Défense nationale National Defence

B-GL-382-005/PT-001

LAND FORCE
MILITARY TRAINING

MAPS, FIELD SKETCHING, COMPASSES AND THE GLOBAL POSITIONING SYSTEM

(ENGLISH)

(Supercedes B-GL-318-008/PT-001 dated 1976-10-12)

Canada

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Issued on the authority of the Chief of the Land Staff

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Canada

FOREWORD

1. B-GL-382-005/PT-001, *Military Training Maps, Field Sketching, Compasses and the Global Positioning System* is issued on authority of the Chief of the Land Staff.

2. This publication supersedes B-GL-318-008/PT-001 *Military Training, Volume 8, Maps, Field Sketching and Compasses* and becomes effective upon receipt.

3. This publication is designed specifically to provide the background information necessary for non-specialized map reading instruction in the land forces. Much of its contents however, have wide application throughout the Canadian Forces.

4. Suggestions for amendments should be forwarded through normal channels to Chief Land Staff (Attention DAD 8).

5. Unless otherwise noted, masculine pronouns apply to both men and women.

6. The NDID for the French version of this publication is B-GL-382-005/PT-002.

7. Published on the authority of the Chief of the Land Staff by the Army Publishing Office, Fort Frontenac, Kingston, Ontario.

TABLE OF CONTENTS

TABLE OF FIGURES AND TABLES

CHAPTER 1
GENERAL

SECTION 1
INTRODUCTION

PURPOSE

1. This publication is intended for the use of all map users, however its primary purpose is to provide instructors in map reading with a comprehensive book of reference. The publication covers only the factual information common to most maps, leaving the full understanding of map reading to be attained by practical instruction and by personal experience. To be truly effective, much of the instruction must be conducted on the ground.

SCOPE

2. The publication covers the basic information required for the reading and use of normal topographical maps, Military Town Plans, Training Area Maps and 1501 Joint Operations Graphic (AIR) (JOG (AIR)) maps on scales from 1:25 000 to 1:250 000. It covers the use of map referencing systems, bearings and compasses. Also covered in this publication is the basic understanding and use of the Global Positioning System (GPS).

3. The use of air photographs and of map substitutes produced from air photographs are also covered, as is basic field sketching.

4. Orienteering, an excellent method of teaching and testing practical map reading, is given comprehensive coverage. Lesson guidance has been provided to facilitate instruction in map reading.

PROCUREMENT OF MAPS

5. All military units have an authorised allowance for maps. The map requisition form, to request maps, is form CF 391. To order a map it is necessary to provide the scale of the map and both its series and map number. This information is found on the map sheet itself or in the Department of National Defence, Catalogue of Maps. The catalogue is available at unit level or on the internet at http://www.web.defgeo.ottawa-hull.mil.ca

6. Figure 1-1, is an example of a simple index of the map coverage available in a specific series, in this case the JOG (AIR) and Figure 1-2 contains the general information necessary to the understanding of the National Topographic System.

SECTION 2
MAP READING

INTRODUCTION

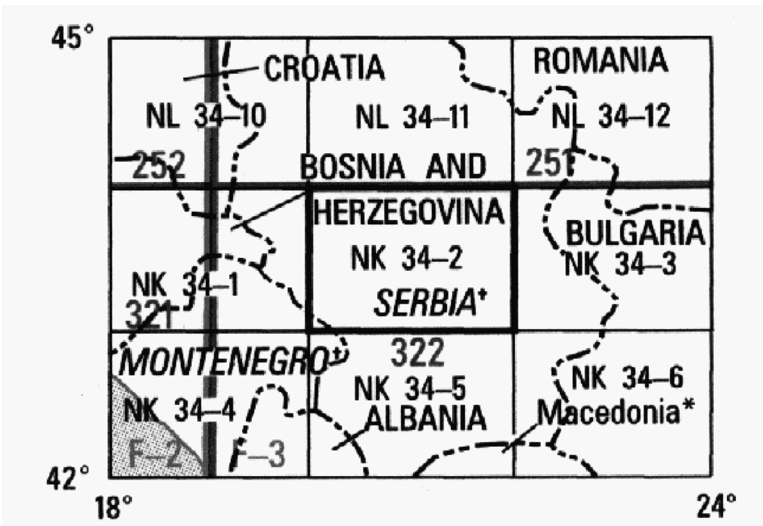


Figure 1-1: Example of Coverage Index, JOG (AIR)

7. Map reading is a wider subject than is sometimes realised. It covers not only the ability to interpret the symbols shown on the map and to understand the information given in pictorial or written form, but it also comprises a true understanding of the ground portrayed, and an appreciation of the reliability and value of the particular map being used. These different aspects of map reading are explained more fully in the following paragraphs.

READING OF MAP INFORMATION

8. The full understanding of the information shown on the map is the basic requirement of map reading. This includes not only the meaning of the various symbols and conventions, but also the understanding of the supplementary information given in the margins of the maps. Conventional signs are not completely standardised, but each map generally provides all the information necessary to enable a map user, unfamiliar with a particular map, to make effective use of it.

9. The reading of map information includes the ability to locate and to give map references, the understanding of scales and the use of them for measurements, position findings and the description and navigation of routes by day or by night. The greater part of this publication is devoted to these aspects of map reading.

UNDERSTANDING OF THE GROUND

10. The ability to obtain from the map a mental picture of the ground portrayed is an essential but much less frequently understood part of map reading. It is sometimes called “mapcraft”.

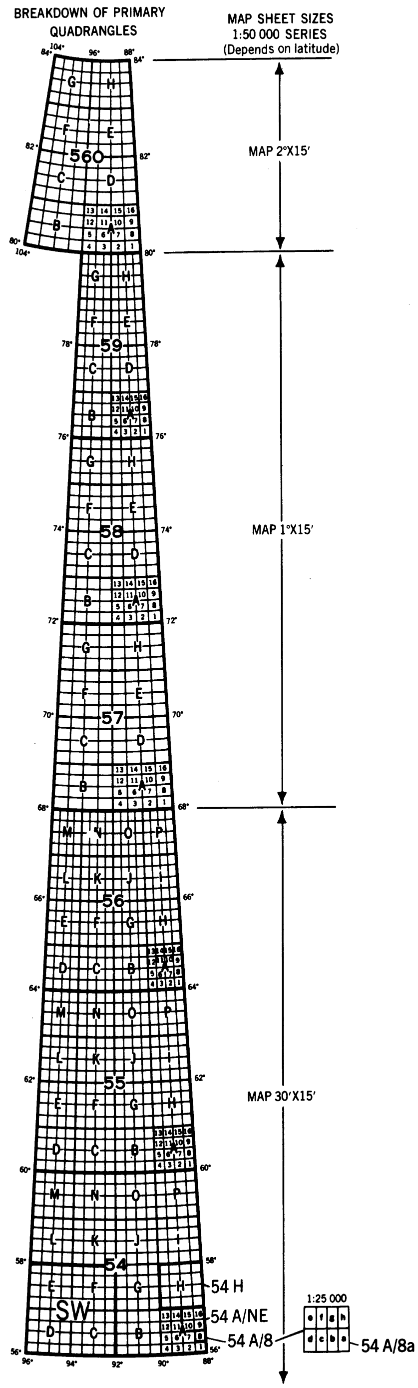


Figure 1-2: General Information, The National Topographic System

GENERAL INFORMATION
THE NATIONAL TOPOGRAPHIC SYSTEM

ITEM

11. Under this system Canada is divided into numbered quadrangles each 4° latitude by 8° longitude (16° longitude north of 80°). Map limits and identification for each series are based on the subdivision of each primary quadrangle as is exemplified in the following:

a. 54 is a primary quadrangle and denotes a map of the 1:1 000 000 series.

b. 54 S W is a quarter of a primary quadrangle and denotes a map of the 1:500 000 series.

c. 54 H is a lettered quadrangle and denotes a map of 1:250 000 series. South of 68° maps are one- sixteenth of a primary quadrangle and lettered A to P. North of 68° maps are one-eighth of a primary quadrangle and lettered A to H.

d. 54 A/N.E is a quarter of a lettered quadrangle-denotes a map of 1:125 000 series.

e. 54 A/8A is a sixteenth of a lettered quadrangle and denotes a map of 1:50 000 series.

f. 54 A/8a, denotes a map of the 1:25 000 series, which is one-eighth the area of a 1:50 000 quadrangle and is identified by a lowercase letter suffix.

12. Some 1:50 000 scale maps were produced as two map sheets an East half and a West half Topographical Map Coverage International.

13. Maps of the World at the scale of 1:1 000 000 are not complete. Canada, however, is covered at the scale of 1:1 000 000 with Topographic Maps, which previously served as base maps for Aeronautical Charts.

14. Series and map numbers are shown on the Map Catalogue of the Department of National Defence but edition numbers are not indicated. All demands will be filled with the current edition.

15. From the lines and symbols on a map it is relatively simple to gain a mental picture of natural detail, such as woods and streams, and man-made objects like roads and buildings. Real mapcraft, however, lies in the ability to visualise the shape of the ground, which is shown on the map by contours and spot heights.

16. The reading of contours and the ability to gain from them a mental picture of the ground cannot be taught from a textbook. Chapter 5 gives the necessary basic information on the interpretation of relief, but mapcraft is a skill. It must be learned by practice on the ground, an essential to building up experience and developing a "feel" for maps, which should become instinctive.

APPRECIATION OF MAP VALUE AND RELIABILITY

17. All maps are not to the same standard of accuracy, reliability or currency. An effective map-reader should be able to assess these qualities to a considerable degree from the information supplied on the map.

18. The information required to assess a map is generally found in the margins. This should include information on the following points:

a. dates of surveys or of other maps from which the map has be compiled;

b. date and extent of the last revision; and

c. overall map detail.

19. On some maps a reliability diagram may be shown. For more details see Chapter 2, Section 3.

20. When comparing the dates of the last revision of two maps, it is important to check whether the revision was complete or was made only to certain types of information, for example, roads. When comparing relief information, a map compiled from a larger scale map is likely to be more reliable than one compiled directly at the scale of the map. Broken contours generally indicate a lack of reliability.

SECTION 3
TYPES AND SCALES OF MAPS

TOPOGRAPHICAL MAPS

21. Topographical maps are the types of map with which this publication is primarily concerned. Their purpose is to present a picture of the ground as it exists. Topographical maps show, in as much detail as the scale allows, both the physical features of the ground such as rivers, woods and hills with their heights and shapes and the man-made features such as roads, railways, towns, villages, buildings, etc. They also contain a large number of names, both specific names of towns, villages and rivers, and also descriptive names of general features such as railways, fords, post offices, etc.

22. Topographical maps may vary in scale from 1:25 000 to 1:250 000. The references in this publication are principally related to the following map series which are those commonly in use by the Canadian Forces (CF):

a. Training Area Map (Canada). 1:50 000;

b. Foreign 1:50 000; and

c. Military Town Plan (Canada). 1:25 000.

23. Specimens of these maps are illustrated in Figures 4-2, 4-3, 4-4.

24. Variations exist in symbols and in presentation between map series even though they are at the same scale and are produced under allied mapping agreements. Therefore, it is important to emphasise that the information given in this publication is of general application only, and that each map used must be studied on its own to ensure that it is correctly interpreted.

25. **Restricted Edition**. This is a map, 1:25 000 scale, of a city or town, delineating streets and showing street names, important buildings and other urban elements of military importance, which are compatible with the scale of the map. Vertical information is not normally shown. See Figure 4-4 for an example.

OTHER MAPS

26. Other types of maps for military use may generally be divided into two classes:

a. **Maps on Scales Smaller than 1:250 000**. These are used for strategic planning and by air forces. Map detail is generalised and only principal features are shown. Relief, if shown, is normally indicated by layer tints (see paragraph 14) or by other means.

b. **Special Maps**. These include maps to illustrate special items of information, for example, road maps, going maps (to show suitability for vehicular cross-country movement), railway maps and skeleton maps (showing only water and relief). None of the above maps are covered in this publication.

PHOTOMAPS AND MAP SUBSTITUTES

27. These are maps made up of aerial photographs, and are produced only for special requirements. Their use and interpretation are covered in Chapter 10.

SECTION 4
FIELD SKETCHING

SKETCHING

28. Photography is generally the most acceptable means of supplementing map data, which of course is seldom completely up to date. Such a supplement is often required to facilitate a report on special or detailed information that the map does not reflect. However, photography is not always operationally expedient and, in such cases, a field sketch is necessary. For example, a night patrol would certainly not be able to use conventionally photography and a field sketch might be the only satisfactory way of recording detail commensurate with the demands of security. The panorama sketch is a very practical expedient for use in an artillery observation post (OP) for displaying targets and target data related to the zone it overlooks. These techniques are discussed in Chapter 11.

SECTION 5
TRAINING

TRAINING HELPS

29. Practical tips and assistance for setting up and running a course of instruction in map reading are provided in the final chapters of the publication. This includes an extensive discussion of the use of orienteering as a means of teaching and improving map-reading skills.

CHAPTER 2
MARGIN INFORMATION

SECTION 1
GENERAL

INTRODUCTION

1. Before using any unfamiliar map, the first essential thing to do is to have a good look at the information contained in the margins. The margins give much information essential to the full understanding and use of the map and deserve more attention than is frequently paid to them.

LAYOUT

2. On military maps produced under allied international agreements, the layout of the margin information is to a large extent standardized. This is so that users may become accustomed to finding the different types of information they seek in the same part of the margins on all maps, even though the maps are produced by different countries and at different scales. The principal elements of this standardization will be explained in this chapter. However, not all maps conform to these standardization rules, and the user must be prepared for variation in layout, although, in general, the more essential items of information are placed in common positions.

TYPES OF INFORMATION SHOWN

3. Certain information shown is essential to the identification of the map and the correct interpretation of its basic information. This detail is described in Section 2.

4. The remaining information is useful to certain types of users or on those occasions when it is necessary to determine the source of information and hence the reliability of the map. This detail is described in Section 3 and should be known and understood by the map reading instructor, but it is not essential for those who are concerned only with basic map work.

LANGUAGES

5. All Canadian military maps produced by the Canadian Forces are printed in both official languages. National Topographic System Maps produced by Federal Agencies are also produced in both official languages. When maps are too complicated for printing in a bilingual edition, a separate map is printed in English and French. The elements appear together in a panel as in Figure 2-1.

SECTION 2
COMMON USER INFORMATION

MAP IDENTIFICATION

6. The essential elements required to identify a particular map sheet are:

   a. map series number;

   b. sheet number (or name, if there is no number); and

   c. edition number.

7. The elements appear together on the map sheet in a panel as shown in Figure 2-1 and 2-2.

8. The map series number identifies both the area and the scale of the map; the series number can be found from the map catalogue. All operational map series are shown in the Department of National Defence, Catalogue of Maps, with indexes to series show all sheets published; though some may not be available from stock. Allied nations will possess catalogues of their maps and sometimes their overseas commands may produce separate map catalogues in which special purpose mapping of local interest will be included.

9. The edition number identifies the currency of the information shown on the map. The edition number increases at each revision. On Canadian maps a credit note appears in the lower left and lower right hand corners and indicates the authority of the edition, for example, Energy Mines and Resources Canada. The credit note also lists the producer, dates and general methods of preparation or revision. This information is important to the map user in evaluating the reliability of the map as it indicates when and how the map information was obtained. On some maps, the map credits are shown in tabular form in the lower margin, with reliability information presented in a coverage diagram.

10. On allied maps, the letters following the edition indicate the authority under whom the edition has been prepared, for example, "NIMA", National Imagery and Mapping Agency (USA), formerly known as "DMA" Defence Mapping Agency (USA), etc.

11. When requesting a map, only the series number and the sheet number need be quoted. It is the responsibility of the map depot to provide the latest current edition. If the series number is not known, the area covered and the scale required must be stated.

12. In some rare cases, maps are identified by a sheet name instead of by a sheet number.

SCALES

13. The scale of the map, for example 1:50 000, is shown prominently at the top of the map, and also in the bottom margin, usually above the graphic scales as shown in Figure 2-1 and Figure 2-3.

14. The graphic scales are placed in the centre of the bottom margin and are normally expressed in statute miles and in kilometres, with the addition of yards and metres when the map requires it as shown in Figure 2-3. For more details about scales and measurement of distances see Chapter 3.

UNIT OF ELEVATION

15. Each map must carry in a conspicuous position, normally in the bottom margin, a note that indicates "Elevation in Feet" or "Elevation in Metres", as appropriate. It is vitally important to determine from this note the unit of elevation used on the particular map as shown in Figures 2-1 and 2-4.

CONTOUR INTERVAL

16. A note stating "CONTOUR INTERVAL FEET" or "CONTOUR INTERVAL METRES" is shown in the bottom margin near the graphic scales as shown in Figures 2-1 and 2-4.

CONVENTIONAL SIGNS

17. A table showing the conventional signs used on the sheet in their correct colours with their descriptions is shown in the bottom, side margin or back of the map sheet. Sometimes, if space does not permit, a few signs may be omitted, but the road symbols and classification are always shown. See Chapter 4.

INSTRUCTIONS ON THE USE OF THE GRID

18. These instructions are shown in a panel in the bottom or side margin and are normally in the colour used for the grid on the face of the map. The notes explain how to give a grid reference as shown in Figure 2-5. See also Chapter 6.

INFORMATION ON TRUE, GRID AND MAGNETIC NORTH

19. Each map contains the information necessary to determine the true, grid and magnetic bearing of any line within the area covered by the map sheet. This information is given in the form of a diagram with explanatory notes. The diagram may be in the bottom or in a side margin. The diagram and its uses are explained in Chapter 7.

INDEX TO ADJOINING SHEETS

20. A diagram showing the position of the map sheet in relation to adjoining sheets is shown near the lower margin. The diagram shows the sheet numbers of the adjoining sheets and accentuates the sheet in hand as shown in Figure 2-6.

INDEX TO BOUNDARIES

21. The Index to Boundaries diagram appears in either the lower or right margin of military city maps and some maps of the scale of 1:250 000. The diagram, which is a miniature of the map, shows the boundaries that occur within the map such as country, provincial and international.

GLOSSARIES

22. Some maps carry glossaries of geographical terms and of abbreviations used on the map, with translations into different languages as necessary. They are usually in the lower margin. In some instances, glossaries are printed on the back of a map sheet.

SECURITY CLASSIFICATION

23. The Security Classification, if any, is shown in the top and bottom margins in a prominent colour, usually red.

SECTION 3
SPECIALIST INFORMATION

TECHNICAL DETAIL ON GRIDS, PROJECTIONS AND GEODETIC AND LEVELLING DATUMS

24. Information is given on the grid or grids on the map to which lines and figures refer. Projections, spheroid(s), datums, origin and false coordinate origins are stated for each grid, printed in the colour of the figure of the grid to which they refer. The information appears in the lower or right margins as shown in Figure 2-1; it is required for specialist users.

25. This information is also important for Global Positioning System (GPS) users so they can correctly set-up their GPS to provide readings that are complimentary to the map as shown in Figure 2-4. If the GPS uses a different datum or projection than the map, then co-ordinates between the two will most likely be in conflict. The grid information provided on the map is critical for setting-up a GPS correctly to use UTM/MGRS (Universal Transverse Mercator/Military Grid Reference System).

INFORMATION ON MAP REVISION AND RELIABILITY

26. A history note is given in the bottom margin to show what unit or establishment produced the map, the date and the information from which it has been compiled. When the map has subsequently been revised, the date of revision, the extent of the revision, and the source of the information is also stated.

27. When a map has been compiled from several sources, a compilation diagram may be provided in the bottom margin to show the extent of coverage of the basic sources for each portion of the sheet.

28. On some sheets, a reliability diagram may be included to indicate the degree of reliability of different parts of the map as shown in Figure 2-7. Such a diagram will be found only when the reliability is below the standard that would normally expected at the scale and in that area of the map.

GEOGRAPHICAL CO-ORDINATES OF SHEET CORNERS

29. These are shown in degrees, minutes and seconds to an approximate accuracy in terms of the geodetic datum used for the military grid, (for example, the North American datum).

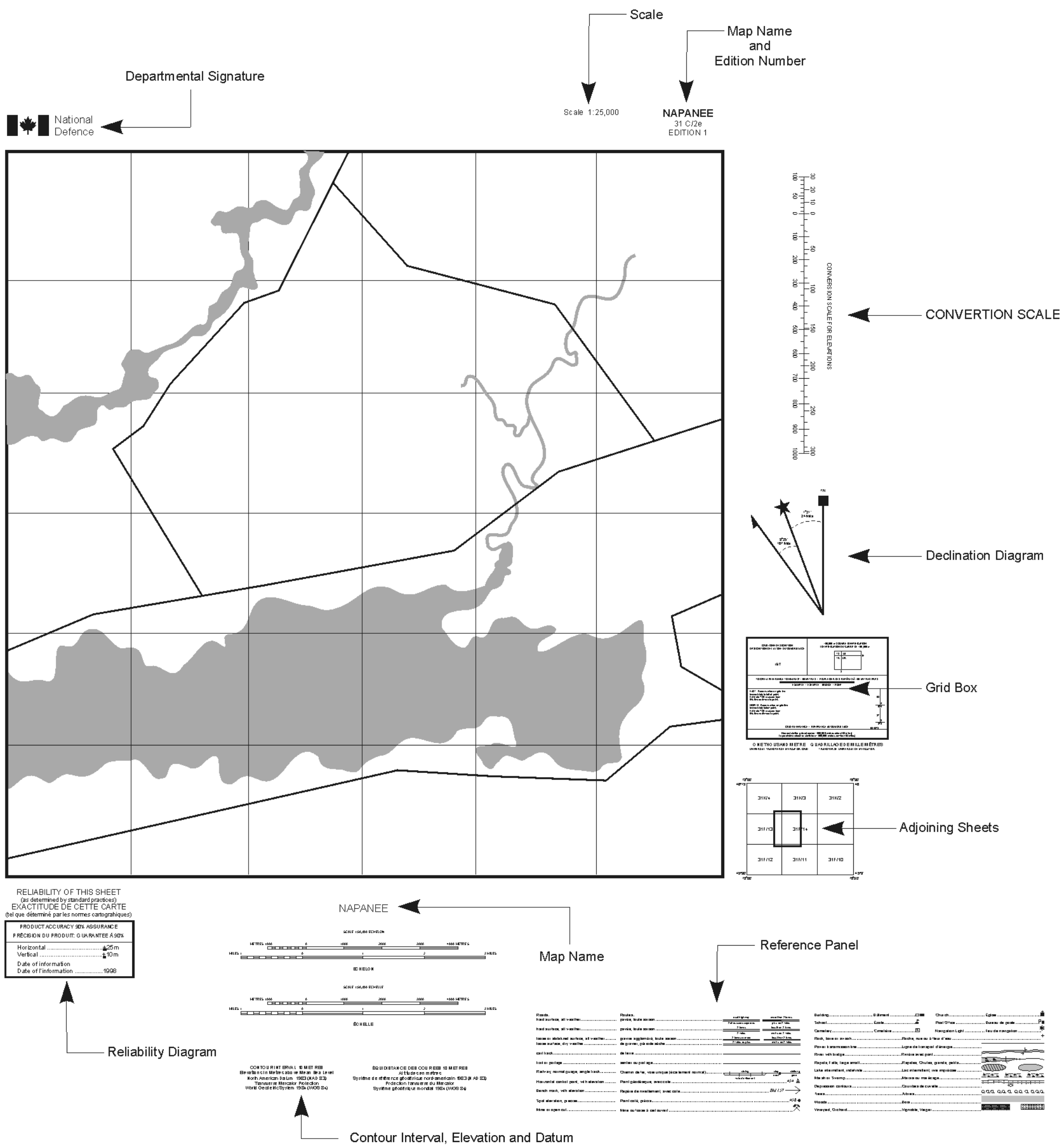


Figure 2-1: Map Identification

Military users, refer to this map as:	SERIES **A901** MCE 320 EDITION 1

Figure 2-2: Map Identification Panel

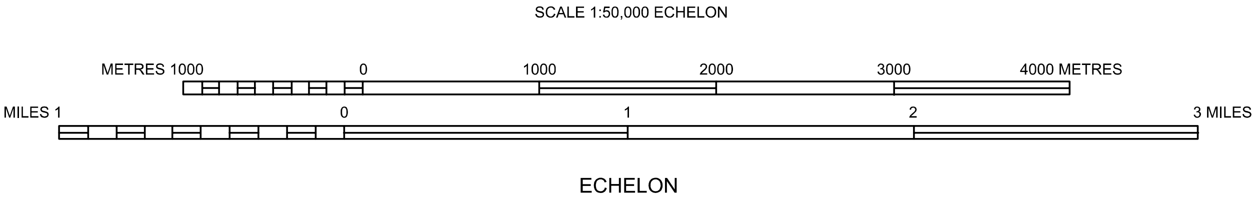


Figure 2-3: Scale

CONTOUR INTERVAL 10 METRES
Elevations in Metres above Mean Sea Level
North American Datum 1983 (NAD 83)
Transverse Mercator Projection
World Geodetic System 1984 (WGS 84)

Figure 2-4: Unit of Elevation and Contour Interval

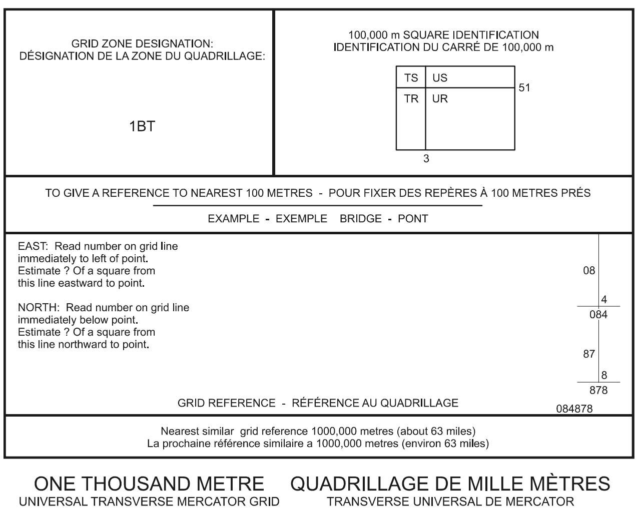


Figure 2-5: Use of Grid Instructions

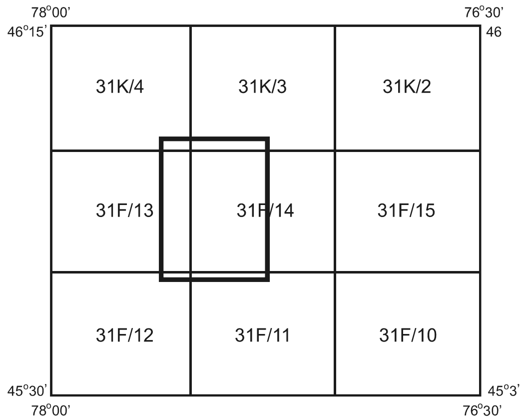


Figure 2-6: Index to Adjoining Sheets

RELIABILITY OF THIS SHEET
(as determined by standard practices)
EXACTITUDE DE CETTE CARTE
(tel que déterminé par les normes cartograhiques)

PRODUCT ACCURACY 90% ASSURANCE PRÉCISION DU PRODUIT: GUARANTEE À 90%
Horizontal ....±25m Vertical ....±10m Date of information Date of l'information 1998

Figure 2-7: Map Reliability

CHAPTER 3
SCALES AND DISTANCE MEASUREMENT

SECTION 1
MAP SCALE

DEFINITION OF SCALE

1. The scale of a map is the relationship between the horizontal distance between two points measured on the ground and the same two points measured on the map. This relationship is constant no matter which direction the distances are measured.

METHODS OF EXPRESSING SCALE

2. There are two methods used for expressing the scale of a map:

   a. by the representative fraction for example, 1:50 000; or

   b. in words for example, one inch to four miles.

REPRESENTATIVE FRACTIONS (RF)

3. The RF is the standard method of expressing a scale on all Canadian Maps and must be understood by all map users. The RF is 1:X, one unit of distance on the map will represent X units of distance on the ground.

4. For example, a scale of 1:50 000 means that one inch/centimetre/metre on the map represents 50 000 inches/centimetres/metres on the ground. The essential connection is that the same unit of measurement applies both to the map and to the ground measurement. For example a distance of 3 centimetres on a 1:50 000 scale map represents 3 times 50 000 centimetres on the round, that is 150 000 centimetres or 1 500 metres.

SCALES EXPRESSED IN WORDS

5. The use of scales expressed in words is obsolescent but is still in use and must also be understood. The most common example is the one inch to one mile map. In this case, one inch on the map represents one mile on the ground. If a direct comparison is required in metres, it is necessary to turn the scale into its representative fraction 1:63 360, i.e., one inch equals 63 360 inches or one mile; therefore: 1 centimetre = 63 360 centimetres = 633.6 metres.

6. For smaller scale maps such as the "Quarter Inch", one may express its scale as either ¼ inch to one mile, or four miles to one inch. The smaller the scale, however, the more likely one is to use the form "Miles to the Inch".

COMPARISONS OF MAP SCALES

7. There is no clear defining line between "large scale" and "small scale" maps. Typically maps with scales of 1:50 000 and less are considered "large scale" and maps with scales of 1:100 000 and greater are considered "small scale". The terms can be applied to different map scales according to the circumstances. It is however, important to be clear what is meant by "larger" scale or "smaller" scale when comparing two map scales. One map has a "larger" scale than another, if a given distance on the ground (say one kilometre) is represented by a greater map distance than on the other map. A feature portrayed on a "large scale" map will be larger than the same feature when it is portrayed on a "small scale" map. For example, a map scale of 5 centimetres to one kilometre is "larger" than a map scale of one centimetre to one kilometre. In the case of representative fractions, the same principle applies, but this means that the denominator in the fraction is smaller when the scale is larger (for example a scale of 1:50 000 is larger than a scale of 1:250 000).

EFFECTS ON A MAP OF CHANGE IN SCALE

8. It is important to realize, when map reading, the effects of a change of scale from a map with a scale of say 1:50 000 to one of 1:250 000. It is obvious that the distance between two identical points on the maps will be reduced to a fifth when changing from the larger to the smaller scale. It is not so obvious that this reduction of the distances takes place in all directions equally, and that consequently both sides of a rectangle will also be reduced to a fifth and the resultant area will be one twenty-fifth of the area on the larger scale map. Similarly, the space between items of detail will be proportionately reduced, and detail will appear more congested. See Figure 3-1. This is an important factor in map appreciation.

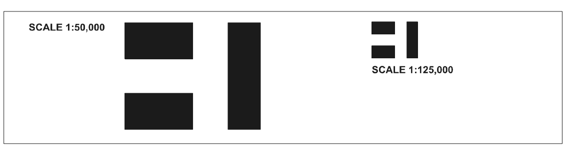


Figure 3-1: Effects of Change in Scale

SECTION 2
MEASUREMENT OF DISTANCE

SCALES ON MAPS

9. All maps carry graphic linear scales (usually in the centre of the lower margin) from which any horizontal distance may be measured on the map in statute miles, kilometres, metres, yards and nautical miles. These may appear in various combinations and various sizes depending on the type and scale of the map sheet. An example is shown in Figure 3-2.

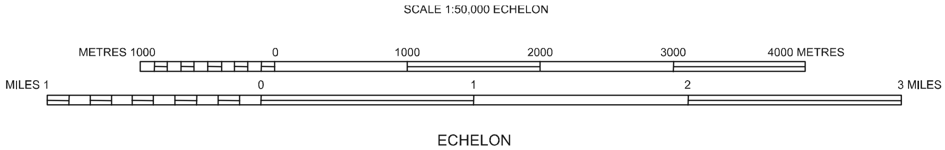


Figure 3-2: Linear Map Scale

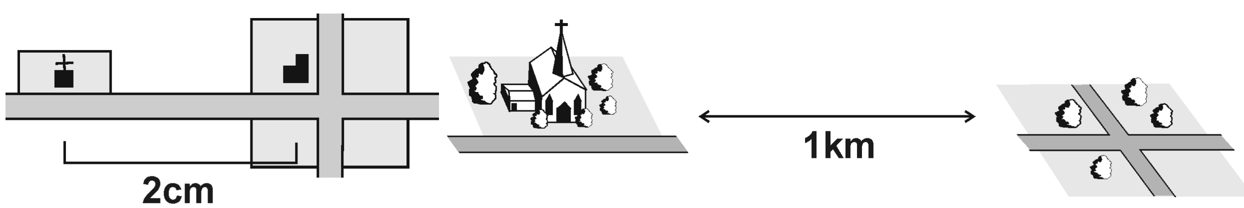
10. The zero is set back from the left of the scale by one major division, and this division is then usually subdivided into 10 equal sub-divisions. Measurements falling between these sub-divisions must be estimated.

MEASURING A STRAIGHT-LINE DISTANCE

11. To measure a straight-line distance between two points place a straight edge of a piece of paper against the two points and at each point mark the paper. Then place the paper along the scale line on the map with the right hand mark against one of the major divisions so that the left hand mark lies against the sub-divisions to the left of the zero on the scale. The total distance is then the number of major divisions plus the distance measured to the left of the zero.

USE OF SEPARATE SCALES

12. Separate scales such as those on the Protractor C2, (see Figure 6-4), may be used for measuring short distances on maps. It must be remembered when measuring long distances that the paper of a map may stretch or shrink quite appreciably, while a metal, plastic or wooden scale does not. The scale drawn on the map stretches or shrinks with the map, and therefore always provides a scale in conformity with the map detail. See paragraph 13 for further details.

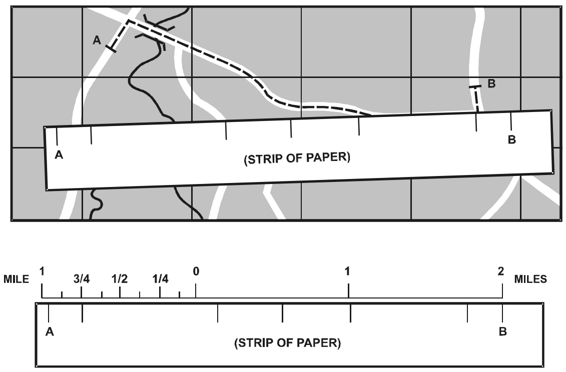


Distance sur la carte Distance on the map	Distance sur le terrain Distance on the ground

$$\frac{\text{Distance on the map}}{\text{Distance on the ground}} = \frac{2\text{ cm}}{1\text{ km}} = \frac{2\text{ cm}}{100{,}000\text{ cm}} = \frac{1}{50{,}000}$$

= 1/50,000 scale

Figure 3-3: Measure of Scale



USE OF GRID LINES

13. Most military maps carry grid lines (see Chapter 6). The grid lines are a fixed distance apart and may be used to make quick estimations of distances between two points. Separate scales may be checked against the grid lines before use to make sure that the map and the scale agree.

Figure 3-4: Measuring a Road Distance Off a Map

MEASURING A ROAD DISTANCE

14. To measure a distance that is not straight (for example along a 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 with a tick at the starting point and another at the end of the first section. Then pivot the paper about the second tick until it lies along the second section. Mark the end of the second section with another tick, and repeat the process until the last point is marked. The total distance along the road is then recorded as a straight line on the piece of paper, and can be read off against the scale as in paragraph 11. See Figure 3-4.

CHAPTER 4
MAP DETAIL

SECTION 1
GENERAL

DEFINITION OF DETAIL

1. “Detail” includes all types of natural and artificial features on the ground or on photographs, which are represented on a map. This does not include information such as names, figures, grids and the method of showing relief.

TYPES OF DETAIL

2. The following are the general types of detail:

a. towns, villages and buildings;

b. natural features, including vegetation;

c. communications features;

d. miscellaneous artificial detail; and

e. boundaries.

GENERAL METHODS OF SHOWING DETAIL

3. Where possible, detail is shown on maps by a representation to scale of its plan position on a horizontal plane. On large scale maps and plans (1:25 000), this can be done for a high proportion of the detail. As the scales get smaller, it becomes more and more necessary to generalize these shapes, or to resort to the use of symbols and conventional signs to illustrate the existence and position of the detail without any attempt to show its shape.

4. Where a shape can be shown, the outline of that shape is shown by a solid line or, if its limit is indefinite, by a dashed line. Solid lines always define buildings; dashed lines usually show the edges of vegetation or similar indefinite limits. Within the outline there may be a coloured filling or letter to distinguish between features or to provide extra information.

5. When the detail has length rather than width, it is usually shown by line symbols of varying thickness. The line symbols may be a double line, (for example—roads or broad rivers), or it may be single line. The lines may be solid or broken. Where they are broken, the pecks (chain dotting) and the spaces between them may be varied to provide distinctive symbols, and single or multiple dots may be added within the spaces between the pecks. In this way, by varying the thickness of the line and the size of the pecks, and by the use of cross bars and chain

dots, it is possible to produce a wide variety of line symbols on any single map. This enables the mapmaker to distinguish different classes of railways, roads, tracks, boundaries, etc. The use of different colours further increases the variety possible. Normally, the most important roads, boundaries or tracks are shown with thicker lines and with longer pecks, since these show up more clearly.

CONVENTIONAL SIGNS

6. In addition to the general methods of showing detail as described in paragraph 3, a number of symbols are used on maps. These are used to indicate pictorially or conventionally an item of detail, which cannot be shown either by outline or by line symbol. There are many such symbols, some of which are established by long usage and others by similar standardisation agreements (see Section 2). They cover many types of artificial detail such as town symbols, railway stations, churches, etc, and forms of vegetation such as coniferous and deciduous trees, marsh, etc. The meaning of the symbols should be obvious but if in doubt look at the table of conventional signs shown on the map. Figure 4-1 provides a typical example of such a table.

Serial No.	Description	Symbol
73	Rice paddies	
74	Marsh or swamp	(a)
75	Land subject to seasonal inundation	
76	Salt pan (salt evaporator)	
77	Index contour (thickened)	
78	Intermediate contour	
79	Auxiliary (supplementary) contour	
80	Depression contour. (Ticks on depression side of contour)	
81	Contour number. Numbers to read uphill, i.e. Tops of the figures towards the greater height	200
82	High cliff	
83	Medium and low cliff or escarpment less than contour interval	
84	Distorted surface (uneven rock, karat, etc)	(b) Rocky

Serial No.	Description	Symbol
11	Railroad, normal gauge in use in country. Two or tracks. Single track. (Differentiation between broad and normal gauge to be noted in this legend or by labelling along the symbol).	(a)
12	Same, not in operation (under construction, abandoned, etc)	(a)
13	Narrow gauge railroads and tramways, in operation. Two or more tracks. Single track. (Not to be used for minor industrial railways).	(a)
14	Same, not in operation (under construction, abandoned, etc)	(a)
15	Other lines, e.g. Aerial cableway, ski lift, funicular, conveyor belt, telephone line, telegraph line, etc	
16	Railway yard	
17	Railway station. Position of sign in relation to railway sign to indicate side of approach if approach to the station is only possible from one side.	(C)
18	Halt. (Flagstop). Position of sign in relation to railway sign to indicate side of approach if approach to halt is only possible from one side.	(C)

Serial No.	Description	Symbol
19	Level crossing.	
20	Overpass and underpass.	
21	Tunnel, road or railroad.	
22	Railway bridge	
23	Road bridge	
24	Foot bridge	
25	Ferry across narrow open water area	(a)
26	Ford for road across wide double line stream.	
27	Ford for road across wide double line stream.	
28	Built up area, showing main roads, secondary roads, railways and conspicuous buildings. Minor streets may alternatively be shown by single lines. Colour of the filling is optional.	
29	Individual buildings.	
30	Christian place of worship.	(c)
31	Muslem place of worship.	(c)

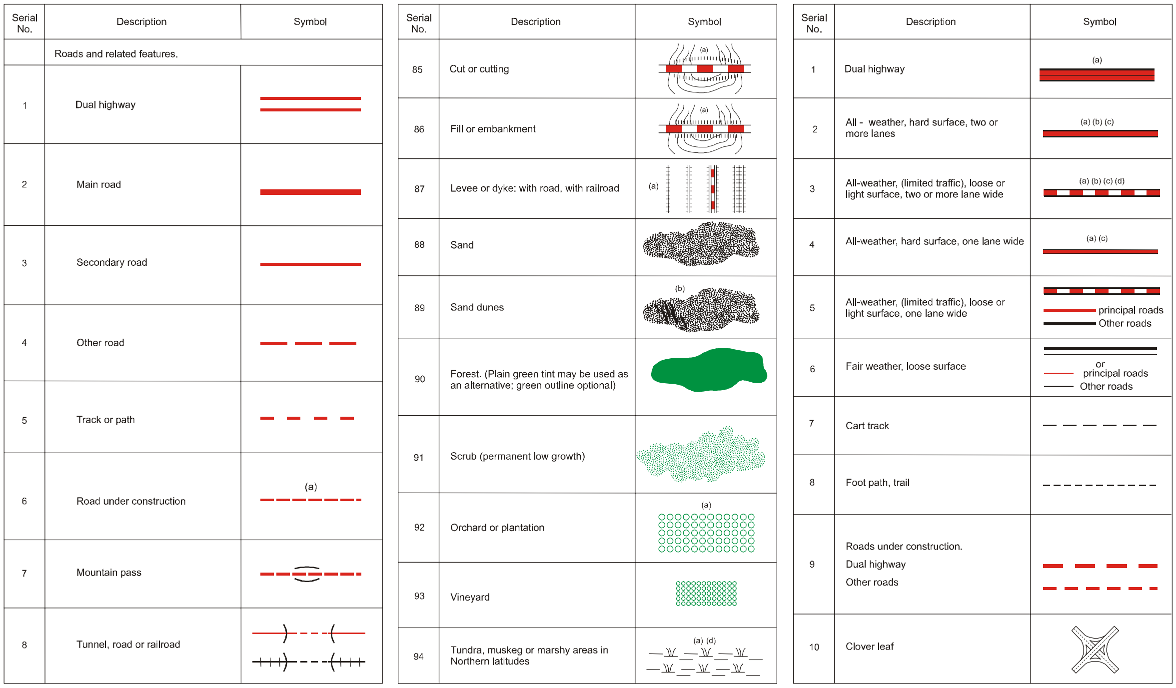


Figure 4-1: Conventional Signs

DESCRIPTION

7. Where a conventional sign or other type of symbol may have several meanings, the sign or symbol may be clarified by a descriptive word, (for example tank or tower written beside it).

USE OF COLOUR

8. The use of different colours is a major means of showing and distinguishing detail of any or all of the types of detail listed in paragraph 2. As there are conventions for symbols, there are similarly conventions for colours. Unless governed by international agreements, these colour conventions are not binding, but they are well established by usage and are therefore normally followed.

9. The following colours, which are illustrated in Figure 4-1 are normally used as follows:

a. blue—water, marsh; permanent ice and snow features;

b. black—outlines of all artificial detail (rocks and cliffs on a coast);

c. red—main roads and sometimes buildings;

d. green—woods, vegetation; and

e. brown—contours and sand.

FILLINGS AND TINTS

10. A "filling" is the term used for a colour printed within an outline to aid in the identification or the emphasis of the item. For instance, different coloured fillings may be used to distinguish between different classes of road.

11. For larger areas such as woods or water areas, the fillings are normally light in colour so that detail within them is not obscured. Alternatively, the edge of the areas concerned may be shown by a band of colour fading away from the edge, leaving the centre of the area clear.

SECTION 2
INTERPRETATION OF MAP DETAIL

CONVENTIONAL SIGNS

12. The following figures are provided to exemplify the symbols on a variety of maps that are in common use. The figures should be studied in conjunction with a copy of each type of map illustrated. Each figure includes a section of the map concerned but does not necessarily include all the symbols shown on its table of conventional signs:

a. figure 4-2—1:50 000 Training Area Map (TAM);

b. figure 4-3—1:50 000 Foreign; and

c. figure 4-4—1:25 000 Military Town Plan (MTP).

13. Paragraphs 15 to 24 will explain the principal features of common design and the major points of difference, with references to these typical maps, for the main categories of detail listed in paragraph 2.

14. Each map must be studied on its own merits and with careful reference to its own legend. While a great variety exists in symbols and colours, there is much in common in the general pattern, and a map-reader should soon be able to interpret correctly the symbols on any map he uses.

TOWNS VILLAGES, AND BUILDINGS

15. The symbols for buildings are indicated in solid black, as is the case for the foreign map, Figure 4-3. In Figure 4-4, buildings are grey except for buildings relating to numbered features, which are shown in their appropriate colour. The built-up areas on 1:50 000 maps are indicated by a pink tint and on 1:25 000 maps by an orange tint. On smaller scale maps, individual buildings or groups of buildings are not always shown.

16. It should be noted that on all of these maps the size and style of type used for the name of the town or village plays an important part in distinguishing the relative status of the place. The basis of this distinction is not always explained on the map owing to lack of space available, but

capital letters and larger sizes of type are used for the more important place names to draw attention to them, the size of type getting smaller as the degree of importance diminishes. This relative importance may be based on the administrative status of the place, for example a capital city, or on the size of the population, or on a combination of these factors.

NATURAL FEATURES

17. On all figures, water features are shown in blue and contours in brown. Names of water features are also shown in blue. Where the width permits within the scale, rivers are shown using double lines; otherwise using a single line represents them.

18. On Canadian maps, woods are shown on all the maps with a green tint. On the German 1:50 000 maps, deciduous and coniferous trees are distinguished by symbols; other forms of vegetation are also indicated by different symbols as shown in the "Legend", i.e. the table of conventional signs. On 1:250 000 scale maps less detailed information is available.

COMMUNICATIONS

19. The symbols for roads and railways are appreciably different on the various map examples contained in this publication but they have a number of common points. Roads are shown by double lines with coloured fillings or solid colours only, the more important the road is the wider the symbol. Broken coloured fillings denote a lower importance than a solid filling, as shown in Figures 4-3. In Figure 4-2, less important roads are shown by a change in colour and width. The less important roads and tracks are shown by single lines, the lowest grade being a single pecked line. Dual highways on the different scales are shown in a variety of ways.

20. Railways symbols vary. The distinctions however, are usually between standard gauge and lesser gauge lines, and between single and multiple tracks (see Figure 4-2). Railway symbols are nearly always in black.

21. Canals are shown by double or single lines if their width permits at the scale; on the 1:25 000 scale (see Figure 4-4, the Rideau Canal top right) navigable canals are symbolized with double lines.

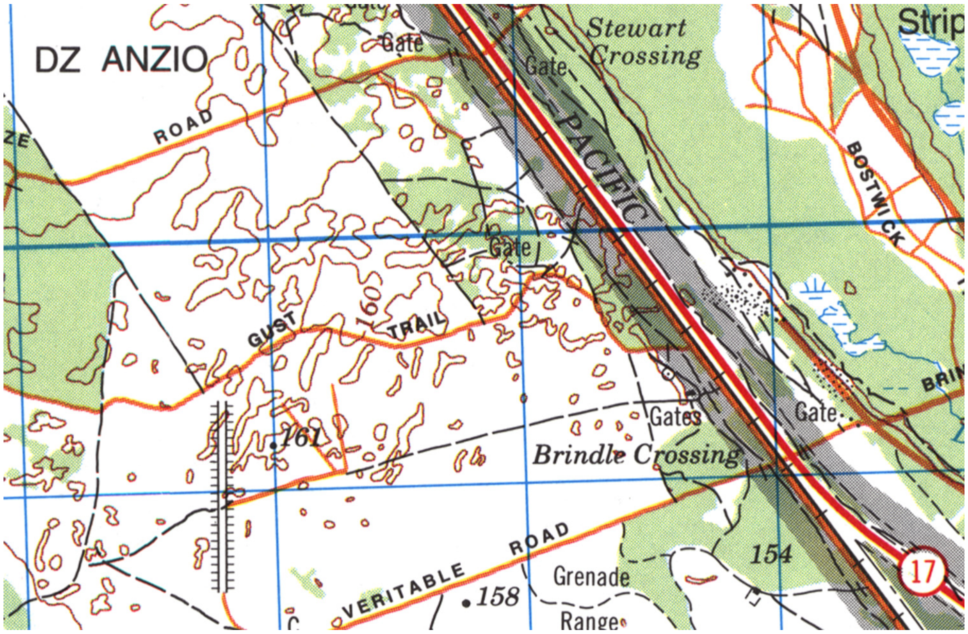


Figure 4-2: TAM 1:50 000

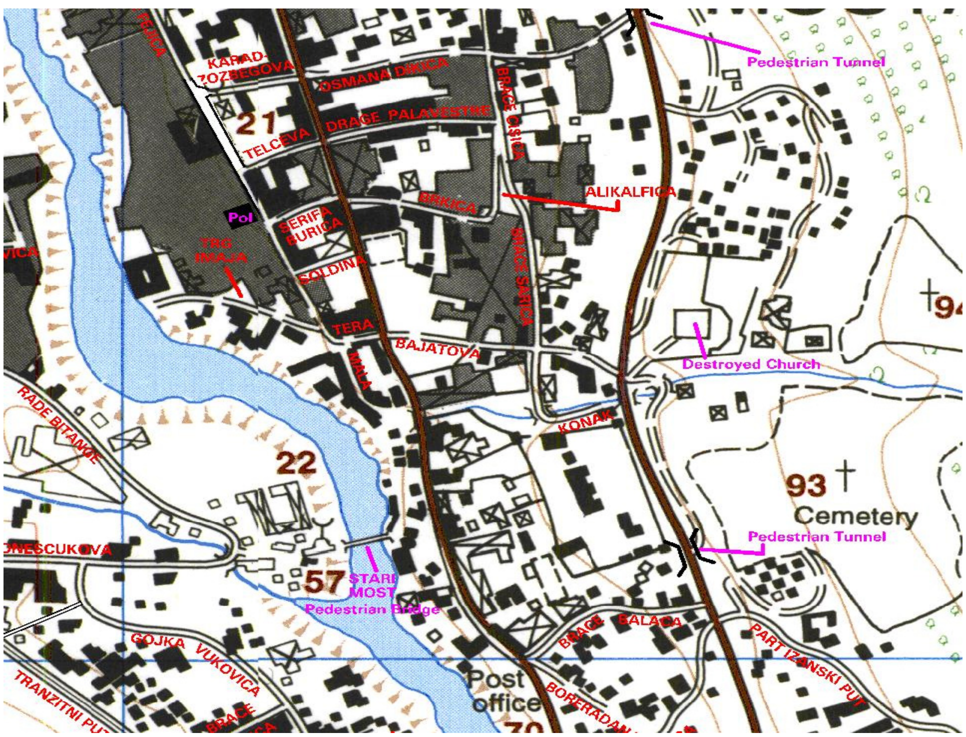


Figure 4-3: Foreign 1:50 000

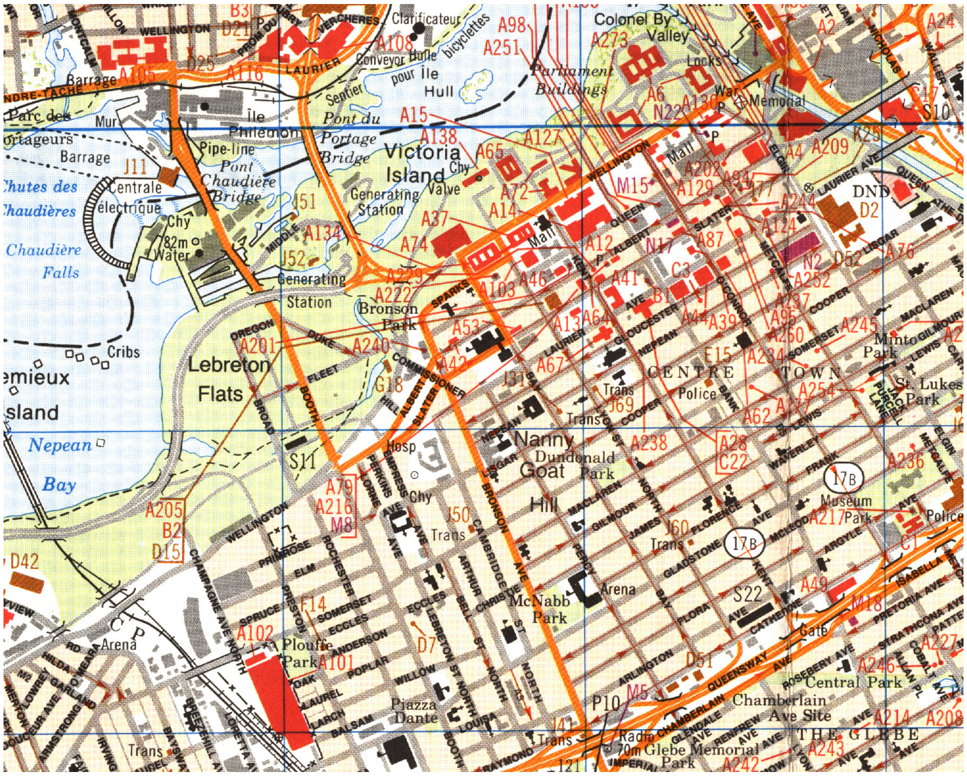


Figure 4-4: Military Town Plan 1:25 000 Miscellaneous Artificial Detail

MISCELLANEOUS ARTIFICIAL DETAIL

22. On the 1:250 000 and 1:50 000 scales, there are a great variety of symbols, usually in black except for water items that are in blue. Symbols aim to indicate the nature of the item shown, for example church symbols always include a cross. The symbols for embankments and cuttings are generally standard: note that the hachures always taper down the slope, (i.e. away from the road or railway on an embankment and towards them in a cutting).

23. On the 1:250 000 scale, there is less artificial detail shown. On all scales, symbols may be supplemented or replaced by abbreviations or descriptions.

BOUNDARIES

24. Boundary symbols vary but are always single line symbols with pecked lines and dots whose thickness varies. International boundaries may have a colour band to emphasize them.

POSITIONING OF DETAIL

25. Detail is normally placed in its correct map position: there are, however, some exceptions, which should be understood.

26. Symbols frequently occupy a larger map space than their actual size on the ground warrants. For example, a double line road usually represents a greater width at the map scale than its actual width on the ground: similarly conventional signs for trees, buildings, etc., occupy more map space than their actual position on the ground.

27. The correct positions for such objects for measurement purposes on the map are normally as follows:

a. for double line symbols, halfway between the lines;

b. for rectangular or circular symbols, the centre; and

c. for vertical symbols, such as a lighthouse, the centre of the base.

28. There are, however, occasions when detail has to be displaced owing to lack of space at the scale to show all the symbols in their correct positions, (for example when a road runs alongside a river or a house stands alongside a road). In such cases, the position of one item may be displaced from its true position to maintain a picture of the relative positions of the two items. There are no hard and fast rules as to which item is displaced (sometimes both may be moved), but normally the artificial feature, such as the house, will be moved to suit the road. The map-reader must realise that the scale of the map imposes limits on positional accuracy and must make allowances accordingly.

SECTION 3
MILITARY INFORMATION

GENERAL

29. It is often necessary to show purely military information on a map in addition to the topographical detail. Such information includes positions of formations, units and headquarters both enemy and friendly, also formation boundaries and other military requirements. The symbols to be used to show this information are laid down in B-GL-331-001/FP-001 *Command Support Doctrine* and B-GL-331-003/FP-001 *Military Symbols for Land Operations*.

OVERPRINTS AND OVERLAYS

30. The information may be shown by overprinting on the normal map of the area, or on a special printing of the map in subdued colours to enable the military information to show up more clearly. Such overprinting, however, is only likely when the information is required in quantity, and of course when time permits.

31. Military information is normally added by hand in unit and formation headquarters on a transparent plastic overlay fitted over the normal coloured map. Information is added by coloured marker pencils, and is amended by hand as required. It may also be entered digitally when using a digitized Command and Control Information System.

CHAPTER 5
THE SHAPE OF THE GROUND

SECTION 1
METHODS OF SHOWING RELIEF

DEFINITION OF RELIEF

1. “Relief” is a general term applied to the shape of the ground in a vertical plane. The representation of relief on a map is the showing of the heights and shapes of the ground, above or below a datum, which is normally sea level.

2. On some plans and maps, no relief is shown, but on all topographical maps and on almost all maps required for military purposes, some representation of relief is necessary. The extent to which it is shown and the accuracy required will vary appreciably according to the scale and purpose of the map.

ELEMENTS IN REPRESENTATION OF RELIEF

3. There are two distinct elements in the representation of relief. These are:

    a. representation of height; and

    b. representation of shape.

4. Representation of height is a factual matter in which the variations will arise from the type, density and accuracy of the information provided. On the other hand, representation of shape may be largely artistic, and this method will vary on different maps.

UNIT OF VERTICAL MEASURE

5. The standard unit of vertical measure for Canadian military maps is in metres. Many of our allies use the metre unless there are special reasons for the contrary, for example, charts used by some of their air forces. In the latter case, the foot is still the unit of height, and when the same basic map is used by both ground and air forces, such as Joint Operations Graphic 1:250 000, separate editions are usually prepared for land and air use. Therefore, always check to be certain which unit of measurement is being used. It is stated prominently in the margin of every map. See chapter 2, paragraphs 15 and 16.

REPRESENTATION OF HEIGHT

6. Fixing the height above mean sea level at selected points shows height, without reference to shape. These points in descending order of accuracy may be:

a. **Levelled Heights (Benchmarks)**. These are the most precise heights and normally appear only on scales of 1:25 000 or larger. They are indicated by the symbol BM (benchmark) and the height expressed to one or more decimal places. A benchmark is usually a permanent mark, cut on a stone built into a wall or on the side of a triangulation pillar; the height given is the height of the mark and not the level of the ground.

b. **Trigonometric Heights**. Trigonometric stations and survey control points of similar accuracy are usually shown on maps when they are defined on the ground by a pillar or other recognizable mark. They are usually indicated by a small triangle with the height expressed to the nearest unit.

c. **Spot Heights**. These are less accurate heights and normally without any definite mark on the ground. They are selected to indicate the height of the ground at prominent points such as tops of hills or slopes, bottoms of valleys, ridge points and saddles, and are used to supplement the information provided by the contours. They are shown by a dot with the height. Their accuracy will vary, but should be as accurate as the contours.

CONTOURS

7. A contour is a line on the map joining points of equal height, and is the standard method of showing relief on topographical maps. Contouring combines an accurate indication of height with a good indication of shape, especially when used in conjunction with spot heights (see paragraph 6).

8. Contours are shown at a regular vertical interval, i.e., difference in height between successive contours, which varies according to the scale of the map and to the type of terrain mapped. The contour interval is always stated prominently in the lower margin of the map near the graphic scales (see chapter 2, paragraph 16). On a 1:50 000 map with average relief the contour interval may be 20 metres; at 1:250 000 scale it is probably 60 metres.

9. Contours are normally drawn as continuous lines. Every fourth or fifth contour (depending on the vertical interval) is called an "Index Contour" and is shown by a thicker line; this helps in reading and counting the contours to determine a height. Contour values are placed in breaks made in the contour lines. They are positioned so that they read the right way up when looking up the slope.

10. When a small rise within the standard vertical interval is of particular significance, auxiliary contours at an intermediate vertical interval may be shown to supplement the standard contours. This occurs on maps of essentially flat ground. Auxiliary contours are usually broken to distinguish them from standard contours and their values are shown.

11. The interpretation of contours is covered in Section 2. Vertical interval is often abbreviated as VI.

FORM LINES

12. Form lines are approximate contours sketched to show the general shape of the ground rather than its height. They are used when it has not been possible to obtain accurate contours. They are usually shown by broken lines, but are not given height values. They are to be found only for poorly mapped areas.

HACHURES

13. Hachures show the relief by means of short disconnected lines drawn down the slope in the direction of the water flow. The lines are short and close together on the steeper slopes, and longer and more spaced out on the gentler slopes. This is an artistic method, which can give a good idea of shape but no definite height information. It was employed on many earlier maps but is now generally used only to depict cuttings, embankments and steep slopes. When used for these purposes, they are usually shown in black.

LAYERING (ALTITUDE TINTS)

14. A layer is a uniform tint applied on the map to all ground between defined limits of heights above or below a datum, for example all ground between 60 and 200 metres above sea level. By using different tints for different layers, it is easier to give a clear picture of the variations of height or depth over an area. Layers are normally used in conjunction with contours to assist the user in gaining a quick appreciation of relief. They are occasionally used alone or in conjunction with hill shading (see paragraph 15) to give a general impression of relief in areas where there is insufficient accurate height information for contouring. They are normally shown only on scales of 1:250 000 and smaller.

HILL SHADING

15. Hill shading is a commonly used technique to indicate shapes, either alone or in conjunction with contours and/or layers. It does not itself give any indication of height, only of the steepness of the slope, but it gives an excellent visual picture of relief. Basically, hill shading is designed to provide contrast by shading the "Dark" side of a feature and lighting up the "Sunny" side. The darker the shading, the steeper the slope on the shadow side. The light is normally assumed to come from the northwest corner of the map.

HYDROGRAPHIC RELIEF

16. Hydrographic relief, (the showing of depths below sea or water level), is shown in a similar way to ground relief, which is, by depth values and contours. Contours are shown similarly to land contours except that they are normally in blue. Their values are usually related to mean sea level, but for inland water, they must be related to the surface level of the water. The datum should be stated on the map. Hydrographic information for coastal waters is

normally taken from Hydrographic Charts. The unit of measure on these charts will indicate depths in fathoms, in feet (one fathom is six feet) or in metres.

SECTION 2
INTERPRETATION OF CONTOURS

GENERAL

17. Figure 5-1 shows a perspective view, elevation (side view), and plan of a hill with its contours. The shape of a contour indicates the shape of the ground. When these contours are further apart there is a greater distance to travel to gain or lose the height of the vertical interval between contours, and therefore the slope is less steep than when the contours are closer together. When the contours are an equal distance apart, the slope is uniform.

18. Figure 5-2: illustrates a number of features as shown by contours and elevation. The following points should be noted:

a. Contours are continuous. No matter how far they run, they must in the end return to their starting points; the only exception is when a contour runs into a cliff where the slope is so nearly vertical that there is no room in a plan view to show the contours separately. In such cases, the cliff is usually shown by a symbol, and the contours run into it and out of it on either side where the slopes permit them to be shown.

b. When the spacing of contours down a slope becomes close together at the bottom, the slope is convex. Convex slopes mean short visibility and fields of fire, dead ground will be in close.

c. When the spacing of the contours gets further apart at the bottom, the slope is concave. This facilitates extended visibility. Meandering contours separated by varying distances, but never close, mean undulating ground. In such country, one must look for the general fall of the ground.

d. Irregular and closely spaced contours indicate rugged and broken slopes. Smooth contours indicate smooth slopes, except that at smaller scales the contours tend to be smooth as part of the generalization process to eliminate minor detail.

e. Contours always point up rivers and streams. The sharper the angle at which the contours turn on the stream, the steeper the slopes on the sides.

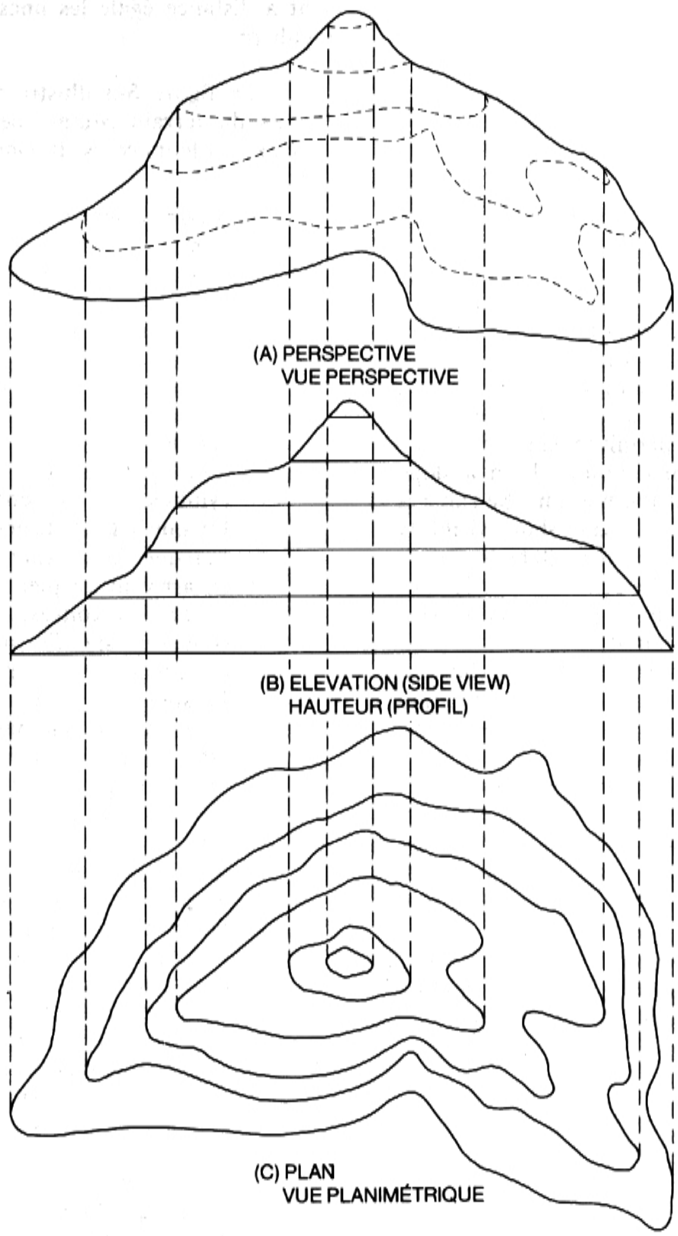


Figure 5-1: Contours

INTERPRETATION

19. The correct interpretation of the shape of the ground from the contours requires practice and experience on the ground. It is essential to study the various features, comparing the map and the ground in each case. First, concentrate on the major features (ridges, valleys, etc) and then study the minor features, variations in slope, etc. With practice, it will be possible to build up a mental picture of the shape of the ground from the study of the map only.

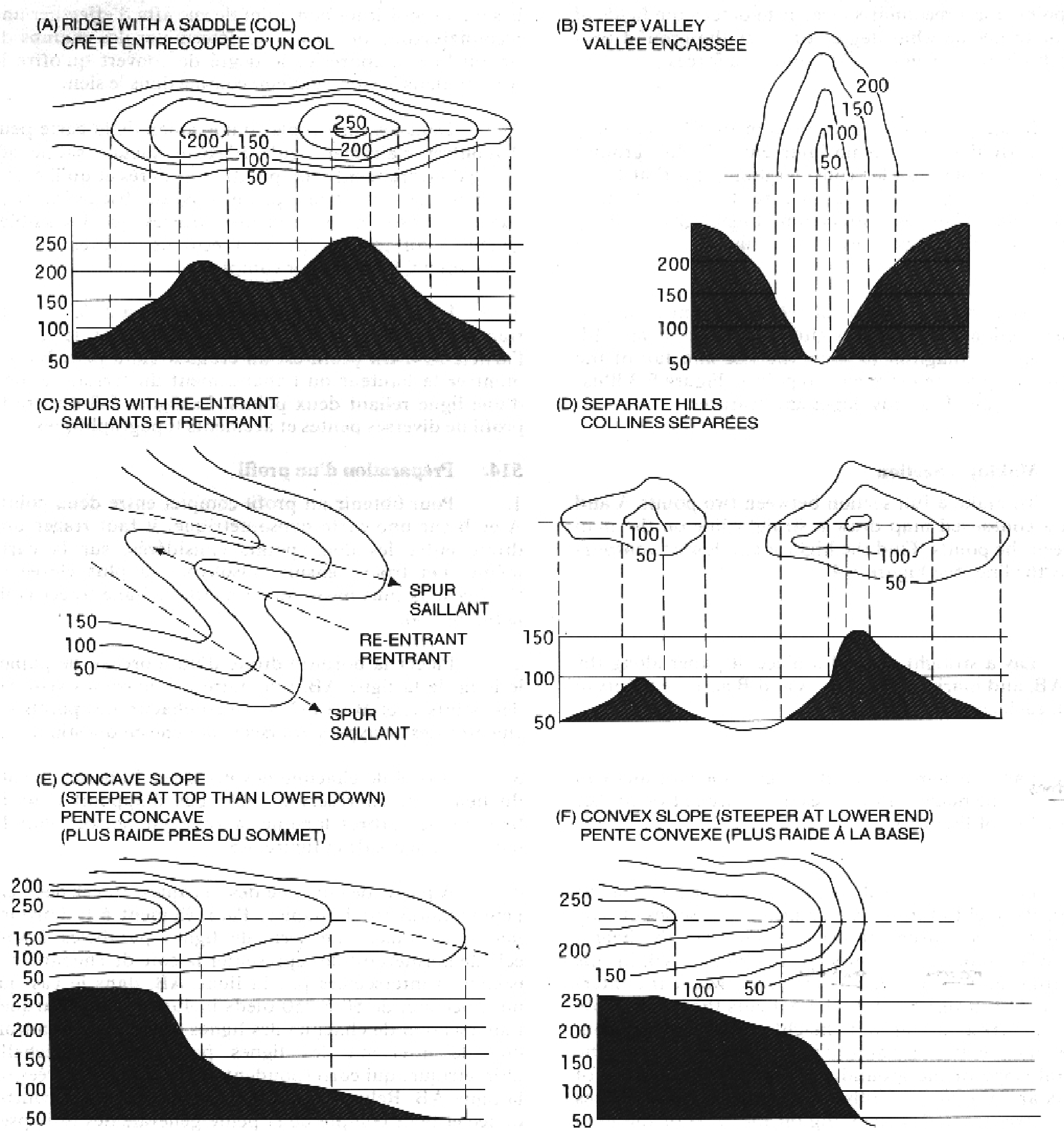


Figure 5-2: Contour Shapes and Features

SECTION 3
INTER-VISIBILITY

GENERAL

20. It is often necessary to find out if one point can be seen from another. One may also be require to select good viewpoints for a reconnaissance, to determine fields of fire, or to decide what degree of cover the ground provides, both to the enemy and to your own forces.

21. In simple cases, an inspection of the map may show clearly that there is no intervening higher ground between the points under consideration, and that there is or is not a convex slope to obscure the view. Obvious obstructions, other than intervening higher ground, may be trees or buildings, and these must be taken into account.

22. Where the answer is not certain, it is necessary to make a section of the line of sight as explained in paragraph 23. A section is a diagram to show the rise and fall of the ground along a line between two points. Figure 5-2 illustrates a section of various slopes and features.

MAKING A SECTION

23. To make a full section between two points A and B on a contoured map draw a straight line on the map between two points. Find the highest and lowest contours cut by the line. See Figure 5-3.

24. Lay the straight edge of a piece of paper along the line AB, and mark on its points A and B and the points at which each contour cuts this line.

25. Label each mark with its height, allowing an extra 20 metres for the height of the trees in the area of woods. See the top line of Figure 5-4.

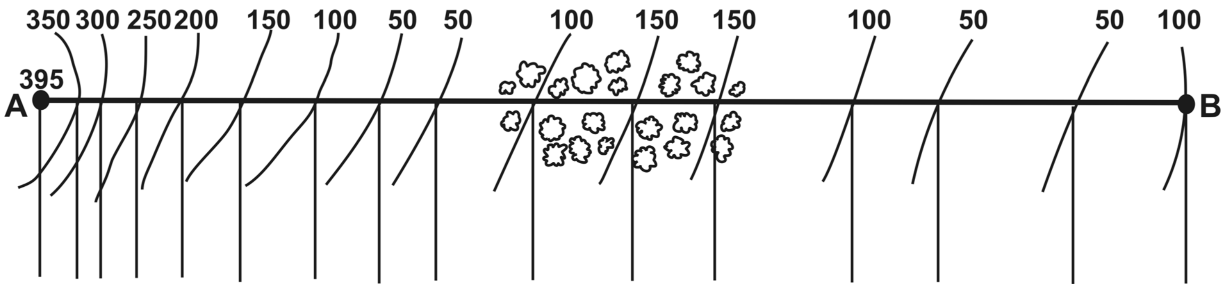


Figure 5-3: Making a Section. (Highest contour 350 metres. Lowest 50 metres. Average height of trees 20 metres)

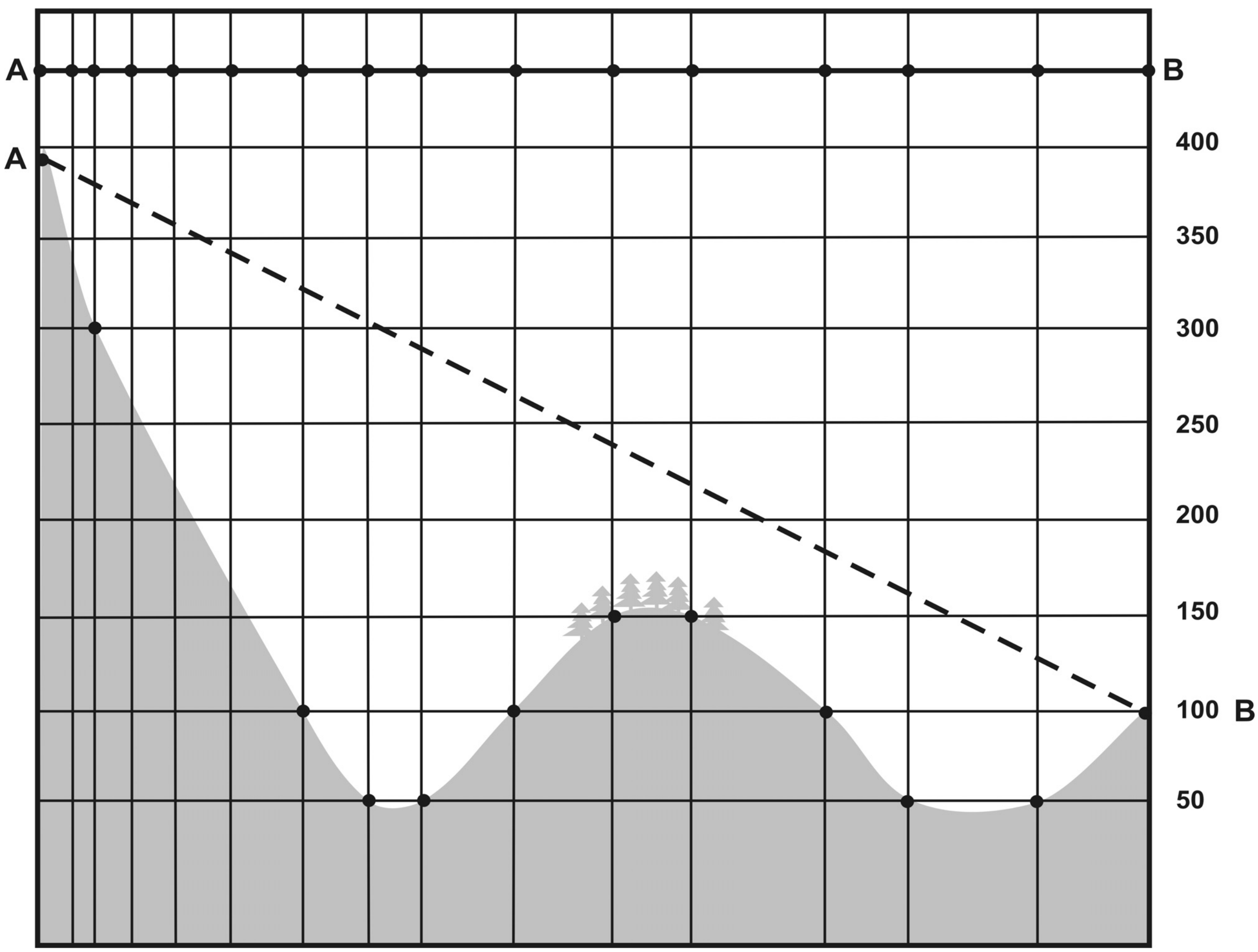


Figure 5-4: Section Showing Inter-visibility

26. From each mark drop perpendicular lines on the paper. Parallel to this marked edge draw a series of parallel lines at a convenient scale to represent the height value of each of the contours cut by the line AB, in this case from 50 to 350 metres inclusive. Mark the intersection of each vertical line where it cuts the height scale parallel corresponding to its height on the line AB. Join these marks with a smoothly curved line, allowing for the general slope of the ground contours at the bottoms of valleys and the tops of hills. See Figure 5-4. The slopes will be exaggerated, depending on the ratio of the map scale to the vertical height scale selected, but otherwise the section will give an accurate representation of the surface of the ground along AB.

27. The use of grid paper makes the drawing of a section easier and quicker.

DETERMINING INTERVISIBLITY

28. The section in Figure 5-4 may now be used to determine whether points A and B are intervisible, by putting a straight edge between these points on the section. It will be seen that there is a clearance of about 20 metres above the trees. This would not have been obvious by inspection from the map alone.

29. In many intervisibility problems, there is only one possible obstruction point, as in this case. In such instances, there is no need to make a full section, all that is required is to check whether the line of sight clears the one obstruction or not. This is done simply and quickly, by making a partial section, plotting only the three points involved. Allowance must be made for trees or buildings, wherever this may be critical.

WARNING

30. Intervisibility problems cannot always be solved accurately from a map. Buildings and trees are not always shown on maps (due to new buildings, new growth, or other reasons), and the positioning of contours is not always exact. Where the visibility problem is critical, it is essential to make sure on the ground.

31. It may often happen that the obstacle to visibility is the slope of the ground immediately in front of the viewpoint, and this point must be watched. A convex slope may shut out the view of lower points, unless they are far away.

SECTION 4
GRADIENTS

DEFINITION OF GRADIENT

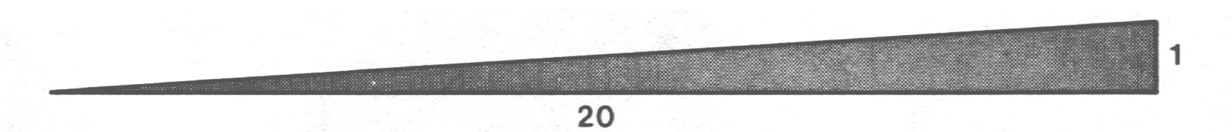


Figure 5-5: Gradient

32. The steepness of a slope is normally defined as a gradient. Figure 5-5 illustrates a gradient of 1 in 20, i.e., 1 unit in the vertical direction for each 20 units in the horizontal. As long as the units are the same in both directions, it makes no difference whether they are in feet or in metres. The gradient is sometimes written as 1/20.

33. Gradients are often expressed as percentages. To convert a gradient expressed as a fraction multiply by 100.

a. For example: 1 in 20 = $\frac{1}{20}$ X 100 = 5 per cent.

b. To convert the opposite way divide by 100. For example:
20 per cent = $\frac{20}{100}$ = $\frac{1}{5}$ or 1 in 5

DETERMINATION OF ROAD GRADIENT FROM A MAP

34. Visualizing gradients by eye is difficult. It is more effective to take measurements off a map. To determine the gradient of a road at any point from a map, measure the horizontal distance on the map between successive contours and express this in the same unit as the contour interval. For example, if the contour interval is 20 metres and the distance measured on the map between two successive contours is 200 metres, the average gradient between those contours is 20/200 = 1/10, 1 in 10 or, 10 per cent.

35. To find the steepest gradient on a road, find the point at which two successive contours are closest together, and measure the gradient as in paragraph 1 above.

36. If it is desired to check that the maximum gradient along a road does not exceed say 1/6, then the distances between successive contours at a 20-metres vertical interval must not be less than 6 x 20 m or 120 metres. Marking on a piece of paper a distance of 120 metres at the map scale, the interval between successive contours can be checked to see whether the distances at any point is less than the set distance. If so, the gradient is steeper than 1/6.

ROAD SECTIONS

37. Sometimes, it is desirable or necessary to make a section of a road to get a visual picture of all the gradients. This is done in the same way as described in paragraph 23, but in this case the base line of the section is the length of the road as measured along the road taking its centre line. Similarly, the distance between the successive contours must also be measured along the road.

CHAPTER 6
MAP REFERENCES

SECTION 1
GRID REFERENCES

GENERAL PRINCIPLES

1. A grid is a rectangular system of lines superimposed on a map, within which, any point can be defined and located by reference to the lines enclosing the square within which the point falls. The principle of all systems of grid reference is the same.

2. Maps are normally printed so that north is approximately at the top of the sheet when the writing is the right way up. Therefore, the rectangular lines of the grid are drawn so that one set of lines runs approximately north-south, and the second set of lines runs approximately east-west. Its distance east of a north-south line, and north of an east-west line thus indicates the position of each point within a square.

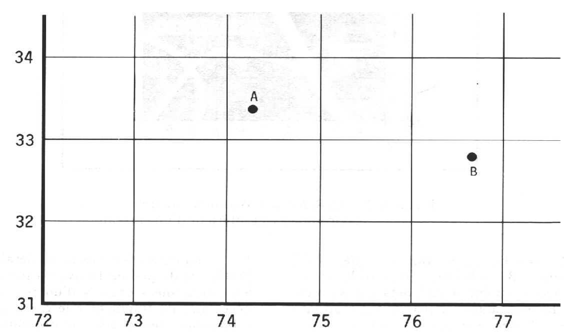


Figure 6-1: Grid Squares

3. North-south lines are given values called "eastings" according to their distances east of an origin falling at the southwest corner of the grid system; similarly east-west lines are given values called "northings" according to their distance north of this origin.

HOW TO GIVE GRID REFERENCES

4. Figure 6-1 illustrates a part of a typical grid system with the north-south lines given eastings of 72 to 77 units, while the east-west lines are given northings of 31 to 34 units. A and B are two points on the map of which grid references are required.

5. Grid references are always given with the easting value first followed by the northing value. The grid reference of the intersection of easting line 74 with northing line 33 is therefore 7433.

6. When giving a grid reference to a square, the reference is always to the southwest corner of the square. Thus the reference to the square in which A falls in Figure 6-1 is 7433. Similarly, B falls in square 7632.

7. A reference to a grid square is only adequate if accompanied by a brief description, for example the village in square 7433. When, however, the reference is to an item of which there is more than one in the square, for example a bridge, it is necessary to give a more precise reference if the correct bridge is to be identified. This technique is described in paragraph 8.

GRID REFERENCES WITHIN A SQUARE

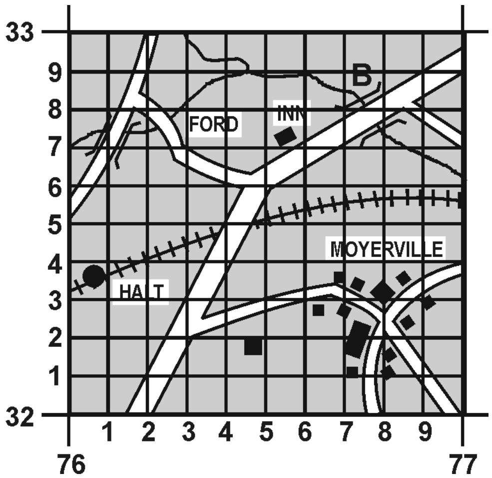


Figure 6-2: Grid Reference Within a Square

8. Figure 6-2 shows the detail within the square 7632, which contains point B, a bridge. To provide an accurate grid reference to a point of such detail, it is necessary to break up the grid square shown on the map into 10 subdivisions in each direction as shown in Figure 6-2.

9. The centre point of this bridge is in the small square whose southwest corner is 7 units east of easting 76, and also 7 units north of northing 32. Its easting is thus 76.7 and its northing 32.7 units. Omitting the decimal points, the grid reference is thus written as 767327. This is termed a six-figure grid reference.

10. The two other bridges within the square are at 761327 and 764324. Similarly, the church is at 768323 and the railway station is at 760323.

11. In Figure 6-2, the breakdown of the grid square into tenths has been drawn to help describe the method. In practice, the tenths of a unit are estimated, or may be measured with a romer as described in paragraph 21.

12. Should it be necessary to indicate a position even more accurately, the same method of estimation may be extended another stage by dividing each of the small squares again into further tenths and by adding a fourth figure to each of the eastings and northings. The fourth figure represents one hundredth of a unit. The reference to the railway station in Figure 6-2 could be written as 76053236, but such a reference is only required when a six-figure reference is not precise enough to define the point without any doubt.

13. Important points to remember are that:

a. All the easting figures are always given before the northing figures, i.e., the first half of any grid reference is the easting and the second half the northing.

b. Grid reference figures are never rounded up to the nearest figure, but are always given to the reference lines west and south of the point. The six-figure reference to the railway station is thus 760323 and not 761324.

GRID SQUARE UNITS

14. The grid references described in paragraph 8 have all been expressed in terms of “Units”, as the principle is the same whatever these units may be. In practice, in most grids used by the military (see Section 2) the grid unit is the metre. The grid unit is always stated on the map. All examples given in this publication are in metres.

SIZES OF GRID SQUARES

15. The spacing of the grid lines to define the sizes of the individual grid squares depends on the map scale. It is desirable to have a square which is small enough to enable the user to estimate tenths by eye, but which is not so small as to make the frequency of the grid lines over-power the map. The following may be taken as a general guide:

a. 1:25 000 and 1:50 000 1 000-metre squares; and

b. 1:250 000 and smaller 10 000-metre squares.

ACCURACY OF GRID REFERENCES

16. As explained in paragraph 8, the normal grid reference, to a point of detail, is made by estimating tenths of a square. Based on the square sizes in paragraph 9, the accuracy to which such a reference can be given is therefore one tenth of the square size, i.e..

a. 1:25 000 and 1:50 000 100 metres; and

b. 1:250 000 and smaller 1 000 metres.

17. Using references to a further decimal place as in paragraph 12, the references can be given to the nearest 100 metres, 10 metres, and 1 metre respectively. For survey purposes, even more precise references may be given.

GRID LETTERS

18. Most grid systems use letters to identify the 100 000-metre squares: this is further explained in Section 2. To avoid all possible error, a full grid reference must include the grid letter as well as the grid reference in numbers since the grid figures will recur at intervals of 100 000 metres. When using maps of 1:250 000 scale and larger, the use of the letters is, however, necessary only when a 100 000-metre line falls in the sheet. In such a case, the grid letters are shown on the face of the map in the borders on either side of the junction line. On maps of 1:500 000 scale and smaller, the grid letters are shown in the body of the map in the centre of the 100 000-metre square to which they refer.

GRID VALUES

19. Grid values (eastings and northings) are written in full on the grid lines nearest to the southwest corner of the sheet and may be written in other corners also. Grid values for the other grid line are usually shown by one, two or three figures (depending on the scale) omitting the final zeros which represent decimals of the grid square. For grid reference purposes, the map user need normally use only those grid values, which appear in large type against the grid and are repeated within the body of the sheet.

GRID REFERENCE BOX

20. As stated in Chapter 2, Paragraph 18, each map carries a panel in the lower or side margin explaining how to give a grid reference. The panel shows any grid letter applicable to the sheet, and explains in detail a grid reference to a selected point of detail within the sheet. On some maps, the grid reference example may not necessarily apply to a point on the map.

ROMERS

21. A romer is a device for measuring the position of a point within a square instead of estimating the tenths. An example of a romer is shown in Figure 6-3. To use the romer put the corner against the required point with the edges parallel to the grid lines. The distances east and north within the grid square can then be read against the west and south grid lines of the square. Clearly, a different romer must be used for each scale of map.

22. Romers for 1:25 000 and 1:50 000 scales in metres are included on the Protractor C2 illustrated in Figure 6-4. Similar romers in metres are included on the C6 Compass (Chapter 8, Section 3). If such romers are not available, a romer may be made easily from a piece of paper or card, marking off the appropriate sub-divisions of a grid square from the scale on the map.

SECTION 2
GRID SYSTEMS

PURPOSES OF GRID SYSTEMS

23. In addition to the purpose of providing a reference system as described in Section 1, a grid system in mapping has the following important purposes:

a. To provide a rectangular framework within which all control points may be computed and plotted in rectangular coordinates, thus simplifying the calculation for bearings and distances.

b. To simplify the layout of standard sheets and the joining together where necessary of neighbouring sheets.

c. To provide a map framework within which distortion due to various causes can be measured simply and effectively.

RELATION OF GRID TO PROJECTION

24. As explained in paragraph 23, a grid is not merely a reference system but is also an important technical element in map making and use. A grid is desirably based on and closely related to the projection used for the map. The purpose is to provide as true a representation of the earth's surface (which is spherical) as is possible by a rectangular grid on a flat piece of paper. Clearly, it is impossible to make this representation 100 per cent accurate over a wide

area. Projections and grids are therefore designed to make the best fit. It is not within the scope of this publication to explain grids and projections in great technical detail. It is important however that users should understand that map grids are not just a set of grid lines, which can be continued indefinitely as straight lines, regardless of the scale and area covered. For a more comprehensive coverage of the subject see B-GL-371-011/FP-001 *Locating Artillery, Theory of Survey*.

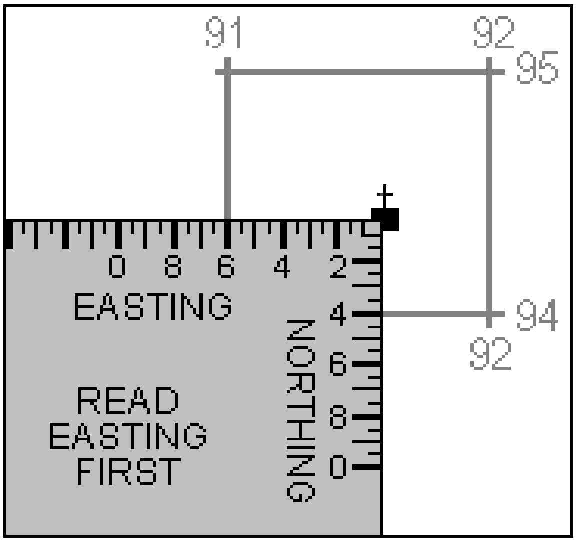


Figure 6-3: Romer

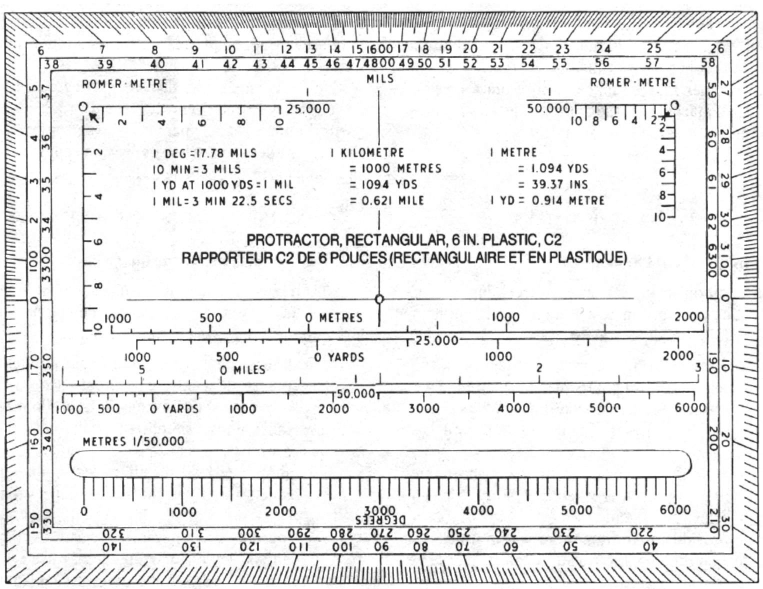


Figure 6-4: Protractor C2 (Romer), 6 Inch, Mils / Degrees / Metres

UNIVERSAL TRANSVERSE MERCATOR GRID SYSTEM

25. Most military mapping is now based, or is being based, on the Universal Transverse Mercator (UTM) system. It is a universal grid system which can cover the world except for the

polar regions, and is based on 60 separate modified transverse Mercator projections, each six degrees of longitude wide and extending from 80ºS to 84ºN latitude.

26. The UTM grid is divided into “Zones”, each covering six degrees of longitude and eight degrees of latitude (except for the most northerly band from 72ºN to 84ºN, which covers twelve degrees of latitude). The 60 longitude bands are numbered and the 20 latitude bands are lettered, each grid zone thus being one rectangle of the grid pattern established by their bands and designated by the figures of the longitude band followed by the letter of latitude band, for example 14U. See Figure 6-5 for an example of the system as it applies to Canada.

27. Each grid zone has, what is termed, a central meridian or central meridian of longitude. Thus grid zone 14U would have for its central meridian, the longitudinal line 99° W.

28. Each of these grid zones is subdivided into 100 000-metre squares. All the vertical lines run parallel to the central meridian of the zone except for one, which is in fact coincident with the central meridian. All horizontal lines run parallel to the equator.

29. The squares formed by the intersection of these 100 000-metre lines are almost always further subdivided into 10 000-metre, 1 000-metre, and even 100-metre lines, depending on the scale and purpose of the map. Information is always provided in the margin relating the map to the zone and giving the grid spacing, for example: one thousand metre universal transverse mercator, grid zone 17.

30. Horizontal lines of the above mentioned 100 000-metre squares are designated by their distance from the equator in metres. Because Canada’s southernmost point is about 4 620 000 metres from the equator, all horizontal lines in Canada have a “northing” value above that figure.

31. Vertical lines of those same 100 000-metre squares are counted from the central meridian or 500 000-metre line, those to the left of it having an “easting” value of less than 500 000 metres, and those on the right having a value above that.

32. For a given point on the map, its full designation or “coordinate” would include the zone number, followed by the easting value and then by the northing value as outlined in Section 1 of this chapter.

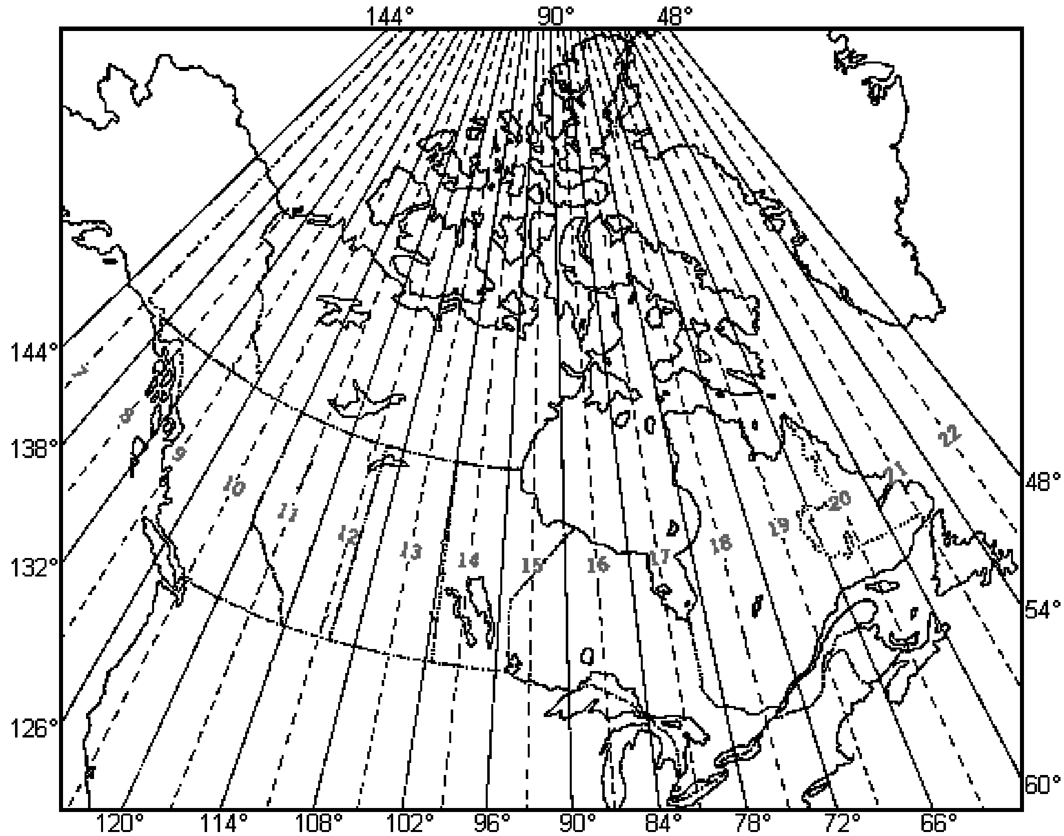


Figure 6-5: Universal Transverse Mercator Grid Zones (UTM)

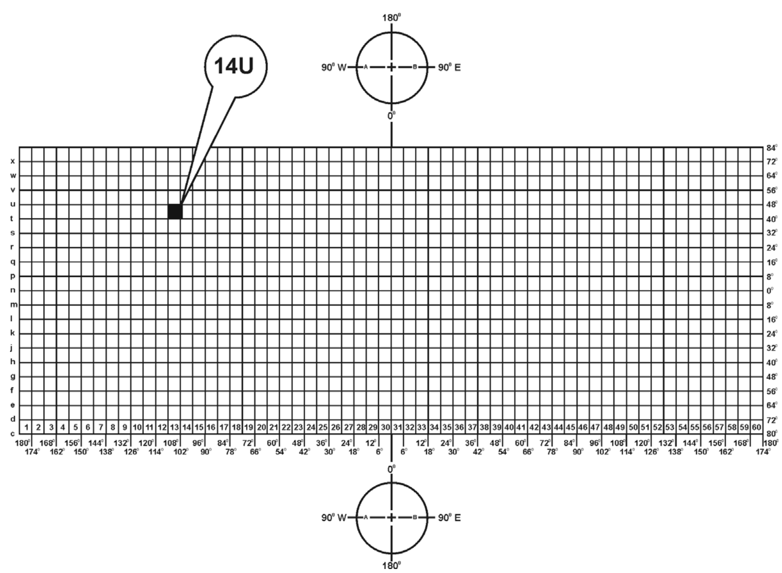


Figure 6-6: UTM Grid Zones

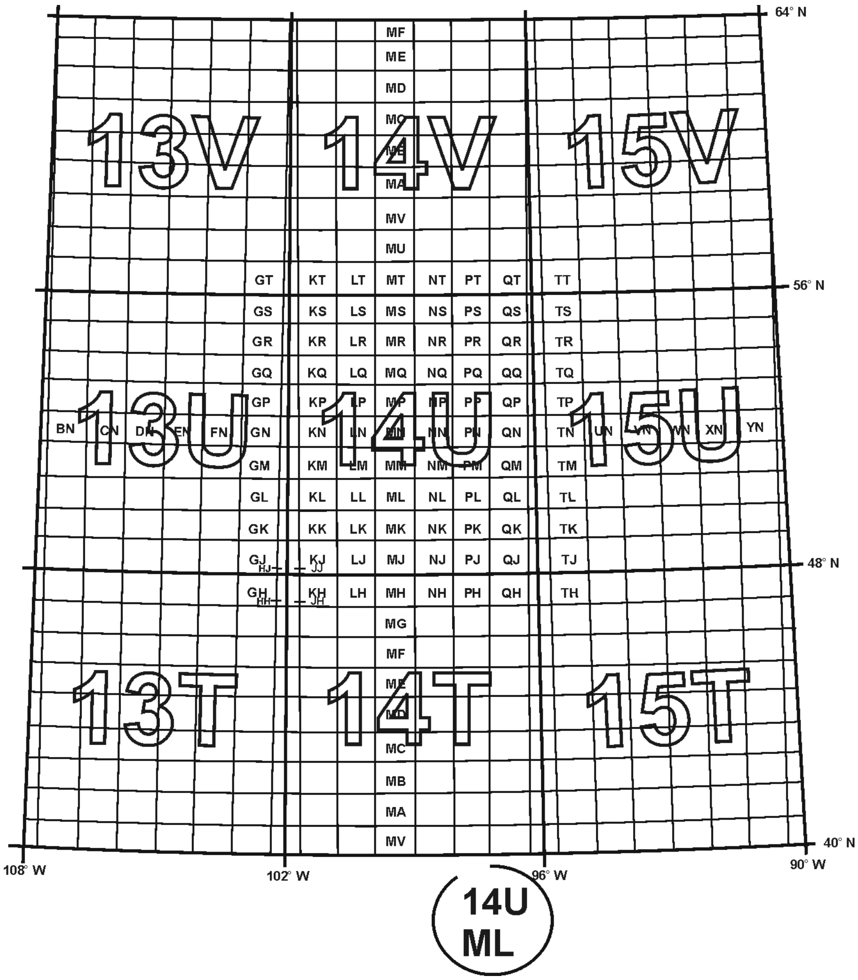


Figure 6-7: Layout of Military Grid Reference System

33. Grid references on the UTM grid are given on the same principle as explained in Section 1, starting normally with the 100 000-metre square letters as shown in Table 6-1.

Scale of Maps	Normal Interval Between Grid Lines in Metres
1:1 000 000	100 000
1:500 000	10 000
1:250 000	10 000
1:50 000	1 000
1:25 000	1 000

Normal UTM Grid Reference	Locates a Point Within
ML 9507	10 000 metres
ML 9507	1 000 metres
ML 9507	1 000 metres
ML 957075	100 metres
ML 957075	100 metres

Table 6-1: UTM Grid References

34. If the grid zone designation is necessary to avoid ambiguity, it is added before the 100 000-metre letters, for example: 14 U ML 90. This, however, is not normally required.

MILITARY GRID REFERENCE SYSTEM (MGRS)

35. The system of designating UTM grid coordinates is straightforward but does, however, require the use of large and somewhat cumbersome figures. To get around this, military mapmakers have developed a somewhat different system consisting of a combination of letters and numbers.

36. As in the UTM system, described above, each grid zone is subdivided into100 000-metre squares, see Figure 6-7. Each column and each row is identified by a letter which are combined to identify the 100 000-metre square, for example, ML which falls within grid zone 14U making its full references 14UML. Whilst the pattern of the letters is repeated at intervals, the distance between similar letters for 100 000-metre squares is very great (normally 18° longitude), and where there may be a risk of error in identification, the use of the zone designation avoids this.

37. For a more comprehensive coverage of how these columns and rows are assigned their alpha designations, refer to National Imagery and Mapping Agency (NIMA) Technical Manual 8358.1.

SECTION 3
GEOGRAPHICAL COORDINATES

GRATICULES

38. A “Graticule” is the network on a map of lines of longitude and latitude (meridians and parallels). Some maps, particularly on scales of 1:10 000 000 and smaller, only have a graticule and no grid. Maps, on larger scales, may be bounded by graticule lines, for example degree squared and also carry a grid superimposed on them. Other maps may be based on grid lines, but carry cutting marks and values of the graticule so that a graticule could be drawn up if desired. See Figure 6-8.

39. Thus, by various means, almost all maps carry the necessary information to enable a user to find out the latitude and longitude of any point of the map.

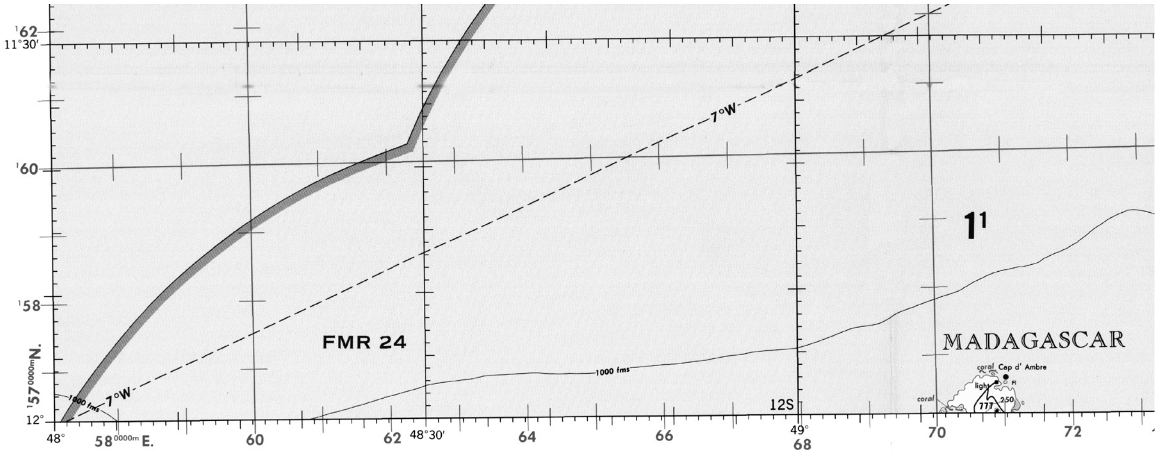


Figure 6-8: Grids and Graticules on Tactical Piloting Chart (TPC)

GEOGRAPHICAL COORDINATES

40. The latitude and longitude of a point constitute its geographical coordinates. Both values are expressed in degrees, minutes, and seconds: latitudes are north or south of the Equator; longitudes are east or west of the meridian of Greenwich.

41. Geographical coordinates are used as map references for a wide variety of purposes, but generally only in small scale mapping (1:1 000 000 or smaller), and when considering large areas in extent. They are particularly used in air and sea operations, and on all charts designed for those types of use.

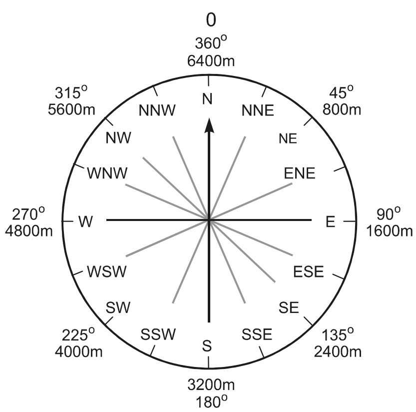
42. A reference system called GEOREF using geographical coordinates in a similar way to grid coordinates is used by air forces and for some other purposes, but it is not normally required by land forces and is therefore not described in this manual. Details on the use of GEOREF may be found in A-GA-198-001/FP-000, *Manual of Pilot Navigation*.

CHAPTER 7
DIRECTION

SECTION 1
DESCRIBING DIRECTION

THE POINTS OF THE COMPASS

1. The four cardinal points of a compass are North, East, South and West. There are in all 32 points of the compass, but only 16 of them are normally used in map reading. These are the four cardinal points and the twelve intermediate points shown in Figure 7-1.



2. In Figure 7-1, the letters N, E, S and W stand respectively for North, East, South and West. In the intermediate points these letters are combined, for example SE is south-east, and NNW is north-north-west, etc. These points describe directions only to within one-sixteenth of a full circle. For a more precise indication of direction it is necessary to use sub-divisions of the circle called mils or degrees, as described in subsequent paragraphs.

Figure 7-1: The Points of the Compass

THE MIL SYSTEM

3. The standard military system is to divide the circle of the compass into 6 400 mils, the zero being at the north point. The four quadrants of the circle are each 1 600 mils, and so the east, south and west points fall at 1 600, 3 200 and 4 800 mils respectively. This is shown in Figure 7-1. Angles are expressed in mils and decimals of a mil. The symbol normally used for mils is m with a slash across: 200 m̸

THE DEGREE SYSTEM

4. The degree system is used principally by air and naval forces, and is used on maps to express geographical coordinates and for some angular measurements. References to angular measurements in this manual are normally given in mils.

5. In the degree system, the circle is divided into 360 degrees, each quadrant being 90 degrees. Each degree is sub-divided into 60 minutes, and each minute into 60 seconds. The indicators for degrees, minutes and seconds are °, ′, and ″ respectively, written as 60° 15′ 45″.

CONVERSION BETWEEN MILS AND DEGREES

6. Where it is necessary to convert from degrees to mils or vice versa, the following conversion factors may be useful:

a. 1° = 17.8 mils (18 mils approximately);

b. 1' = 0.3 mils; and

c. 1 mil = 3.4'.

THE GRADE SYSTEM

7. A further system of angular measurement found on German and some other continental maps is the grade system. The circle is divided into 400 grades, each quadrant being 100 grades. Each grade is divided into 100 centigrades. The abbreviations are g and c respectively.

a. Thus 100 g = 90° = 1,600 mils

b. 1 g = 54' = 16 mils

c. 1 mil = 0 g 6.3 c

BEARINGS

8. A bearing is the angle, measured clockwise, that a line makes with a fixed zero line. The zero line is, by default, always north, unless some other zero line is stated. If one stands at point P, and says that the bearing of A is 700 mils, it means that the line PA makes an angle of 700 mils with the north line as shown in Figure 7-2(a). If the bearing of A is 300 mils from a zero line PB, it means that the angle between PA and PB is 300 mils, measured clockwise; as illustrated in Figure 7-2(b).

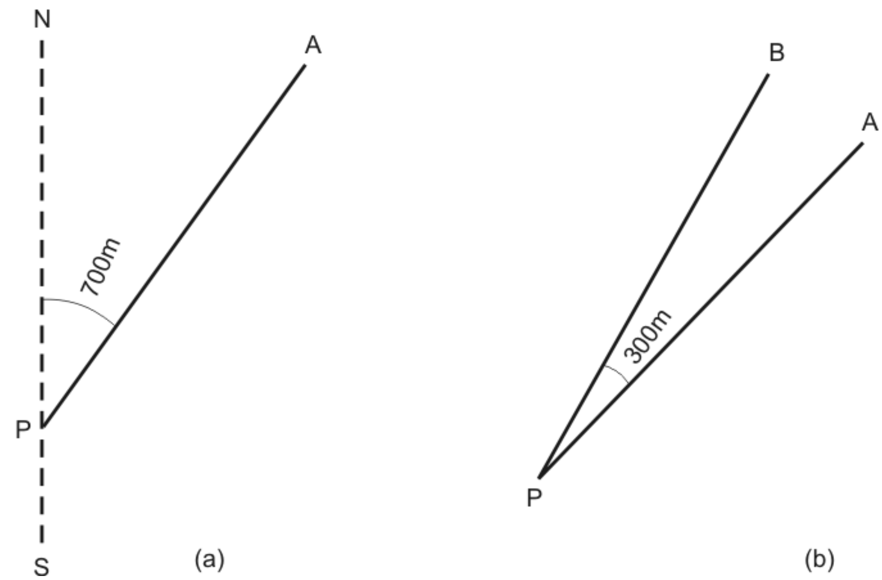


Figure 7-2: Bearings

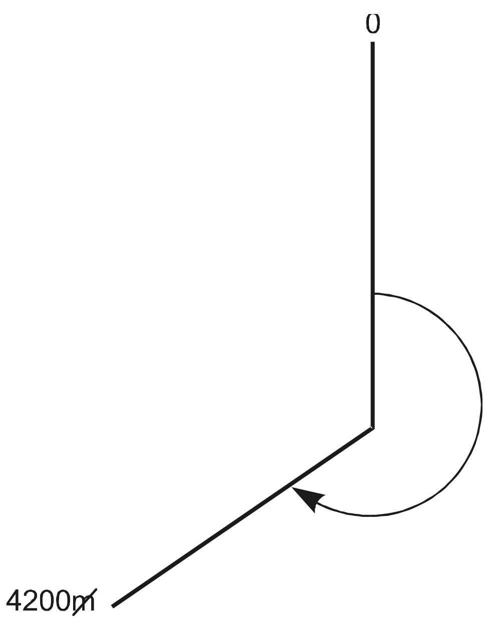


Figure 7-3: Bearings

9. The essential point to remember is that bearings are always measured clockwise from the zero line, which is normally north. Thus bearings of any direction to the east of the north-south line fall between 0 and 3 200 mils. Bearings of any direction to the west of the north-south line fall between 3 200 mils and 6 400 mils. Figure 7-3 emphasizes how the angle of the bearing is always measured clockwise.

BACK BEARINGS

10. A bearing gives the direction of a line from the point of observation P to a point A. A back bearing gives the direction from the point A back to the point of observation P.

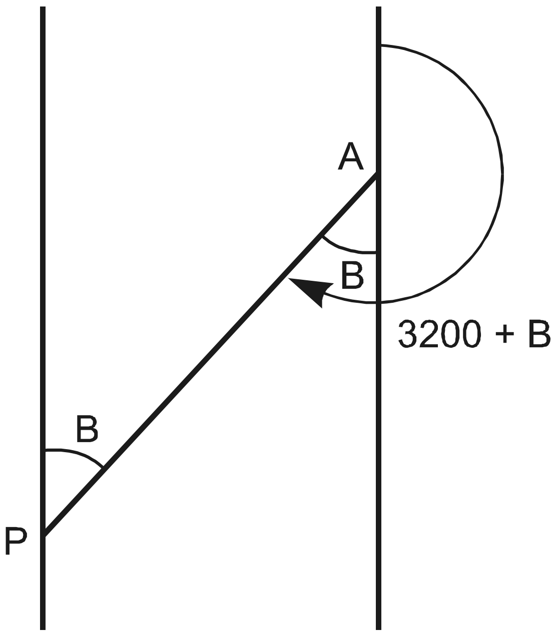


Figure 7-4: Back Bearings

11. Figure 7-4 illustrates that the difference between a bearing and it's back bearing is 3 200 mils. Therefore, given the bearing, to find the back bearing, add 3 200 mils or if the bearing is more than 3 200 mils, subtract 3 200 mils. Service protractors give the values of both the forward and the back bearings along the same line. Examples:

Forward Bearing	Back Bearing
450 mils	3 650 mils
4 000 mils	800 mils

SECTION 2
TRUE, MAGNETIC, AND GRID NORTH

DEFINITIONS OF NORTH

12. In Section 1 it is explained that directions are measured by bearings, and that bearings are the angles measured clockwise from a zero line that is normally in the direction of North. There are, however, three types of north, each of which differs by a small amount. These are:

a. True North;

b. Grid North; and

c. Magnetic North.

13. True North is the direction of the North Pole. On a map, the direction of True North is shown by the lines of longitude (meridians). Bearings measured from True North are called "True" bearings; map-readers normally do not use these.

14. Grid North is the direction of the north-south grid lines on a map. As explained in Chapter 6, Section 2, a grid system, being a rectangular system, imposed on a curved surface cannot exactly fit the lines of longitude and latitude. There is, except along the "Standard" meridian on which the grid is based, a small angle between the direction of Grid North and True North. This angle increases with the distance east or west from the standard meridian. The grid lines on a map provide the most useful and normal reference for measuring bearings on a map; such bearings measured from Grid North are called grid bearings and are the bearings most commonly used in map reading.

15. Magnetic North is the direction in which a compass needle points when free from error or disturbance (refer to chapter 8, section 3). This direction is to the magnetic pole, which differs from the North Pole. Its position varies slightly from year to year (see paragraph 18, below). Bearings measured from Magnetic North are called magnetic bearings; these are the bearings read on a magnetic compass.

ANGLES BETWEEN NORTH POINTS

16. Figure 7-5 illustrates the angle between the three north points. They are defined as follows:

a. **Magnetic declination**—the angle between Magnetic and True North at any point.

b. **Grid convergence**—the angle between Grid North and True North.

c. **Grid magnetic angle**—the angle between Grid North and Magnetic North. This is the angle required for conversion of magnetic bearings to grid bearings or vice versa.

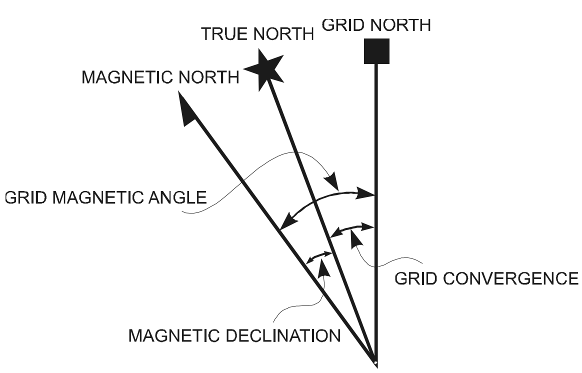


Figure 7-5: North Points

17. It must be realized that the relative direction between the north points will vary in different grid systems. The definitions of the angles, however, remain constant. For the practical application of these angles in map reading, see Section 3.

ANNUAL MAGNETIC CHANGE

18. As stated in paragraph 15, the magnetic pole varies in position. The amount by which its direction changes annually, i.e. the annual change in the grid magnetic angle, is called the annual magnetic change. This must be taken into account when converting magnetic bearings to other bearings or vice versa. Section 3 will detail how this is done.

SECTION 3
PLOTTING, READING, AND CONVERTING BEARINGS

PLOTTING AND READING GRID BEARINGS

19. The plotting and reading of grid bearings on a map may be done by using either a Protractor C2 illustrated at Figure 6-4 or a C-6 Compass described in Chapter 8, Section 2.

20. To plot a bearing with a Protractor C2, a north-south line parallel to the grid must first be drawn through the point (point A) from which the bearing is to be plotted. The protractor is then placed with its zero line on this north-south line, and with the centre point of the zero line on the point A.(See Figure 7-6). If the bearing to be plotted falls between 0 and 3,200 mils, the protractor should be placed so that the mils scale is to the east of the north-south line. If the bearing to be plotted falls between 3,200 mils and 6,400 mils, the protractor should be placed so that the mils scale is to the west of the north-south line. Next, find the required bearing on the protractor scale and mark the map next to the bearing scale. Remove the protractor and draw a line from point A through the bearing mark – this is your bearing line.

21. To measure the grid bearing of a line drawn on the map, place the protractor with the zero line along any convenient north-south grid line which is cut by the bearing line, with the centre point, of the zero line, at the intersecting point of the bearing and grid lines. The mils scale is to be placed east or west of the grid lines as required in accordance with paragraph 20 above. The grid bearing is then read off the protractor on the appropriate scale. See Figure 7-7.

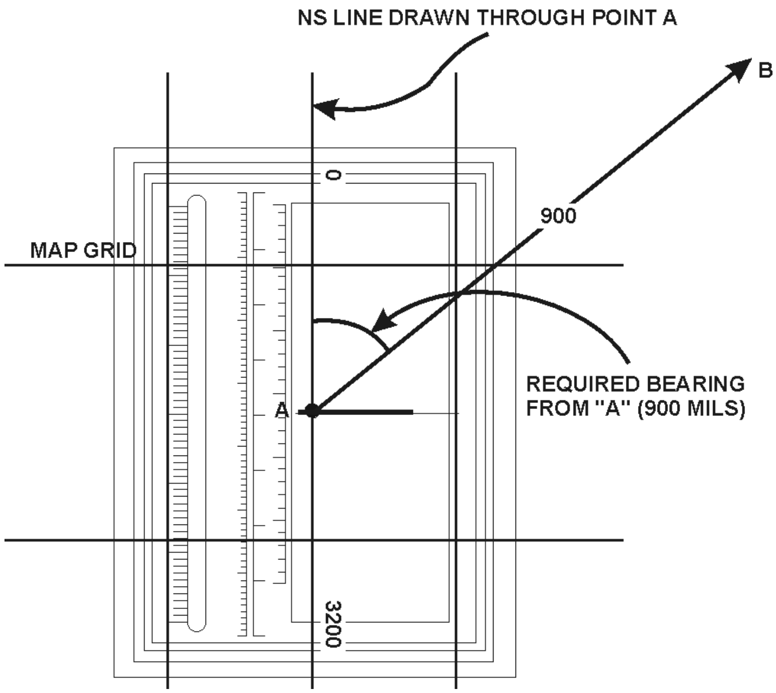


Figure 7-6: Plotting a Bearing on a Map from Point A

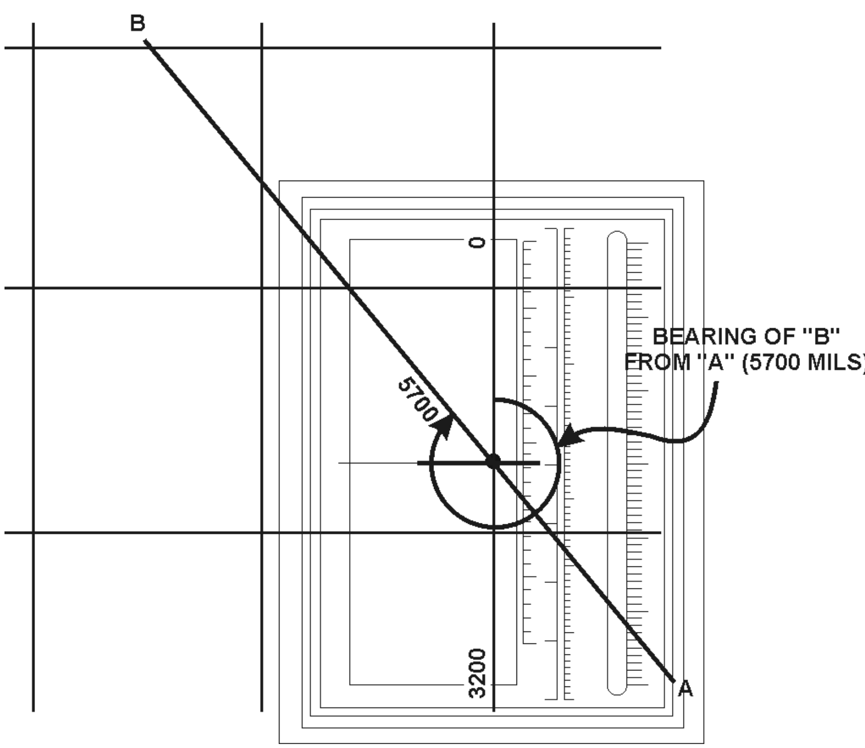


Figure 7-7: Reading a Bearing from a Map

22. If a C-6 Compass is used, the procedure for measuring the grid bearing of a line on the map is described in chapter 8, section 2, paragraph 23 and 24. If it is desired to plot a grid bearing from a point A, the required bearing should be set by twisting the compass dial against the line of travel. Then place the compass with a long side of the base plate against point A (see

figure 7-8), and twist the whole compass— pivoting around point A—until the compass meridian lines are parallel to the north-south grid lines (with the "N" arrow pointing to the north). The long side is then set on the required bearing in the direction of the line of travel.

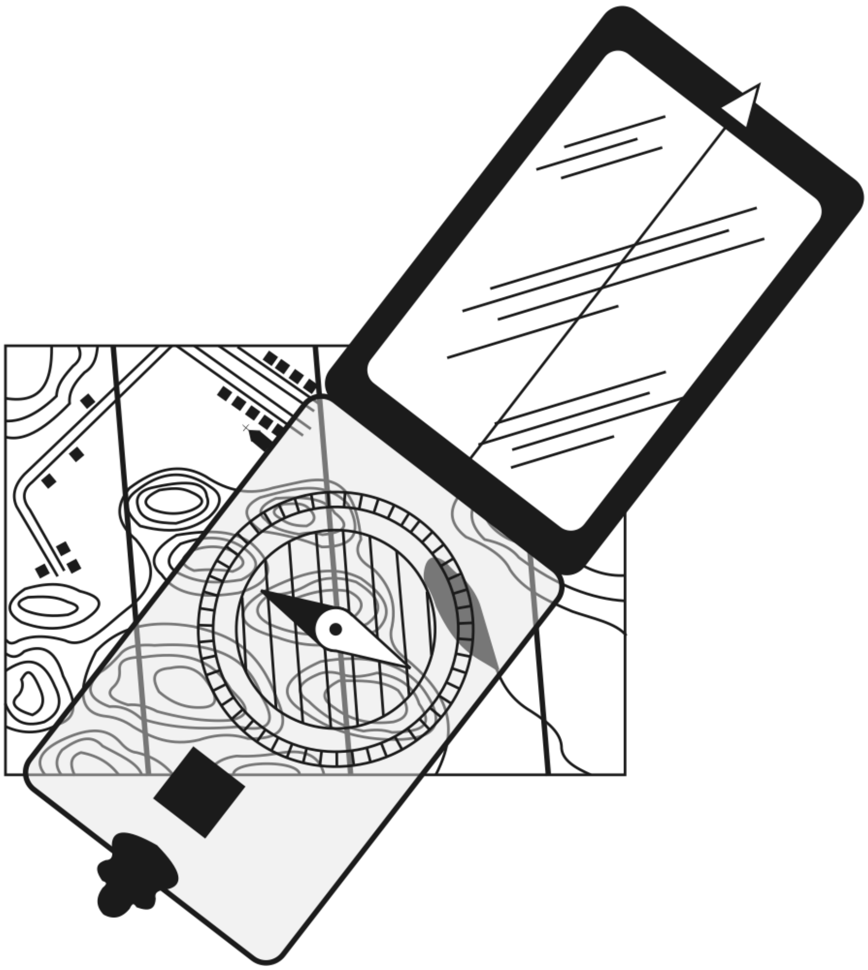


Figure 7-8: Plotting a Bearing using a C6 Compass

TRUE BEARINGS AND MAGNETIC BEARINGS

23. All bearings on a grid map are best plotted as grid bearings. As a result, if it is necessary to plot or to read a true bearing or a magnetic bearing, it is better to convert these to grid bearings before plotting; this conversion is explained below. If, however, the map does not have a grid system and if the lines of latitude and longitude are shown or can be established from the data given on the map, it will be possible to plot true bearings in a similar way to grid bearings. In any case, a magnetic bearing must first be converted either to a grid bearing or to a true bearing as required.

CONVERSION OF BEARINGS

24. To convert a bearing from one sort to another, it is only necessary to add or subtract the appropriate angle between the two north points concerned. The necessary information about these angles should always be given in the margin of the map. On maps prepared under NATO and ABCA agreements, the information is given in the form of a diagram showing the north points with annotations as reflected in Figure 7-9. On other maps it may be given in written form only, and this is discussed further in paragraph 33.

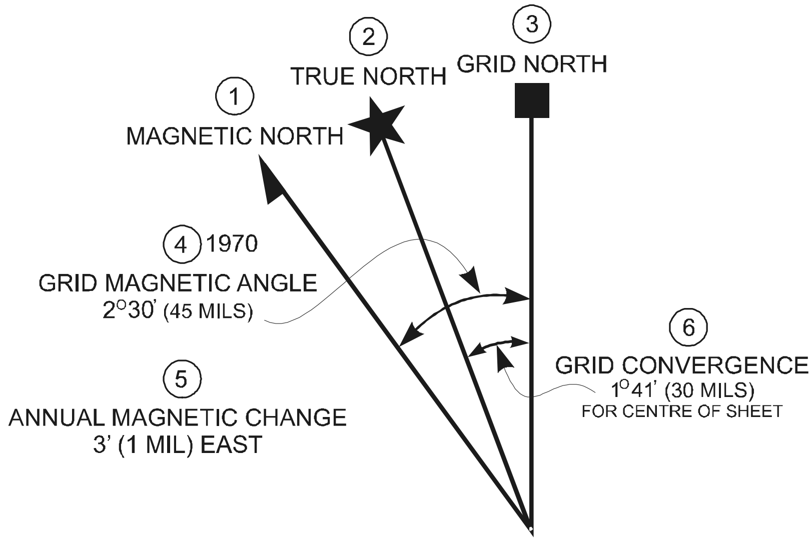


Figure 7-9: Conversion of Bearings

ANNUAL MAGNETIC NORTH DECLINATION ADJUSTMENT

25. Due to dynamic forces on the Earth the Magnetic North continually migrates, subsequently an annual adjustment calculation must be made to obtain the correct Grid Magnetic Angle at the date of observation. The amount of adjustment, to be made, is provided in the diagram (or written information) on north points, as discussed in paragraph 24. For example, using the values given in Figure 7-9, if the observation is made in 1975, the grid magnetic angle at that date would be calculated as follows:

a. Change in angle from 1970 to 1975

(1) = number of years X annual change

(2) = 5 X 1 mil EAST

(3) = 5 mils EAST

b. This is to say that, Magnetic North has moved 5 mils towards the east, and therefore, in this case, the grid magnetic angle has become smaller by this amount. Hence, the grid magnetic angle in 1975 was 45-5 = 40 mils.

GRID BEARINGS/MAGNETIC BEARINGS

26. To convert a grid bearing to a magnetic bearing, or vice versa, one must first refer to the north points diagram and obtain the Grid Magnetic Angle (the angle between Grid and Magnetic North) and adjust it for annual change. Next, remembering that all bearings are measured clockwise from their north point, it is clear from the above example (figure 7-9) that the magnetic bearing will be greater than the corresponding grid bearing by the amount of the grid magnetic angle. Therefore, in the above example, to convert a 1975 grid bearing to a magnetic bearing, one had to add the grid magnetic angle of 40 mils to the grid bearing. Conversely, to convert a magnetic bearing to a grid bearing, one had to subtract 40 mils from the magnetic bearing. See Figure 7-10.

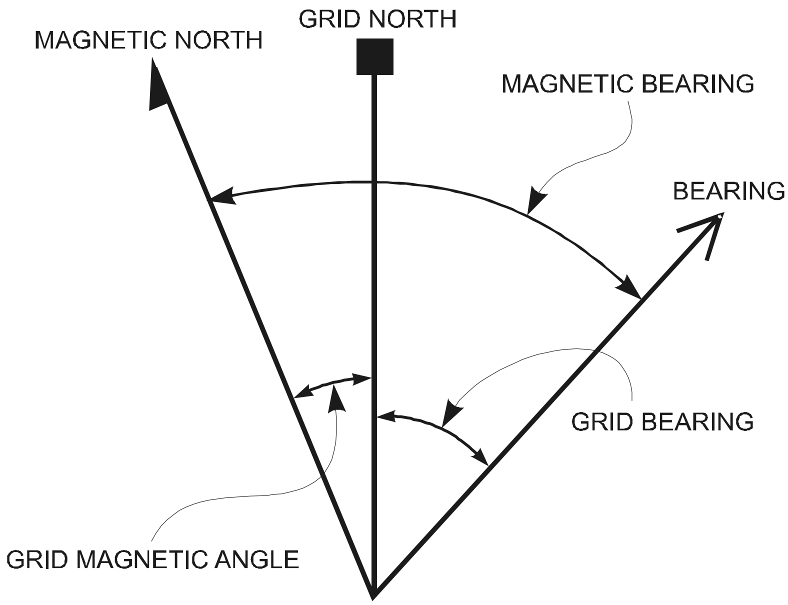


Figure 7-10: Grid North is East of Magnetic North (Grid Bearing = Magnetic Bearing—Grid Magnetic Angle)

27. In this case, on maps which conform to NATO agreements, a note such as that which follows may be placed on the map adjacent to the diagram in Figure 7-9: To convert a magnetic bearing to a grid bearing “SUBTRACT” grid magnetic angle.

28. Where the magnetic north is east of Grid North, this note reads “ADD” in lieu of “SUBTRACT”. This is shown in Figure 7-11.

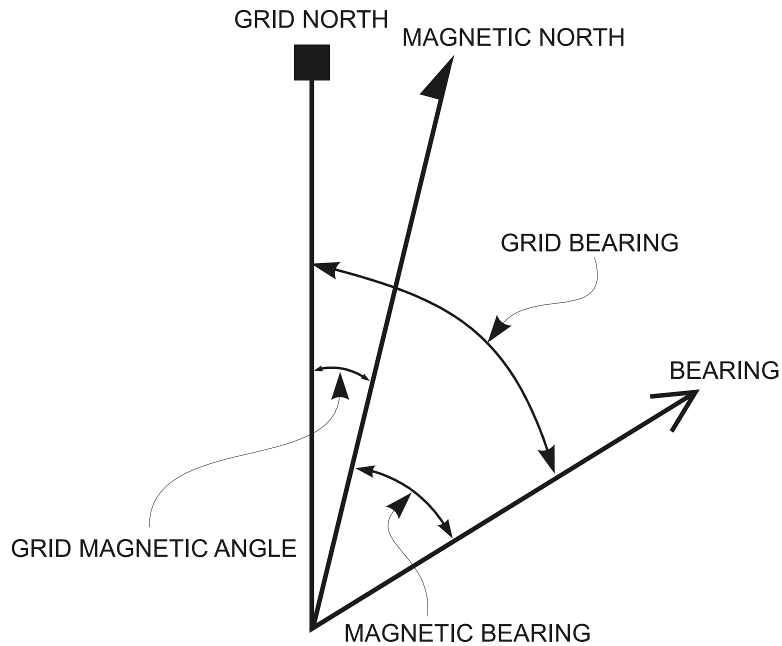


Figure 7-11: Grid North is West of Magnetic North (Grid Bearing = Magnetic Bearing + Grid Magnetic Angle)

29. If working in degrees, the information on the map is given in degrees as well as in mils (See figure 7-9) and the same principles apply. In the example given in paragraph 25, the grid magnetic angle in degrees in 1975 is 2° 30' – (5 X 3') = 2° 15'. This is added to the grid bearing in degrees or subtracted from the magnetic bearing in degrees as in paragraph 26.

CONVERSIONS TO/FROM TRUE BEARINGS

30. In converting grid bearings to magnetic bearings and vice versa, the grid convergence does not enter into the calculation. It is, however, an essential factor for any conversion between true bearings and either grid or magnetic bearings. To convert grid bearing to a true bearing or vice a versa, one must refer to the north points diagram to obtain the grid convergence angle and to ascertain if this angle must be added or subtracted in the required calculation. As an example, in Figure 7-9, it is clear that to convert a grid bearing to a true bearing it is necessary to add the grid convergence (30 mils) to the grid bearing; similarly, to convert a true bearing to a grid bearing one subtracts 30 mils from the true bearing. This relationship is constant and is not affected by the date.

31. To convert a magnetic bearing to a true bearing or vice a versa, it becomes more challenging and one must refer to the north points diagram to determine the angle between Magnetic North and True North called the Magnetic Declination (see figure 7-5). Depending on the relative orientation of Magnetic and True North the Magnetic Declination calculation method will vary. However, it is first necessary to determine the correct grid magnetic angle at the time of observation as in paragraph 25. In the case of Figure 7-9 it is possible to determine the value of the angle between Magnetic North and True North at that time by subtracting the grid convergence from the grid magnetic angle in this case 1975, i.e., 40 – 30 = 10 mils. Thus, to convert a true bearing to a magnetic bearing one adds 10 mils to the true bearing. To convert a

magnetic bearing to a true bearing one subtracts 10 mils from the magnetic bearing. This relationship is of course not constant. It changes yearly.

32. It should be noted that the grid convergence is normally given only for the centre of the sheet. This implies that it is adequate for conversion to or from true bearings throughout the sheet. If, in certain special cases, this single value is not accurate enough, extra values are given for the east and west sides of the sheet, and the value appropriate to the position of the line of bearing on the sheet should be used. This difference is unlikely to affect any use other than for specialist purposes.

CONVERSION INFORMATION NOT SHOWN IN STANDARD FORM

33. There are, however, a large number of maps in current use in which the essential information is given but not in the standard NATO form previously described. There may, for instance, be no diagram to illustrate the relative positions of the north points, and the terms in which the angles are described may be different.

34. However, in whatever form this information is given, it is essential for the map user to construct a diagram of their own on the lines of Figures 7-10 or 7-11. The diagram will show the relative positions of the north points and the values of the angles from the information supplied. It is vitally important to place the north points in their correct positions relative to each other in accordance with the map information supplied. The relative positions vary and are not always as shown in Figure 7-9. Once a correct relative diagram has been made and the values inserted, the conversion of bearings is straightforward.

SECTION 4
FINDING TRUE NORTH FROM SUN OR STARS

INTRODUCTION

35. When a map is not available, or when map reading without a compass, it is often useful to find the approximate direction of True North (or South). The methods described in this section will give adequate results for this purpose, but are not sufficiently accurate for reading bearings or for other precise measurements.

FINDING TRUE NORTH FROM A WATCH

36. Since the sun rises in the east, moves (in the northern hemisphere) through the southern sky, and sets in the west, the position of the sun, when it is visible, is always a rough guide to the direction of north. Calculations must be based on local Standard Time.

37. Lay the watch flat with the hour hand pointing to the sun. In the northern hemisphere, True South will then be midway between the hour hand and twelve o'clock on the watch as illustrated in Figure 7-12.

38. In the southern hemisphere, lay the watch with twelve o'clock pointing to the sun; True North then lies midway between the hour hand and twelve o'clock.

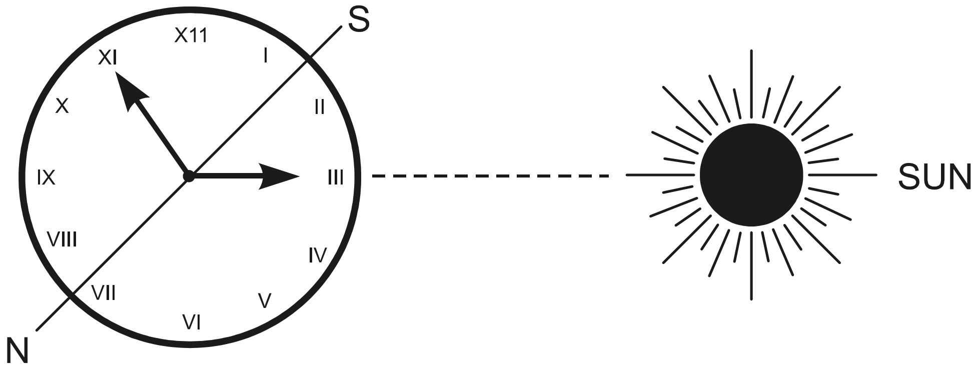


Figure 7-12: Finding True North from a Watch

39. When the sun is high up in the sky, this method cannot be used with much success. In any case, the result is unlikely to be accurate to better than about five degrees.

TRUE NORTH BY THE MOVEMENT OF THE SUN

40. If the sun is high in the sky, True North can be found by observing the shadow of a vertical stick stuck in the ground, see Figure 7-13. This is more accurate than the watch method.

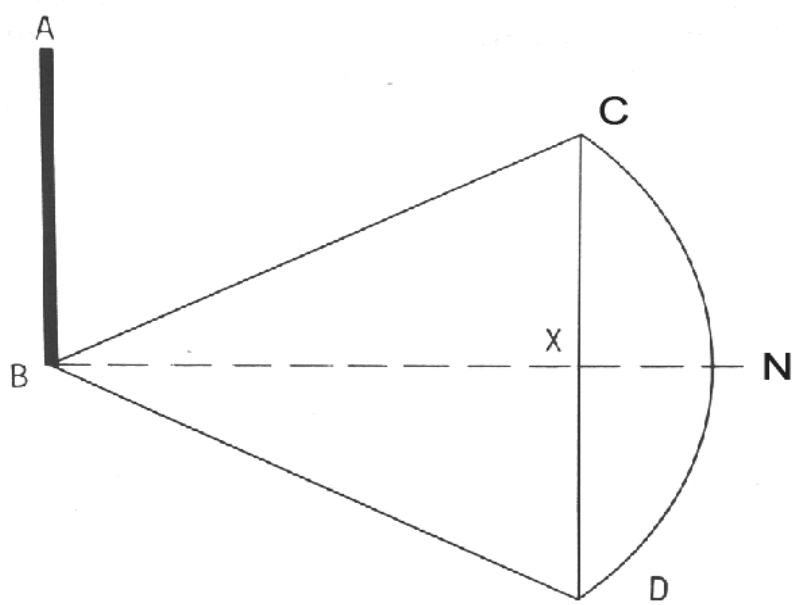


Figure 7-13: Finding True North by the Movement of the Sun

41. Choose a piece of level ground free from shadow, where one can easily make marks on the ground surface. Plant a straight stick (AB) vertically in the ground, the longer the stick the better. About two hours before midday, mark the position of the end of the stick's shadow C, and with the aid of a string tied to the foot of the stick B, mark on the ground the arc of a circle with radius BC in the direction of movement of the stick's shadow. The shadow will grow shorter

until midday and the end of it will recede from the marked circle. After midday it will lengthen, and eventually (about two hours after midday) it will reach the circle again. Mark the point where it does so D. Find and mark the point X midway between C and D. The line joining X and B is then the true north-south line.

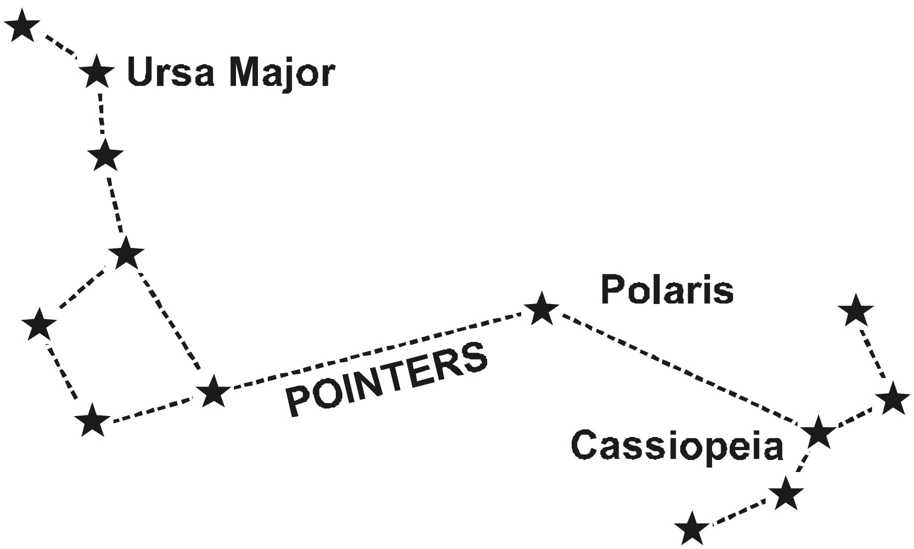


Figure 7-14: Finding True North by the Stars (Northern Hemisphere)

TRUE NORTH BY THE STARS (NORTHERN HEMISPHERE)

42. In latitudes less than 60°, Polaris (north polar star) is never more than about 40 mils away from True North. The "Pointers" of Ursa Major (the Great Dipper), indicate the position of Polaris, as shown in Figure 7-14. All stars revolve round Polaris and the Great Dipper may be either below it, down near the horizon and "Right Way Up", or above it high in the sky and "Upside Down", or in any position in between. If the Great Dipper is obscured or below the horizon, Cassiopeia which is shaped like "W" and is on the opposite side of Polaris from the Great Dipper, may be visible: Polaris is the nearest bright star within the arms of the "W".

43. Above 60° latitude Polaris is too high in the sky to be a good guide to North. At the North Pole it is vertically overhead.

TRUE NORTH BY THE STARS (SOUTHERN HEMISPHERE)

44. The Southern Cross (see Figure 7-15) is not so convenient a guide as Polaris, because it may be appreciably off south. To find South, consider the Southern Cross as a kite. Extend the greater axis about 4½ times in the direction of the tail, and the point reached will be approximately True South.

45. To find South rather more accurately, continue the line for another two lengths of the greater axis and you will reach a bright star in the constellation of Hydra. When this star and the tail star of the Southern Cross are vertically one above the other, they are very nearly True South.

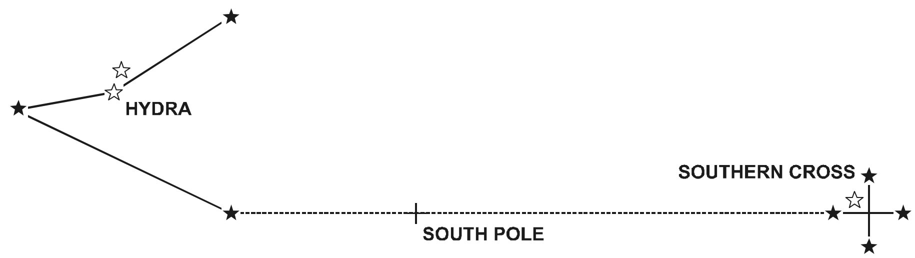


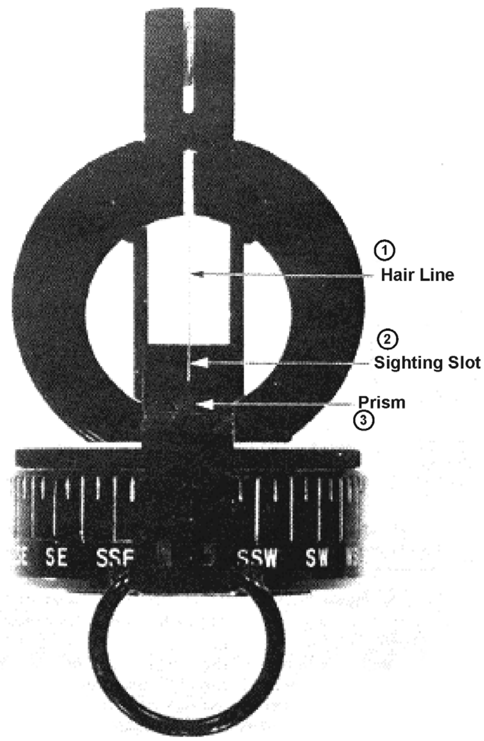
Figure 7-15: Finding True North by the Stars (Southern Hemisphere)

CHAPTER 8
COMPASSES AND THEIR USE

SECTION 1
THE PRISMATIC COMPASS

DESCRIPTION

1. The Prismatic Compass is one of the two principal compasses employed in the Forces. It is a compass that is used primarily by the artillery. It is illustrated in Figures 8-1 and 8-2, but to understand this section fully, it should be read with a compass at hand. Figure 8-1 shows the compass opened for reading through the prism. Figure 8-2 shows the compass out flat.



2. The body of the compass box has a double glass cover over the compass card. The north point on the card is marked by a luminous triangle, and the card is engraved with an inner and an outer circle of mils. The inner circle reads clockwise from 0 to 6 400 mils, starting at the north point, each small division being 100 mils. The outer circle, printed for viewing through the prism, reads clockwise from 0 to 6 400 mils, starting at the south point, each small division being 20 mils. The compass needle is fixed below the card so that the two swing together. The box is filled with oil so as to allow the card to float and to dampen its movement.

Figure 8-1: Prismatic Compass Open for Reading Through the Prism

3. The upper glass cover is marked with black figures 2 to 6, each division being 100 mils. The cover is held by a brass ring and can be rotated to any desired position, and clamped in that position by a screw near the lid hinge.

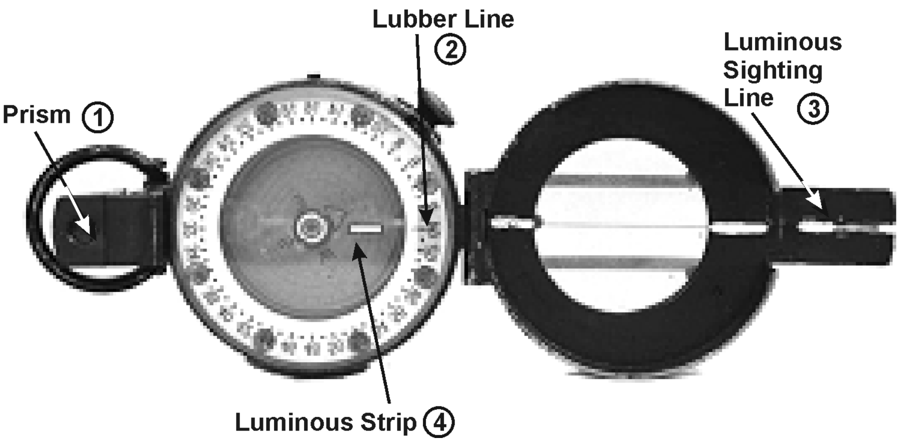


Figure 8-2: Prismatic Compass Opened Out

4. On the white ring below the black figures of the upper glass cover there is a black line on a luminous patch opposite the centre of the lid hinge. 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. Inside the lid the lubber line is further extended by the hairline on the glass of the lid, and by a luminous line reaching to the end of the tongue where there is a notch. On the outside of the ring attached to the box, and by which it may be held, is another luminous notch. When the compass is opened out flat as in Figure 8-2, all these lines and notches are in a straight line passing through the centre of the compass card; this line marks the axis of the compass.

5. At each end of the engraved hair line on the lid there is a small hole to allow a hair or thread to be fixed as a temporary substitute should the glass get broken.

6. Opposite the hinge and covered by the tongue on the lid when the box is closed is a small triangular block which contains the magnifying prism. When the box is open, it can be turned over the glass into the reading position shown in Figure 8-1. This figure also reveals the eyehole and the sightline slit above it. While looking through the eyehole you can see the magnified figures of the outer circle of the compass card. The prism may be raised or lowered on its slides to get the best focus. On the bottom of the box inside, directly below the prism, is a luminous patch against which markings on the compass card can be read at night.

OBSERVING WITH THE PRISMATIC COMPASS

7. Hold the compass steady in both hands with a thumb through the ring. The lid must be vertical and the prism turned over in the reading position (see Figure 8-1). The compass must be held level so that it can swing freely.

8. To take a bearing, look through the sighting slot on top of the prism and line up the hairline on the lid with the object on which the bearing is to be taken. At the same time, observe through the eyehole the readings on the card. When the card comes to rest, read off the bearing against the hairline. A bearing to the nearest 20 mils can be read without difficulty. Readings increase from right to left as seen through the prism. See Figure 8-3. It helps if the hand or

elbows can be rested on a firm object, but avoid any metallic object that would attract the compass (see paragraph 26).

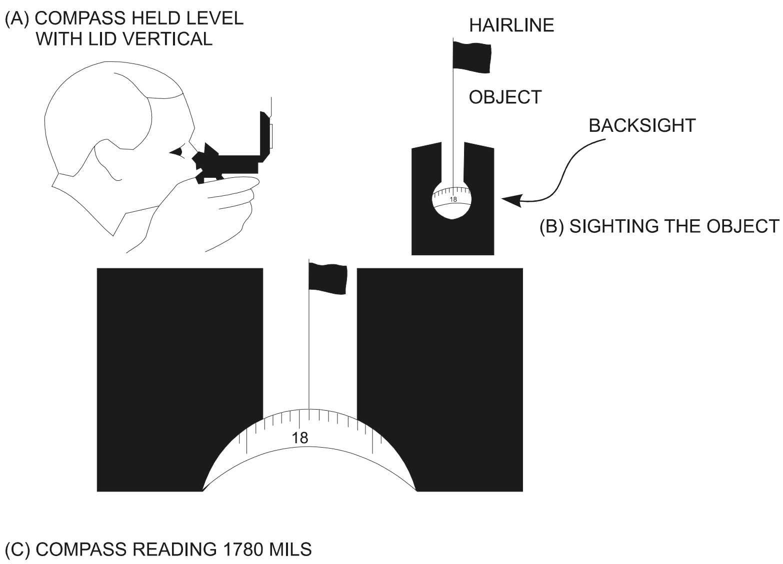


Figure 8-3: Compass Reading

9. The compass can be used without the prism but with much less accuracy. The bearing is then read from the inner circle against the lubber line. One must be careful to read with the eye vertically over the lubber line.

10. All bearings observed are magnetic bearings and must be converted to grid bearings for plotting on a map as discussed in Chapter 7, Section 3.

SETTING THE PRISMATIC COMPASS FOR MARCHING ON A BEARING

11. Convert all bearings to magnetic. Turn the outer glass cover with the brass ring until the reading of the graduations against the lubber line shows the required magnetic bearing, corrected of course, for compass error. Clamp the cover in this position. The axis of the compass through the lubber line will then be on the required bearing when the north point on the card coincides with the luminous strip on the glass cover.

12. The compass can be set most accurately by laying it on a table on the required bearing, using the prism, and then turning the cover until the luminous strip coincides with the north point on the card. Check the bearing before clamping the cover.

13. The prismatic compass can be set in the dark, as the bearings can be read through the prism against the luminous patch in the bottom of the box. This procedure is not easy and should not be attempted unless it is absolutely necessary.

14. To employ such a pre-set compass by night, open it out flat as illustrated in Figure 8-2, and turn it until the north point on the card coincides with the luminous strip on the glass cover.

(The brilliance of these luminous points may be increased by exposure to light.) The axis is then on the required bearing. Sight along the axis and select an object to march on. It need not be directly on the bearing, simply estimate how much right or left of it to move.

SECTION 2
THE C6 COMPASS

DESCRIPTION

15. Several different contractors manufacture the C6 Compass, but the principal features of each remain the same. The compass is calibrated in mils. It is in many respects easier and more convenient to use than a prismatic compass and when used correctly it will serve with good accuracy. Figure 8-4 shows the compass opened out.

16. The compass is mounted on a transparent plastic baseplate at one end of which there is a hinged cover containing a sighting mirror and sight. The plate also includes romers at 1:25 000 and 1:50 000 scales in metres.

Figure 8-4: C6 Compass

17. The compass needle is white at the south end, and red with a luminous patch at the north end. The compass dial is graduated in 50-mil divisions from 0 to 6 400 mils. It can be rotated by hand taking with it, on a baseplate below, a series of meridian lines parallel to the 0-3 200 mils axis of the graduated circle. An arrow on the central meridian always points to 0 on the dial. The dial may be set to any desired bearing, the reading being taken at the index pointer.

18. The sighting arrow, index pointer, sighting mirror and line, and the sight are used to align the compass on the “Objective”. This line marks the axis of the compass or line of travel.

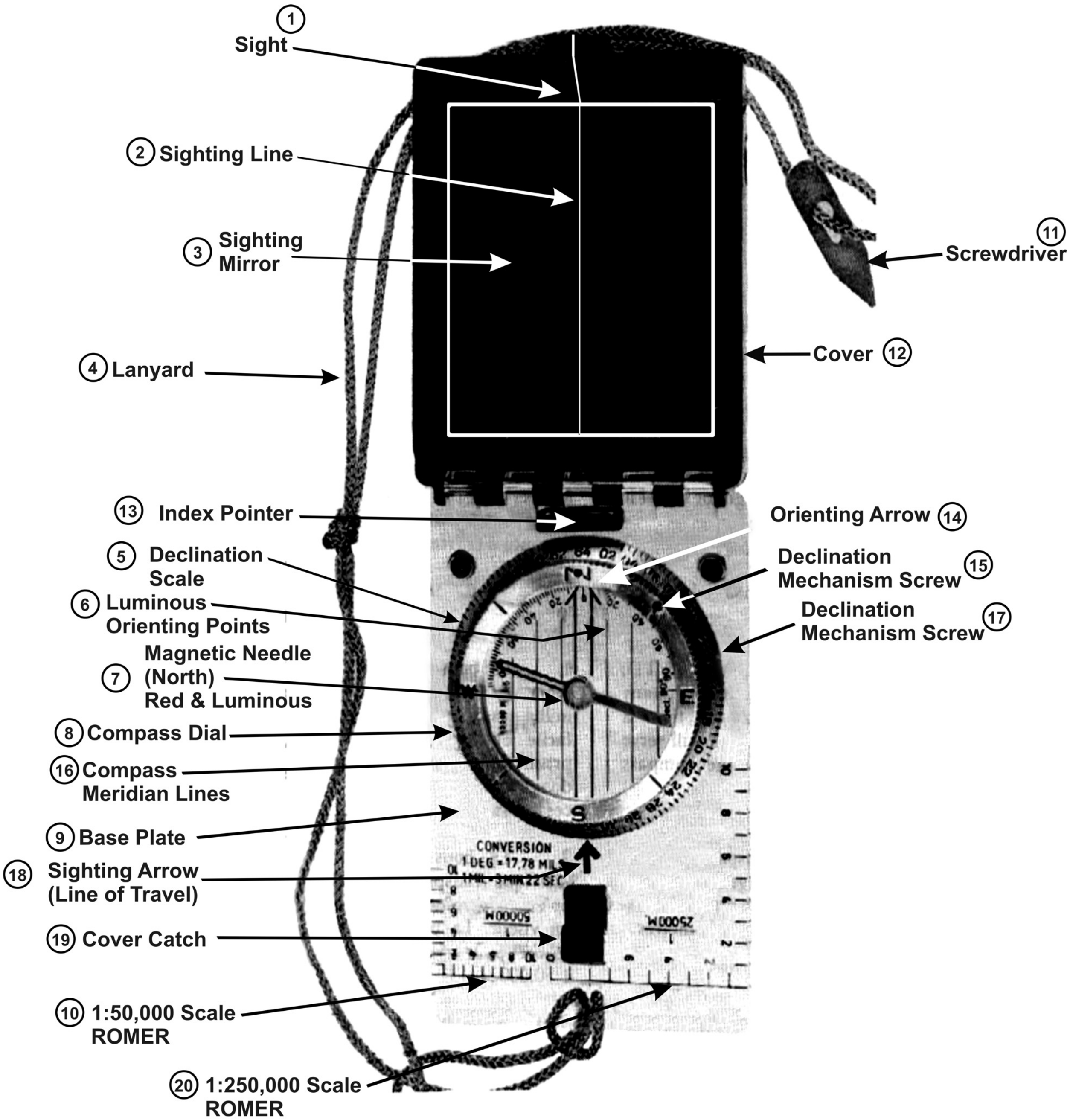


Figure 8-5: The C-6 Compass

MAGNETIC DECLINATION MECHANISM

19. The C6 Compass is equipped with a declination offsetting mechanism, which can be used to make permanent allowance for the magnetic variance in the area. To apply this to the compass the following steps are to be taken:

a. Determine magnetic variance in the area from a local map. Ensure magnetic variance is computed in degrees.

b. Move the orienting arrow to the desired setting on the declination scale by means of turning the adjusting screw located on the compass dial. See Figure 8-6.

c. If the declination in the area is 10° west, turn the adjusting screw clockwise so that the orientating arrow points to 10° on the west side of the scale as shown in Figure 8-7. If the declination in the area is 10° east, turn the adjusting screw anti-clockwise so that the orientating arrow points to 10° on the east side of the scale as shown in Figure 8-8.

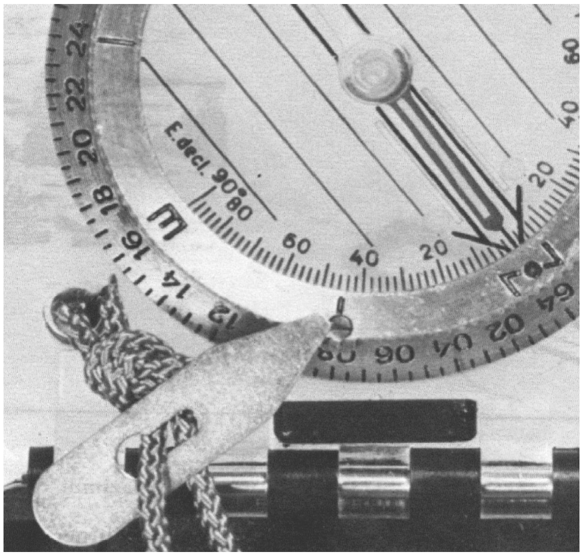


Figure 8-6: Declination Mechanism

OBSERVING WITH THE C6 COMPASS

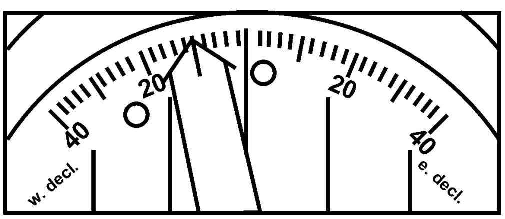


Figure 8-7: Declination West

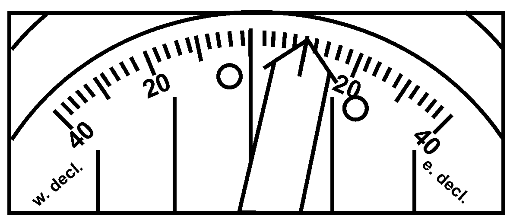


Figure 8-8: Declination East

20. The following steps are taken to obtain a bearing or direction to an object which is visible:

a. Open the compass cover wide and hold it level and waist high in front of you.

b. Pivot the compass around until the sighting line points straight to the object on which a bearing is required. See Figure 8-9.

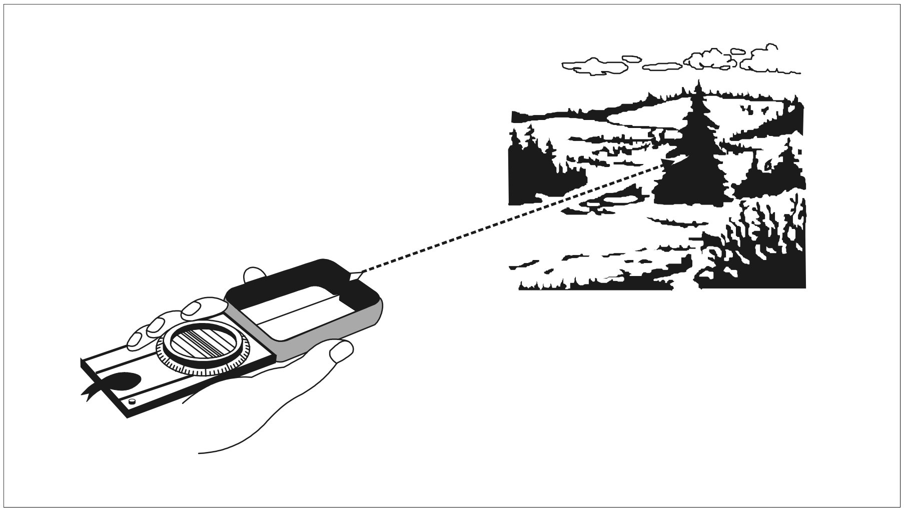


Figure 8-9: Taking a Bearing

c. Turn the dial until the orienting arrow and the magnetic needle are lined up with the red end of the needle lying between the two orienting points.

21. The bearing to the object is the mil reading indicated at the index pointer, subject of course to any individual compass error. See paragraph 32.

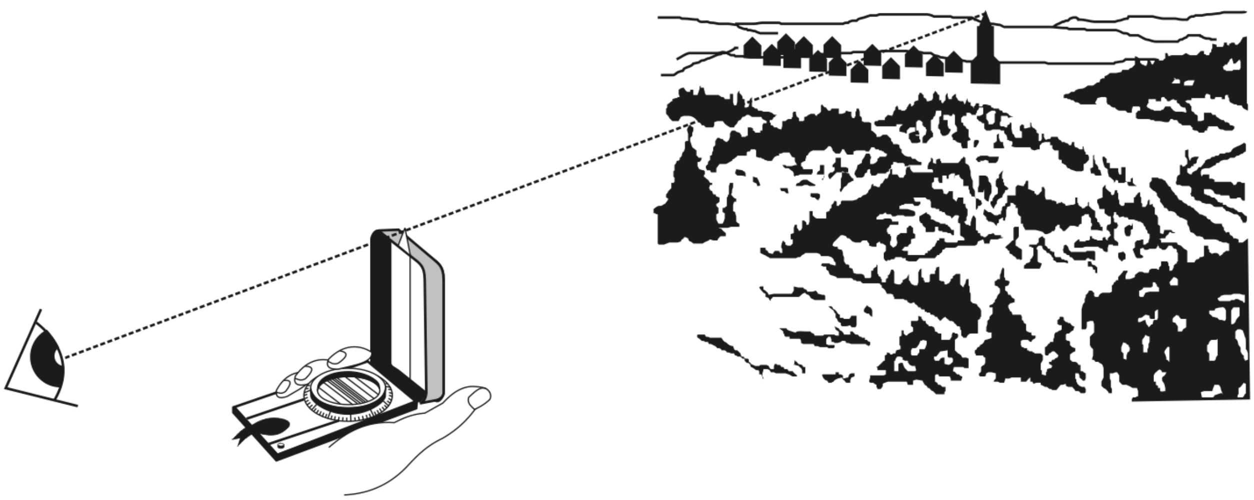


Figure 8-10: Taking a Bearing with more accuracy

22. For greater accuracy, bearings can be determined by using the sighting mirror as described below:

a. Hold the compass at eye level and adjust the cover so the top of the dial is seen in the mirror. Face toward the object using the sight and align on the desired point. See Figure 8-10.

b. Look in the mirror and adjust the position of the compass so the sighting line intersects the index pointer and sighting arrow.

c. While sighting on the objective across the sight and continuing to ensure that the sighting line intersects the index pointer and sighting arrow, turn the dial so the orienting arrow is lined up with the needle, its red end between the orienting points.

TAKING A GRID BEARING FROM A MAP

23. To take a grid bearing from a map, the compass can be used as a protractor, ignoring the compass needle. To read a grid bearing from A to B place the compass with a long side on the line AB and with the sighting arrow of the line of travel pointing in the direction of travel. See figure 8-11.

24. Then, holding the compass in position on the map, turn the graduated dial so the compass meridian lines are parallel to the map north-south grid lines (eastings) ensuring that the north on the dial is towards the top of the map. The grid bearing of B from A is then read off the graduated dial at the index pointer. See figure 8-12.

25. In doing these steps, the compass has in fact been set for the mil reading to the objective. By rotating the whole compass, line up the red end of the magnetic needle between the orienting points on the orienting arrow. The compass will now be pointing in the direction of the objective. Holding the compass at waist height straight in front of you, march in the direction of the line of travel arrow. As long as the compass needle and the orienting arrow are kept coincident, the line of travel arrow will remain on the bearing. For night marches, the luminous bar on the magnetic needle and the two orienting points on the orienting arrow will assist in maintaining this coincidence. The line of travel is indicated by the luminous sighting arrow, index point and sight.

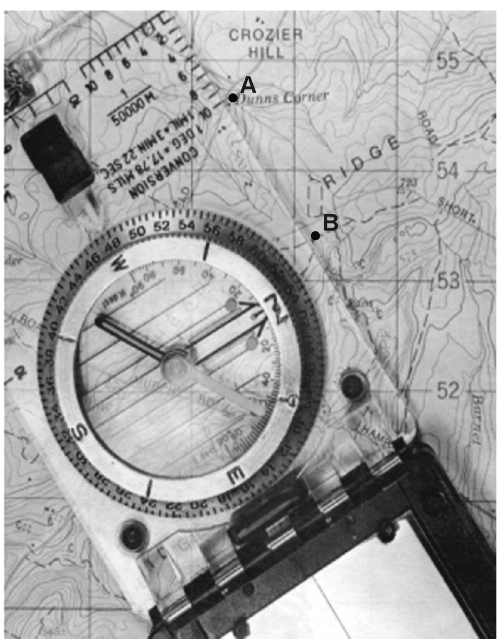


Figure 8-11: The C6 used as a Protractor

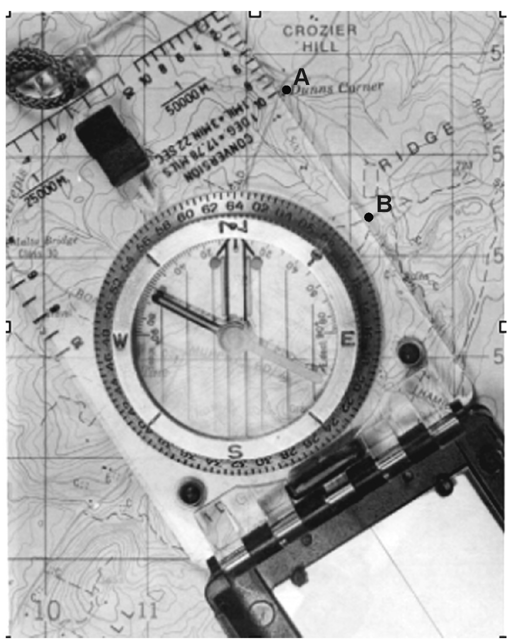


Figure 8-12: Determining the Grid Bearing

SECTION 3
GUIDANCE FOR EFFECTIVE USAGE

LOCAL MAGNETIC ATTRACTION

26. A compass is sensitive to iron and steel. Even small quantities near the compass may cause a false reading. Some items, which may affect the reading are overhead or buried electrical cables, pipelines and chain link fences. Items carried by the soldier, such as the rifle, heavy metal wristwatches or magazines could also affect the readings. The issued helmet, made of Kevlar, should not affect the compass. Small items will not affect the reading if kept away from the compass such as in a trouser pocket, but larger articles such as a rifle should be kept at least two or three metres away. Tanks and guns may affect the reading within 50 metres, a wire fence at 10 metres. If there is any doubt as to whether articles carried are affecting the reading, they should be removed, and the readings confirmed as outlined in the following paragraph.

27. In case of doubt about possible local disturbances, tests may be carried out in two ways:

a. Take a bearing on a distant object, move a few metres away in various directions and take more readings. Provided the object is far enough away, all readings should be the same. If they are not, there is a local disturbance. This test is not foolproof as there may be a general magnetic disturbance, but that is rare.

b. Select two points about 100 metres apart. Take bearings from each point on the other. The bearings should differ by 3,200 mils. If they do not, there is a disturbance at one or both points.

28. If local magnetic attraction is suspected to be present, even though not proven, another location to conduct readings should be selected.

EFFECTS OF TEMPERATURE

29. Due to changes in temperature, a small bubble may sometimes form in the liquid. This will not affect accuracy. However, extreme cold will increase the viscosity of the liquid and slow the rotation of the compass. When taking a reading under these conditions, this must be catered for.

30. A compass should not be placed in a location where extreme changes in temperature are likely to occur. The expanding liquid may damage the capsule.

DAMAGED PIVOT

31. Most forms of damage to a compass are obvious. A damaged pivot, however, may not be. A compass should swing freely and easily. If it does not do so, and does not return always to the same position, the pivot is probably damaged. It should be returned for repair.

COMPASS ERRORS

32. Almost every compass has an individual error and does not, therefore, point exactly to Magnetic North. This can be the result of the compass needle not being quite true with the markings on the card, or there may be slight divergences for other reasons. The error may be negligible or comparatively large. Before use, every compass should be checked against a known bearing or against another compass of known error. Of course, errors may be due to an individual's variation in reading and allowance should be made for this. Checks should be made from time to time by the individual, and annually by a specialist.

33. When taking bearings, the compass must be applied, plus or minus "x" mils, before reporting or plotting the bearing.

SECTION 4
NIGHT MARCHING

GENERAL

34. The normal way to maintain direction on a night march across country is to use the compass. Before any night march, the bearings should be worked out and the compass set, by day. As much as possible of the route should be reconnoitred by day, even if only from a distance, and the ground should be studied on air photographs. Conspicuous features that will be visible at night, and features that will have to be crossed, should be carefully noted as a check on distance and directions.

35. It is not easy, under any circumstances, to hold to a constant course in the dark. Plenty of practice is needed before it can be done consistently and with confidence.

36. If more than one compass bearing is needed for a march, it is best to have a log that designates each separate compass bearing that can be referenced.

MARCHING ON DISTANT OBJECTS

37. Even at night, it is often possible to distinguish objects at some distance, especially against a skyline. On moonlight nights they can be seen from a considerable way off. When things can be seen in this way, the best method is to pick out an object on the required bearing, as far distant as can clearly be seen, and to march to it. Then select another object, march on that, and so on.

MARCHING ON STARS

38. If no suitable object exists on which to march, choose a star. The following precautions must, however, be taken.

a. Choose a star that is conspicuous and easily identified. Do not march far without taking your eyes off it. You must be able to pick out the right star easily and quickly each time you glance at it.

b. Choose a star not too high in the sky, nor too low. It is difficult to march on a star at an elevation of more than about 30º above the horizon; on the other hand, stars loose their brightness when near the horizon and are more difficult to pick up. Choose one so that as far as possible, the star and the ground are visible at the same time.

c. Stars move. A star fairly low in the sky may move about 100 mils sideways in 20 minutes. An error of 100 mils is 100 metres in one kilometre of march. It is advisable to choose a new star every 15 minutes.

DARK NIGHT WITH NO STARS

39. When the night is dark and cloudy so that no stars or distant objects can be seen, send someone ahead on the required bearing as far as he or she can be seen, close up to that person, then repeat the process.

40. When there is no need for silence the person can be called to halt after progressing the maximum distance while still within sight. When silence is essential, determine how far the person can go and still be seen, also count the number of paces (say 20). Use a stick to give the person a good direction and tell him/her to go forward 20 paces each time, keeping as straight as possible, and then halt. Judge how far the person has gone to the right or left, and move up into the correct position.

41. The person can be seen at a greater distance if wearing a square of white paper or cloth on their back. If longer bounds can be made, progress will be quicker.

DISTANCE

42. On a night march, the tendency is to imagine that you have gone further than you actually have. There is a tendency to think that the objective has been missed when in fact you may be well short of it. Unless there are frequent landmarks, it is always advisable to arrange a check on distance, pacing is frequently not accurate enough.

43. If it is absolutely necessary to ensure accurate distance measurement then a possible method is to detail two persons to carry a rope or tape of a specified length, say 50 metres. The front member moves off and halts when the rope tightens, signalling the other to come forward by jerking on the rope. The same procedure is repeated as often as necessary. The essential point is to keep an accurate tally of the number of tape lengths measured. If there is much rough ground, it may be necessary to have a third person helping with the rope and to keep it clear of snags.

TRAINING

44. It is not enough to know how a night march should be made. To carry out even a simple night march successfully, the drill must be perfect. Training is essential to ensure perfection.

45. An officer, warrant officer, or non-commissioned officer (NCO) should know at what speed they can expect to move over different sorts of country, under various conditions and with what accuracy should be expected to reach the destination.

CHAPTER 9
MAP SETTING, POSITION FINDING AND THE GLOBAL POSITIONING SYSTEM

SECTION 1
SETTING (ORIENTING) A MAP

INTRODUCTION

1. “Orienting” a map means turning the map so that map directions and hence map detail correspond with the ground. This is also called “Orientating” the map. Orienting a map is not always necessary, and it is sometimes more convenient to hold the map so that the names are the right way up. However, if you have any doubt about where you are, or in which direction you should turn, it is advisable to orient the map. Also moving over a complex route it is generally more important to hold the map correctly oriented than to have the names the right way up.

2. There are two basic methods of orienting a map:

a. by inspection of the surrounding detail; and

b. by orienting on the north point.

ORIENTING A MAP BY INSPECTION

3. This is the simplest and quickest way of orienting a map, provided that some idea of the present position is known.

4. If you are on a straight road, line up the road on the map with the road on the ground, pointing it in the right direction. At a crossroads, the map can be oriented similarly.

5. If not on a road, or on a road which is not straight and the bends are not identifiable, it is necessary to locate other objects such as a particular house, church or bridge whose direction you can check in relation to your own approximate position.

6. On open hilly ground, you may have to rely on the shape of the ground and on the corresponding positions of the contours. If you are on a ridge or a spur, orient the map so that the feature corresponds with the contours. Check for direction by using a recognizable hilltop, saddle or some other pronounced feature.

7. Orienting a map by this method is not precise, but the map can be oriented quickly and accurately enough to be sure of your direction, and to be confident of your position within an acceptable margin of error. Figure 9-1 illustrates this procedure.

ORIENTING A MAP BY THE NORTH POINT

8. If it is not possible to immediately recognize sufficient detail around you to orient the map as described above, the simplest approximate method of orientation is by the sun, if it is visible. Assuming you have a watch, the direction of True North (or South) can be found by the method described in chapter 7, paragraph 36. The orientation will not be precise, but should be accurate enough to enable the recognition of local detail.

9. If, however, there is no local detail, or if you need to orient the map more precisely, a compass must be used. With a C6 Compass, ensure that the magnetic declination has been applied (see chapter 8, paragraph 19). Have the compass dial "zeroed" with the index pointer and then place the compass on the map so that the compass meridian lines (and base plate) are parallel to the map "eastings". Rotate the map with the compass on it until the compass needle is oriented with the orienting arrow - between the two luminous points on the orienting arrow. The map is then oriented with the grid lines pointing to grid north.

10. If a prismatic compass is used, lay the compass with its axis along an easting, and turn the map and compass until the inner circle of mils reads the appropriate grid magnetic angle against the lubber line. If the magnetic declination is east of grid north the bearing on the compass must read 6,400 mils minus the grid magnetic angle.

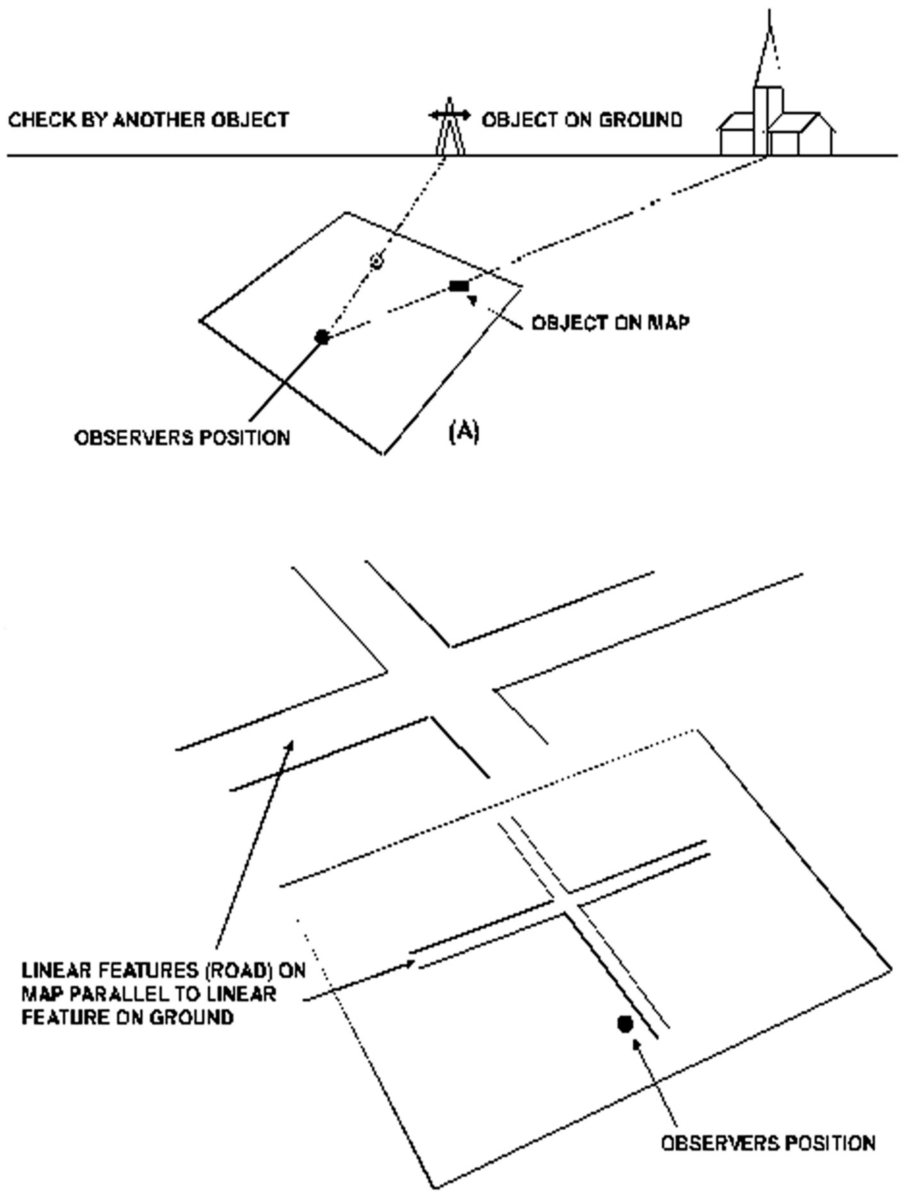


Figure 9-1: Setting a Map by Inspection

11. In all cases, the grid magnetic angle must be determined for the current year as explained in Chapter 7, Section 3.

SECTION 2
FINDING YOUR POSITION

GENERAL

12. If your present position is unknown, the first essential step is to orient the map by one of the methods described in Section 1, preferably with a compass.

FINDING POSITION FROM LOCAL DETAIL

13. In the normal case where your approximate position is known but you wish to pinpoint it more accurately, and where there is local detail marked on the map, identify at least two definite points as close to you as possible and preferably at right angles to each other. Keeping the map correctly oriented, as initially determined, mark the direction of your own position from each selected point and note where these intersect. The point of intersection should be your position. Check this by sighting on a third point in a different direction. To confirm your findings, verify that the approximate distances from your position to the identified points are correct.

14. Lining up your present position with any identifiable straight line on the map, for example, a section of a railway or a road, or between two identified points, will also confirm the orientation of your map and the line on which your position must be. A direction cutting this line from a known point at right angles will give you your position. Again this should be confirmed by sighting on another point.

15. On hilly ground, the contours will help in determining your position, especially if you place yourself on the line of a ridge or spur, which is clearly defined, or in more open country on a distinctive hilltop. Streams and stream junctions are also useful landmarks.

FINDING POSITION FROM DISTANT DETAIL (RESECTION)

16. In the absence of local detail, and contours which are not sufficiently close or shaped to give you a reliable indication of position, your position can only be determined from distant objects such as hilltops, corners of woods, or other natural features, possibly on a sky line. Select three points around you so that your position is within the triangle formed by the points, and preferably so that the lines from each point cut each other at angles exceeding 800 mils.

17. If you have a means of accurately marking the line of sight from each point on your map, while still keeping it correctly oriented, do so. If your map is correctly oriented these lines will meet at a point, which is your position, or at least they will make a small triangle within which your position falls. Check by sighting on a fourth point, if available. This procedure is illustrated in Figure 9-2.

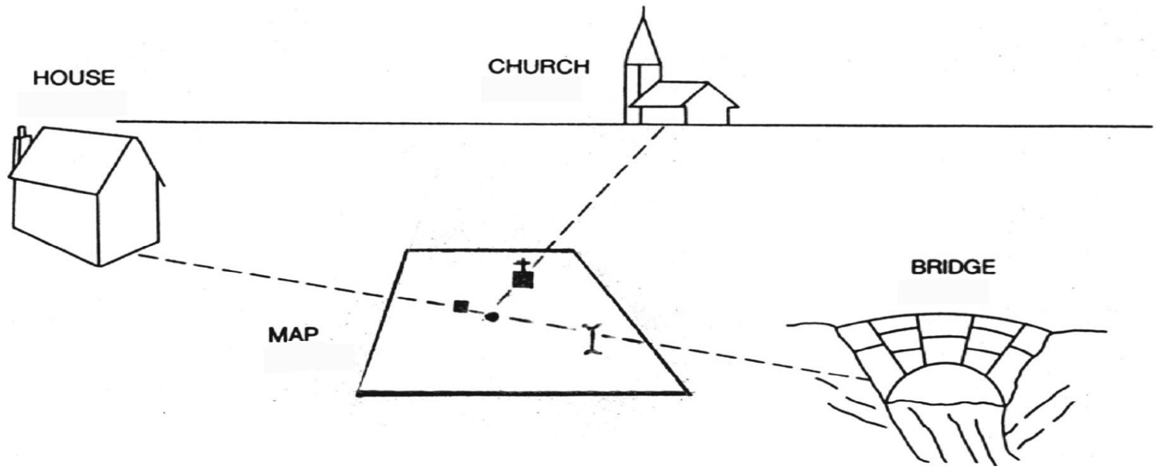


Figure 9-2: Resection

18. If, however, you have a compass, it may be easier to determine the bearing to each point, record it, and convert it to a grid back bearing (see chapter 7, paragraph 10). Then plot on the map the grid back bearing from each point. These lines should then meet at a point or in a small triangle of error, as in paragraph below. Alternatively, plot the bearings using a protractor or compass on tracing paper or talc, and then fit the pattern of the three lines to the map so that they pass through the points observed. Your position is then the point where the three lines meet. This method avoids the need to convert the magnetic bearings to grid bearings.

19. It is important to select three points so that you are inside the triangle formed by them. If the points are roughly equidistant, your position should be at the centre of any triangle of error. Always check your determined position from a point of local detail.

20. The C-6 Compass provides us with yet another variation of effecting a resection to determine our position:

a. Assume you are somewhere in the area shown on the map at Figure 9-3. Find a readily identifiable object that can be both seen on the map and that can be visually observed on the ground.

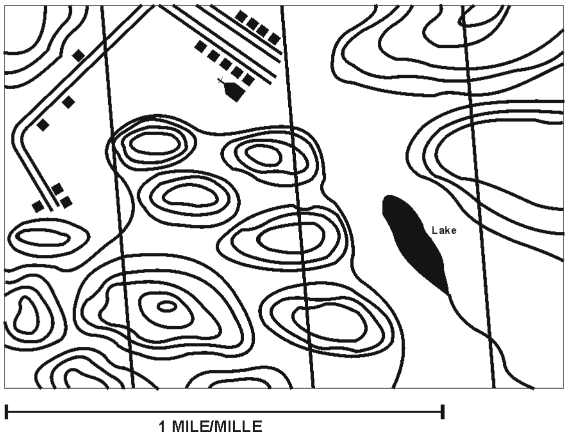


Figure 9-3: Resection by C-6 Compass—Situation

b. As an example, take a bearing (chapter 8, paragraph 20) to the church indicated in Figure 9-3 and 9-4.

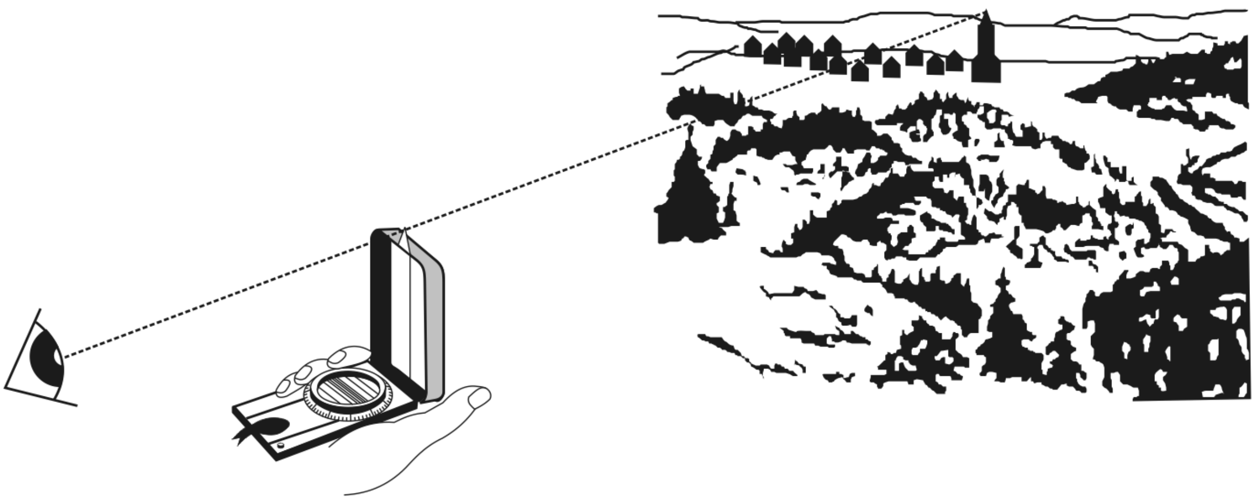


Figure 9-4 : Resection by C-6 Compass—Step 1

c. Without disturbing the dial setting, place the compass on the map so that either side of the baseplate intersects the church as shown in Figure 9-5.

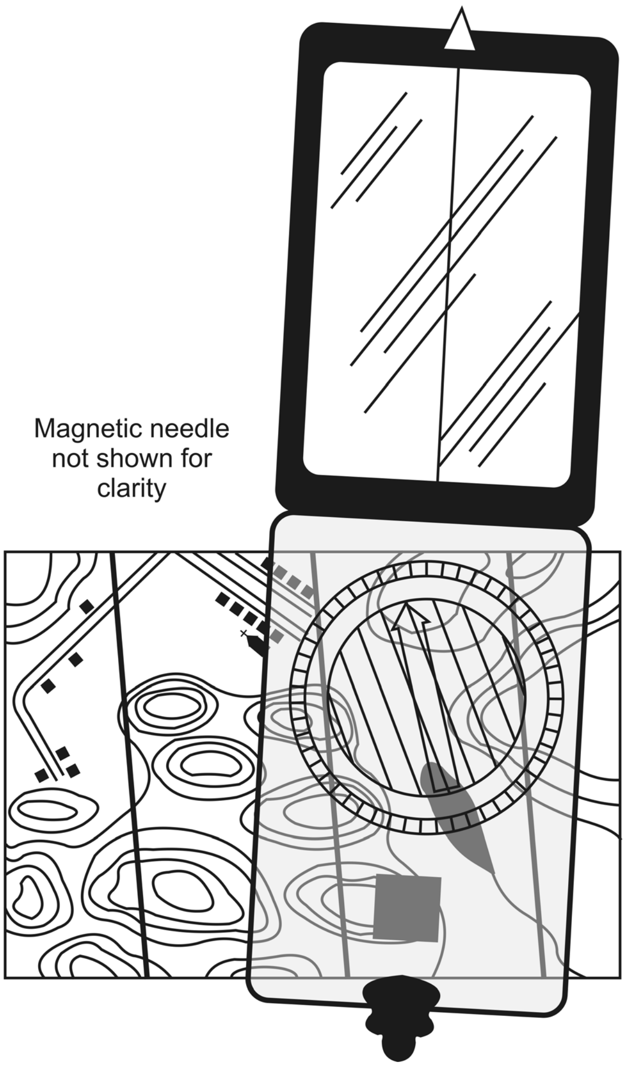


Figure 9-5: Resection by C-6 Compass—Step 2

d. While keeping the edge of the compass base on the symbol of the church, pivot the entire compass on the map until the compass meridian lines on the bottom of the dial are parallel with the eastings on the map, and so the orienting arrow points up or north on the map, as in Figure 9-6.

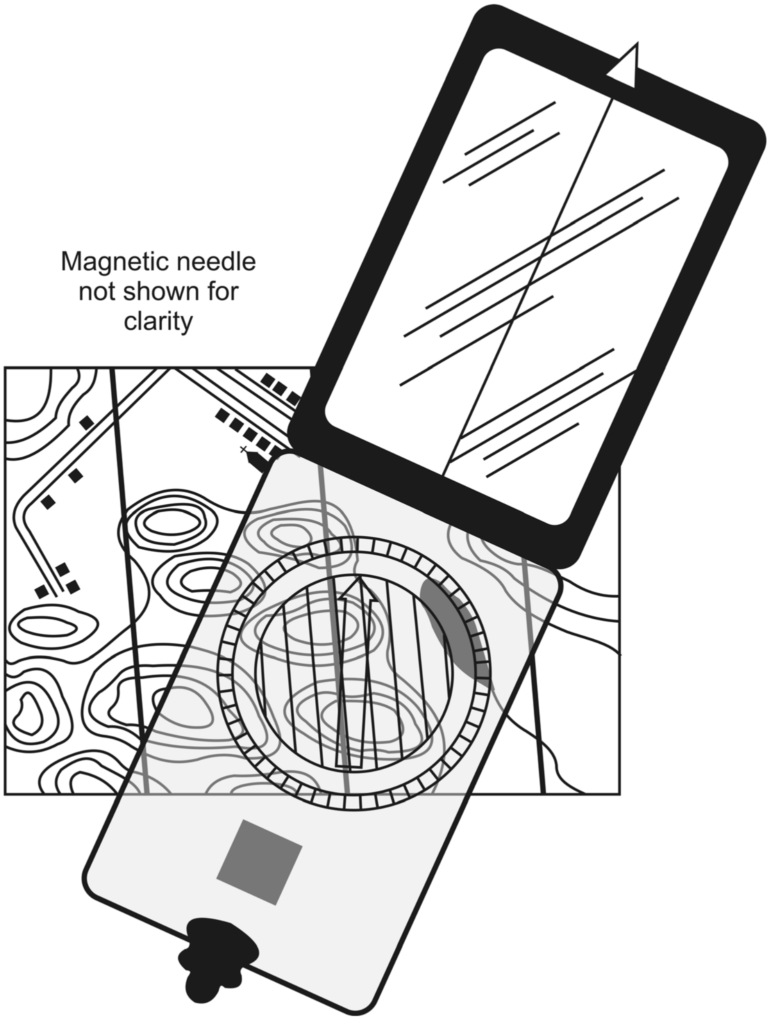


Figure 9-6: Resection by C-6 Compass—Step 3

e. Draw a line on the map along the edge of the compass, intersecting the symbol for the church. Your position is somewhere along this line. To establish your exact position along the line you need another bearing.

f. Take a second bearing - on a different object - by repeat the steps taken in subparagraphs b, c and d. In this example, take your bearings, this time, to the north end of the lake as shown in Figures 9-3 and 9-4. The line drawn on the map will intersect the line drawn from the church - where the two lines cross is your exact position. This is illustrated in Figure 9-7

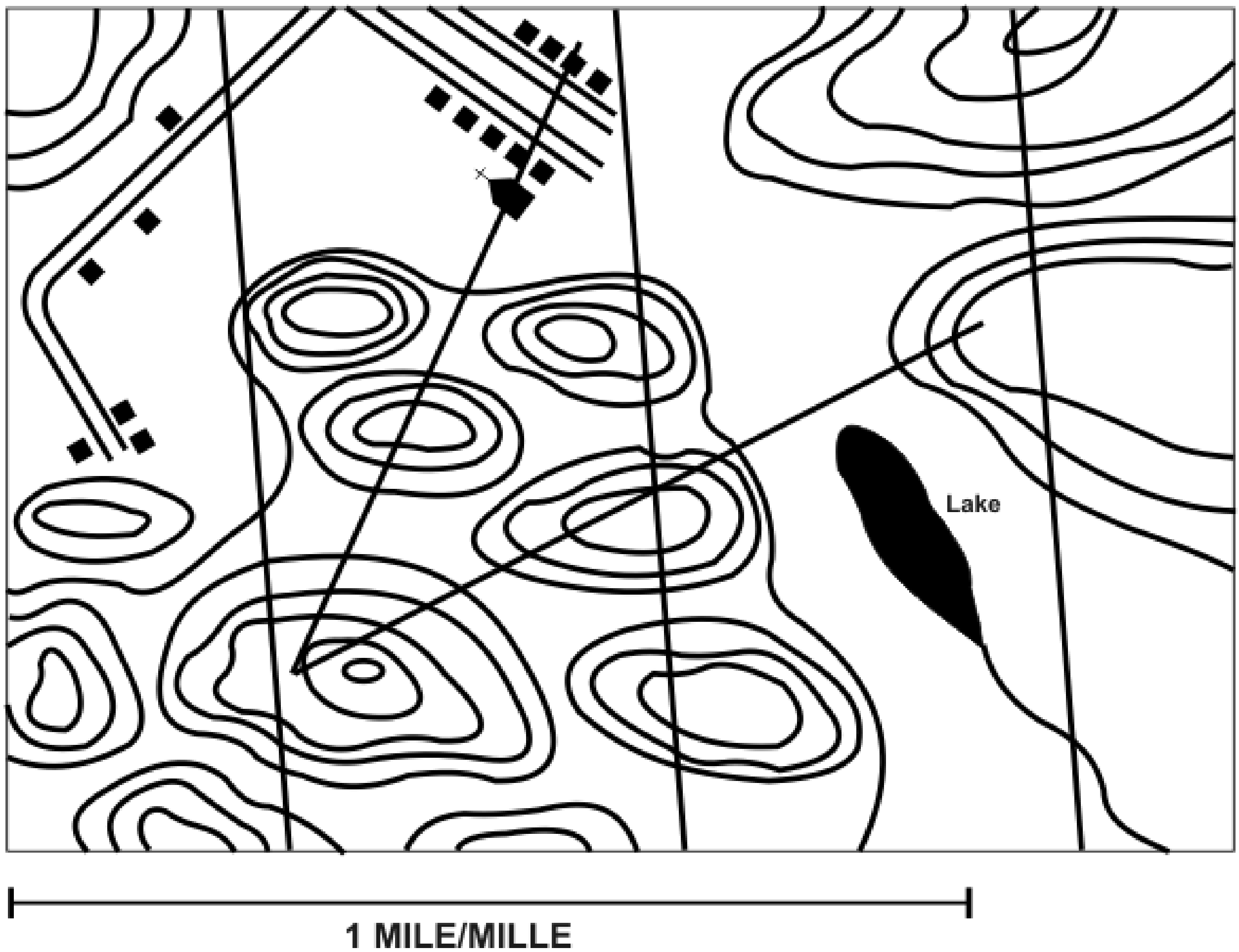


Figure 9-7: The Resection

SECTION 3
FINDING THE POSITION OF A DISTANT OBJECT

GENERAL

21. It may be necessary to locate the position of a distant object for one of two reasons:

a. to locate the position on the map of an object visible on the ground; or

b. to find on the ground an object whose position is known on the map.

LOCATING A VISIBLE GROUND OBJECT ON THE MAP

22. The simplest way of solving the first problem is by the use of a compass. Take up a position, which you can identify on the map, and take the compass bearing of the object (do not forget to allow for compass error.) Plot the grid bearing on the map. Your object will then lie on this line.

23. Orient your map (Section 1) and study it along the line, comparing it with the features on the ground. Determine the approximate distance at which your object lies in relation to these features, for example, between a river and a hill. Assuming your object is marked on the map, such as a building or a road junction, you should then be able to locate it on the map. If it is not marked, identify objects close to it, which are marked, and determine its position by reference to these objects, for example, 20 metres to the right of the building and 50 metres beyond the road junction.

24. If the object is not marked on the map, and an accurate grid reference is required, it will be necessary to plot another line of sight to the object from a second known point of observation. The intersection of the two lines of sight will then be the position of the point you wish to locate. It is necessary for your two points of observation to be far enough apart to allow for a minimum 40-mil angle of intersection at the point you are trying to locate.

25. If you have no compass or cannot use one for any reason, place the map (correctly oriented) between you and the object in such a position as to enable you to look along the line of sight from your position on the map to the object to be located. Mark this line on the map. This will then give you the approximate line on which your point should fall. Then carry on as in paragraph 23.

LOCATING A MAP POSITION ON THE GROUND

26. To find on the ground a position known on the map, draw on the map the line of the bearing from your position to the object. Measure the grid bearing and convert it to a compass bearing. With your compass, look along this bearing and identify the point on the ground by reference, if necessary, to adjacent detail that is more readily recognizable.

27. If this is not possible, orient the map and look along the line of bearing to identify the point as in paragraph 25.

SECTION 4
GLOBAL POSITIONING SYSTEM

PRINCIPLES OF OPERATION

28. The heart of the Global Positioning System (GPS) is a Constellation, which consist of 21 satellites and three spares orbiting in six planes, see figure 9-8. Circling the Earth twice daily, each satellite is in a fixed orbit, approximately 10,900 nautical miles above the surface of the earth, inclined at 55 degrees from the equator.

29. Information provided is precise and transmitted in real time. The most accurate, on demand worldwide navigation system, GPS is extremely resistant to interference from weather and earth-based radio signals.

30. All of these advantages make GPS greatly superior to any other navigation system.

Figure 9-8: GPS Constellation

SATELLITE RANGING

31. GPS is based on satellite ranging, which means we can determine our position on the earth by measuring our distance from a group of satellites in space. For example we know our distance from satellite A to be 11000 miles (17600 km). That tells us that we are somewhere on an imaginary sphere (Figure 9-9), that is centred on the satellite and that it has a radius of 11000 miles (17600 km). If at the same time we also know that we are 12000 miles (19200 km) from satellite B that narrows down where we are because the only place in the universe where we can be is on the circle where the two spheres intersect. If we then take a third measurement we can really pinpoint ourselves if we know that at the same time we are 13000 miles (20800 km) from satellite C then there are only two points in space where that can be true. Those two points are where sphere C cuts through the circle made by the intersection of sphere A and sphere B. By ranging from three satellites we can narrow down where we are to just two points in space. With a fourth satellite we can precisely locate ourselves on the earth.

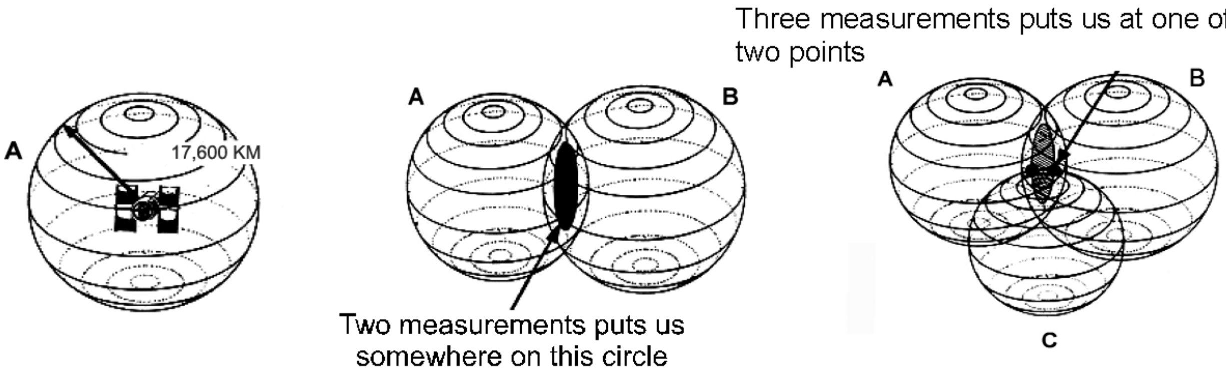


Figure 9-9: Precise Positioning of any Object in Three Dimensional Space.

NAVIGATION BY SATELLITE

32. Each GPS satellite continuously transmits two types of orbit data used to calculate a position: almanac and ephemeris. Tracking only one satellite, a GPS receiver can gather the almanac information, which contains the approximate location of every satellite in the system. From the almanac, the receiver determines which satellites will give the best geometry. The better the geometry, the more accurate the positional fix. The ephemeris data is more precise and is used in obtaining the exact position of each satellite.

33. In addition to this information, two codes are transmitted to provide two services. The standard position service and the precise positioning service. The precise position service is reserved for the Department of Defence while the standard position service has unlimited access.

34. The use of code has two purposes. It provides immunity of the signal to interference from undesired signals. Secondly, the code is used in determining the precise range of the user from each satellite—the first stage in calculating a position fix.

READING SATELLITE INFORMATION

35. While the Global Positioning System is complex, navigation with a well-designed GPS receiver can be simple. It uses the signal information in a fundamental geometric equation, solves the equation and presents the information in easy-to-use navigation displays.

36. To obtain a position fix, a minimum of three satellites are "read" (in two dimensions). First the receiver determines the time of transmission and reception of the signal from each satellite. It then multiplies the difference in these times by the speed of light (300 000 km per second) to arrive at an estimate of the satellite's distance from the receiver.

MILITARY APPLICATIONS

37. The Global Positioning System was primarily designed for real-time military positioning. Some of the most obvious applications are:

a. enroute navigation;

b. low-level navigation;

c. target acquisition;

d. remotely operated vehicles;

e. updating inertial navigation systems;

f. missile guidance; and

g. command and control.

38. The most remarkable feature of the GPS is its accuracy. Positional accuracy of 30 metres or better is commonly obtained from Course/Acquisition (C/A) code GPS receivers.

39. The completed GPS constellation of 21 satellites plus spares provides 24-hour continuous coverage worldwide. Unlike all other electronic navigation systems, the signal never weakens because of distance from the broadcast source.

40. Another remarkable feature of GPS is its resistance to interference from conditions which disturb other electronic navigation systems: thunder, lightning, heavy weather, radio signals, on-board electronics, passing ships, on-shore electronic installations, ignition of the boat engines, portable radio receivers and so forth.

41. The high frequencies (1 227 MHz and 1 575 MHz) used by GPS means that it operates in a wave environment where there is less interfering radiation. More important, GPS uses spread spectrum technology that greatly reduces any possible interference in the frequencies where it operates.

CHAPTER 10
AIR PHOTOGRAPHS

SECTION 1
INTRODUCTION

SCOPE AND PURPOSE OF THIS CHAPTER

1. The object of this chapter is to help all ranks in the use of air photographs to supplement the map, or, where necessary, to use the photographs as a substitute for a map. The detailed interpretation of air photographs for intelligence and similar purposes is beyond the scope of this chapter, nor does it cover the making of maps from air photographs. Its essential purpose is to assist the non-specialist who has to handle air photographs, photomosaics and photomaps to make the best use of them.

ADVANTAGES AND DISADVANTAGES OF AIR PHOTOGRAPHS

2. The advantages of air photographs over topographical maps are:

   a. **Up to Date Information**. An air photograph is usually more recent than the latest available map, and will therefore show more up to date information. The date and time of the photograph is normally shown on it.

   b. **Additional Minor Detail**. Maps, by necessity must omit much minor detail depending on their scale; vegetation is generalized and heights of buildings are not show. On air photos individual trees, bushes, rocks, and similar minor objects can be identified, and may be items of particular value as an aid to location of one's position or of the position of a target. Enemy gun positions, vehicles, and tracks of vehicles are all identifiable. The height of buildings, chimneys, trees, etc, can be assessed from the lengths of their shadows.

3. The disadvantages of air photographs are:

   a. **Difficulty of Interpretation**. The detail on the ground is viewed in the photograph from an unusual viewpoint and therefore training and experience are needed to interpret it correctly. An expert interpreter can extract a considerable amount of information, which is not apparent to an untrained observer. With practice, though anyone who can read a map will be able to interpret most topographical detail.

   b. **Inconsistency of Scale**. On a map the scale is constant over the map, and distances can be measured accurately between two points within the limits imposed by the scale of the map. On an air photograph, there are variations in the scale due to differences in the height of the ground and to errors in position caused by the tilt of the aircraft and camera at the instant of exposure. These variations are explained in more detail in Section 3, but at this point it needs only be accepted that air photographs are not true to a constant scale, and distances measured on them are not accurate.

4. To sum up, a map gives a clear, broadly accurate, but often out of date picture of the ground. The air photograph gives an extremely detailed and up to date picture, but one which needs careful reading and which sometimes contains large distortions. The best answer is obtained by using both mediums together.

INTERPRETATION OF AIR PHOTOGRAPHS

5. To cultivate an eye for an air photograph, four qualities are needed:

a. The ability to identify an object viewed from above.

b. Appreciation of the effect of shadows and their shapes.

c. Appreciation of the effect of tone; this is apparent on all types of photographs.

d. An ability to deduce the meaning of the detail shown on a photograph, for example, tracks converging on a point probably indicate the presence of something of importance. The basic points in interpretation of air photos are given in Section 5.

INSTRUCTION IN THE USE OF AIR PHOTOGRAPHS

6. Only a few specimens of air photographs are shown in the manual. It is assumed that instructors will have typical air photographs and stereoscopes available for issue to the class in conjunction with maps of the same area. For initial instruction, it is essential to have photographs of areas and objects, which can also be visited on the ground.

SECTION 2
TYPES AND CHARACTERISTICS OF AIR PHOTOGRAPHS

TYPES OF AIR PHOTOGRAPHS

7. There are two basic types of air photographs:

a. vertical, and

b. oblique.

8. For a vertical photograph, the camera points vertically downwards from the aircraft in level flight. This gives a plan view of the ground. This is the type of photography used for mapping, and is most commonly issued for supplementary map information. An example is shown in Figure 10-1.

9. For oblique photographs, the camera points in a slanting direction towards the ground. The photograph gives a side view, similar to that obtained from a hilltop or from a high tower. Oblique photographs are principally used for intelligence purposes to cover particular objects, and to get side views from which extra information may be obtainable. It is now rarely used in Canadian mapping.

10. There are two types of oblique photographs, "High Angle" and "Low Angle". In a high angle oblique the camera points only slightly downwards, and the view will always include the horizon. With a low angle oblique, the camera points steeply downwards and the horizon does not appear in the photograph: most objects are seen more or less in side view, although those in the foreground are seen almost in plan view. Figures 10-2 and 10-3 illustrate these two types of oblique photographs.

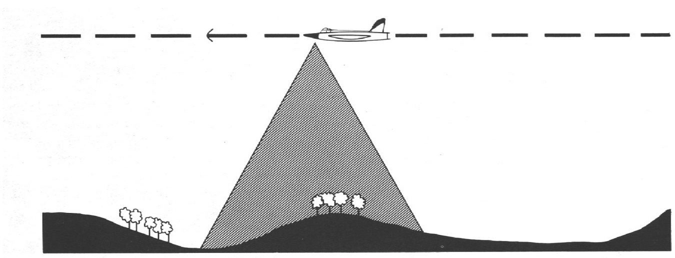


Figure 10-1: Vertical Photography

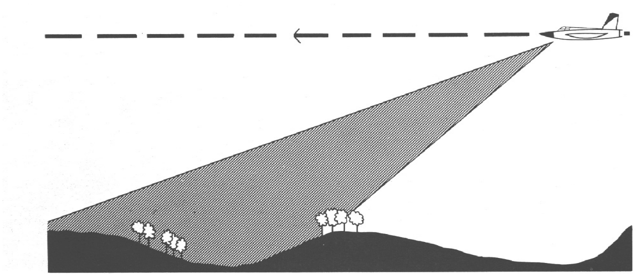


Figure 10-2: High Angle Photography

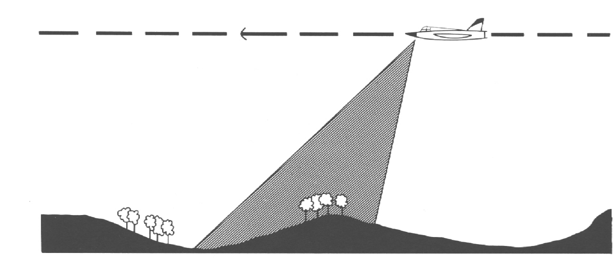


Figure 10-3: Low Angle Oblique

11. It should be noted that the terms "High" and "Low" have no relationship to the height of the aircraft above the ground, but only to the angle of the camera.

CHARACTERISTICS

12. A vertical photograph gives a plan view of the ground, and is therefore easy to compare with a map. Objects of some size, such as, woods, on the photograph can normally be identified easily by their shape on the map, and vice versa. Most objects will normally be visible, with the exception of those, which may be masked by tall buildings, overhead cover or ground obscured by deep shadow. The relief of the ground can only be seen with the aid of a stereoscope, as discussed in Section 4. A typical vertical photograph is shown in Figure 10-4.

13. An oblique photograph gives a perspective view of the ground. The scale of the photograph varies considerably, and it is therefore more difficult to relate the photograph to a map. There is dead ground behind buildings and trees, though it may be possible to see vehicles under overhanging trees which are not visible in a vertical photograph. The shape of the ground can be seen to some extent, but small undulations do not show up clearly, and it is easy to miss an area of dead ground. The heights of buildings and other objects in the foreground relative to each other can be judged fairly accurately.

14. In a low angle oblique the foreground is much closer than in a high angle oblique taken from the same height; the ground can therefore be examined more closely. In a high angle oblique the area covered by the photograph is much larger and more distant. See Figures 10-5 and 10-6 for examples.

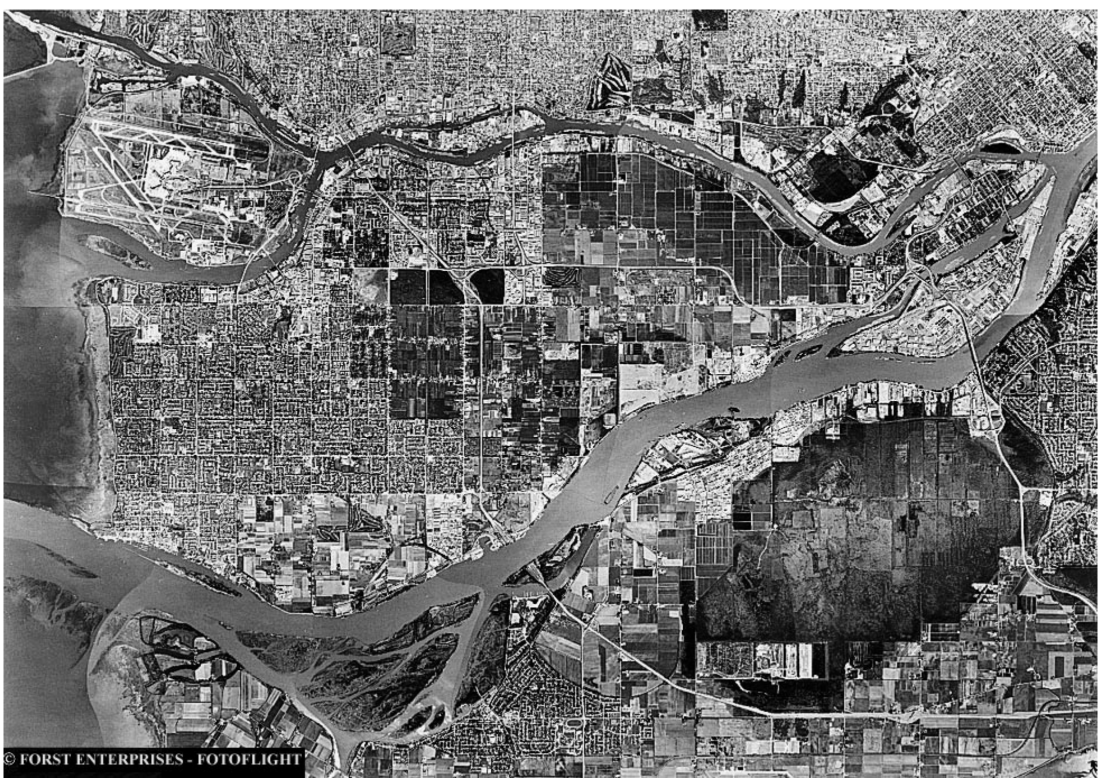


Figure 10-4: Vertical Photograph

Figure 10-5: High Angle Oblique Photograh

Figure 10-6: Low Angle Oblique Photograph

TITLING ON AIR PHOTOGRAPHS

15. The initial photograph of a photo mission contains the information necessary to permit the full utilization of the photographs of the mission. Figure 10-7 is a typical example of what will be found on the initial print. An explanation of each line is as follows:

a. A23692-1: The first six digits reflect the roll number, the (-1) is the photo number of the mission.

b. ICAS 74.3: Interdepartmental Committee on Air Surveys number.

c. Line 1-E (1-21) Item 7, Camp Shilo, Man. 13,700' ASL, 12-5-74: The line numbers reflect successive flight lines over the area. They may move progressively northward, i.e., the southern edge of the mission area is flown first and the 'E' or 'W' indicates the direction of flight. The (1-21) is the number of photos in the line. The "Item" number indicates an item of the total contract of the mission flown by civilian photo mapping establishments. The mission was flown at 13,700 feet above average sea level (sometimes mean sea level, MSL) on 12 May 74.

d. ZEISS RMK A15/'23, MAG. 111615, PAN-CHROMATIC FILM: ZEISS RMK, the camera name, is followed by its serial number and then the magazine serial number and type of film.

e. LENS 112650, 153.22 mm ZEISS B: The lens number, focal length and type of filter being used.

f. 026: This figure reflects the actual photograph number in the overall sequence.

g. The bottom edge of the film may include, from left to right, the contractor, the local time, a levelling bubble and an altimeter.

16. Subsequent prints in the strip will include the following detail: roll number; camera and lens number together with the focal length of the latter; photo number, local time, levelling bubble and altitude. This information will permit the determination of the scale of any particular photograph. See also Section 3.

17. In special cases, a security classification will be marked on the photo.

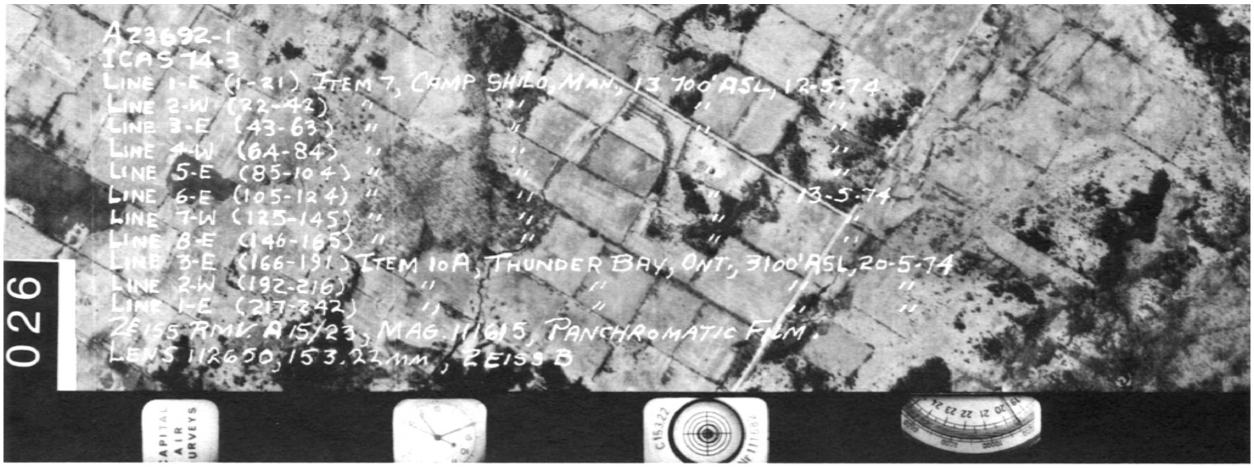


Figure 10-7: Air Photograph Titling

METHODS OF PHOTOGRAPHY

18. Vertical photographs are usually taken in “Strips” along a straight line. Within each strip, the successive photographs should have an overlap of about 60 per cent. This allows the centre of each photograph to appear on the succeeding photograph, the two photographs thus forming a pair for stereoscopic viewing. To cover an area a series of parallel strips are flown, each overlapping the strip next to it by a minimum of 20 per cent: this is called a “Block” of photography.

19. When a single object is to be photographed, a single photograph or a pair of photographs may suffice. This is called pinpoint photography.

20. Oblique photographs may be taken in strips or as pinpoints. They are not normally used for block photography. Oblique photographs may however be taken in strips as part of a “Fan Array” of three cameras, one vertical in the centre and one oblique on each side.

SECTION 3
SCALES AND MEASUREMENTS

VARIATION IN SCALE

21. As stated in Section 1, the scale of an air photograph normally varies over different parts of it. Only in perfectly flat country, with the axis of the camera truly vertical, can the scale of a photograph be constant over the whole area. In hilly country, the scale will vary because the top of a mountain is nearer to the camera than the bottom of a valley, and therefore it appears larger. A deduced scale of a photograph can therefore only be approximate, and when there are marked differences in ground height between adjacent photographs the variation in scale between them will make it difficult to fit the photographs together.

DEDUCING THE SCALE FROM A MAP

22. To deduce the approximate scale of a vertical photograph from a map of the same area, identify two points on both the photograph and the map and measure the distance between them on each. If the scale of the map is 1:X, the distance between the points on the map is D, and the distance between the same points on the photograph is d, (D and d being expressed in the same units), then the scale of the photographs is 1: P where $1:P = \frac{d}{X \times D}$

23. For example, if the scale of the map is 1:50 000, the distance on the map is 5.6 cm, and the distance on the photograph is 8.4 cm, then the scale of the photograph

$$1:P = \frac{8.4}{50\,000 \times 5.6} = 1:33\,333$$

24. To obtain the best general approximate scale, several different pairs of points should be measured on different parts of the photograph, and the average scale accepted. If, however, measurements are required only in one part of the photograph, it is better to deduce a scale for that part only.

SCALE FROM PHOTOGRAPHIC DATA

25. When no map is available or when no suitable points can be identified on both map and photo, the approximate scale can be deduced from the focal length of the camera lens and from the height of the aircraft above the ground, see paragraph 15e and 15g on how to obtain these values. The scale of the photograph is then:

$$1:P = \frac{\text{Focal length of lens}}{\text{Height of aircraft above the ground level}}$$

NOTE

Both items must be expressed in the same unit. For example with a height of aircraft of 20 000 feet and a focal length of 6 inches (6/12=0.5 feet) the scale of the photograph:

$$1:P = \frac{6}{20\,000 \times 12} = 1:40\,000$$

26. It must, however, be noted that the height of the aircraft recorded on the titling strip of the photograph is normally the height above mean sea level. If, therefore, in the above example the general level of the ground in the photograph is 5 000 feet above mean sea level, the height of the aircraft above the ground becomes 20 000 – 5 000 = 15 000 feet, and in consequence the scale of the photograph becomes 1:30 000 instead of 1:40 000.

27. This method of course gives only the scale of a contact print taken directly from the negative. If the photograph has been enlarged, the scale will have been increased

correspondingly. For example, if the scale of the original contact print is 1:30 000 and the print is enlarged three times, then the scale of the enlarged print will be

$$\frac{1}{30\ 000} \times 3 = 1:10\ 000$$

OBLIQUE PHOTOGRAPHS

28. The scale of an oblique photograph will vary widely from foreground to background, and a mean scale is of no value. A local scale can be obtained, using the map method, by measuring of points of detail lying close and parallel to the object to be measured, but this scale cannot be applied to other parts of the photograph.

BEARINGS

29. Approximate bearings can be measured on a vertical photograph by comparison with the map. Measure on the map the grid bearing of the line joining two points identifiable on both the map and the photograph. Then, on the photograph lay off this bearing from the line joining the two points and thus establish a north-south grid line through one point. Other bearings from this point may then be measured on the photograph.

COMPARISON OF VERTICAL PHOTOGRAPH WITH MAPS ON DIFFERENT SCALES

30. Figure 10-8 shows maps at 1:50 000 and 1:250 000 scales respectively covering the area of the vertical photograph illustrated. The average scale of the photograph is about 1:20 000. The dates of the photograph and of the two maps are different, and discrepancies of detail are therefore to be found; the photograph is the most recent.

31. The 1:50 000 map is approximately 2½ times smaller than the photograph and the 1:250 000 map is at a scale 7½ times smaller. The latter scale makes direct comparisons difficult.

32. Particular points for identification and comparison are:

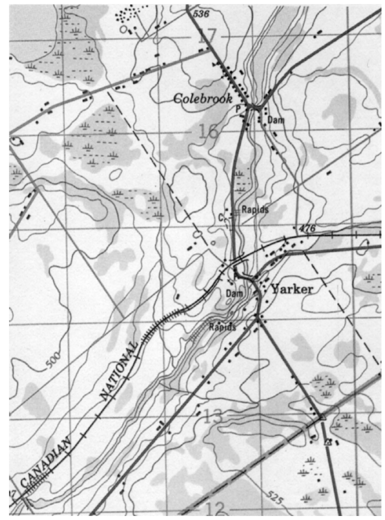
a. main roads, the railway and the dam;

b. buildings, note changes and development;

c. pattern woods, isolated clumps readily identifiable;

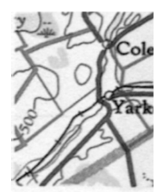
d. water features, differences in tone (see Section 4); and

e. loss of detail under trees.



Scale 1:25 000

Scale 1:250 000



Scale 1:20 000

Figure 10-8: Photo/Map Comparison

SECTION 4
PRINCIPLES AND USE OF THE STEREOSCOPE

STEREOSCOPY

33. Stereoscopy is the ability of the brain to accept an image of an object from each eye, and with these two images to create a three dimensional or stereoscopic image of the object. If each eye looks simultaneously at a separate air photograph of the same area of ground taken from different positions in the air, then the brain will create a three dimensional image of the area of ground. In practice, this is achieved by looking simultaneously at two successive vertical photographs in a strip which overlap each other by about 60 per cent (see paragraph 18). The instrument, which assists this viewing of two photographs simultaneously, is called a

stereoscope. It is possible to view two photographs stereoscopically without a stereoscope, but this requires concentration and practice; it is better to use a stereoscope.

STEREOSCOPES

34. There are many different types of stereoscopes. The simple basic stereoscope consists of a frame holding two lenses for the eyes at a fixed distance apart set up on two legs. These legs hold the frame with the lenses at a distance of about 15 cm from the table on which the photographs are placed side by side, see Figure 10-9. The lenses give a measure of magnification (usually about two or three times), and are focused to suit viewing of the photographs at the fixed distance of the height of the legs.

35. More refined stereoscopes enable the photographs to be set wider apart, and can provide variable magnification. The principles of viewing, however, remain the same.

Figure 10-9: Hand Stereoscope

USING THE STEREOSCOPE

36. A pair of photographs must be correctly placed under the stereoscope if the ground is to be seen properly in relief. The rules are:

a. The photographs must be a stereo-pair; that is to say, they must contain the same area of ground taken from two different viewpoints. Normally, they are two successive exposures in a strip.

b. They must be positioned so that the common areas of the two photographs are adjacent and the line of flight is parallel to the line joining the lenses of the stereoscope.

37. Place one photograph of the pair on the table in a convenient position for viewing. Place the second photograph on top of the first so that the detail common to both is overlapping. Move the top of the first about five cm to the side, carefully keeping it in the same orientation relative to the first photograph. Place the stereoscope over the photographs. Look through the stereoscope, and the ground should appear in relief. If the image appears double, move the upper photograph slightly sideways or up and down until the two images appear in coincidence. After fastening the photo down by weights or pins, the stereoscope can be moved to examine any part of the common overlap.

38. If, when the photographs are set as above, the top photograph overlaps the lower one, thus obscuring a strip of it from view, the overlapping edge may be turned up gently to clear the line of sight. Take care not to crease the photograph, which will damage it for further viewing.

SECTION 5
PHOTO INTERPRETATION

INTRODUCTION

39. Interpretation of air photographs should be carried out under a stereoscope, if possible. If photographs are to be used in the field without a stereoscope, then photographs should be studied under a stereoscope before setting out.

40. The full interpretation of air photographs requires much training and experience and is beyond the scope of this section, which deals only with the basic principles.

PRINCIPAL FACTORS

41. Photo interpretation is based on the following factors:

a. shape;

b. size;

c. shadow;

d. tone; and

e. associated features.

42. Shape can often provide immediate identification. Size is often a question of comparison with other objects of known size. If the scale of the photograph can be calculated reasonably accurately, sizes can be measured.

43. Shadow is an important factor when light conditions of photography are good. Many objects can be identified readily from their shadows while their plan view does not show their nature at all, for example, tall buildings and chimneys. If the photographs are taken when the sun is low, the value of shadows is enhanced. Shadows can, of course, obscure detail as well as reveal it, especially in hilly areas.

44. Tone is related to texture and colour, and is the measure of the amount of light reflected from the object. Texture has more effect on tone than colour. Smooth surfaces reflect more than rough surfaces; hence a black toned road may appear lighter than a field of rough green grass.

45. Many objects can be identified from their associated features. Tracks may reveal the presence of objects not otherwise noticeable.

CAMOUFLAGE

46. Camouflage is applied in two ways:

a. camouflage of the object itself, usually by painting with the dual purpose of breaking up its distinctive outline and to make it merge into the background; and

b. camouflage by concealing the object itself with netting, scrim, branches, etc.

47. Camouflage of the first kind is more effective against an observer on the ground than in an air photograph, the latter is not materially affected. Camouflage of the second kind is more effective against air photography, but it can be detected when viewed under a stereoscope, since this may reveal a mound or some object above ground level. Changes in position of such objects over a number of days combined with the location of tracks leading to the area will assist in revealing the identity.

WATER

48. For various reasons, the tone of water may vary widely from white to black; it is therefore normally identified by its associated features and by the natural shape of its banks. Water features such as canals or drainage ditches are harder to distinguish from other artificial features.

VEGETATION

49. Woods and trees are dark toned. Conifers are generally darker than deciduous trees. Orchards and plantations are prominent because of their regular spacing. Shadows of individual trees help in the identification between deciduous trees and conifers.

50. Crops and grasslands are distinguished by their tones, generally the taller the crop the darker its tone. The smoother textures are also lighter in tone. Ploughed fields have a regular dark toned appearance.

ROADS AND TRACKS

51. Roads are generally uniform in width and may run in straight stretches of varying lengths, but the curves are not as regular as those of railways. Concrete roads tend to appear lighter than tarred or undeveloped roads; the latter are usually less regular and may show separate wheel tracks. Bridges, embankments and cuttings can generally be identified from their shadows.

MILITARY FEATURES

52. Military features are similarly identifiable but this is a specialist task and is not covered in this publication.

SECTION 6
PHOTOMOSAICS, PHOTOMAPS, AND ORTHOPHOTOS

PHOTOMOSAICS

53. A photomosaic is a collection of overlapping air photographs assembled to form a composite picture of the ground. It may be issued either to supplement a map for a special operation or as a substitute for a map when no adequate map is available.

54. Photomosaics can be produced more rapidly than a normal map and have the advantages and disadvantages inherent in air photographs as listed in Section 1.

55. Photomosaics vary in accuracy according to the amount of "Control", i.e., points of known position used to position the photographs when making the assembly. The more control used, the more accurate the photomosaic will be, but the longer it will take to produce it. The accuracy to which it is made is therefore dependent on the availability of both factors: control and time. In general, the user must assume that it is not as accurate as a map at the same scale, and distances and bearings measured on it must be treated with caution. It does, however, provide a better aid than a collection of individual photographs, and in some cases it may approach the accuracy of a map.

56. The interpretation of detail is the same as on an air photograph, but in this case, the stereoscope cannot be used, as there are no overlapping pairs.

PHOTOMAPS

57. A photomap is a printed photomosaic, on which the background detail of the mosaic has been cartographically improved (sometimes with the addition of colour) to clarify the interpretation, and to which a grid and map framework have been added. It is thus an advanced form of photomosaic on which much more preparation work has been carried out and which therefore takes longer to produce. On the other hand, its accuracy is closer to that of a map. (See Figure 10-10.)

58. The photomap shows the photographic detail but roads may be coloured or otherwise emphasized, important buildings may be made prominent, vegetation may be classified, and names may be added. The amount of cartographic work undertaken will vary according to circumstances, the object of the cartographer being to provide the best document possible within the time and resources available.

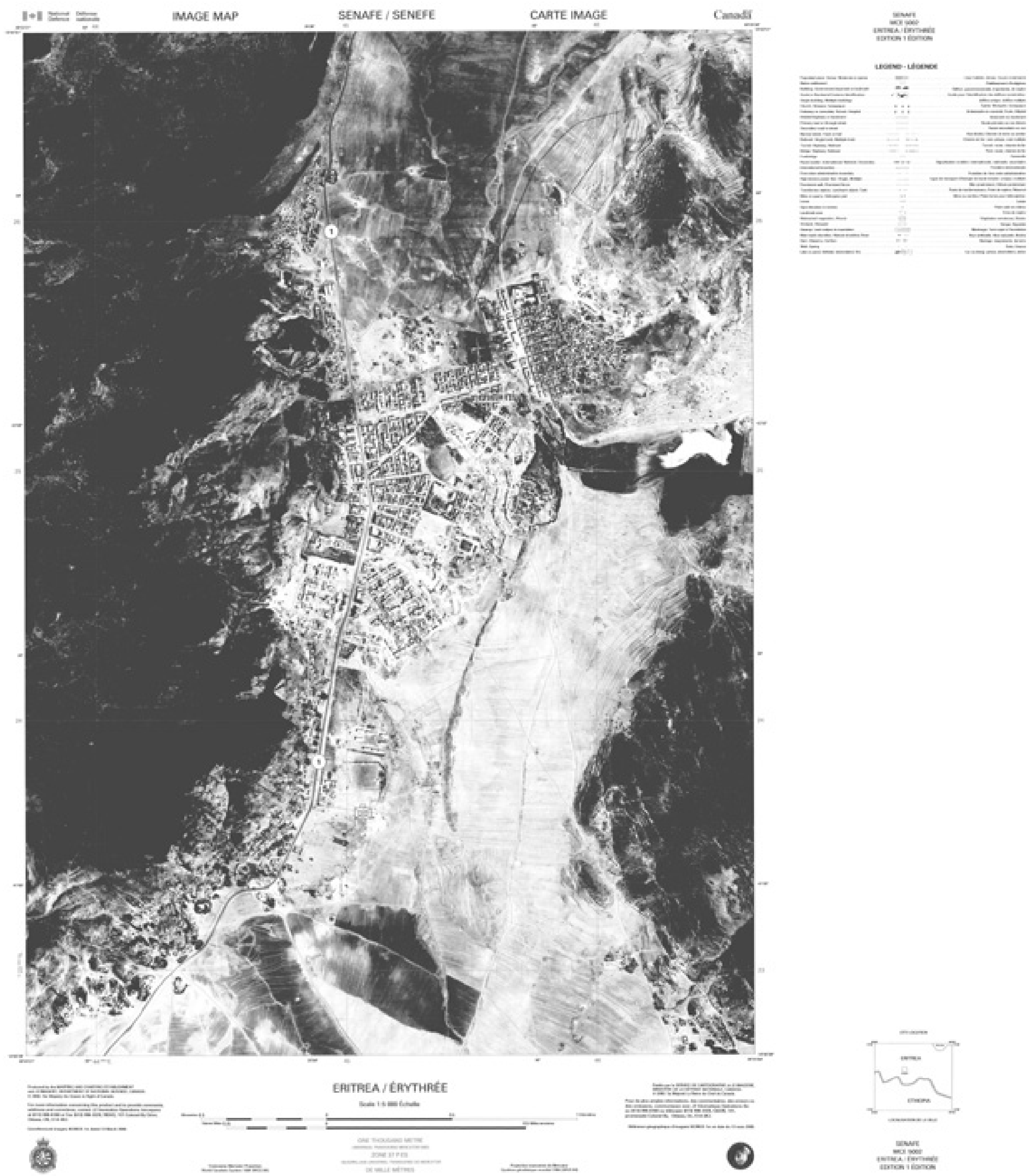


Figure 10-10: Photomap

59. Photomaps are issued as map substitutes when no normal map is available. In some circumstances, they may be issued because the nature of the area or the local requirements make a photomap more useful than a normal map.

ORTHOPHOTOGRAPHS

60. Air survey equipment is now available that will produce vertical air photographs that may be reproduced and assembled in photomosaics (orthophotomosaics). With this equipment the distortions in scale due to hilly ground and or air camera tilt have been eliminated. The final product is still a vertical air photograph or mosaic, but its accuracy is as good as a normal surveyed map. Orthophotographs are not yet available for general issue, but in due course this may occur, and for this reason they are mentioned in this publication.

CHAPTER 11
FIELD SKETCHING

SECTION 1
INTRODUCTION

GENERAL

1. A sketch is a large scale, free-hand drawn map or picture of an area or route of travel, showing enough detail and having enough accuracy to satisfy special tactical or administrative requirements. Sketches are useful when maps are not available, the existing maps are not adequate, or to illustrate a reconnaissance report.

2. Sketches may vary from hasty to complete and detailed, depending on the time element, the accuracy requirement, the situation, climatic conditions, skill of sketcher and the area being sketched. In addition, the degree of accuracy will vary with the purpose of the sketch, for example a minefield sketch must be more accurate than a defensive position sketch.

TYPES OF SKETCHES

3. There are two types of sketches—the military and the panoramic. The former is the vertical view of the ground. They include road and area sketches. Road sketches show the natural and military features on and in the immediate vicinity of the road. Area sketches show the natural and military features pertaining to a particular area. The panoramic sketch is an oblique view of the ground. Only panoramic sketches are discussed in this publication in any detail.

SCALES OF SKETCHES

4. The scale of a sketch is determined by the object in view and, the amount of detail required to be shown.

SECTION 2
THE PANORAMA

GENERAL

5. A panoramic sketch is a drawing of the view seen from a given point. It shows the horizon which is always of military importance, and intervening features such as crests, woods, structures, roads and so on, which are of military value or an aid in the location of detail of military value. Such a drawing can be of the greatest value in illustrating a report and will be undertaken when photography is not available or feasible. As is the case for all drawings, artistic ability is an asset, but satisfactory panoramas can be produced by anyone regardless of his artistic skill. Practice is, however, essential, and certain principles must be observed. These are:

a. Work from the whole to the part. Before putting pencil to paper study the ground carefully both with the naked eye and through binoculars. Decide what is the extent of the country that is to be included in the drawing. Select the major features that will form the framework of the sketch.

b. Do not attempt to put too much detail into the drawing. Minor features should be omitted unless they are of tactical importance, required to aid recognition or to lead the eye to some adjacent feature of tactical importance. Only practice will teach how much detail should be included in the sketch and what should be left out.

c. As far as possible, draw everything in perspective. The general principles of perspective are:

    (1) The further away an object is, the smaller it should appear in the drawing.

    (2) Parallel lines receding from the observer appear to converge; if prolonged they will meet at a point called the "Vanishing Point". The vanishing point may be assumed to be always on the same plane as that on which the parallel lines rest. Thus railway lines on a perfectly horizontal surface, receding from the observer, will appear to meet at a point infinitely far away on the horizon, which is the eye level of the observer. If the plane on which the railway lines lie is tilted, either up or down, the vanishing point appears to be similarly raised or lowered. Thus the edges of a road running uphill and away from the observer will appear to converge to a vanishing point above the horizon, and if running downhill, the vanishing point will appear to be below the horizon. Figure 11-1 gives an example of perspective drawing.

d. Roads and all objects such as trees and hedges should be shown by conventional outline, except where peculiarities of shape make them useful landmarks and suitable as reference points. This means that the instinct to show the actual shapes seen should be suppressed, and conventional shapes used, as these are easy to draw and convey the required impression. Buildings should normally be shown by conventional outline only but actual shapes may be shown when this is necessary to ensure recognition or to emphasize a feature of the building, which is of tactical importance. The filling in of outlines with shading or hatching should generally be avoided, but a light hatch may sometimes be used to distinguish wooded areas from fields.

e. All lines must be firm and continuous.

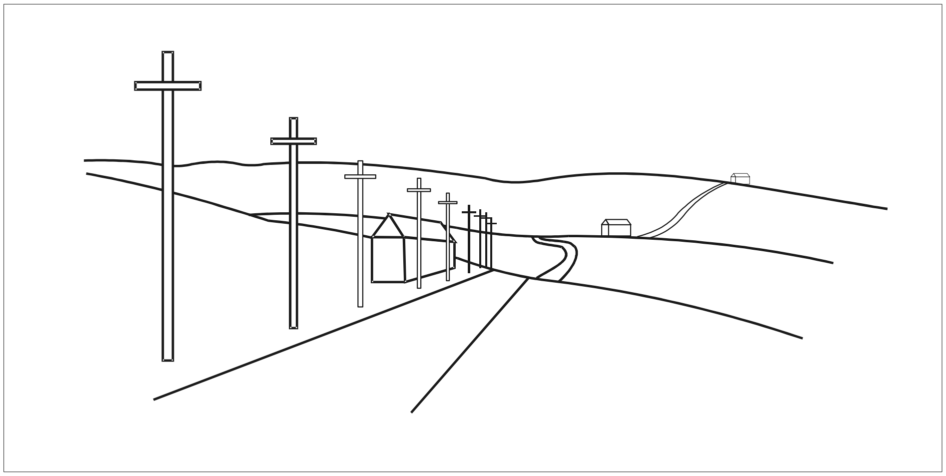


Figure 11-1: Example of Perspective Drawing

6. The panorama sketcher should have with him the following items:

   a. a service protractor and/or suitable graduated ruler;

   b. a pencil capable of producing both fine and firm black lines, “H” is recommended;

   c. a penknife or razor blade to sharpen the pencil;

   d. an eraser;

   e. a length of string; and

   f. suitable paper, squared for choice, clipped on to a board, or in a book with a stiff cover to give a reasonable drawing surface.

EXTENT OF COUNTRY TO BE INCLUDED

7. Before beginning a panorama sketch, the extent of country to be included must be decided. Military conditions and requirements will usually provide the answer. It will be found, however, that an area subtending 30 degrees of arc is a suitable maximum to draw on a single sheet of paper. Should a wider scope be required, it is usually better to produce two panoramas, one of each half of the total area wanted, and to stick them together afterwards.

8. A convenient method of making a decision as to the extent of country to be drawn in a single sketch, is to hold a service protractor about a foot from the eye. Then close one eye, and consider the section of country thus blotted out by the protractor to be the area to be sketched. The extent of this area may be increased or decreased by moving the protractor nearer to, or further from the eye. Once the most satisfactory distance has been chosen, it must be kept constant by means of a piece of string attached to the protractor and held between the teeth.

FRAMEWORK AND SCALE

9. The next step is to fix on the paper all outstanding points in the landscape in their correct relative positions. This is done by denoting the horizontal distances of such points from the edge of the area to be drawn, and their vertical distances above the bottom line of this area, or below the horizon. If the size of the sketch is limited in the horizontal direction to the length of the protractor, the horizontal distances in the picture may be acquired by lowering the protractor and noting which graduations on its upper edge coincide with the feature to be plotted. The protractor can then be laid on the paper and the position of the feature marked above the graduation noted. If the sketch is longer horizontally than the length of the protractor, the horizontal readings must be increased proportionally when plotting. Vertical distances may be similarly acquired by turning the protractor with its long side vertical. Thus, the exact position of any piece of detail may be plotted accurately on the paper. Squared paper, such as contained in a Field Message Book, will be of assistance.

10. The eye appears to exaggerate the vertical scale of what it sees, relative to the horizontal scale. It is preferable, therefore, in panorama sketching to use a larger scale for vertical distances than for horizontal ones. This will preserve the perspective of things as they appear to the observer. A suitable exaggeration of vertical scale relative to the horizontal is 2:1, which means that every vertical measurement taken to fix the outstanding points in the landscape should be doubled, while the horizontal measurements of the same points are plotted as read.

FILLING IN THE DETAIL

11. When all the important features have been plotted on the paper in their correct relative positions, the intermediate detail is added, either by eye or by further measurements from these plotted points. In this way, the panorama will be built up on a framework as shown on Figure 11-2. All the original lines should be drawn in lightly. When the work is completed, it must be examined carefully and compared with the landscape to make sure that no detail of military significance has been omitted. The work may now be drawn in more firmly with darker lines, bearing in mind that the pencil lines should become darker and firmer as they approach the foreground.

CONVENTIONAL REPRESENTATION OF FEATURES

12. The following methods of representing natural objects in a conventional manner should be borne in mind when making the sketch:

a. **Outstanding Points**. The actual shape of all outstanding points which might readily be selected as reference points when describing targets, such as oddly shaped trees, outstanding buildings, towers, etc, would be shown. They must be accentuated with an arrow and a line with a description, for example, “Outstanding Tree with Large Withered Branch” or “Square Embattled Tower”, and the map reference given where possible.

b. **Rivers**. Two lines diminishing in width as they recede should be used.

c. **Trees**. Trees should be represented by outline only. Some attempt should be made to show the characteristic shape of individual trees in the foreground.

d. **Woods**. Woods in the distance should be shown by outline only. In the foreground the tops of individual trees may be indicated. Woods may be shaped or hatched, the depth of shading or hatching becoming less with distance.

e. **Roads**. Roads should be shown by a double continuous line, diminishing in width as it recedes.

f. **Railways**. In the foreground railways should be shown by a double line with small cross lines (which represent the ties) to distinguish them from roads. In the distance they will be indicated by a single line with vertical ticks to represent the telegraph poles.

g. **Churches**. Churches are shown in outline only, but care should be taken to denote whether they have a tower or a spire.

h. **Towns and Villages**. Definite rectangular shapes denote houses, while towers, factory chimneys and outstanding buildings should be indicated where they occur.

i. **Cuttings and Embankments**. These may be shown by the usual map conventional sign, ticks diminishing in thickness from top to bottom, and with a firm line running along the top of the slope in the case of cuttings.

OTHER METHODS

13. The foregoing method of drawing panoramas will be found the easiest and most encouraging for a beginner. There are, however, other methods.

14. A simple device which will help a great deal in panorama drawing can be made by taking a piece of cardboard and cutting out of the centre of it a rectangle of the same size, approximately, as the service protractor. A piece of celluloid or photographic film with the emulsion cleaned off is then pasted over the rectangle. A grid of squares of about half-inch size is drawn with firm lines on the celluloid. The effect is that of a ruled celluloid window in a cardboard frame, through which the landscape may be viewed. The paper on which the drawing is made is ruled with a similar grid of squares. If the frame is kept at a fixed distance from the eye by a piece of string held in the teeth, the detail seen can be transferred to the paper square by square.

15. Another method is to divide the paper into strips by drawing vertical lines denoting a fixed number of degrees of arc and plotting the position of important features by taking compass bearings to them. This method is accurate but slow.

FINISH

16. Figure 11-3 shows an example of a finished panorama. It should be clear and simple. A few touches of colour may be used for emphasis. Thus, rivers may be tinted blue, roofs red, roads brown, but colour must be used lightly and sparingly.

17. No attempt should be made to produce an artistic effect by the insertion of unnecessary detail. The following information should always be given:

a. Map reference of the observer's position.

b. Bearings, names and, where possible, map references of important points, towns, villages, etc, should be written above the panorama, and lines drawn into the work to indicate the position referred to.

c. The bearing of the centre of the panorama from the point of observation.

d. The name, rank and the unit of the observer.

e. The date, time and notes as to the weather conditions.

f. Any indication of troop locations on the panorama should be in the conventional colours, i.e., red for enemy and blue for friendly forces.

Central Axis of sight

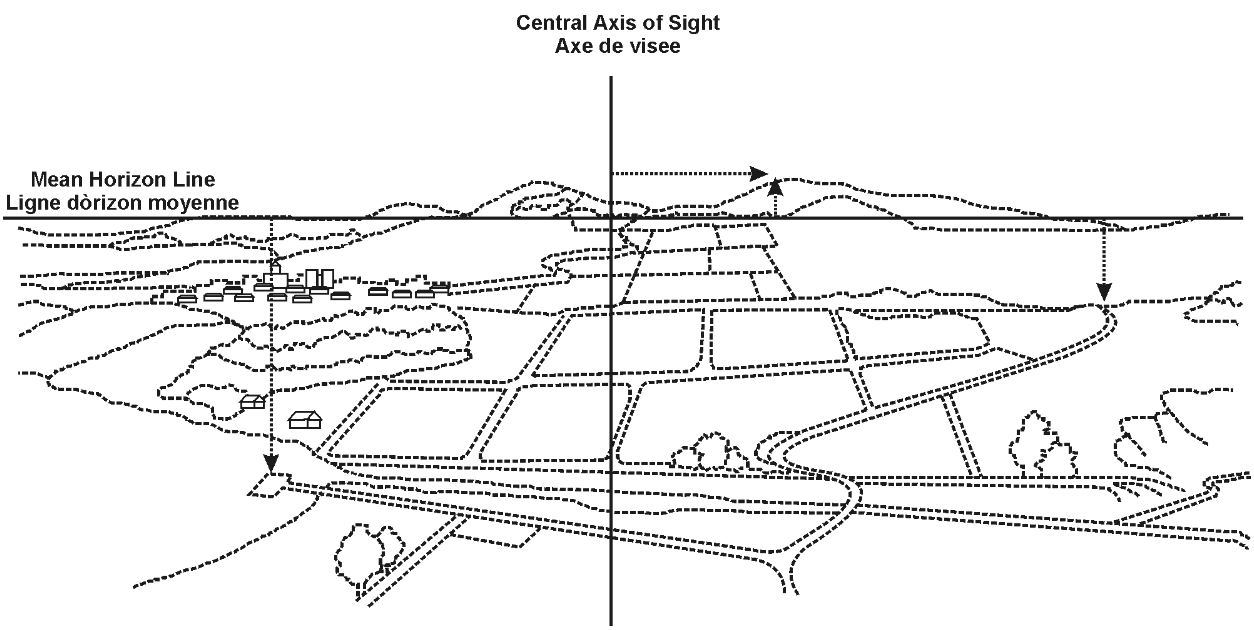


Figure 11-2: Panoramic Drawing

NOTE

Above drawing shows points whose positions, after being plotted from measurements with a protractor, can be used as a framework on which the remaining detail may be hung.

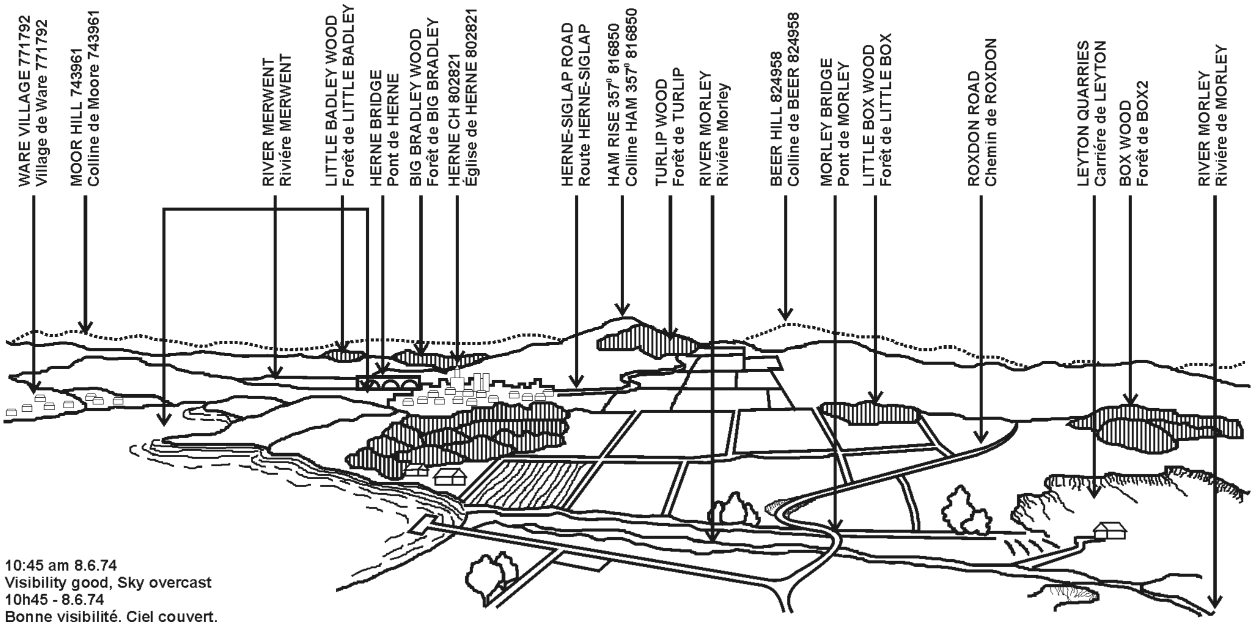


Figure 11-3: Panorama from Top of Littleham Hill 835746

SECTION 3
PANORAMAS FOR ARTILLERY USE

OBSERVATION POST PANORAMAS

18. In addition to the view that can be seen from the observation post, a panorama drawn for artillery purposes should show a central line drawn through some conspicuous point in the zone of observation. It should also have a network of vertical lines showing the lateral angles right and left of the central line. The angles of sight to probable targets or target areas should also be shown.

19. The lateral angles can be measured with the director, the prismatic compass or graticulated binoculars.

20. Artillery panoramas are useful for three purpose:

a. as a means of reporting to an artillery commander the view that can be seen from an observation post;

b. as an aid to an artillery commander in the indication of targets for observed fire; such a panorama need only show a few prominent reference points drawn clearly and unmistakably; and

c. as an aide to observation during periods of reduced visibility, such as, smoke, haze, twilight, etc, and to assist in identification of features by moonlight and artificial means.

21. This same type of sketch could be used at an observation post or by a sniper section.

SECTION 4
SUPPLEMENTARY SKETCHES

THUMBNAIL SKETCHES

22. Small sketches, such as shown of Figure 11-4, should be used to illustrate descriptions of details of road turnings, bridges, fords, watering points, wells, sidings, buildings for demolition, detours in a road, etc. For example, in a road reconnaissance where the only available map is on a small scale, such as 1:250 000, and a camera is not available nor practicable, it is simpler to show an intricate turn in a village by a sketch such as Figure 11-4. Or again, in a route reconnaissance for a column moving across country, the point where a change of direction is to be made can be given by a sketch, as in Figure 11-5. This shows the relative positions of detail at that point, such as two houses in line or the relation between a group of trees and some feature in the distance.

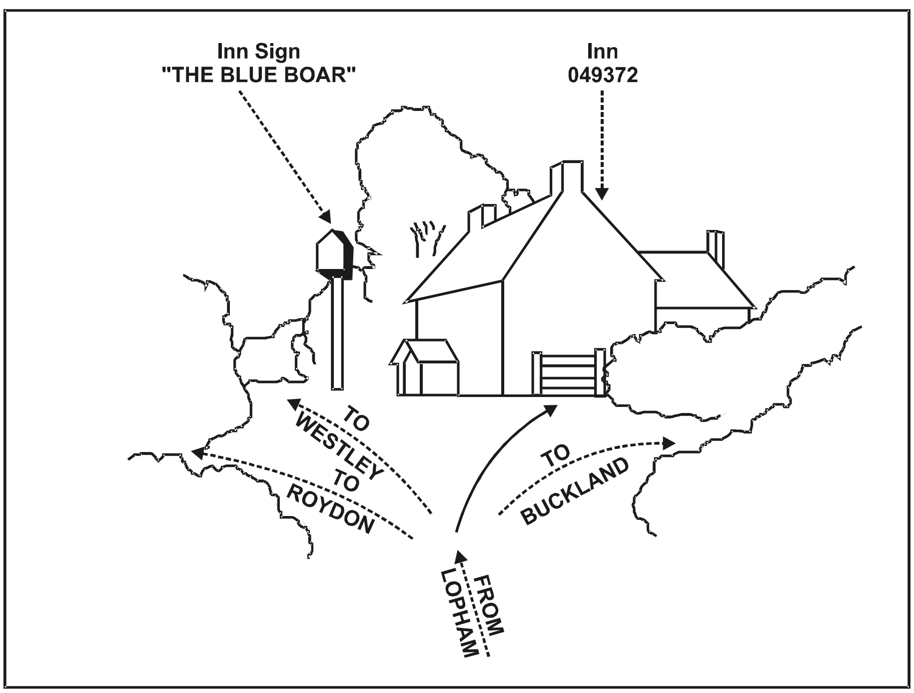


Figure 11-4: Thumbnail Sketch (Sample 1)

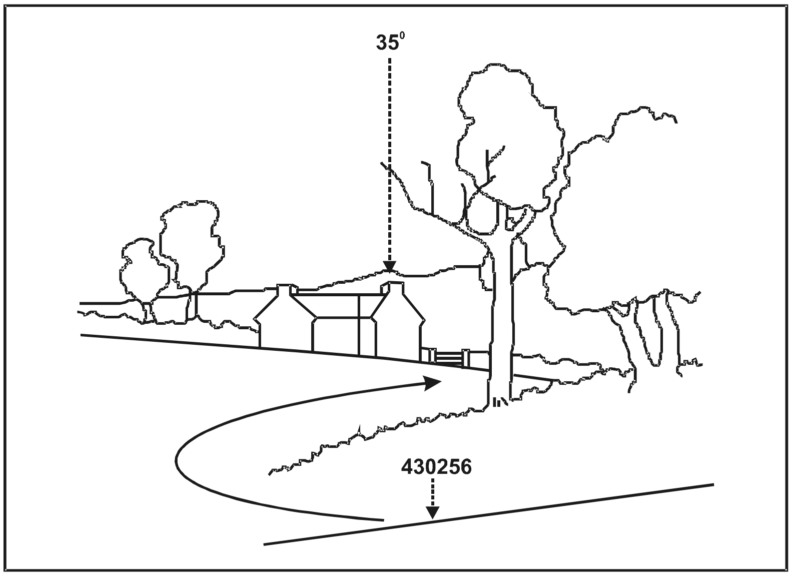


Figure 11-5: Thumbnail Sketch (Sample 2)

23. The principles and methods of panorama drawing apply also to the preparation of thumbnail sketches of special interest. The sketches are drawn by eye, the main proportions being first lightly sketched in by measurement, either with the protractor, as in panorama drawing, or by holding the pencil at arms length and marking off distance on it with the thumb.

24. As with all military sketches, simplicity and legibility should be the keynote.

RANGE CARDS

25. Every section post should have a range card. This card takes the form set out in BGL 392-002, *Infantry*, Volume 3, Section and Platoon in Battle This may be elaborated by a simple panorama sketch of the post's front, showing only the main features and their ranges. Such panorama sketches can also be of value at observation posts.

CHAPTER 12
MAP READING INSTRUCTION

SECTION 1
PLANNING A COURSE

GENERAL

1. Map-reading is essentially a skill, and true proficiency will only be achieved by practice on the ground. Instructors should therefore arrange in the planning of the program for the maximum possible training to be done outdoors. To teach map-reading, the only tool required initially is a map, and the only material required is the ground. There is no excuse for not teaching a great deal of map reading in a practical way on the ground.

2. Obviously, certain map reading knowledge is more conveniently imparted in a classroom situation, and here it is most important to make the maximum use of visual aids (see Section 4). Classroom instruction though must be followed up as soon as possible with practical instruction and practice on the ground.

THE FIRST LESSONS

3. An excellent way of introducing beginners to map reading is to take them out on the ground and to show them that a map is a simplified picture of the ground. The instructor need not worry students, to begin with, about such technicalities as scale, conventional signs, the grid and north points, but just allow them to compare the map with the ground.

4. It is probably best to start with a 1:50 000 map where small features can easily be found. If possible, the class should be taken to a place that they know fairly well, preferable where there are well marked features—roads, woods, streams and buildings. A village is a good place. The instructor should start at a place where students can see for a short distance around. They should all have this place identified on their maps, if possible, the position should be facing north so that all printed information on the map is the correct way up for the student. Initially, the students should not be bothered by such technicalities as setting or orienting a map, but be merely made to line up a prominent straight feature on the map with the same feature on the ground.

5. The instructor can now start showing them how the map reproduces the ground ... "Look down the road, there is a church; just beyond it are the cross roads with a small park, and houses around them; down the road to the right is a bridge over a stream", and so on. Indicate to the students how it all appears on the map. Students can now walk down the road, noticing the various places—the post office, the church, the students should see how these places are marked on the map. When they get to the cross roads the instructor makes them line up the map with the roads again. He lets them see that the church tower is lined up too, if they have done it correctly. He makes them look across the fields, there may be a farm or some other prominent feature about 500 metres away. He asks them to find it on the map, and lets them see that, if they have oriented their map correctly, it appears in the proper direction on the map.

6. Now the instructor can ask the students how far away the farm is. He shows them on the map how its distance compares with the distance from the church, and how they can estimate its distance on the ground. Near the farm is a silo and an unfenced road leading off to the farm. Across the fields, runs a power transmission line. He lets them find these features on the map and to see how they are marked. In this manner he shows them that the pattern on the ground is reproduced exactly on the map.

7. After a lesson of this sort, the class should understand the idea of a map. They will have been introduced to many of the conventional signs. They should have absorbed the basic ideas of scale and direction, and see the reason for orienting a map. None of these things need have been specifically mentioned; they just become obvious and so the ideas are picked up without difficulty.

8. The instructor should encourage the class to ask questions and should ask them questions. Contours could be introduced by asking the question "How can we tell that this road goes down a steep hill?" He shows them on the map the contour lines cutting the road and how by following them, they can find the height marked and thus find that in a certain distance the road drops the vertical distance between contour lines. Another idea has been implanted quite naturally.

9. The instructor should let the members of the class compare notes and work together. He is not trying to make them memorize facts but to absorb ideas. If they can get the ideas from their classmate, so much the better, but the instructor must be sure that the ideas are sound.

SUBSEQUENT LESSONS

10. In a subsequent lesson, the class could be taken to some place that they do not know, and instruction carried on along much the same lines. They could be asked to determine from the map what they would find around a corner or down a dip. They should be shown the scale at the bottom of the map and how to use it to measure distance. One could also show them how a ring contour marks the top of a hill and that the distance the contours are apart is a measure of the steepness of the ground. The area of observation could then be widened and the students asked to identify one or two places up to one or two kilometres away.

11. Such problems should be kept simple at this stage and the aim should not be to test the students but to show them that the pattern on the map reproduces the pattern on the ground.

12. On the way to another lesson students could be asked to describe the place, according to the map, to which they are being taken. Their descriptions should be checked when they get there. If transport is required, then the instructor should try to obtain an open vehicle so that they can practise their map reading on the journey. On this lesson once again they should be given maximum practice in relating objects on the ground with objects on the map. Once again the area of observation can be widened further, they can be asked what lies on the far side of a woods, which side of a hill is steeper and so on.

13. For the next lesson, the instructor could do the same but take his students across country where there are fewer man-made objects, and make them rely more on the natural features and the shape of the ground.

14. After several such lessons the class will not be experts in map reading, but they should have learned that the map is a valuable tool designed to help them, not to make life difficult. If the instructor has done his work well they will be interested and will have absorbed some of his enthusiasm.

15. They should now be ready to go on to learn the other processes of map reading. It should be impressed on them that only by constant practice with a map on the ground could they become expert and learn to extract from a map all that it has to tell them.

FURTHER INSTRUCTION

16. Now that the class has learned to understand a map they can be introduced to other map reading topics. The actual topics covered and the depth of treatment required will depend to a certain extent on what the students are required to do in their service employments, and here reference to the performance objectives will give guidance on the course content.

17. Whatever the subject, the instructor must explain the connection between what they are going to learn and map reading. A talk on bearings, though excellent in its way, might leave the class completely in the dark as to their uses. They will become mystified and soon lose interest.

18. Many classes will have already received basic instruction in map reading but perhaps require further instruction as part of a course or for some particular purpose. The instructor should not assume that they have all reached a common standard but should test the students in one or two practical periods outdoors. The information gained from such a test will have an indication of their strengths and weaknesses, and the course can be designed as required to bring them all up to the necessary standard.

SECTION 2
HINTS ON TEACHING CERTAIN TOPICS

GRID REFERENCES

19. Grid references are probably best begun indoors since they have nothing to do with the interpretation of a map as a plan of the ground. It should be explained clearly to the class that a grid reference is merely a device for enabling any point to be fixed on a piece of paper or on a map.

20. The instructor should spend time in preparing good clear visual aids for this lesson. He could start by explaining the system on a blank grid reproduced on a blackboard, or by means of an overhead projector. He could then progress to showing how this can be applied to a map.

21. The instructor should remember that the only essential knowledge that need be imparted about the grid is how to use it. In his job, the soldier will normally use only the grid reference system; thus it will not be necessary to explain the construction of the grid, its point of origin, and so on. Throughout his teaching, the instructor must bear in mind the amount of map reading the student is actually required to use in his service employment.

SCALES AND DISTANCES

22. Elementary classes will probably require classroom instruction to practise the two basic skills of:

a. measuring distance on the map in a straight line or along a route; and

b. reading that distance correctly off the scale line.

23. This initial instruction should be followed up with plenty of practical problems outdoors, so that students can relate distance on the ground with distance on the map.

RELIEF

24. Students should be taught that the distance between adjacent contours represents a rise or fall of so many metres. This topic should once again be taught outdoors on reasonably hilly ground. It is much easier to explain steep slopes and gentle slopes, convex slopes and concave slopes, spurs and re-entrants by pointing them out on the ground, than by describing them in a classroom situation.

25. The aim should be to teach the students how to recognize the general shape of the ground from the contours on the map. They should be able to tell from where there is likely to be good observation, where there is dead ground or a covered approach.

26. The teaching of relief on a blackboard or plane surface should be avoided if at all possible. The construction of simple three-dimensional models can help, but once again there is no substitute for outdoor instruction.

DIRECTION

27. It may not be necessary for the trained soldier to know much more about direction than what has been gained from the initial practical map reading lessons. He must be able to locate his own position and maintain his direction by reference to known objects or he may perhaps have to identify unknown places by noting their direction in relation to known places. In addition, he may be required to maintain his direction by day and by night using the sun and stars.

28. In his job, the soldier will have to carry out these tasks practically and at times on his own. It is, therefore, important that during training he is given sufficient practices as an

individual to enable him to develop skill and confidence in the maintenance of direction. If the performance objectives specify that he should be able to maintain his direction at night as well as by day, then he must be given practice at night.

29. Once again, simulation of job conditions is important, for example if the soldier is required in his job to maintain direction cross-country in a vehicle, then he should be given practice in vehicle map reading, in a training environment.

BEARINGS AND THE COMPASS

30. Not all soldiers are issued with a compass but all soldiers should know how to use the basic C-6 Compass. The instructor should start by explaining to the class how a knowledge of bearings will help them in their map reading problems. This would include such skills as finding their location, the location of objects and finding specific locations. Until they understand this, bearings will seem to be a piece of dull and fair useless geometry.

31. The stages of instruction could perhaps be as follows:

a. the use of bearings;

b. the difference between magnetic and grid north and how to find it;

c. how to plot and measure bearings on the map; and

d. the compass and how to use it to measure bearings on the ground.

32. The use of good visual aids will help in the teaching of this basic geometric work. Use of colour and overlays on either the blackboard or overhead projector will assist the class in understanding this theory. The overhead projector is a particularly versatile aid for this subject as the class can actually follow the plotting of bearings by the instructor on the screen, particularly if a transparent protractor is used.

33. The compass could be taught outdoors from the start as it is much more stimulating and realistic to take a bearing on a church tower or tree, than on the corner of a classroom. A suggested sequence for teaching the compass is as follows:

a. use as a simple compass to find north, south, east and west;

b. find bearings;

c. setting the compass; and

d. marching with the compass.

SECTION 3
HINTS OF THE USE OF VISUAL AIDS

BLACKBOARD/CHALKBOARD

34. This can be used for the teaching of many of the theoretical aspects of map reading—such as the grid system, introduction to bearings and intervisibility. Some points to remember in the use of the blackboard are:

a. make maximum use of colour;

b. prepare good diagrams well in advance;

c. ensure diagrams are large and clearly visible; and

d. avoid trying to teach relief on a flat surface.

POWERPOINT/ OVERHEAD PROJECTOR

35. This most versatile aid needs to be used with imagination. Some hints on its use in the teaching of map reading are as follows:

a. Make the maximum use of colour-marker pencils and felt tip pens.

b. Prepare good diagrams well in advance, for instance, most diagrams in this manual can be reproduced for use with overhead projectors or for a PowerPoint© presentation.

c. Make sure diagrams are clear and the printing easily visible.

d. Avoid trying to teach relief on a plane surface.

e. Some aspects of compass work can be illustrated with the overhead projector and the C6 Compass.

f. Simple transparent scales and protractors can be easily manufactured for use with the overhead projector.

VIDEOTAPES/DVD

36. Certain map-reading video aides can be obtained from base video libraries or from the CF Joint Imagery Centre. Details of the titles available can be found through reference to the CF Imaging Services intranet website.

37. These aids should not be used in isolation, as they achieve their maximum impact when used as part of a lesson to supplement the teaching of a particular topic.

38. It is also essential that the instructor views any video before showing it to a class, as only by doing this can he be sure that it is relevant to the topic being taught.

SLIDES

39. Colour slides and a slide projector are a convenient method for presenting the instructor's own material. There are normally funds available within most units to purchase colour film for use in training.

40. When showing slides, it is desirable to supply the students with maps of the area displayed so that they can compare map and ground directly.

SECTION 4
PRACTICAL TRAINING

PRACTICAL EXERCISES

41. Once the students have mastered the basic skills of map reading, they will need practical experience in the topic by taking part in practical exercises. To begin with, they may be required to move over varying types of ground, from one pre-selected place to another, probably in small groups at first. Check points should be estimated to ensure that they have followed the correct route. The check points can be manned by instructors or the students asked to record exactly what they see when they get there, so that the accuracy of their route can be checked when they have completed the exercises. Later on, provided the ground is not too difficult or dangerous and as they become more proficient, they can complete this type of exercise on their own. Orienteering is a particularly useful means of building proficiency and confidence in the use of maps and compass. This is discussed in detail in Chapter 13.

SECTION 5
GENERAL SUMMARY

INSTRUCTION MUSTS

42. Before planning a map reading course, it is essential to specify exactly what performances and standards the students must achieve by the end of the course. If the appropriate performance objectives are available, then instructors should prepare their own materiel in a similar format to that generally adopted for performance objectives.

43. Students should be tested throughout the course, as well as at the end of their training. This is necessary to ensure that they have reached the specified standard of performance.

44. Instruction in map reading should, wherever possible, be oriented towards practice with a map on the ground. A map reading topic should not normally be taught indoors, if it is possible to teach the same topic outdoors on the ground.

45. An excellent way of introducing beginners to map reading is by practical work with a map on the ground.

46. It is the responsibility of the instructor to stimulate interest in his class. An enthusiastic class will learn more quickly than a bored class. The maximum use should be made of appropriate visual aids during indoor instruction.

47. A short course in map reading cannot produce experts. Constant practice with a map on the ground is essential even after a course has finished.

48. Finally, every opportunity should be taken on unit exercises to incorporate a map reading requirement, and to pinpoint errors arising from faulty map reading.

SECTION 6
REFRESHER TRAINING

49. B-GL-383-003/FP-001 *Individual Battle Task Standards*, Chapter 3, Annex J provides the standards pertaining to cross country navigation that each soldier must meet on an annual basis.

CHAPTER 13
ORIENTEERING

SECTION 1
PROGRESSIVE ORIENTEERING TRAINING

GENERAL

1. This chapter explains how orienteering can be used to teach and improve map reading skills. The suggested program is designed to give every individual the fullest opportunity to practise map reading. Conventional map reading exercises tend to exercise only one member of a group while the others in the group take no real part in the actual map reading. Orienteering also enables soldiers to spend more time on the ground and less in the classroom, and to map read on the move rather than from static positions. Furthermore it helps soldiers to enjoy map reading and improve their individual skills through competition.

WHAT IS ORIENTEERING?

2. Orienteering is a practical exercise run as a competition between individual soldiers. Participants are equipped with a lightweight C-6 Compass, a transparent and waterproof map cover, a red ballpoint pen and a wristwatch. For each competition they are issued with a 1:25 000 map or Photostat copy of the map of the area over which the exercise is to be run, an event card and a description of each control point. Maps with a scale of 1:50 000 can be used if there is no coverage of the area in the 1:25 000 scale.

FIRST PRACTICAL EXERCISE (PIN PRICK ORIENTEERING)

3. Before the competition, the OPI marks out a route along tracks through the woods with red and white tape tied to branches. Initially, the soldiers are issued with a map stapled onto cardboard, a compass and a few pins. The start is marked on each soldier's map. On the very first exercise, the soldiers and their instructor walk in groups of four to six along the marked route. Each soldier must work out where he is the whole time, by counting paces and associating the map with the ground. When the soldiers in the group come to a yellow flag, they must pinprick the exact location of the flag on the map. The instructor checks each soldier's pinprick with a ruler and deducts one mark from a total of 10 for a deviation of a millimetre. They continue down the course and again pinprick their maps at the next yellow flag. When they come to a blue flag they will find a sighting stick pointing in the direction of an object which is located within 1,500 metres, the soldier goes to the sighting stick, looks along it, then pinpricks the location of the object pointed out. Again, one mark is deducted by the instructor for each millimetre of error. Once the soldiers have completed this type of course a few times in a group, they are sent off individually over similar courses at one-minute intervals. The fastest soldier round the course with the minimum deductions is the winner.

SECOND PRACTICAL EXERCISE (COMPASS WORK AND PACING)

4. The course consists of several short legs (200 to 1 000 metres). The exact course to be followed is marked on a map supplied to each soldier. He must then work out for himself the required compass bearings and number of paces along each leg. Somewhere along the direct route of most legs, one or more control points will be placed. Soldiers will not be told beforehand how many control points there are. Soldiers mark their instruction cards with the code letter of each control point they pass. Marks are awarded in accordance with the number of control point code letters noted.

THIRD PRACTICAL EXERCISE (ROUTE SELECTION)

5. Soldiers line up at a table in fours. Every two minutes, four soldiers are each issued with map, compass and event card, then dispatched to one of four master maps. The soldier who is sent to master map A, for example, copies the two control points marked on the map onto his own map and completes the course as fast as possible. At each control point the soldier will receive a stamp mark on his event card. He then returns to the master map and explains his route to the exercise controller. Once the controller is satisfied that the soldier has found the controls by checking the stamp marks, he analyses the route taken and advises the soldier on route selection and compass skills if any weaknesses have been revealed. Once the controller is satisfied that the soldier has learned the appropriate lessons, he sends the soldier to master map B, and so on in a clockwise manner. The control locations should be set out by the controller, who makes them more difficult with each successive exercise. The platoon commander would normally be the exercise controller.

6. Once the soldier has successfully completed a few of each type of these practical exercises, he is ready to compete as an individual in an orienteering competition.

ORIENTEERING COMPETITIONS

7. **Point-to-Point Event or Free Orienteering Event**. In a point-to-point event, each competitor is given a Photostat copy of part of a 1:25 000 map, and a list of descriptive clues of all control points. Competitors start at one minute intervals, their time of departure being written on their event card. From the start each competitor runs to the master map, about 150 metres away. This shows his exact location and the location of all control points and the order in which they must be visited. These he copies onto his own map. He quickly decides his fastest route to the first control point, then runs as fast as possible to all of the control points in the allotted order. His event card must be appropriately stamped at each control point. The competitor who completes the course in the shortest time, and who can show the stamp marks of every control point is the winner. The OPI who sets the course should make it simple at first, then progressively more difficult.

8. **The Line Event**. Unlike the point-to-point event or free orienteering, where the choice of route is left to the competitor, the line event consists of following a given route. A bold line is marked on the master map showing the whole route from start to finish. The competitor copies

this onto his map and follows the route on the ground in the direction indicated. Along the route there are hidden control points, which the competitor will only find if he is exactly on the route shown on the master map. When the competitor finds the red and white marker of the control point, he stamps his event card and makes a note on his map of his exact location. The competitor who completes the course the fastest with all the stamp marks of the control points on his event card is the winner.

9. **The Scored Event**. In a scored event, the area chosen for the competition is dotted with a large number of control points. The control points near the start and finish carry a low point value, while those farther way, or more difficult to find, carry a higher point value. The competitor is given a time limit in which to find as many control points as possible. He can select any route he wishes to find the control points that he decides will enable him to gain the highest score in the time available. The course must be designed to ensure that there are more control points than can possible be visited in the allotted time. Each control point has a code letter inscribed on it, which the competitor notes on his event card as proof to the judges that he has found it. It is important for the competitor to make a sound time appreciation to arrive back at the finish by the allotted time. If he fails to do so, five points are deducted from his total score for every minute he is late. The time of the competition may vary from one to three hours.

10. **The Night Event**. In a night event, the control points are sited in well-defined locations over simple terrain. They are marked by small red lamps, which can be seen from all directions to a distance of 30 metres. The control points are set up in daylight and sited in a circle around the position chosen for the start and finish. The control points should be sited 400 to 800 metres apart, depending on the terrain. Soldiers are split into pairs and given five minutes in a lighted tent at the start to plot the locations of the six or so control points on their maps. They are despatched at intervals to visit all the control points in any order they wish in the time allotted for the competition. Usually, two or three hours is ample time for a competition of this nature. The correct stamp mark of one of the control points gives a competitor 20 marks, but five marks are deducted for each minute he exceeds the overall time limit. The pair with the highest marks win. After some practice, longer and more difficult night events may be arranged until finally the competition can be run as an individual event. The controller should have a projector pyrotechnic to help guide back any lost competitors.

11. **Variations**. The types of orienteering outlined above may be varied in numerous ways to suit particular requirements. A modified form of orienteering can, for example, greatly assist in the training of APC crews.

GENERAL HINTS FOR ORIENTEERS

12. **Before the Start:**

a. Check that you have all the necessary items of equipment.

b. When the competition map is issued, boldly mark the eastings grid lines with red pen. This helps to speed up the settings of the compass.

c. Tape the event card on to the back of the waterproof cover so that the card can be stamped easily at control points.

13. **During the Competition:**

a. At the master map mark all the control points onto your map with a red circle. If necessary, number these in the order they are to be visited. Draw a straight line between each point. Do not sacrifice accuracy for speed.

b. Tape the issued description clues alongside the map. Place the map in the waterproof cover.

c. Move away from the master map area and concentrate on the first control point:

(1) Check its description.

(2) If the control point is not in an obvious position, choose an attack point about 30 to 200 metres from the control point. For this purpose, select something you can recognize easily, for example, a bridge, a track junction, or a pylon cable crossing a path.

(3) Check the route direct from your present position to the attack point. Check to see if there is a quicker route to the left or to the right.

(4) Decide the best route to follow. Study this carefully. If the attack point is, for example, a stream/track junction, then aim off about 60 mils and get to the stream as fast as possible.

(5) If you have aimed off properly you will know when you reach the stream which direction you must turn to reach the attack point.

(6) At this stage of the competition you simply map read using the compass only as a quick check or guide.

(7) Once at the attack point, calculate the accurate compass bearing and distance to the control point.

(8) Then move accurately to the control point, counting your paces. You should know how many paces you take to run 100 metres over different types of terrain.

(9) When you have run the required distance on an accurate bearing, stop. You should be very close to the control point. Look at your map and the description again and find the control point.

d. Once you have found the control point, quickly stamp your event card then get away in case you attract other competitors. When you are about 30 metres clear, go through the same procedure for finding the next control point.

e. Always keep your thumb over the last position you confirmed on the map.

14. **At the Finish**. Once you have finished the competition and handed in your completed event card, discuss your route with other competitors and try to discover how you could have improved your performance.

ORIENTEERING SYLLABUS

15. The syllabus shown in Table 13-1 has been found suitable for training complete novices to become proficient orienteers.

Lesson	**Periods (40 minutes each)**	**Subject**	**Location**
(a)	(b)	(c)	(d)
1	3	The Map. Introduction and description.	Classroom and outdoors.
2	3	The Fundamentals of Orienteering a. Finding direction without the compass. b. Measuring distances by pacing. c. Associating ground with the map. Exercise. (See First Practical Exercise, paragraph 3).	Simple terrain.
3	3	The Compass and Compass Marching. (Introduction to the C-6 Compass system).	Classroom and simple terrain.
4	3	Compass March with Marked Map (See Second Practical Exercise, paragraph 4)	Simple terrain.
5	3	Line Orienteering	Unknown terrain.
6	3	Compass March with Marked Map.	Simple terrain.
7	3	Route Finding (See Third Practical Exercise, paragraph 5)	Unknown terrain.
8	3	Free Orienteering Exercise	Unknown terrain.
9	3	Scored Orienteering Competition	Unknown terrain.
10	5	Free Orienteering Competition	Unknown Terrain.
11	1	Map Reading from a Static Position	Position with a good panoramic view.
12	5	Free Orienteering at Night	Simple terrain.
	38 periods		

Table 13-1: Orienteering Syllabus