting is read like a normal roamer. Rather than estimate the fourth figure, it can be measured by following the third figure's slanting line downwards until it crosses the left-hand easting. At this point, the left-hand scale will give the fourth figure of the easting. To read the northing, the roamer must be rotated 90 degrees anti-clockwise and the same procedure repeated.

UNIVERSAL GRID REFERENCES

UTM Grid Reference System

213. Under the UTM grid reference system, the whole world between 84 degrees North and 80 degrees South is divided into standard areas or zones, each 6 degrees wide (that is, east-west) called columns, and 8 degrees deep (that is, north-south) called rows. The columns are numbered 1 to 60 consecutively, starting from the 180 degrees meridian and proceeding easterly. Starting from 80 degrees South and proceeding northward to 84 degrees North, the rows are identified alphabetically

from C to X, the letters I and O being omitted. The grid zone is designated in the standard referencing manner, combining the column identification number first, with the row identification letter second.

214. The grid zone is designated in the standard referencing manner, combining the column identification number first, with the row identification letter second. Each of the grid zones is further divided into 100 000-m squares based on the UTM Grid. These are identified by the combination of two letters derived through a sequential lettering system. Starting at the 180 degree meridian and proceeding easterly, the vertical columns of 100 000 m squares or parts thereof at zone junctions, are identified A to Z (I and O are omitted).

215. This sequence covers three zones of 18 degrees of longitude, when the sequence is repeated. Similarly, the horizontal rows of 100 000 m squares are identified A to V (O and I are omitted) from south to north covering an extent of 2 000 000 (approximately 18 degrees of latitude), when the sequence is repeated. In order to increase the distance between 100 000-m squares carrying the same identification, the row identification is staggered. Odd numbered columns commence at the equator with the letter A and even numbered columns with the letter F. The 100 000 m square identification is determined by reading the column letter first, then the row letter.

UPS Grid Reference System

216. In paragraph 213, the letters A, B, Y and Z were not used in the identification of UTM rows. These remaining letters are used for the UPS grid reference system to complete the world coverage. Each polar area is divided into two zones, separated by the 0 degree to 180-degree meridian. In the south polar area, the letter A is the grid zone designation for the area west of the 0-180 meridian, and B for the area to the east. In the north polar area, Y is the grid zone designation for the western area and Z for the eastern.

To Give a Universal Grid Reference

217. The method of giving a universal grid reference is explained on the bottom of most maps. A universal grid reference consists of a group of letters and numbers that indicate:

- a. grid zone designation;
- b. 100 000 m square identification; and
- c. grid co-ordinates (expressed to the desired accuracy).

218. Thus, a point may be referenced as follows:

- a. 49JDG locating a point within a 100 000 metre square;
- b. 49JDG71 locating a point within a 100 000 metre square;
- c. 49JDG7113 locating a point within a 1000-metre square; and
- d. 49JDG717137 locating a point within 100 metres.

Grid Zone Junctions

219. In certain instances, a map sheet may contain more than one grid. This condition results from a junction between two grid zones within the UTM grid system. On large-scale maps, the occurrence of a junction within the sheet is rare since the sheet lines are usually laid out to coincide with junctions. On medium and small-scale sheets, junctions are more prevalent than on larger scale maps owing to the greater area covered.

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CHAPTER THREE

MAP SCALE AND MEASURING DISTANCE

SCALE GENERALLY

301. As a map is a scaled plan, the relationship of horizontal distance between two points on the ground, and the distance between the same two points on a map, is constant, regardless of the direction or location of the distances measured. The determination of distance is an important factor in the planning and execution of a military mission.

302. As discussed earlier maps are produced at various scales for specific purposes. The scales are referred to as small, medium or large, and are defined as follows:

- a. Small scale is 1:600 000 and smaller;
- b. Medium scale is larger than 1:600 000 but smaller than 1:75 000; and
- c. Large scale is 1:75 000 and larger.

Effects of Change of Scale

303. The scale cannot judge a map's reliability. Large-scale maps show more detail. A convoy commander, however, could find himself unnecessarily cluttered with maps should he have to travel a considerable distance using large-scale maps. When selecting a map, the two main considerations are the amount of detail required and the area covered. As a guide, choose the smallest available scale that provides sufficient detail.

304. It is important to realise that halving the scale not only halves the distance of identical points on the maps but, as this occurs in all directions, the map area becomes quartered and maps of differing scales of the same area will clearly show the loss of detail as the scale becomes smaller.

METHODS OF EXPRESSING SCALE

305. The scale of a map is expressed as either:

- a. a representative fraction (RF); or
- b. a graphic scale.

REPRESENTATIVE FRACTION (RF)

306. An RF expresses the distance on a map as a fraction of the corresponding distance on the ground. If the scale is 1:100 000, every distance on the map is 1:100 000th of the distance on the ground (for example, 1 cm on the map represents 1 km on the ground). The numerator of the RF is always 1. The larger the denominator of the RF, the smaller the scale.

Graphic Scale

307. The graphic scale shows how distances are represented on the map and assists in the measurement of distances. On topographic survey maps, the scale is in kilometres with secondary divisions in 100 m. On JOG and smaller scale maps, generally there are three graphic scales for statute miles, kilometres and nautical miles. Care should be taken to ensure that all measurements are taken from the zero mark which, on some maps, is in from the left of the scale.

MEASURING DISTANCES ON A MAP

308. There are many ways of measuring distances on a map, such as using dividers, a length of string or the scale on a protractor or ruler. This section explains the simple method of using the straight edge of a piece of paper.

Measuring Straight Distance

309. To measure the ground distance in a straight line between two points on a map, lay the straight edges of a piece of paper against the two points and, at each point mark the paper with a tick. Then lay the paper along the graphic scale with the left-hand tick against the zero mark to determine the distance.

Measuring Curved Line Distance

310. To measure the distance along a curved line such as a winding road, consider the road as a number of straight, or nearly straight sections. Lay a piece of paper along the first section and mark it at A and at the end of the first straight section. Pivot the paper about the second mark until it lies along the second section. Mark the end of the second section and continue this method until B is reached. The total distance by road is then recorded as a straight line on the piece of paper and can be read off against the linear scale.

CHAPTER FOUR

RELIEF AND CONTOURS

IMPORTANCE OF RELIEF

401. Man-made features, such as towns, roads and railways, are incidents on the surface of the ground. Their details change quite rapidly while the shape of the ground, such as hills and valleys, changes slowly. The relief of the ground has determined the nature of life lived on it, the types of things men build on it, the positions of towns and the direction and forms of communications. Until relief can be read from a map, it is only possible to learn very elementary things about the country.

402. The importance of relief is obvious in navigation and tactics. Relief affects the movement and deployment of units by limiting the routes along which they may travel their speed of movement and the ease or difficulty of attacking or defending an area. Also affected are observation, fields of fire, cover, concealment and the selection of key terrain features.

CONTOURS

Description of Contours

403. Contour lines are lines on a map connecting points of equal elevation. The vertical distance between adjacent contour lines is known as the contour interval and is given in the marginal information. Contour lines are printed orange/brown on maps. Every fifth contour line may be drawn with a heavier line to aid in measuring elevation. These are known as index contour lines. Contours are marked with their elevation at convenient places, with their value read correctly when facing up the slope. Contours not only give representation of height but also indicate the shape of the ground.

Contour Patterns

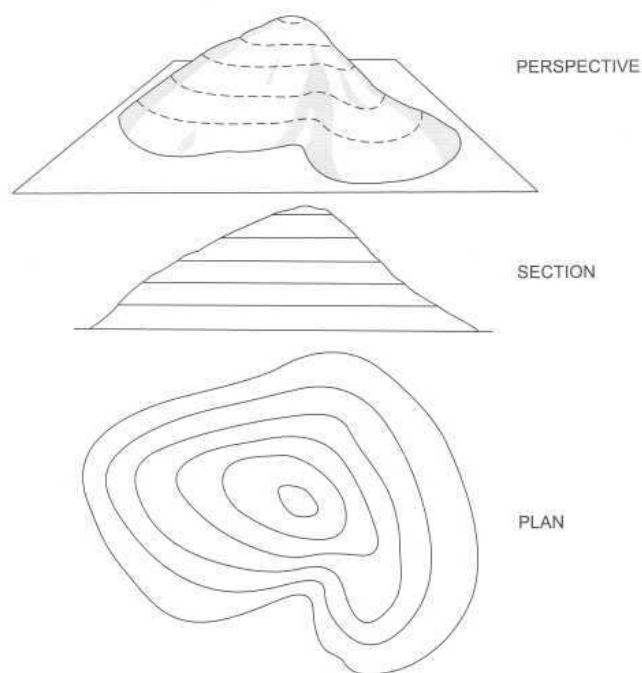
404. Each topographical form, such as a spur or a knoll, produces its own particular contour pattern. The most important things to remember about contour patterns are as follows:

- a. Contours close together indicate steep slopes;
- b. Contours far apart indicate gentle slopes;
- c. When the spacing of contours, reading from high to low, decreases, the slope is convex; and
- d. When the spacing of contours, reading from high to low, increases, the slope is concave.

405. It must be noted that, unless you know the direction of the slope, each pattern might be its opposite. Thus, a spur and a re-entrant have the same pattern. When there are no contour heights marked close by, and there is no feature such as a river to show the direction of slope, always follow the contours to the same point where their height is marked so that you can tell which way the ground falls.

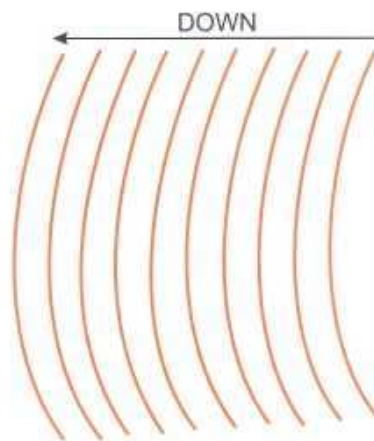
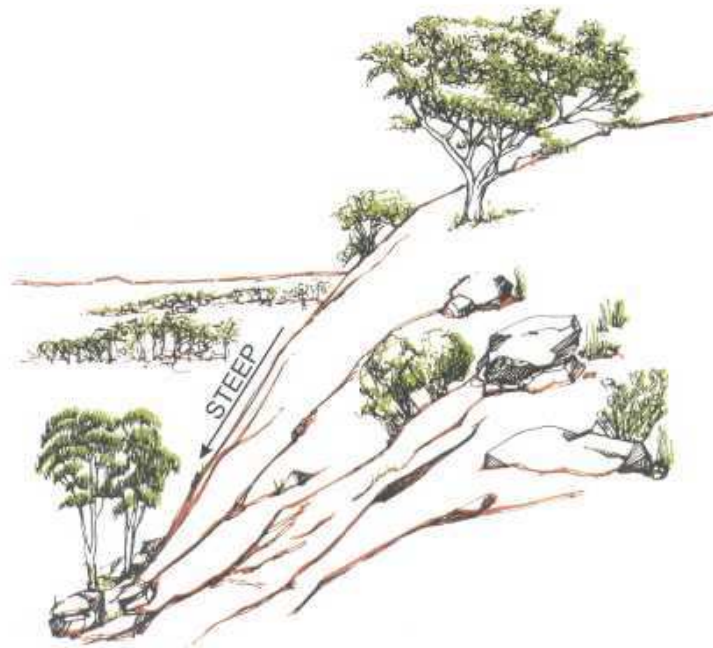
Limitations of Contours

406. The features that can be shown by contours are limited by the vertical interval. If the vertical interval is 20 metres, features of less prominence than 20 metres may not appear on the map. Such features may be of tactical importance, particularly in relatively flat ground. By practice on the ground, a student can learn just how much he can expect the contours on a map to show. It must be remembered that a map can never completely substitute for a reconnaissance.

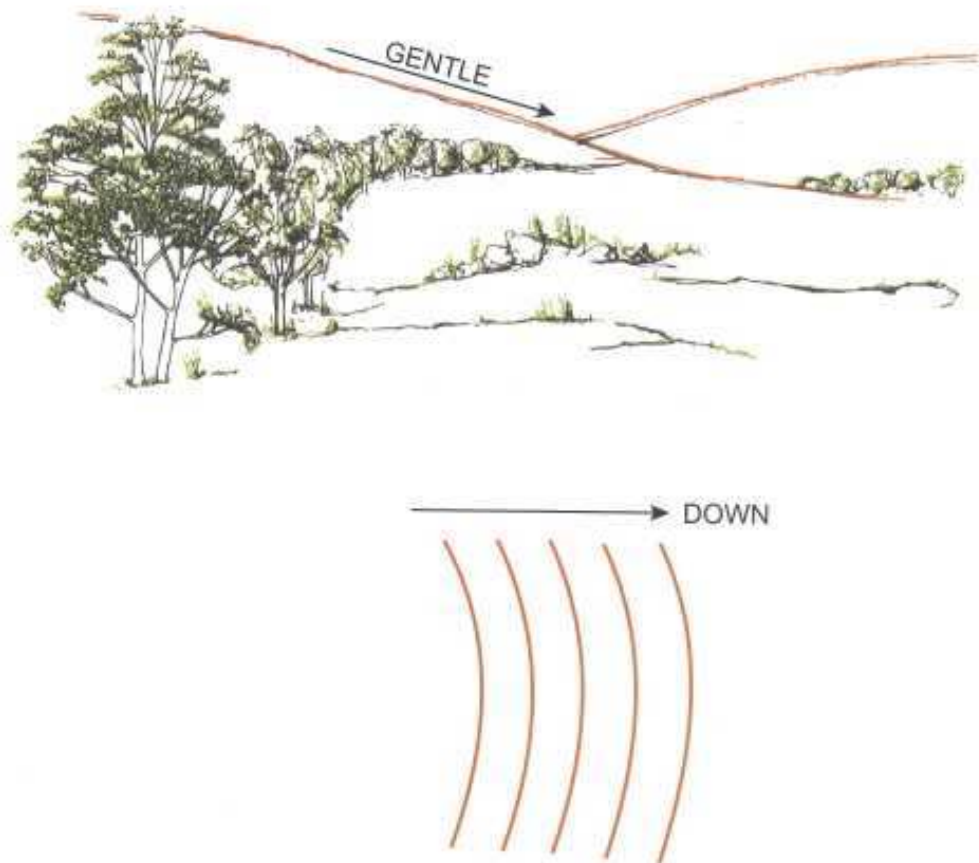


Spot Elevations

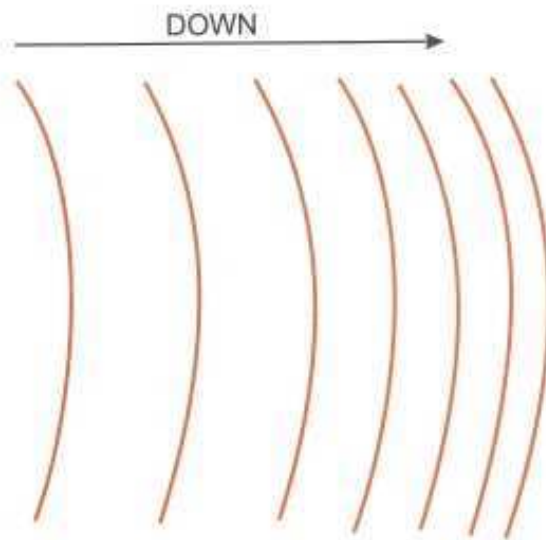
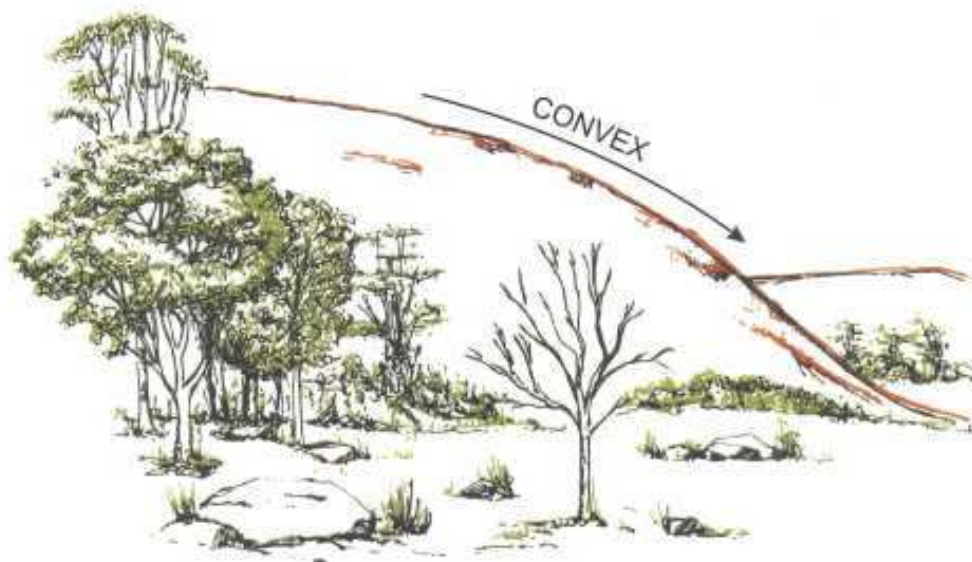
407. Spot elevations (sometimes called spot heights) are points on the map with the height of the particular feature shown alongside. This gives accurate information when used in conjunction with contours. Other types of spot elevations are horizontal control points, trig points and benchmarks.



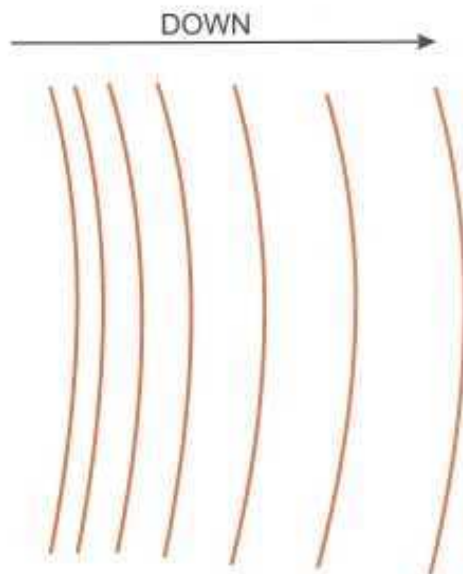
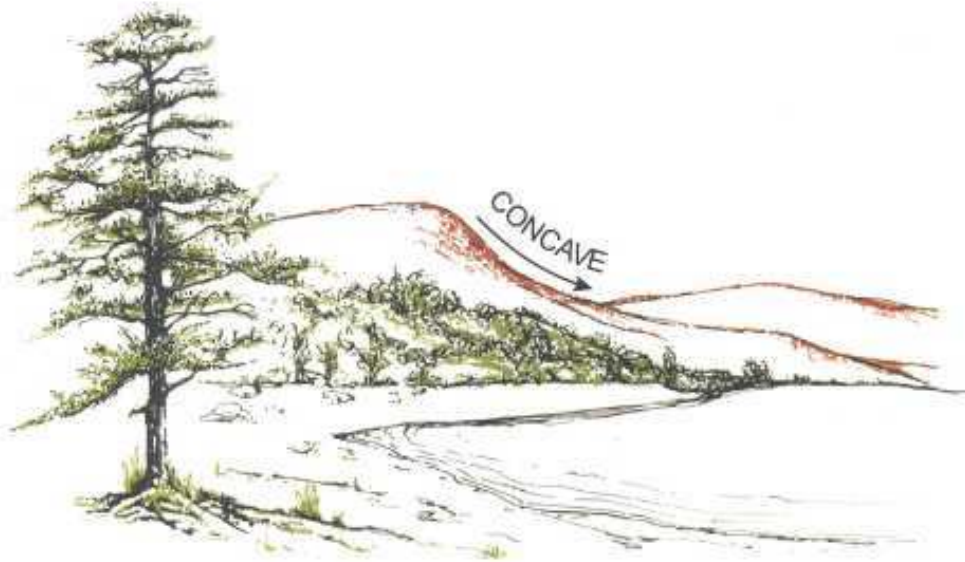
Uniform Steep Slope



Uniform Gentle Slope



Convex Slope



CONCAVE SLOPE

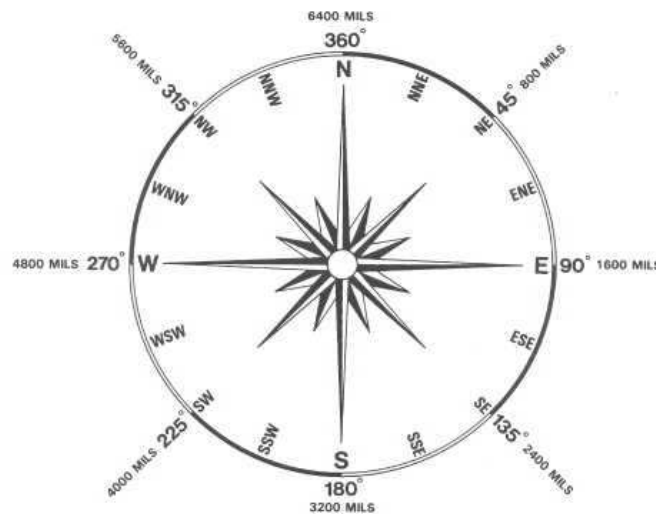
CHAPTER FIVE

DIRECTION AND THE SERVICE PROTRACTOR

DESCRIBING DIRECTION

501. An observer sees his horizon as a circle with himself at the centre. He normally describes the direction of any object by saying that is north, east, south, west, NE, NNE, et cetera. When map reading, a more accurate method is required in describing direction. Two commonly used methods are:

- a. the degree system; and
- b. the mils system.



Describing Direction

The Degree System

502. In the degree system, the circle is divided into 360 degrees; 0 (or 360) being the north point. The four quadrants of the circle are each 90 degrees and, therefore, the east, south and west points are at 90, 180 and 270 degrees respectively.

503. Each degree is subdivided into 60 minutes, and each minute into 60 seconds. Degrees are marked thus: °; minutes ' ; and seconds ". When map reading, the subdivisions of a degree are too small for practical use and measurements to one half of degrees are generally sufficient. The degree system is commonly used outside of the Army.

The Mils System

504. In the mils system, the circle is divided into 6400 mils; 0 (or 6400) being the north point. East, south and west are at 1600, 3200, 4800 mils respectively. Accuracy to the nearest 10 mils is normally sufficient in map reading.

505. The Australian Army uses the mils system. It is convenient for many practical uses as 1 mil subtends approximately one unit of length at a range of one thousand units. For example, 1 mil subtends 1 metre at 1000 metres. The mil system will be used in explanation for the remainder of this pamphlet.

North Points

506. The purpose of a bearing is to give an accurate indication of the direction of one point from another. A bearing is the angle, measured clockwise, that a point makes from a fixed zero. In actual practice, the zero point may be one of three north points:

- a. True North (TN);
- b. Grid North (GN); and
- c. Magnetic North (MN).

True North (TN)

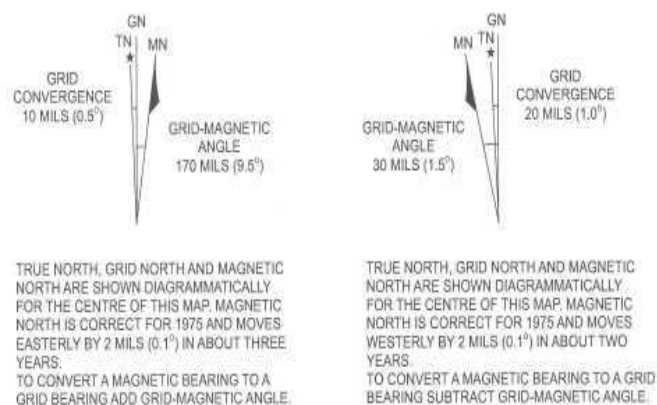
507. TN is the direction of the geographic North Pole from an observer anywhere on the earth's surface. A line which passes through any point and the North and South Poles is called a meridian. These lines converge towards each other at the poles and, consequently, are not parallel. In map reading, there is rarely a practical need for knowing the direction of TN. As the direction of GN is more easily found and is very close to TN, it is used in preference.

Grid North (GN)

508. GN is the direction in which the north-south grid lines point towards the top of the map. Under the UTM grid reference system, the central grid line of each grid column coincides with a particular meridian. Within each grid column, this one grid line points to TN, but all other grid lines, being parallel, point to an imaginary point either to the east or west of the True North Pole.

509. The variation between GN and TN is called grid convergence. The size of this angle depends on how far the particular map sheet is from the selected meridian. Its value is shown in the north point diagram.

Magnetic North (MN), Magnetic Variation and Grid-magnetic Angle



Easterly Magnetic Variation

Westerly Magnetic Variation

510. MN is the direction in which a compass needle points when affected only by the earth's magnetic field. As the magnetic pole is not the True North Pole, there is a variation between TN and MN at any place. The angle made at the observer between TN and MN is called the magnetic variation of that position. As GN is used in map reading more often than TN, it is more useful to know the size of the angle between GN and MN. This is called the grid-magnetic angle and its size is shown in the north point diagram.

511. As GN is used in map reading more often than TN, it is more useful to know the size of the angle between GN and MN. This is called the grid-magnetic angle and its size is shown in the North Pole diagram.

Annual Change in MN

512. The position of the magnetic pole is not fixed. The annual change is not constant, although it can be forecast with sufficient accuracy over a number of years. If the annual change is in the same direction as the grid-magnetic angle, it must be added. If they are in opposite directions, the annual change must be subtracted. The annual change is shown below the north point diagram, in the marginal information. .

Converting Bearings

513. Compass bearings (magnetic bearings) taken on the ground must be converted to grid bearings for plotting on a map. Conversely, grid bearings taken from a map will have to be converted to magnetic bearings before they can be used with a compass on the ground. To convert a bearing from grid to magnetic or magnetic to grid is a simple matter of adding or subtracting the grid-magnetic angle. Unfortunately, it is easy to add when you should subtract, or subtract when you should add.

514. Particular note should be taken to observe that the procedure varies depending on whether MN is to the east or west of GN. For this reason, the north point diagram or a roughly drawn diagram should always be used to avoid errors, although a guide is also given below the north point diagram.

515. Example 1 - magnetic bearing of 780 mils has to be converted to a grid bearing. The year is 1984. From the north point diagram the grid-magnetic angle is 170 mils east in 1975, and the annual change is easterly 2 mils in three years. Therefore, the grid-magnetic angle is 176 mils east in 1984. (Note that map-reading angles are normally rounded off to the nearest 10 mils. Therefore, for all practical purposes the grid-magnetic angle becomes 180 mils east).

Example 2 - A grid bearing of 1570 mils has to be converted to a magnetic bearing. The grid-magnetic angle is 180 mils east. A simple way to remember these conversions is as follows:

- a. Magnetic to Grid adds (MGA - my great aunt); and
- b. Grids to Magnetic subtract (GMS - grandma sleeps).

516. When the grid-magnetic angle is to the west, magnetic north is to the west of grid north. In this case the opposite conversions are true, as follows:

- a. Magnetic to Grid subtracts (MGS); and
- b. Grids to Magnetic add (GMA).

THE SERVICE PROTRACTOR

517. To measure a bearing accurately on a map, a protractor must be used. There are many different types of protractors available and, although they differ in design and shape, they are used in much the same way. They all consist of a scale around the outer edge that radiates from an index mark located at the centre of the protractor circle. The scale divides a circle into units of angular measure.

The Service Protractor

518. The present service protractor is the Protractor, Semi-circular, RAA, Mils, and F6. The scale is graduated in 10 mil intervals, 0 to 3200 mils outside and 3200 to 6400 (0) mils inside. The protractor includes metric scales for measuring distance on 1:50,000 scale maps. These are on the base and also radiate in concentric semicircles from the index mark. A black thread radiates from the index mark to aid in the reading of bearings.

519. To aid in reading grid references, the protractor includes roamers for maps of the following scales:

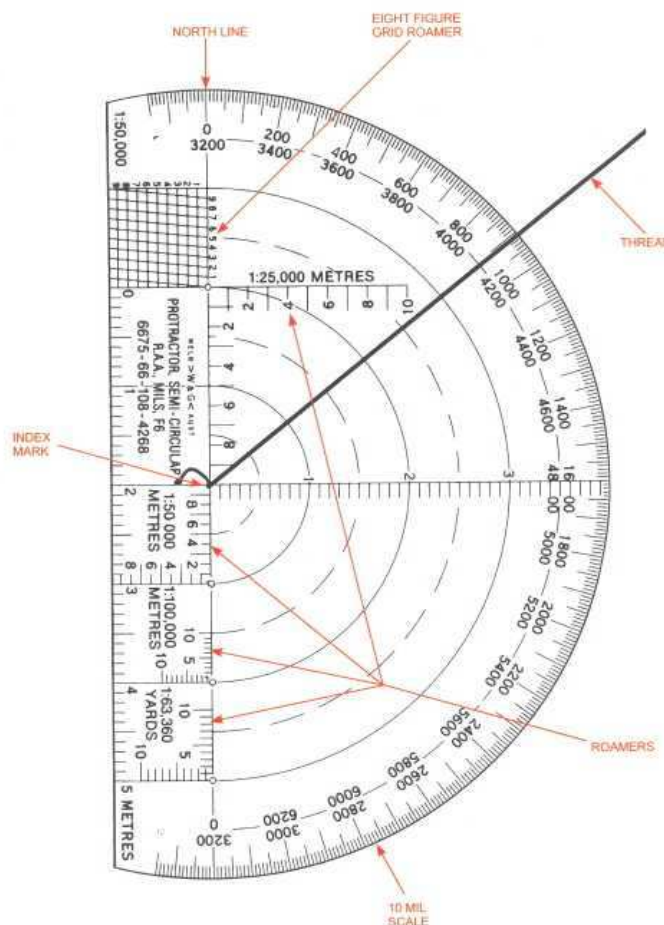
- a. 1:250 000 metres;
- b. 1:63 360 yards;
- c. 1:100 000 metres;
- d. 1:50 000 metres; and
- e. An eight-figure grid reference roamer for 1000 metre maps.

Measuring Bearings

520. To measure the grid bearing from the point A to Point B, proceed as follows:

- a. Using a straight edge and a fine pencil, join point A and point B. If the distance between the two points is less than 8 centimetres, the line should be extended so that it overlaps the scale when the protractor is positioned on the map.
- b. Place the protractor on the map and position it so that the index mark is directly over point A and the north line is pointing to grid north, that is, parallel to the easting. If the north line does not overlap an easting, it will be pointing to grid north if an easting intersects the 10-mil scale at the top of the protractor the same number of divisions from the north line as at the bottom of the protractor.
- c. The grid bearing can now be read from the outside set of figures on the 10 mil scale, where the pencil line meets it.

521. When bearings of between 3200 mils and 6400 mils are to be measured, the protractor is rotated upside down or 3200 mils. The same principles apply, except that the inside set of figures is used on the 10-mil scale.



Protractor, Semicircular, RAA Mils, F6

522. When time prevents the drawing of a fine pencil line on a map, a bearing can be measured using the black thread attached to the index mark. This method is not as accurate, although it has the advantage of not marking the map.

Plotting Bearings

523. To plot a grid bearing on a map, proceed as follows:

- a. Place the protractor on the map and position the index mark directly over the point on the map from which the bearing is to be plotted (originating point) so that the north line is pointing to grid north;
- b. Read off the bearing required on the 10-mil scale and mark the map with a pencil; and
- c. Draw a thin line through the originating point to the pencil mark. This line is the required grid bearing.

Back Bearings

524. A bearing gives the direction of a line from the point of observation to an object. A back bearing gives the direction from the object back to the point of observation. The difference between the bearing and the back bearing is 3200 mils (180 degrees). Therefore, given the bearing, add 3200 mils to find the back bearing, or if the bearing is more than 3200 mils, subtract 3200 mils.

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CHAPTER SIX
THE COMPASS
THE PRISMATIC COMPASS

General

601. The compass is an instrument used for measuring magnetic bearings. Although there are different types, they all consist of a magnetised needle accurately balanced on a pivot point set in the centre of a non-ferrous or plastic box. One point of the compass aligns with the direction of MN.

Description

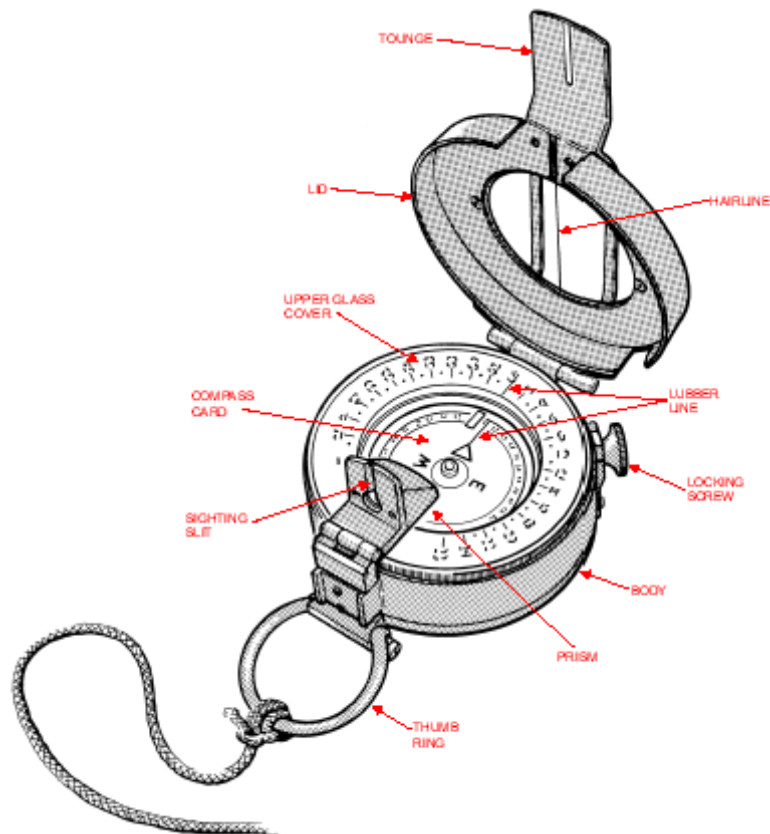
602. When closed, the prismatic compass is a black lacquered, circular, brass box and consists of the following:

- a. Lid;
- b. Body;
- c. Prism; and
- d. Thumb Ring.

603. **Lid.** In the lid is a circular glass window protected by two metal bars and engraved with a hairline. When the lid is opened, it will be seen that the hairline extends to a luminous line reaching to the end of the tongue where there is a notch. At each end of the hairline, there are two small holes to allow a thread to be fitted as a substitute, should the glass be broken.

604. **Body.** The body of the compass consists of the following:

- a. Upper Glass Cover. The upper glass cover is marked with figures that show up against a metal ring. These figures are marked every 100 mils and numbered clockwise every 200 mils to 6400 mils. The upper glass cover can be turned to any desired position. It can be clamped in position by using a locking screw on the outside of the body just to the right of the hinge.
- b. Lower Glass Cover. The lower glass cover is positioned below the metal ring and retains the oil in the body. On the metal ring, by the hinge, is a black line on a luminous patch. It is extended by a hairline on the lower glass cover, reaching to the inner circle on the compass card. This is called the lubber line and it is aligned with the hairline on the lid.
- c. Compass Card. Below the glass covers can be seen the compass card which is mounted upon the magnetised needle. A luminous white triangle, and east, south and west mark the north point on the card, by en-graved letters. The compass card is made of mother-of-pearl and swings on a steel pivot. The body is filled with oil to dampen the movement of the card so that it swings gently and comes to rest quickly. The card is engraved with an inner and outer set of figures. The inner circle reads clockwise from the north point and is numbered every 400 mils to 6400 mils. The outer circle reads clockwise from the south point in subdivisions of 20 mils.



605. **Prism.** Opposite the hinge, and covered by the tongue when the lid is closed, is a small triangular metal block hinged to the side of the body. This contains the magnifying prism. When the compass is open, it can be swung over the glass into the reading position. This reveals the eyehole and the sighting slit above it. When looking through the eyehole, the figures on the outer circle of the compass card are magnified. The prism can be raised or lowered slightly to improve the focus. On the inside bottom of the body directly below the prism, is a luminous patch against which the compass card markings can be read at night.

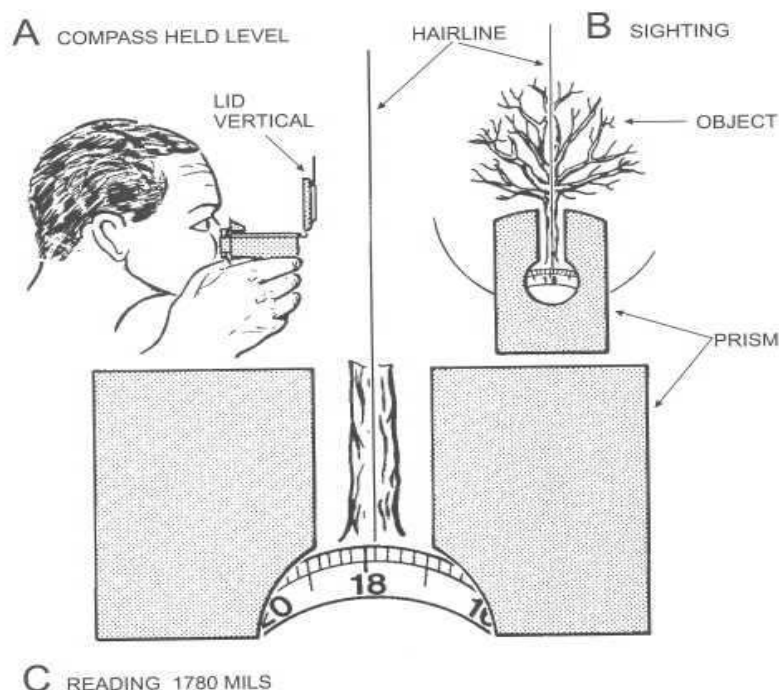
606. **Thumb Ring.** Attached to the prism mounting is a brass ring that is used for holding the compass. A compass should always have a lanyard attached to the thumb ring so that it may be secured to the user or his equipment.

Use of the Prismatic Compass

607. The methods of using the prismatic compass are detailed as follows:

- a. **Taking a Bearing.** Hold the compass in both hands, with a thumb through the ring. The compass must be held level and steady, so that the compass card swings freely. The lid must be vertical and the prism turned into the reading position. Look through the sighting slit and line up the hairline in the lid with the object on which the bearing is to be taken. By looking through the eyehole when the card comes to rest, read off the bearing against the hairline. Note that the figures increase from right to left. Accuracy to within 10 mils is not difficult.
- b. **Finding the Direction of a Given Bearing.** Look through the eyehole and turn the compass until the hairline cuts the required bearing. Note some distant object that is in line with the hairline. This object will be on the required bearing.
- c. **Using the Compass without the Prism.** Either of the operations outlined in subparagraphs a and b can be carried out without using the prism, but with much less accuracy. To take a bearing, open the compass out flat and line it up so that the tongue is directly in line with the object.

The bearing is read from the inner circle of the compass card against the lubber line. To find the direction of a bearing, turn the compass until the inner circle below the lubber line reads the given bearing. The tongue is then pointing in the required direction.



Taking a Bearing Using the Prism

Setting the Compass for Night Marching

608. Having determined the bearing required, the locking screw should be loosened so that the upper glass cover can be turned freely. This should be positioned so that the graduation against the lubber line shows the required bearing. The glass cover should be kept in this position by tightening the locking screw. The tongue of the compass will then indicate the required bearing when the north point on the card coincides with the luminous strip on the glass cover. The luminous strips on a compass fade with age. They will often regain their brightness if the luminous strip is exposed to sunlight before night activities commence.

THE SILVA COMPASS

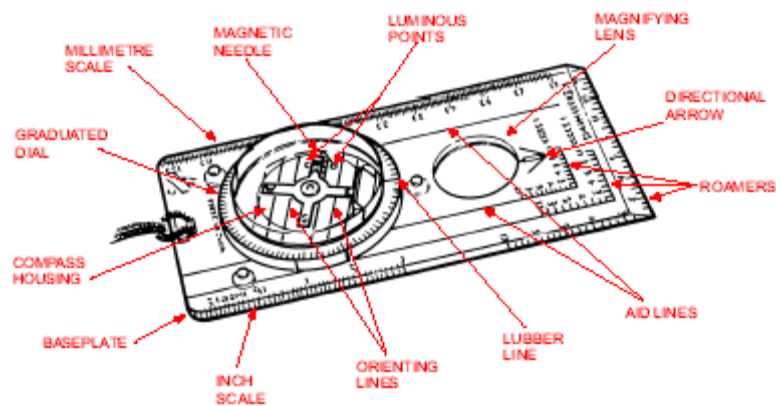
Description

609. There are many different types of Silva compasses available. However, the basic construction for all types remains the same. The compass enables the user to plot and calculate bearings rapidly and accurately on a map without the use of a protractor. This is done by combining, on a common base plate, both a compass and a protractor. The figure below shows the major components of the Type 4 Silva compass. There is a model available which uses a prism for more accurate readings. Its use is similar to the Prismatic compass.

610. **Compass Housing.** The Type 4 Silva compass consists of a magnetized needle in a liquid-filled acrylic housing. The north end of the compass is painted red and has a luminous strip. The dial of the housing is graduated in 50 mil intervals and this freely rotates in the base plate. The base of the housing has six parallel orienting lines and an orienting arrow for alignment with the compass needle. On either side of the arrow are luminous points for use when night marching.

611. **Base Plate.** On the base plate is a small magnifying lens. Down the centre of the base plate and either side of this lens is the lubber line. The lubber line is the point against which the graduated dial is measured. It also has a directional arrow and a luminous mark. The left edge of the base plate has a scale in millimetres while the opposite edge is marked in inches. To aid in reading grid references, the base plate includes roamsers for maps of the following scales:

- a. 1:63 360 m,
- b. 1:50,000 m, and
- c. 1:25 000 m.

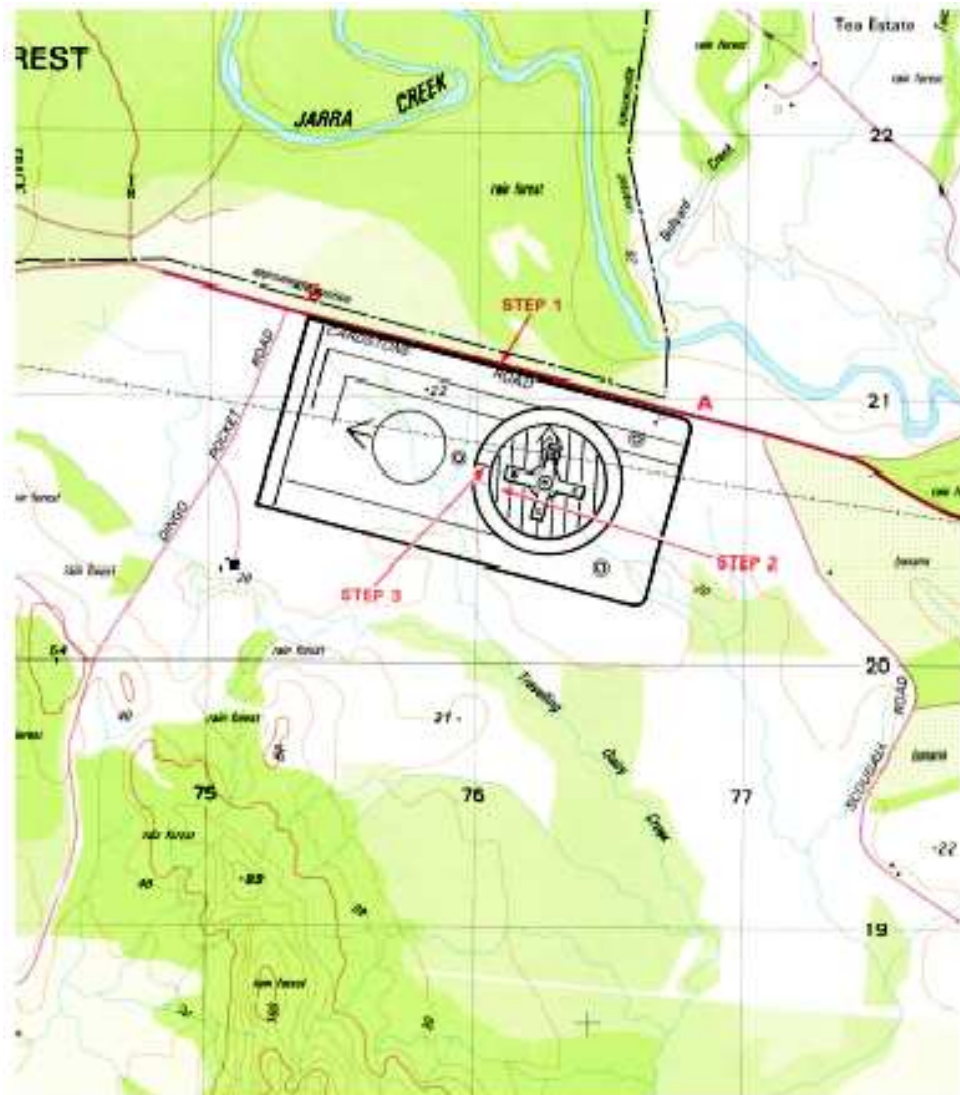


The Silva Compass

Use of the Silva Compass

612. **Taking a Grid Bearing.** The map below shows the procedure for calculating a grid bearing from a map as follows:

- a. **Step 1.** Place the long edge of the base plate (or an aid line) along the desired bearing, making sure that the direction arrow points in the direction that it is wished to travel (that is along line AB in the map).
- b. **Step 2.** Turn the compass housing so that the meridian lines are parallel with the eastings on the map.
- c. **Step 3.** Read the grid bearing on the graduated dial against the lubber line.
- d. Note that before marching, the grid bearing must be converted to a magnetic bearing and the dial adjusted appropriately.



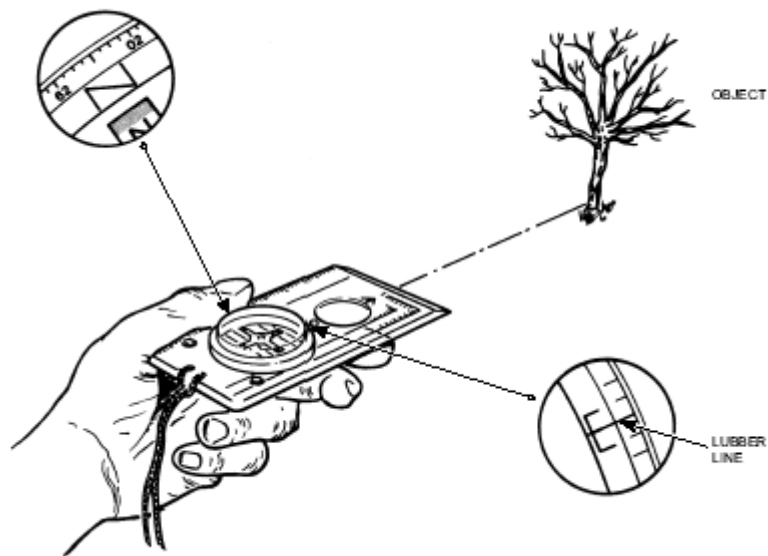
Taking a Grid Bearing Using a SILVA Compass

613. **Taking a Magnetic Bearing.** The procedure for taking a magnetic bearing to an object is detailed below:

- Hold the compass in the positions shown in the figure below, with the direction arrow pointing to the object.
- Rotate the compass housing until the orienting arrow is directly beneath the north (red) end of the compass needle.
- Read the magnetic bearing on the graduated dial against the lubber line.

614. **Setting the Compass on a Magnetic Bearing.** The procedure for setting a compass on a magnetic bearing for marching by day or night is as follows:

- Set the magnetic bearing on the compass by rotating the compass housing until the required bearing on the graduated dial is in line with the lubber line.
- Hold the compass flat in the hand and turn around until the north end of the compass needle is directly above the orienting arrow.
- The direction arrow now points along the required magnetic bearing.

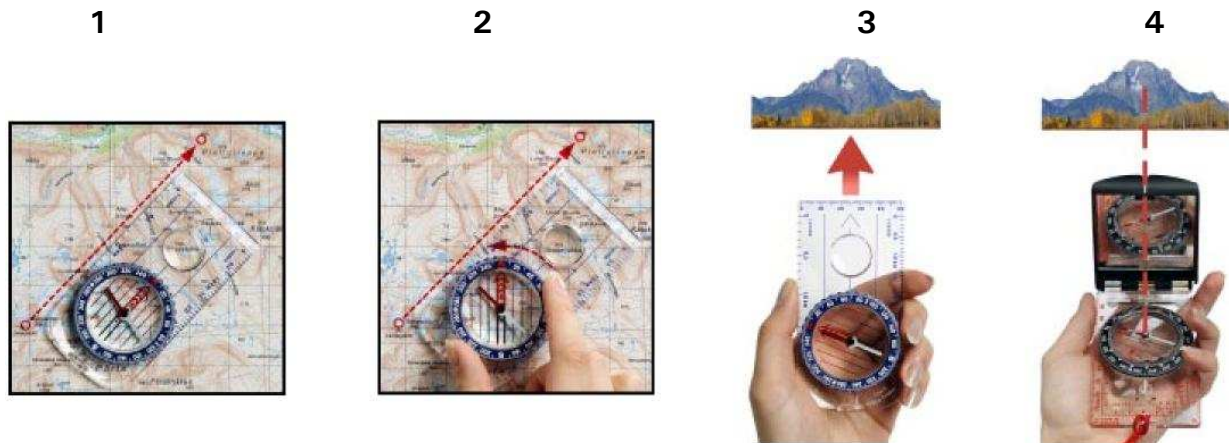


Taking a Magnetic Bearing Using the Silva Compass

SILVA 1-2-3

615. The next page provides an aide-memoire for the use of the SILVA compass.

SILVA 1-2-3 System



1. Place compass on map with edge along desired line of travel. Make sure Direction of Travel arrow points towards your destination.
2. Rotate capsule until "N" on graduation ring point towards North on the map. Check compass housing North/South lines are parallel to map meridians.
3. Hold compass horizontally in front of you. Turn yourself until red end of the needle points towards "N" on the compass graduation ring. (Red end of needle will now be aligned to red North arrow in bottom of the compass capsule). Direction of Travel arrow now points precisely to your destination. Look up, sight on a land-mark and walk to it. Repeat this procedure until you reach your destination.
4. When using a sighting compass with a mirror, hold compass as per picture so that you can check direction by looking at compass housing in the mirror while sighting in correct direction of travel.

Magnetic declination and how to compensate for it

5. The difference, between Geographic North (North/South map meridians) and Magnetic North (towards which red end of the compass needle points), is called declination. The amount and direction of declination is shown on the map. For ex. 20 degs. For Easterly declination, adjust as follows:



With the declination scale inside the capsule (Field 7, Ranger 3 etc.) turn yourself until red end of the compass needle points to 20 degs. on the "E. decl." scale – now the direction of travel arrow points in the correct direction.



With compasses that have a declination adjuster, (Voyager 9020, 8010 and 8040 etc) you simply hold the graduation ring and turn the compass capsule until the red end of the North arrow points towards 20 degs. on the Eastern side of the declination scale. When this is done the compass will automatically adjust the bearing.

Remember though, to use the North/South lines on the graduation ring as map North reference lines when taking the bearing on the map.

NB!

- Always check the functionality of the compass before using it in the field.
- Never expose compasses to extreme temperatures (above + 60°C or below -40°C), or to magnetic fields such as knives, radio speakers, magnets etc. Such exposure can cause permanent damage to them.

COMPASS ERRORS

Individual Compass Error

616. Each compass has its individual variation; that is, it does not point exactly to magnetic north. The compass needle itself may not be quite true with the markings on the card and slight divergences may be caused in other ways. The error may be negligible or comparatively large and it is, therefore, important to have compasses checked regularly. Any known error should be noted on the compass and, when readings are taken, allowance must be made for the individual variation.

617. To test the individual variation of a compass, the magnetic bearing between two points should be found. To obtain accuracy, the bearing should be measured from a map not smaller than 1:50,000 and the two points should be at least 1 km apart. Once the map (grid) bearing has been converted to a magnetic bearing, it can be compared with the compass bearing. Carrying out the same procedure once or twice again for points in different directions should check this variation east or west. If one measurement is different, there is probably local magnetic attraction, so further checks should be conducted.

618. When a compass has been identified as having an individual variation the following occurs:

- a. If a sample bearing is known to be magnetic north and the compass shows a bearing of 100 mils (that is, to the east), when aligned between the same points as the sample bearing, then the compass card is pointing to the west. This can be compensated for by using the compass error as an additional magnetic angle to the east for that particular compass and it must be added to each bearing taken with that compass.
- b. If the sample bearing is 3500 mils (that is, to the west) then the compass card is pointing to the east. This can be compensated for by using the compass error as an additional magnetic angle to the west for that particular compass and it must be subtracted from each bearing taken with that compass.

Local Magnetic Attraction

619. Local magnetic attraction is due to the presence of iron or iron ore nearby. The compass is a delicate instrument and quite small quantities of iron have a surprisingly large effect on its behaviour. A wristwatch, steel-framed spectacles or steel helmet will affect the compass reading. Precautions should be taken to see that all iron or steel objects are at a safe distance before using the compass. Small articles will be safe in a trouser pocket but larger articles should be placed 2 or 3 metres away. Listed in the table below are the safe distances from various common objects.

Transmission high tension lines	80 metres
Tank	75 metres
Field gun	60 metres
Fencing wire	10 metres
Steel helmet	3 metres

619. To check for local magnetic attraction, select two points about 100 m apart. From one take a bearing to the other. Then move to the other and take a bearing back to the first. The two bearings should differ by 3200 mils (back bearings). If they do not, there is magnetic disturbance at one point or the other, or at both.

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CHAPTER SEVEN

MAP SETTING AND POSITION FINDING

MAP SETTING

701. A map is said to be set, or oriented, when the features on the map are in the same relative position as the features on the ground. This requirement is met when grid north on the map is pointing to grid north. As a consequence, a map may be set by either:

- a. Inspection; and/or
- b. Compass.

702. The purpose of setting a map is to make the reading of it easier. Sometimes, the lettering is not the right way up, but since place-names are usually irrelevant to the navigation task at hand, that usually does not affect the use of the map.

Setting a Map by Inspection

703. Usually, when map reading, your position is known, so the quickest and simplest way of setting a map is by inspection of the map and the ground. If there is a linear feature such as a straight road, turn the map until the road on the map is aligned with or parallel to the road on the ground.

704. If there is no convenient road or railway, the map can be set by lining up on distant objects, provided your position is known. Lay a ruler, or any straight edge, on the map so that it passes through your position and through that of one of the objects. Sight along the ruler to the object on the ground to set the map.

705. In both the methods outlined in paragraphs 703 and 704, a check should be conducted against other features. If none can be recognised, at least the slope of the land can be checked.

Setting a Map by Compass

706. If you are not aware of your exact position and it is difficult to identify sufficient detail on the map and on the ground, a map may be set very accurately by use of a compass. The compass should be placed so that its axis lies along any easting. The map and compass are then turned until the north point of the compass is east or west of the lubber line by the amount of the grid-magnetic angle.

707. Placing the axis of the compass on MN in the north point diagram should not set the map, as this diagram may only be representational and not accurately drawn.

POSITION FINDING AND RESECTION

Finding your Position from Local Objects

708. Once the map has been set, if the area is well developed and fully mapped, it is relatively easy to locate your position by comparison of the map detail with the features on the ground. Your position should be fixed roughly in relation to the major features around, such as hills and towns. If the map was set by use of a road, an approximate position can be obtained as its direction is already known and the distance can be estimated. Your exact position is found by use of minor features, such as creeks, tracks, fences and houses. Remember that the shape of the ground is most helpful when locating your position, and it is far more reliable than artificial features.

Resection

709. A resection is a means of locating your position on a map if you are unable to do so by comparison of detail on the map with the features on the ground. The method of carrying out a resection is as follows:

- a. Select three prominent, widely spaced features that can be recognised on the map and on the ground. Two features can be used to obtain an approximate position;
- b. On the ground, take magnetic bearings to these features with a compass;
- c. Convert these magnetic bearings to grid bearings;
- d. Convert the grid bearings to back bearings;
- e. Using a protractor, plot on the map the back bearings from the identified features; and
- f. These lines will either intersect to locate your position or form a small triangle of error.

710. **Triangle of Error.** If a triangle of error is formed, your true position can be determined by the following rules:

- a. If the triangle of error is inside the triangle formed by the three features (ABC), your true position will be inside the triangle of error. If the triangle of error is outside the triangle ABC, then your true position will be outside the triangle of error;
- b. If the triangle of error is outside the triangle formed by the three features, ABC, then your true position will be either to the left or right when facing the fixed points of all the lines drawn on the map from the respective features through the triangle of error; and
- c. Regardless of whether your true position is inside or outside the triangle of error, the distance from that position to the lines will be directly proportional to the length of the lines (that is, your position will be nearest to the shortest line and furthest from the longest line). Depending on the size of the triangle of error, your position within the triangle can be worked out exactly by this method. By approximations, your true position can be confirmed by relating the map to the ground.

CHAPTER EIGHT

AIDS TO NAVIGATION

INTRODUCTION

801. Before the magnetic compass was invented, man navigated across continents and explored the world with the aid of the sun and stars. As a magnetic compass is useless in the polar regions, in areas of iron ore or when navigating from a vehicle, a knowledge of the movement of the sun and stars is still essential for navigation.

802. Even when a magnetic compass is available, the sun and stars provide a useful check upon the accuracy of the compass. Soldiers who don't have a compass, but can read the sky, can still know the direction that they are travelling. This will develop self-confidence and is a useful aid as a survival technique.

DIRECTION FROM CELESTIAL BODIES

Motion of Celestial Bodies

803. At the equator, just as the sun and the moon rise from the east and set towards the west, so do the stars at night. At the North and South Poles, the stars can be seen to rotate about a central point which is directly overhead at the poles. Like the sun at the poles in summer, these stars never set. At the South Pole, the stars rotate clockwise about the South Celestial Pole. At the North pole, the stars rotate anti-clockwise about the North Celestial Pole.

804. Just as the sun resumes the same position in the sky at the same time of each day due to the earth's rotation on its axis, the stars resume the same position in the sky at the same time of each year due to the earth's revolution about the sun. As the earth sun takes approximately 365 days to revolve about the sun, approximately $1/360^{\text{th}}$ of one degree is completed each day. This is seen at the equator, with the stars rising $1/360^{\text{th}}$ of a day or four minutes earlier each day.

805. The new moon is not visible at night as its position in the heavens is close to that of the sun. Similarly, at fixed times each year, certain constellations are not seen because they are also too close to the sun.

806. This movement pattern can be portrayed by examining the movement of the constellation Orion. In July, this constellation rises due east just before sunrise. It rises four minutes earlier every night and, by September, it rises at midnight and reaches the middle of the sky (the meridian) by sunrise. (The meridian is an imaginary line across the sky starting on the horizon due south of the observer.) Orion does not pass directly overhead in Australia, and when it crosses the meridian, it is to the north of the observer. Later, in December, Orion rises (due east) at sunset, reaches the meridian at midnight, and sets at sunrise. By March it is already on the meridian at sunset, sets at midnight, and in May, it will only be seen setting (due west), just after sunset. In June, Orion is too near to the sun to be seen at all.

807. Most of the other constellations go through a similar yearly cycle, though not all of them rise due east and set due west, as Orion does.

Finding Direction from the Southern Polar Sky

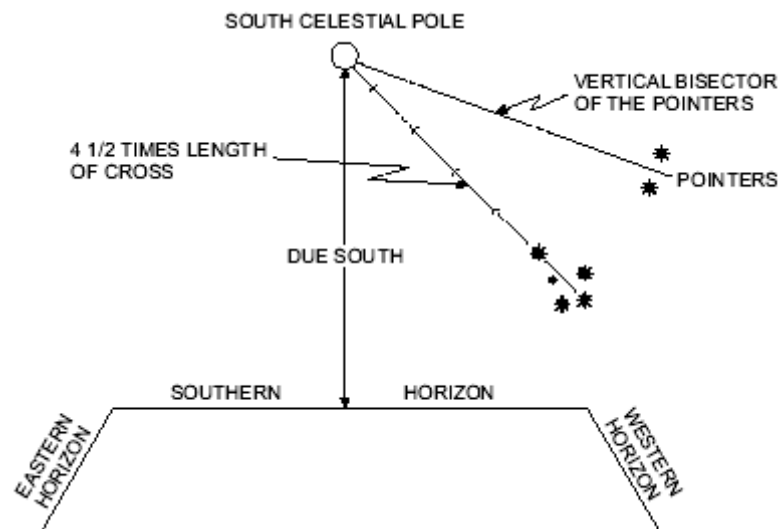
808. Unfortunately, there is no prominent star located at the South Celestial Pole, which is that point directly above the South Pole. However, its position can be determined approximately by using one of the following star groups:

- a. Southern Cross and pointers,
- b. Achernar and pointers, and
- c. Sirius and Canopus.

809. **Southern Cross and Pointers.** The South Celestial Pole can be found by extending the longest axis of the Southern Cross four and a half times. This should be checked by ensuring that the vertical bisector of the line joining the pointers meets the Southern Cross prolongation at this same imaginary point. This point is the general direction of south (See figure below). The pointers should always be used as a check, to ensure that one of the false crosses has not been used by mistake.

810. **Achernar and Pointers.** An examination shows that the South Celestial Pole is located half-way between Achernar and the pointers.

811. **Sirius and Canopus.** If a line from Sirius (the brightest star in the sky) to Canopus is extended the same distance again, the approximate position of the South Celestial Pole is found.



Finding South Using the Southern Cross

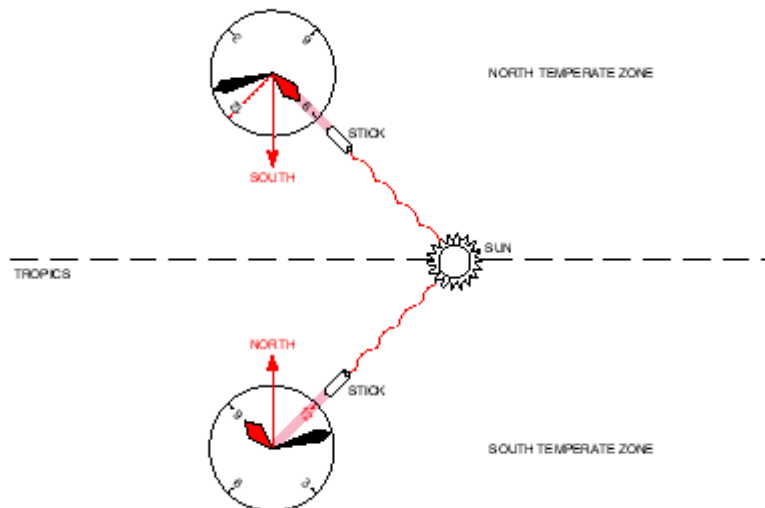
Finding Direction from the Sun

812. To determine direction accurately from the sun, a sun (astro) compass or shadow stick should be used. Direction can also be determined approximately by the watch method.

Watch Method

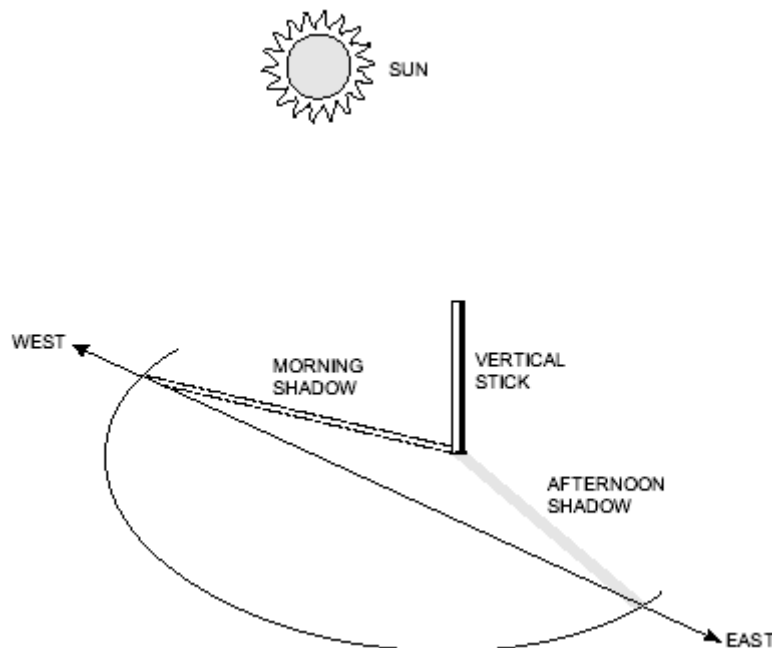
813. If the watch is set on daylight saving time, convert it to standard time. When south of the Tropic of Capricorn, hold the watch so that the 12 of the clock points to the sun. This can be checked by ensuring that the shadow of a vertical stick falls along the 12 axis. The direction of NORTH is then found by bisecting the angle between 12 of the clock and the hour-hand.

814. The watch method can be used between the Tropics of Cancer and Capricorn, provided the sun's seasonal movements are known. If the sun is vertically overhead at midday, the method will not be very accurate and then the sun should only be used in its early and late phases for the general direction of east or west.



Direction from the Sun – Watch Method

815. **Shadow Stick.** The shadow stick method is very accurate and, for something like 5000 years, it was the basis of all surveying. Its major drawback is that a person must remain in the one location for several hours over midday. Before noon, a level space is cleared which is exposed to sunlight. On this space a straight stick is erected and set vertically with an improvised plumb bob. A circle is then described about the stick with the radius equal to its shadow, by using a sharp twig on the end of a string as a compass. As the shadow moves, its end is marked at intervals. These marks will form an ellipse, except during the equinoxes, when they form a straight line. The ellipse formed from the shadow's end will cut the circle at a second point after midday. A line drawn between the start and a second point is a true east-west line (See figure on next page). Great accuracy can be obtained by commencing the shadow stick at about 1000 hours.



Direct from the Sun – Shadow Stick

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PART 2. NAVIGATION

CHAPTER NINE

NAVIGATION PLANNING

PLANNING CONSIDERATIONS

901. It is essential that, before setting off on a course, detailed planning be carried out. This will save unnecessary hardship over 'bad going' and greatly reduces the chances of error. The map and air photos, if available, should be studied in detail, making note of the main features, the direction of river flow and changes in vegetation. The map should be studied in detail, making note of the main features, the direction of river flow and changes in vegetation. The map should be updated from the air photos, if necessary.

902. In most instances, the task and the tactical situation determine the route taken. The following factors will have an influence upon the final decision:

- a. **The Grain of the Country.** It is physically easier to follow the grain of the country than to go against it. Although cross graining may be slower, it of-ten provides more navigation checks, such as spurs and streams;
- b. **Ridges.** The vegetation along ridges is generally less dense than in valleys. The ridge serves as a direction guide and makes observation of land marks easier. In addition, animals often make tracks on ridges so the going may be easier than in valleys;
- c. **Rivers.** While rivers are useful aids to direction keeping, it is generally poor policy to follow them. In rugged country, they are winding and are usually bordered by dense vegetation; and
- d. **Close Country.** As movement through close country is slow, the distance travelled is often over-estimated. As visibility is limited through the vegetation, a small undulation can often be mistaken for a significant spur. Unless the navigator is experienced in close country navigation, a straight route on a compass bearing should be followed rather than navigating from feature to feature.

903. Once the route has been selected, it should be lightly marked on the map with a pencil. This route should then be mentally traversed to check for obstacles and 'bad going' and altered if necessary.

904. Unmistakable objects, such as river junctions or hills, should be selected as bounds. Where possible, they should not be more than one hour's march apart, so that the navigator's exact position can be pinpointed regularly. Linear features which cross the proposed route should be noted for use as navigation checks.

905. Finally, the detail of bearings, estimated distance, marching time and going is worked out for each bound. This should be recorded on a navigational data sheet.

ESTIMATING DISTANCE

906. When planning a route, the distance to be travelled must be calculated, as thick vegetation will prevent position finding by inspection. When actually navigating, distance can be measured by pacing and by time.

Pacing

907. Pacing is the most reliable method of measuring the distance travelled. As each individual takes a different length of stride, everyone must determine the average number of paces that he takes for 100 metres over varying types of ground. With experience, the counting of paces and their conversion to metres will give the individual an accurate gauge of the distance covered.

Even so, it is always advisable to have a check pacer. As he is likely to have a different stride, the check pacer must always convert his distance covered to metres for the navigator's use.

908. There are various techniques for pacing. Some soldiers will find it easier to count every time their right foot comes to ground, that is, every second pace, when they are travelling a long distance. Their total paces must, of course, be doubled before conversion to metres. Whatever method is adopted, a reliable method must be used for recording the total paces, so that they are not forgotten when the cadet is distracted. Some proven methods are:

- a. the use of a pace or sheep counter;
- b. tying a knot in a piece of string to represent each hundred paces; and
- c. transferring a pebble from one pocket to another at each hundred paces.

909. When estimating distance from the maps, allowance must be made for the rise and fall of ground. Where the measured distance on the map is 1000 metres, it will only be accurate if the ground is flat. If there is a hill included in the 1000 metres, its height will have to be taken into account and the pacing count adjusted for climbing it on one side and going down the other.

Time

910. Time is a good check on the distance travelled when movement is continuous and does not involve the crossing of many obstacles. The average cadet, carrying basic equipment, will walk over flat, open country at a speed of about 5 km/h. The factors that would reduce this rate of movement are:

- a. the tactical situation;
- b. relief and drainage;
- c. vegetation;
- d. night time;
- e. the cadet's load; and
- f. extremes of climate.

911. The following rates of movement are provided only as a guide for use in Australia:

- a. Non-tactical Movement.
 - (1) By day over open undulating country, 5000 m/h.
 - (2) By day in close flat country, 3000 m/h.
 - (3) By day in extremely rough country, deep sand or snow, 1500 m/h.
- b. Tactical Movement.
 - (1) By day over open undulating country, 2000 m/h;
 - (2) By day in close flat country, 1000 m/h;
 - (3) By night over open undulating country, 1000 m/h; and
 - (4) By night in close flat country, 100 to 500 m/h.

THE NAVIGATION DATA SHEET

912. As an aid in planning navigation, and to record the bearing and distance between bounds, a navigation data sheet should be produced. The navigational data sheet can be written on any notepaper, but should be legible so that it can be checked and copied by a check navigator. An example is shown below.

Serial	From GR	To GR	Magnetic Bearing	Distance in Metres	Estimated Time (Mins)	Going	Remarks
1	561 703 Track Junction	567 709 Hut	640 mils	920 (1104 paces)	25 mins	420m downhill 500m gentle uphill	Creek 440m Dirt Road 700m
2	567 709 Hut	563 724 Ruins	5900 mils	1600 (1920 paces)	50 mins	Undulating Ground Medium Vegetation	Cross Creeks At 400m & 1300m

913. To write down all the information about going and the shape of the ground that can be determined from a map, would take a prohibitive amount of time. Consequently, a navigation data sheet can never replace the map. Its information is only to aid the memory.

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CHAPTER TEN

CONDUCT OF NAVIGATION

General

1001. Having planned a route carefully, a cadet required to navigate must combine good map reading with the correct use of aids. Successful navigation will depend on:

- a. keeping direction; and
- b. knowing the distance travelled.

1002. In most instances, the navigator has other tasks, such as commanding a patrol, directing scouts, passing field signals and sometimes talking on a radio. Although the responsibility for accurate navigation remains with the commander, the pressure on him can be eased by the use of a check navigator and one or more check pacers.

1003. A junior leader must continue navigating even when he is no longer required to lead the column to ensure its accuracy.

1004. A junior leader should use one hand for holding and checking the map or using the compass so he can still pass field signals. Each of these functions should be done in turn and not attempted together. A leader who waves a map in his hand when passing a field signal will be observed more easily. A lanyard to prevent its loss must secure a compass. When the map is being used, the compass should be stored in a convenient pouch and, similarly, when the compass is in use, the map case should be placed in a pocket, or in the shirtfront, or be attached by a strap. Although it is inconvenient to be shuffling map and compass, continual reference must be made to both. The task is made easier once the leader knows how to maintain direction.

1005. The leader must locate each bound before proceeding on the next leg. If, at the end of the required time and distance, a bound is not located, an error in navigation may have occurred and must be corrected before continuing the march. A temporary halt is then necessary, while reconnaissance is carried out. Reconnaissance parties sent out to locate a bound must be given a definite duration of movement.

MAINTAINING DIRECTION

Maintaining Direction by Day

1006. When moving through close country, continuous checks must be made using the compass. To maintain direction, a prominent object (such as a tree), which lies on the magnetic bearing, is selected. Once the navigator has reached this object, he selects another object that is on the bearing and moves to it. This method is continued until the destination is reached.

1007. In open country, direction can be maintained by reference to prominent landmarks that can be easily read from the map. Although continual reliance upon the compass is not necessary, it should still be regularly checked to ensure an error in map reading has not occurred.

1008. In daytime navigation, knowledge of the sun's movement provides the navigator with a double check on his direction.

Maintaining Direction by Night

1009. Before any night activity, the luminous strips on a compass should be exposed to light to ensure their maximum brightness. If the skyline or prominent objects are visible, direction can be maintained by methods similar to those employed in daylight.

1010. Stars are ideal for maintaining direction. The most convenient stars to select for marching on are those which are at an altitude of 250 mils (15 o) to 500 mils (30 o); stars below 250 mils may become lost in haze, while those above 500 mils change direction faster. As a star may move 90 mils (5 o) every 20 minutes, the direction should be regularly checked against the compass.

1011. Often due to fog or cloud cover, no stars or prominent objects are visible. If this occurs, another cadet should be sent in the approximate direction until he is just visible. The navigator then notes by means of the compass whether the cadet is standing on the true bearing or to the right or left of it. The navigator moves up and places himself on what he judges to be the correct alignment. He then sends the cadet forward again. When the conditions are very dark, the cadet can hold luminous tape to greatly increase the rate of advance.

LOCATING A PIN-POINT OBJECTIVE, BYPASSING AND DEAD RECKONING

Locating a Pin-point Objective

1012. In open country, it does not matter greatly if navigation results in an error of a few mils, because the objective will be in view from a distance of hundreds of metres. In close country, however, it is possible to be within 20 metres of the objective and not see it. Therefore, when aiming for pinpoint objectives, it is advisable to select as an auxiliary objective the middle of a nearby linear feature with clearly defined limits, such as a length of track, an arm of a stream, or a border of cultivation. These must stretch across the pinpoint. An error of a few mils is then less likely to cause the party to miss the broader auxiliary objective. On arrival, it should be a comparatively simple matter to locate the nearby pinpoint objective.

Bypassing

1013. When unexpected 'bad going' is encountered (for example, swamp or bamboo forest), a decision must be made as to whether it would be quicker to go round it or through it. If the decision is to bypass it, any tendency to cling to the edge of the area and 'feel' a route round must be avoided, as a loss of direction will result.

1014. There are two methods of bypassing which eliminate the possibility of error:

- a. Method 1. From the edge of the area, plot a fresh course at 1600 mils from the line of march and move a pace distance, say 500 paces. When the 500 paces mark has been reached, swing back on a parallel line of march for a sufficient distance to ensure bypassing. Then swing back 1600 mils in the direction of the original line of march for the desired distance (in this case 500 paces) to get back to a point from which the march can be continued.
- b. Method 2. Select an object to a flank. Plot a new course to this object, and from it; plot another course to another object on the line of march.

Dead Reckoning

1015. Dead reckoning (or traversing) is a method of navigating by plotting direction and estimated distance travelled. The method enables the navigator to always know the direction and distance back to his start point. Dead reckoning is most commonly used:

- a. when maps are not available;
- b. in poorly-mapped or featureless areas; and
- c. when patrols are forced to travel beyond the edge of their map sheet.

1016. The route is most accurately plotted when graph paper or the squared paper found in the field message and notebook is used. Directions can be left in magnetic bearings to save time, although the result must be converted to a grid bearing if applied to a map. Any scale can be used, although it is most convenient to use the same scale as the map, as the plot can then be superimposed upon it.

1017. The plotting should be done with a sharp pencil and protractor. From a start point, the bearing and distance of the first leg is drawn. Each subsequent leg is then drawn in from the end of the previous one.

ACTION IF LOST

1018. If lost, the navigator should not act hastily. He should halt and consider:

- a. whether he has drifted left or right of his line;
- b. whether he could have already passed the objective, or whether the time and distance travelled was badly estimated;
- c. whether the ground covered conformed to his mental picture of the going he expected from the map;
- d. whether there are any features in the area which will help him to fix the position, or enable him to conduct a resection; and
- e. the possibility of local magnetic attraction, compass error or inaccuracy in the map, although extreme care should be taken before attributing one's 'being lost' to the map.

1019. As a result of careful consideration, it should be possible to narrow the situation down to two or three probable locations. Short reconnaissance patrols in opposite directions should bring back sufficient information to allow a fix of the position.

1020. Leaders must always brief their cadets on the action to be taken if they become separated from the group. The brief must be kept simple and the action required should remain the same for all legs of a route. If they are told to move in specific directions, it should be worded in terms of 'north' or 'south' rather than 'left' or 'right', as direction can then be found with only a basic knowledge of the movement of the sun and stars. For example, 'move east to the railway, then follow it south'.

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CHAPTER ELEVEN

NAVIGATION TRAINING

General

1101. As navigation is a skill, true proficiency is only achieved by practice on the ground. This practice takes time. If a cadet is not already competent in his navigation before he is considered for first advancement, he is unlikely to develop the required skill before he is given the responsibility for leading his section. It is, therefore, essential that cadets be given all their formal instruction on map reading and navigation, and sufficient practice to ensure that this knowledge is assimilated, before they complete their recruit and initial employment training.

1102. As time is generally restricted at training establishments Cadet Instructors must accept the responsibility of regular continuation training. As the cadet of today is the junior leader of tomorrow, a leader can only ensure that navigational errors do not interfere with the execution of his mission by ensuring that all cadets are regularly practised on camps.

INITIAL INSTRUCTION

Introduction

1103. The aim of this section is to help the instructor and the junior leader in his task of teaching navigation. The order of chapters follows a logical sequence but this may not be the most appropriate sequence for a particular instructional requirement. Cadet Instructors cannot blindly follow the book through from chapter to chapter, and must plan their courses to meet the requirements of their particular students.

1104. As the most difficult aspect of navigation for students to grasp is the relationship of the map to the ground, map-reading lessons should be conducted as much as possible out of doors, using a map of a particular piece of ground. To be effective, this type of instruction requires an instructor-to-student ratio as high as one is to six.

1105. Obviously, certain map reading knowledge is more conveniently and quickly imparted in a classroom situation and here it is most important to make the maximum use of visual aids, in particular, audio-visual sequences. Classroom instruction must be followed up as soon as possible with practical instruction and practice on the ground. It is particularly important that this confirmation on the ground is conducted after relief and contours have been taught, and before proceeding on to other topics such as bearings.

1106. When planning a course of instruction, the first essential is to establish exactly what navigational skills and knowledge a student will need in his employment. Before deciding on the subject content and length of course, the instructor must specify exactly the standard of performance that his students must reach at the end of their training (that is, the training objectives). Although training objectives are an essential step in deciding course content, they do not necessarily describe the method or sequence in which the individual topics are to be taught. They will, however, give considerable guidance in the planning of a course, and enable the instructors to identify related subjects and prepare a balanced program.

Suggested Training Program

1107. To assist instructors the following sequence of lessons is given as a guide only. It does not align with the Cadet TMP lesson in terms of time. It is a stand-alone program, the latter parts of which could be useful in Level 2 or 3 programs.

Lesson	Subject
---------------	----------------

- | | |
|----------|---|
| 1 | Introduction to the Map (Class-room) <ul style="list-style-type: none">a. The aims of map readingb. Care of mapsc. Distinguishing types and scales of mapsd. Interpreting marginal informatione. Interpreting conventional signs |
|----------|---|

Audio-visual sequences are available on scale, marginal information and conventional signs. Only a few conventional signs need to be taught initially, as long as students are introduced to the others in subsequent lessons.

- | | |
|----------|--|
| 2 | Grid References (Class-room) <ul style="list-style-type: none">a. Indicating a grid square by a four-figure grid referenceb. Indicating points on a map using six and eight -figure grid referencesc. Use of a roamer |
|----------|--|

An audio-visual sequence is available on grid references. In initial periods, there is no need to teach the construction of the UTM grid reference or how to give a universal grid reference. Conventional signs not taught in lessons 1 and 2 can be introduced. Each student should be required to construct his own roamer, rather than complicate the lesson by the introduction of the service protractor. In all future lessons, all points on the map to which attention is directed should be given as grid references.

- | | |
|----------|---|
| 3 | Measure Distance on a Map (Class-room) |
|----------|---|

An audio-visual sequence is available on 'measuring distances'. The student should be taught how to measure distance on the map, on a straight or curved line, and correct reading of the distance from the scale. This lesson, like grid references, is purely mathematics and does not relate the map to the ground.

- | | |
|----------|---|
| 4 | Identify the Shape of the Ground on a Map (Class-room) <ul style="list-style-type: none">a. Description of contoursb. Contour patterns (steep, gentle, convex, concave, re-entrant, spur, knoll and saddle) |
|----------|---|

An audio-visual sequence is available on contours. It should be emphasised that the shape of the ground changes very slowly, so relief is more reliable than man-made features for navigation. A layered model is useful in describing contours. Students should be asked to describe the slope or feature at various grid references given.

- | | |
|------------|---|
| 5-6 | Basic Map to Ground (Field) <ul style="list-style-type: none">a. Relating of distance on the map to distance on the groundb. Setting a map from local objectsc. Finding position from local objectsd. Indicating points on the ground by grid reference |
|------------|---|

These are practical lessons conducted in open, undulating country with an instructor for each small group of students (maximum of six). The instructor should start on a high piece of ground by an obvious linear feature (such as a road) and, preferably, with his students facing north so that when they set the map, the writing is upright. The students should be practised in identifying objects on the ground by grid reference. Once students have determined their position, a simple route should be taken so the students can follow their route by relating map to ground. They should be taught to keep their map orientated throughout the route. Each student should determine the number of paces that he takes for 100 m.

- 7 **Direction and Service Protractor** (Class-room)
- a. North Points
 - b. Calculating grid-magnetic angle
 - c. Converting bearings
 - d. Reading and plotting grid bearing with a protractor
 - e. Calculating back bearings

Audio-visual sequences are available on north points, the service protractor, and bearing. Students should be practised in converting bearings when MN is either east or west of GN. Students should be taught to draw a rough diagram to convert bearings, and should be practised until they become proficient.

- 8–10 **The Compass** (Field)
- a. Determining direction with a compass
 - b. Setting a map by compass
 - c. Setting a compass for night marching
 - d. Compass errors

An audio-visual sequence is available on the prismatic compass for initial class-room instruction if, for some reason, sufficient compasses are not available. Preferably, each student should be able to handle and examine the various parts of the compass as they are described to him.

11–15 **Find Position by Resection** (Class-room and Field)

An audio-visual sequence is available on map setting and position finding. This provides revision on map setting, and it also covers resection. The first period in the class-room should be spent with the students practicing their plotting based on magnetic bearings given by the instructor. The second period should be practised with the compass, protractor and map in the field.

16–20 **Practise Reading Ground from the map with the Aid of a Compass** (Field)

The lessons providing practice at reading ground from the map with the aid of a compass are conducted in a manner similar to that used for lessons 9 to 12. However, more difficult terrain should be used, as cross-country movement can be aided by the use of a compass. Distant objects on the ground should be identified by grid reference with the aid of a compass.

- 21 **Determine Direction from Celestial Bodies** (Class-room/field)
- a. Sun and watch method
 - b. Southern Cross

- 22–23 **Navigation Planning** (Class-room)
- a. Planning considerations
 - b. Estimating Distance
 - c. Compiling a navigational data sheet

Students should complete these lessons with a navigational data sheet.

- 24–30 **Conduct of Navigation** (Class-room and Field)
- a. Maintaining direction
 - b. Determining distance travelled
 - c. Locating a pin-point objective
 - d. Bypassing an obstacle
 - e. Completing a traverse or dead reckoning exercise

The first period is conducted in the class-room to instruct various techniques involved in navigation. The audio-visual sequence on navigation could be shown in this period. The lessons in the field should be conducted in small groups, each with an instructor, although each member should conduct the navigation individually.

CONTINUATION TRAINING

1108. The aim of continuation training is not only to maintain the standard of navigational ability achieved in initial training, but also to give all cadets the practical experience necessary to reliably navigate in all types of terrain. Cadet training should be of sufficient regularity and difficulty to ensure that all cadets advancing towards leadership have already achieved the necessary navigational ability required of that rank.

1109. For continuation training to be successful, there must be a maximum of variety and the individual must find it challenging. This does not simply mean the conduct of navigational exercises in a variety of terrain, and by day and night. Navigational training can also be conducted in conjunction with other exercises, such as survival training or escape and evasion exercises.

110. Cadets should be taught to rely upon their compasses and paces. However, it also is essential that they be given practice in relating the map to the ground. This type of practice can be given by navigational exercises in open country without a compass, where the cadet is forced to use the landform or the sun to derive direction.

111. Even in training areas that are continually traversed by roads, worthwhile navigational training can be conducted by the use of Navigation Special Maps (relief and drainage maps). These maps are only printed with the map grid, the contours and the waterways. As all vegetation and artificial features are removed, a cadet is forced to ignore any road that he comes across and must rely upon reading his map carefully.

Orienteering

112. Orienteering is an ideal way to teach and test navigation in an enjoyable way. An orienteering event can be conducted for up to a hundred or more individuals. Participants are required to navigate about the countryside from one predetermined point to another, using map and compass, in the shortest time possible. These predetermined points, which are called control points, are usually clearly defined and recognisable positions, for example:

- a. the track junction GR 724389,
- b. the cattle grid GR 728392; and
- c. the fence corner GR 733393.

113. Attendants can man these control points, but it is more usual to mark them with red and white squares or red flags. At each control point, a competitor can mark his event card with a self-inking stamp or a coloured crayon to prove that he completed the course, or perhaps word clues can be left to form an answer to a question posed at the commencement of the activity.

114. To prevent collusion between competitors, they are normally started at one-minute intervals and may be sent around the course in opposite directions. Several courses may be superimposed upon the one area of countryside to discourage competitors from following one another. The competitor who finds all the control points in the shortest time or the most points in the allocated time is the winner.

115. Another type of event is to have a large number of control points in an area. Each control has a point's value. Those controls which are furthest away from the start, or the most difficult to locate, are awarded the highest value (30 – 50 points), while those controls near to the start and easy to find are given a low value of only 5 to 10 points. Each competitor is allowed to set a time (for example, 90 minutes) to locate as many controls as he can and so amass as large a point's total as possible. This allows the competitor to visit the controls in any order and plan any route. The course should be so designed that the competitor cannot possibly find all control points in the time allowed. Any competitor who takes more than the allowed time is penalised (for example, one point for every 10 seconds) the winner is the competitor who finishes with the highest score.

1116. Orienteering exercises can be varied considerably and the exercises outlined in this section are merely a few suggestions on how to use them as teaching and testing lessons in navigation. More detailed information on the sport can be obtained from the books and pamphlets which have been written on the subject.