

SURVEYORS BOARD OF QUEENSLAND

DIRECTIONS TO SURVEYORS

The Surveyors Board of Queensland exercising the powers vested in it by the Surveyors Act 1977 at a meeting duly convened on 4th May, 1978, resolved to issue the following Directions to Surveyors pursuant to Regulation 20 of the Surveyors Regulations 1978 and these Directions shall, subject to Sub-regulation 20(2), be binding on all surveyors from the date of the commencement of this Act.

These directions shall be published in the following form including explanations and statements of recommended practices which the Board considers necessary for the guidance of Surveyors.


PRESIDENT

The date of commencement of this Act is 29th April, 1978.

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DIRECTIONS AND RECOMMENDED PRACTICES FOR SURVEYS

1. INTRODUCTION

(1) The Surveyors Act 1977 and the Surveyors Regulations 1978 provide the basic precepts for the regulation of the practice of surveying, defining the principles and processes essential for the preservation of the integrity of cadastral boundaries and the development of an integrated system of surveys.

(2) Regulation 20 authorises the Board to issue directions complementary to the basic precepts of this Act. The Board also considers that statements of recommended practices should be issued to describe processes which are considered to be effective in satisfying community needs using knowledge and equipment now available. These directions and recommended practices will be reviewed frequently to accommodate changes in community needs or in knowledge and equipment.

(3) In accordance with Regulation 20, these directions are binding on surveyors but departures from recommended practices would be accepted if a surveyor can show that another method can obtain a result satisfactory to the Board.

(4) In considering the application of recommended practices, a surveyor should accept that he has a responsibility to advise the most appropriate solution to any survey problem, bearing in mind:

- (a) The present and future requirements of persons effected by the survey;
- (b) The requirements of registering authorities;
- (c) The relative costs and benefits.

It is important to remember that the community at large censures not only the individual surveyor for indiscretion, but the profession as a whole.

(5) Meaning of "Accuracy"

In the Act and Regulations the word "accuracy" has the commonly understood meaning -

precise, exact, correct, in accordance with a standard -

and so has a wider meaning than that frequently used by surveyors when referring to accuracy of measurement.

Certification in the words used in Form 13 of the First Schedule of the Regulations - "that the plan is accurate" implies a declaration that the plan is correct in every particular and is in accordance with the standards prescribed in the Regulations and Directions.

2. DIRECTION REGARDING REGULATION 28(1) (a) (UNMARKED CORNERS)

(1) Where a surveyor is satisfied that there is no immediate requirement for a corner or boundary under survey to be marked, he may leave them unmarked provided:

- (a) Sufficient permanently marked control is established as would permit any unmarked corner or line to be readily marked at a future date from that control;
- (b) The accuracy of the unmarked boundary as calculated through the control is shown to be of the same accuracy as is required of the whole survey or a higher accuracy;
- (c) Corners and boundaries left unmarked are clearly shown as such in survey records and on the plan.

(2) Where a surveyor is required to mark any previously unmarked corner or boundary, Regulation 31 shall apply.

3. RECOMMENDED PRACTICES REGARDING UNMARKED CORNERS

— See Sheet X

(1) The provisions permitting corners and lines to be left unmarked are intended to apply to roads in low value rural areas, to long line easement surveys where structures within the easement provide adequate reference marks, and where the cost of marking and clearing all corners and boundaries in some classes of survey is inconsistent with the purpose of the survey. They will enable the surveyor to satisfy the requirements of a registering authority whilst minimising the cost of the surveys.

(2) The Surveyor should ensure that all parties affected by the proposed boundary understand that the boundaries will not be marked and that if future marking is required, a licensed surveyor must be retained. It would be prudent to include signed statements by affected owners in the survey records.

(3) As a general rule a marked station in the control surveys should be established adjacent to any unmarked corner.

(4) Where use of these provisions concerning unmarked corners is considered appropriate in cases other than those referred to in paragraph 3(1), prior approval of the Board should be obtained to the action proposed.

4. DIRECTION REGARDING EASEMENT SURVEYS

(1) Easement surveys shall be carried out in accordance with the regulations and in addition:

- (a) A separate plan on the standard plan form shall be drawn for each property traversed by the easement: except -
 - (i) where the easement is shown on a plan of subdivision to be lodged in the office of a registering authority;
 - (ii) where adjoining registered proprietors each agree to endorse on one plan their agreement to an easement extending over their separate properties.

Re: Road Surveys through low-value lands
for action through the Lands Department
in accordance with Regulation 28(1)(a),
Direction 2 and Recommended Practice 3

The following are a list of Minimum Requirements to
be met by Surveyors effecting surveys of the type mentioned above.

1. Approval of the use of this method of survey together with any other requirements should be sought from this Department in the first instance.
2. Signed statements are to be obtained from the affected owners stating that they are aware that the survey is sufficient for road requirements only and that additional marking by a Licensed Surveyor may be required in the future for fencing and subdivisional purposes. Subsequently, the original statements are to be forwarded to this Department to enable the party instigating the road action to be informed.
3. A traverse of an existing road is to be marked by conventional P.M's or other suitable "permanent" marks, so placed as to be intervisible.
4. Sufficient reference marks (trees, pins etc.) are to be provided at traverse stations. Where possible beyond the limits of existing or anticipated road formation and clearing to allow for future reinstatement.
5. Sufficient astronomical observations are to be taken to verify the accuracy of the traverse meridian.

As a minimum plan requirement, the following information is necessary to meet the requirements of Regulation 38(2)(a)(i):-

1. Road boundary corners (pegged or designed) on one side of the road are to be referred by bearing and distance to the road traverse stations.
2. Secants are to be shown (surveyed or calculated).
3. Dimensions are to be shown for all road boundaries.

As a guideline for the plan presentation, a copy of an existing plan of this type is enclosed. This sample plan is correct except that the reference mark tabulation is not in accordance with current practice (vide Survey Plan Manual).

- (b) Sufficient information shall be obtained to ensure that the position and azimuth of the easement can be related to the continuation of the easement through adjoining properties;
 - (c) Construction pegs shall not be moved or interfered with in order to place cadastral survey marks.
- (2) Where a surveyor is satisfied that there is no immediate requirement for the corners or boundaries of the easement to be marked he may leave them unmarked in accordance with the direction regarding unmarked corners.
- (3) Where a surveyor can satisfy the Board that:
- (a) the cost of precise definition of the easement is unjustifiable;
 - (b) a reliable location to a lesser accuracy than specified in Regulation 32 would satisfy the parties to the easement;
 - (c) the land traversed by the easement is not closely developed and is unlikely to be further subdivided;

the survey may be carried out as a location survey in accordance with recommended practice 5.11.

(4) The Board may approve that a plan of an easement may be compiled without survey under regulation 29 and the compiled survey shall provide sufficient information to enable the easement to be marked on the ground at some future time. The plan shall carry a notation describing the sources from which it was compiled.

5. RECOMMENDED PRACTICES FOR EASEMENT SURVEYS

- (1) Easements may be surveyed by traversing the centre line, any offset line, or one of the boundaries of the easement, or may use the survey concerned with the setting out of the structures in the easement in accordance with Regulation 28(h) and the easement boundaries may be calculated from the traversed line.
- (2) Boundaries of properties intersected by the easement should be reinstated and the intersection pegged where appropriate.
- (3) An acceptable severance closure between the easement and existing boundaries is required.
- (4) In grazing farms or pastoral holdings measurements should be recorded to major internal fences, with bearings read along the fence line.
- (5) Where an easement runs close to a surveyed boundary without intersecting it, a connection should be made to that surveyed boundary.
- (6) Connections should be made to significant or unusual topographic features or vegetation and significant structures and descriptions of the features should be recorded.

- (7) Where an engineering survey has been carried out along the easement, connections should be made to marks of that survey sufficient to relate the two surveys to each other.
- (8) Connections should be made to structures along the easement and the descriptions and numbers of the structures should be recorded. Where a definite point on a structure is available and suitable as a survey reference mark, a reference connection should be made and recorded. In the case of transmission lines, a connection should be made to the centre of towers and to wooden poles. It is to be noted that electricity authorities advise that inserting nails or spikes into power poles is a hazard.
- (9) Survey marks placed to define an easement boundary should be marked with an "E" as identification.
- (10) Where the easement survey is carried out before clearing of the easement or construction of easement structures, reference marks are to be sited so as to be safe from clearing or construction activities. If reference trees are taken they should be outside of the strip to be cleared in the easement.
- (11) Where a location survey is to be undertaken in terms of direction 4(3):-
- (a) The centre line of the easement should be connected, with a standard of measurement of about ± 0.03 metres plus one part in 3,000 of the distance, to original survey marks or occupation so that the location of the easement and its position on the title can be determined.
 - (b) Sufficient survey work should be carried out, and recorded, to establish the reliability of occupation but detailed reinstatement of original boundaries is not required.
 - (c) Where an engineering survey has been done, accurate connections should be made where practicable to nearby cadastral marks from the engineering survey.
 - (d) The survey should be tested by closure using any survey data available.
 - (e) The boundaries of the easement need not be pegged but if any accurate reinstatement of a corner is necessary, reference marks should be placed near that corner.
 - (f) The positions and descriptions of structures in the easement should be recorded.
 - (g) The plan, drawn on a standard plan form, should carry a notation that the measurements on the location survey were made to a standard of ± 0.03 metres plus one part in 3,000 (or the standard actually used). Any measurements at a higher standard should be noted on the plan.

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6. RECOMMENDED PRACTICES FOR MERIDIAN DATUM (REGULATION 33)

(1) If co-ordinated permanent marks exist within a convenient distance of the land to be surveyed, the meridian datum of the survey should be established on AMG from the co-ordinated marks if it is practicable to do so. Both the accuracy of determination of the datum and the cost of the connection should be considered in making the decision.

(2) Where it is not practicable to establish the meridian datum of a survey from co-ordinated permanent marks, the datum should be established,

- (a) by solar or stellar observations taken in pairs east and west of the meridian from the same station, calculated separately to derive AMG datum (see attached computation form), or
- (b) from re-establishment of the original survey or adjoining surveys.

(3) Where the meridian datum of a survey is derived from reinstatement of earlier surveys which were not referred to true meridian, CAM or AMG, solar or stellar observations should be taken as described in (2)(a)-above.

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(4) In extensive surveys, solar or stellar observations should be taken as necessary to keep a check on the angular deviation from the adopted meridian. In general, observations should be taken at intervals of about 10kms, but in rough country, additional observations may be required. Alternatively, if the survey has been connected to co-ordinated permanent marks, angles may be read to co-ordinated control survey stations and check bearings calculated.

(5) Permanent marks, existing or placed during the survey, should be used as instrument stations in fixing the meridian datum, but if this is not practicable, careful connections to the permanent marks should be made to ensure a high level of confidence for future reinstatement of the datum.

(6) Opportunities should be taken to read accurate angles from stations of the survey to beacons on control survey marks and to precisely identifiable parts of buildings or other structures to assist future reinstatements.

(7) Where the meridian datum of earlier surveys differs from the datum adopted for the new survey, the relationship between old and new datums should be clearly recorded.

(8) Where a survey consists of separated parts, the same datum should be used for the parts. The common datum may be obtained by measurement or by calculation.

7. RECOMMENDED PRACTICES FOR TRAVERSES (REGULATION 35)

(1) Traverse stations should be marked or referenced in such a way that they can be easily and accurately reinstated in the future, but pegs should not be used if they are likely to be taken as boundary marks by land holders.

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3 (1) The practice of describing the meridian of a survey in terms of the meridian of a previous survey, should only be adopted when there is no advantage in referring the survey to AMG or CAM or when the cost of doing so cannot be .../6.

6. RECOMMENDED PRACTICES FOR MERIDIAN DATUM (REGULATION 33)

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(b) from re-establishment of the original survey or adjoining surveys.

(3) Where the meridian datum of a survey is derived from reinstatement of earlier surveys which were not referred to true meridian, CAM or AMG, solar or stellar observations should be taken as described in (2)(a) above.

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(7) Where the meridian datum of earlier surveys differs from the datum adopted for the new survey, the relationship between old and new datums should be clearly recorded.

(8) Where a survey consists of separated parts, the same datum should be used for the parts. The common datum may be obtained by measurement or by calculation.

7. RECOMMENDED PRACTICES FOR TRAVERSES (REGULATION 35)

(1) Traverse stations should be marked or referenced in such a way that they can be easily and accurately reinstated in the future, but pegs should not be used if they are likely to be taken as boundary marks by land holders.

(2) Where traverses consist of a series of short lines or where they are in closely settled or timbered areas, reference marks should be placed at intervals of approximately 500 metres. Traverses consisting of longer lines or sited in open flat country, should have reference marks at intervals of 1 to 2 kilometres.

(3) On traverses of natural features, the tree nearest to each unreferenced traverse station should be blazed with three horseshoe marks, with the centre mark facing the station.

8. RECOMMENDED PRACTICES FOR BOUNDARIES (REGULATION 24)⁸

(1) Pegs should be used to mark corners and boundaries of land.

(2) Where a fence post is used as a corner it should be branded with a broad arrow and the parcel identification except where a reference tree is taken.

(3) Boundary lines need not be cleared unless clearing is necessary for the making of measurements or is required by the client. Where clearing is required, scrub, undergrowth and trees less than 200mm in diameter should be removed.

(4) Unless fencing is to proceed immediately, trees standing nearest to the line should be blazed with a horseshoe shaped mark cut into the heart-wood on opposite sides of the tree in such positions that the marks face along the survey line.

(5) Trees through which the boundary line passes should be double blazed on opposite sides so that the marks face along the boundary line.

(6) Pins should be included wherever practicable among the reference marks placed adjacent to corner and bends. The positions and depths at which pins are placed should be decided by the surveyor so as to minimise the chance of disturbance from any cause and the depth at which the pin is placed should be recorded if the depth varies from the standard depth.

(7) When a tree is used as a reference mark, the bark should be removed in the form of a shield about 1.5 metres from the ground and exactly facing the corner. On this barked space a broad arrow and the block number in arabic numerals not less than 100mm high, should be cut at least 10mm deep into the heart-wood. The bearing and distance should be observed from the corner to a chisel cut in the centre of a bench mark cut well into the heart-wood at the base of the tree and exactly facing the corner.

(8) Designed boundaries of land - (Regulation 28)

(a) Where a design showing the proposed arrangement of boundaries is provided, it is the responsibility of the surveyor to interpret the design to ensure that the location of roads and boundaries is compatible with the topography and substantial occupation.

(b) Where any major divergence from the design is necessary or where there are incompatible design specifications, approval of the relevant authority should be obtained or details submitted to the Surveyor General for consideration.

- (c) Where a fence occupies or is adjacent to a proposed boundary, fence posts at the angles should be adopted as corners or bends and the straight line between these fence posts surveyed as the boundary, provided that the fence does not deviate from the boundary by more than 0.5 of a metre, or 2 metres for each kilometre of the length of the line, whichever is the greater. The practice of establishing corners by placing pegs adjacent to fence posts should be avoided.

(9) Water Course and Tidal Boundaries (Regulations 28, 30)

- (a) The term "high water mark" has been used in previous regulations and by surveyors to describe the boundaries of land abutting tidal waters, subject to the qualifications that sandy beaches, mangroves, bare mud flats, etc. are generally to be considered to be below "high water mark".
Line of the mean high tide between ordinary Spring and neap tides,
- (b) "High water mark" is a common law term not yet clearly defined by statute and should not be used by surveyors when surveying a boundary between land and tidal waters. Where a surveyor is specifically required to define a boundary which is "high water mark" he should use the mean high water mark as defined by common law.
Crown is owner of Land to L.W.M.
- (c) The limits of any land bounded by a water course or the sea, granted by the Crown under deed of grant should be capable of being determined from the traverse and offset information in the field notes. Normally the boundary of the land granted will be a discernable topographic feature, for example, top of bank etc.
- (d) Additional land should not be included in a parcel on resurvey unless there is evidence of slow and imperceptible accretion.
- (e) Where accreted land is claimed, the survey should be done in accordance with Regulation 28(e) and an application, accompanied by a plan of resurvey on a Department of Mapping and Surveying Plan form and supporting evidence, should be made to the Land Administration Commission for correction of title under Section 9 of the Land Act.
- (f) In the Water Act, the bed and banks of a water course are defined as follows:

"Bed" and "banks" with reference to any water course or lake, means the land over which normally flows or which is normally covered by the water thereof, whether permanently or intermittently, but does not include land from time to time temporarily covered by the flood waters of such water course or lake, and abutting on or adjacent to such bed or banks.
"Bed" means the relatively flat and "banks" the relatively steep portions of the first mentioned land.

(g) The flow in most water courses has three distinct patterns:

- (i) The low or dry weather flow which is confined to a relatively small channel. The flow may cease entirely in very dry times. This is the condition of the water course most of the time.
- (ii) Freshes occurring several times per year (in higher rainfall areas - less frequently in drier regions) following seasonal heavy rain. The flow may extend from bank to bank.

Conditions (i) and (ii) constitute the normal flow in the water course.

- (iii) Infrequent very high flows following extended periods of very heavy rain in which the water course overflows its banks and spreads over the adjacent countryside.

The term "flood waters" used in the definition of "bed" and "banks" in the Water Act refers to those waters overtopping the banks in (iii) and spreading out.

The "bed" and "banks" of the water course (in law) extend between the tops of the banks which confine the flow in (ii) and which are overtopped by the infrequent flood waters in (iii).

- (h) The Water Act provides that where a water course or lake forms the boundary wholly or in part of a parcel of land alienated by the Crown, the bed and banks thereof remain the property of the Crown and vest in the Commissioner of Irrigation and Water Supply. The Water Act further provides that the owner or occupier of land adjacent to such water course or lake shall have the same rights for access, grazing and remedy for trespass over the adjacent bed and bank that he would have if he owned the land comprising the bed and bank.

(10) Railway Boundaries (Regulation 30)

- (a) Prior to 1914, surveys of railway land were not normally carried out unless the land was being resumed from a surveyed portion held under leasehold or freehold tenure.
- (b) Section 92(1)(3) of the Railway Act 1914 vested in the Commissioner of Railways, all Crown Land within railway fences. It is generally accepted that this applied only to land fenced in prior to 1914.
- (c) As there is usually no conclusive evidence as to the age of the fences it is normally sufficient, where vacant crown land or roads are involved to adopt the fences as the boundary of railway land.

(11) Resumption Boundaries (Regulations 28, 30)

- (a) Where a survey is required of land to be resumed, the plan should show the boundaries of the land to be resumed and:
 - (i) if the land is leasehold, the plan should show the boundaries of the balance of the parcel from which the land is taken;
 - (ii) if the land is freehold, sufficient connections should be obtained to enable a plan of the balance of the affected title to be compiled.
- (b) Resumption lines should be pegged where they intersect the common boundaries of parcels held under one ownership with separate titles or under consolidated titles, except where this procedure is waived in the directions regarding easement surveys and unmarked corners.
- (c) Where new fencing has been erected along a resumption boundary prior to the survey, advice should be obtained from the resuming authority on whether the fence should be adopted. In the case of resumption for the Main Roads Department, the new fencing is to be adopted as the new boundary and the resumption plan detail should be disregarded where it conflicts.
- (d) Where a Main Roads Department resumption plan indicates that an area of road is available for closure, sufficient survey should be carried out to enable the road to be closed if required or to remain open if application for closure is not forthcoming.
- (e) Where land is being taken by resumption, boundaries should be cleared and marked except where damage to cultivation would result.

9. RECOMMENDED PRACTICES FOR ROADS (REGULATIONS 28, 30)

(1) Opening and Closure

- (a) Wherever possible, roads in freehold land should be opened by dedication in the Titles Office. This does not apply to Main Roads Department resumption surveys instructed by the Department of Mapping and Surveying.
- (b) Where road closure is required in conjunction with the opening of a new road, application should be made to the Land Administration Commission and the plan drawn on a Department of Mapping and Surveying form to enable a new deed of grant or lease to be issued.
- (c) It is not essential that the intersection of a new road and road to be closed be surveyed, provided that the surveyed status of the amended road system and any affected land is maintained.

(2) Reservations

- (a) In the subdivision of freehold land containing areas reserved for road purposes, surveyors should ensure that the transaction is not delayed because of the encumbrance.
- (b) Road reservations which are no longer required may be purchased by the owner. Early application for purchase should be made to the Land Administration Commission so that the title to the land can be corrected under Section 9 of the Land Acts, to include the area of the reservation prior to lodgement of the subdivisional plan.
- (c) Where reservations are not acquired by purchase, the plan of subdivision will require the Surveyor General's endorsement as to the allocation of the road reservation. This is required after lodgement of the plan in the Titles Office. As the allocation of the reservation is made at the discretion of the Surveyor General, the areas of one or more of the lots on the plan may be reduced, and consequently, any contracts of sale entered into may be affected.

10. RECOMMENDED PRACTICES CONCERNING PERMANENT MARKS (REGULATION 36)

- (1) It is preferable to place the new permanent marks, referred to in Regulation 36, in close proximity to the survey rather than to make lengthy connections to existing marks.
- (2) Where local conditions preclude the placement of permanent marks, an explanatory report should be included in the survey records.
- (3) Every opportunity should be taken to make connections to existing permanent marks in close proximity to the survey, particularly those not previously connected to cadastral surveys. Details of permanent marks that have been previously connected to cadastral surveys are shown on survey plans. Sketches of unconnected permanent marks are available from the Department of Mapping and Surveying.
- (4) On Main Roads Department resumption surveys, a search should be made for permanent marks installed during road construction. Some of these may be indicated by a white finder post, while others may be found in concrete structures associated with the project.

11. RECOMMENDED PRACTICES FOR SURVEY RECORDS (REGULATION 37)

(1) Field Notes

- (a) Field notes, when submitted to supplement the survey information shown on the plan, should be recorded in the standard field books approved by the relevant registering authority.
- (b) Field notes should be so clearly made as to enable a draftsman to draw a true plan of the survey.

(2) Sketches

- (a) Diagrams may be substituted for field notes or used in standard field books where appropriate.
- (b) Diagrams should be suitable for photographic reproduction.

(3) Calculations

- (a) Meridian calculations and sufficient information to enable the calculations to be checked should be lodged with the plan.
- (b) Calculations showing that the accuracy specifications for the survey have been achieved should be lodged with the plan.

(4) Reports

A report should accompany the plan where necessary to clarify the method of reinstatement of original boundaries, the positioning of new boundaries and any discretion exercised by the surveyor.

12. DIRECTIONS REGARDING PLANS (REGULATION 38)

- (1) Directions and recommended practices for plans are contained in the 'Plan Manual'.

(2) Sketches

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RECOMMENDED FIELD PROCEDURES FOR THE EXECUTION OF CADASTRAL SURVEYS BY PHOTOGRAMMETRY

1. INTRODUCTION

- 1.1 The Surveyors Act 1977 Section 77 provides that the Governor-in-Council may make regulations not inconsistent with the Act providing with respect to the provision and prescription of any matter or thing concerning the accuracy of surveys. Accordingly Regulation 28 of Surveyors Regulations 1978 dealing with new boundaries, Sub-regulation (1)(g) allows that the boundaries of land may be determined by a photogrammetric method approved by the Surveyor-General.
- 1.2 This paper sets out recommended field procedures for use in the establishment and definition of cadastral boundaries by photogrammetry. The recommended procedures are based upon the recent experience of the Department of Mapping and Surveying and are designed to ensure a result within constraints of economy and good survey practice.

GENERAL CONSIDERATIONS

2.1 Value of Land

- 2.1.1 Photogrammetry may be used as a means of establishing and defining cadastral boundaries where it can be clearly shown that the inherent value of the property does not justify the cost of boundary definition by conventional field survey techniques. Such a situation would exist if, say, cost of field survey was in excess of 20% of the value of the property based on good valuation practice, and where the cost of a photogrammetric survey could be shown to be less than 50% of the cost of a conventional field survey of the same property.
- 2.1.2 In general terms the unit cost of photogrammetric survey compared with conventional field survey is substantially cheaper only when large survey areas are being considered. Photogrammetric survey may not offer a significant advantage where the survey area is less than 50 000 hectares, unless air photography can be obtained on an opportunity basis in conjunction with another mission already planned and reliable survey control is available. Existing photography may be used to define natural boundaries.
- 2.1.3 In assessing whether or not photogrammetry should be recommended as a technique for establishing and defining cadastral boundaries, the following points are relevant:
- (a) Market value of land to be surveyed and likelihood of future closer settlement;
 - (b) Extent of land to be surveyed;
 - (c) Complexity of internal boundaries between parcels and in relation to road reserves;
 - (d) Estimated cost of conventional field survey carried out in accordance with the minimum requirement of the Surveyors Regulations 1978;
 - (e) Estimated cost of photogrammetric survey;
 - (f) Availability of existing horizontal and vertical control for photogrammetric survey;
 - (g) Amount of additional horizontal and vertical control which may be required, (competent photogrammetric advice should be sought, taking into account the adjustment procedure to be adopted and the resulting accuracy to be achieved);
 - (h) Any other option using a combination of conventional field survey and photogrammetric techniques, or using specialised equipment, e.g. doppler satellite position fixing equipment.

2.1.4 Specific advantages and disadvantages resulting from the use of photogrammetry in cadastral survey are:

Advantages

- (a) Cost of survey may be substantially less;
- (b) Survey can be completed in less time;
- (c) Results of survey are more homogeneous and (depending on quality of control use) may be more readily incorporated into a co-ordinated system based on Australian Map Grid;
- (d) Monumentation, although more sparse than for conventional survey, should be more substantial;
- (e) Photographic imagery with positive corner identification is available to proprietor as either contact prints at flown scale or as enlargements, as an aid to property management and further visual boundary definition.

Disadvantages

- (a) Fence lines not 'run' and cleared;
- (b) Distances not determined by direct measurement;
- (c) Marking occurs only at corners (offset marks can be placed along long line boundaries if expense is considered warranted);
- (d) Less marking is provided;
- (e) Not suited to short lines or 'dog-legged' boundaries (the adoption of a 'give and take' boundary in relation to an existing 'dog-legged' fence may be necessary);
- (f) Road boundaries defined on one side only;
- (g) Natural boundaries, e.g. watercourses, difficult to define precisely due to frequent direction change and often indefinite nature of floodbank (nevertheless photogrammetry may be specifically used to define some natural boundaries which do not require ground marking e.g. watershed areas, edge of mangroves and well defined watercourses);
- (h) Further conventional survey may be required at a later date at proprietor's expense should exact definition of a boundary be required along its length.

2.2 Type of Tenure

At present photogrammetry may be used only as a means to establish and define cadastral boundaries of land parcels under leasehold tenure and therefore the control of the Land Administration Commission. All proposals for boundary definition by photogrammetry must be submitted to the Surveyor-General for approval. In each circumstance the proposal submitted must be sufficient for issue of Deeds of Grant.

2.3 Agreement on Boundary Position

2.3.1 The boundaries of each land parcel within the subdivision must be agreed to by adjoining proprietors and by the Land Administration Commission. Where the land to be surveyed is already occupied and fenced, the subdivision may proceed 'as occupied'. Concurrence of the interested proprietors should nevertheless be sought. Should only the terminals of a particular boundary line be co-ordinated, the legal boundary is the straight-line joining those terminals.

The existing fence may deviate from the boundary line and where such deviation is substantial, a further corner may need to be inserted. If intermediate points along the course of a straight boundary are deemed necessary such points can be selected and targetted as close to the boundary line as practicable allowing right offsets to be subsequently calculated for the target point to the boundary. Where an existing fence is dog-legged with numerous corners occurring between end corners, a 'give and take' boundary where the boundary follows an approximate median line through the course of the fencing, may be adopted. The clear concurrence of the abutting proprietors must be obtained for the adoption of a 'give and take' boundary.

2.3.2 The Land Administration Commission should be advised at an early stage that a photogrammetric survey is intended. All boundaries between adjoining parcels, road reserves and other reserves within the area of subdivision must be approved by the Land Administration Commission. Where boundaries are subject to negotiation between abutting owners and agreement cannot be reached or is in any sense doubtful, the boundary must be referred to the Land Commissioner for resolution.

2.3.3 It is essential that all boundaries are fully agreed to by all parties concerned before the photogrammetric survey proceeds. If this does not happen and some adjustment is required after targetting is completed and photography flown, this can be achieved only by additional ground survey and the advantage of the photogrammetric process will be largely lost.

2.4 Connection to Australian Map Grid

2.4.1 It is desirable that any large survey scheme carried out for any purpose, cadastral, engineering, environmental, be connected to Australian Map Grid (AMG). Such a connection may be effected by one of the following procedures:

- (a) Connection to primary or supplementary traverse or trilateration (aerodist) stations on the national geodetic adjustment, or State geodetic network;
- (b) Connection to any other control station for which reliable AMG values are available or can be calculated;
- (c) Connection to an existing doppler satellite observation station;
- (d) Observation by doppler satellite equipment on one or more corners comprising the surrounding control network to give AMG values and to stabilize the selected control network.

2.4.2 The connection from the existing AMG station into the control network surround may be by direct measurement using electromagnetic distance measuring equipment or some other means, through a series of traverse stations or where intervisibility permits by figure observation. Doppler satellite observations in the translocation mode may be a further option.

2.5 Meridian

2.5.1 The meridian datum of the survey shall be determined in accordance with Surveyors Regulations 1978, Regulation 33. It is desirable that on large survey schemes carried out by photogrammetric techniques, AMG meridian should be adopted as the basis of all computation and photogrammetric adjustment.

2.5.2 The comparison between true meridian obtained from the meridional observation and the meridian adopted for the photogrammetric adjustment should be obtained at least once within the survey area

3. OUTLINE PROCEDURE

3.1 The effectiveness of a photogrammetric survey undertaken for boundary definition will depend largely on targetting and ground-marking. It is essential that permanently marked points are well targetted to ensure that their imagery is guaranteed in the subsequent photography.

3.2 The detailed procedure for photogrammetric surveys for cadastral purposes will vary with the nature of the task, its location, size, control requirements, existing artificial or natural boundaries. Nevertheless the following outline procedure will apply to a greater or lesser extent:

- (a) Assess area to be surveyed from existing cadastral and topographical maps and State reference photography. An uncontrolled photo-mosaic might be of use;
- (b) Investigate existing control from the surrounding cadastral network and/or other control networks including the possibility of connection to AMG;
- (c) Initiate calculation to determine accuracy of surrounding network;
- (d) Assess requirement for vertical control, taking account that vertical position has only a versine affect on planimetric position;
- (e) Design flight lines to give full photographic coverage of area for aerotriangulation at a flying height to give desired positional accuracy. Competent photogrammetric advice should be sought in carrying out this task;
- (f) Arrange air photography contract and establish liaison with firm;
- (g) Through liaison with the Land Commissioner and property holders within and abutting the survey area, resolve all boundary positions;
- (h) Visit all points selected for ground marking and targetting and determine requirements;
- (i) Commence field work. Establish additional horizontal control where necessary and carry out any additional field survey required to augment the photogrammetric survey. Establish vertical control sufficient to meet planimetric accuracy requirements;
- (j) Target all horizontal control stations and cadastral points previously selected within the survey area. (Targetting should be carried out as close as possible to the time of flying air photography);

3. 3.2 (k) Fly air photography;
- (l) Submit data for aerotriangulation, computation and plan drawing.

4. CADASTRAL STATION DEVELOPMENT

4.1 The Photogrammetric Cadastral Station will normally comprise the following components:

- (a) Property Corner;
- (b) Permanent Survey Mark (PSM);
- (c) Recovery Marks;
- (d) Reference Marks;
- (e) Aerial Target;

In addition the following may be required:

- (f) Auxilliary Survey Mark (Permanent or Temporary).

4.2 In all cases the permanent survey mark (PSM) is the monument which remains as the permanent ground record of the survey. The target, which is temporary and is removed after the photography is flown, is accurately and symmetrically laid out around the PSM, so allowing the PSM to be positively identified on the air photography. Within the cadastral station site, the property corner mutually agreed upon is the primary point to which the PSM is referenced.

4.3 The following criteria should be applied in selecting the position of the PSM to be targetted.

4.3.1 The PSM should be sited so as to avoid inconvenience or danger to land users.

4.3.2 The PSM should be placed in such a position as to avoid the likelihood of damage, disturbance or destruction. Well used cattle pads, fire breaks and vehicular tracks along fence lines should be avoided.

4.3.3 The PSM should be sited to minimise clearing requirements, either for subsequent air photography or meridional observation.

4.3.4 The PSM to be targetted should be sited on natural ground surface offering good contrast with the target material. (See also para. 7.3 Target Siting).

4.4 Clearing

To ensure that air photography imagery is uninterrupted by the surrounding vegetation or the shadow cast by vegetation, all such vegetation should be cleared below a line having an elevation 'E^o' from ground level at the outer edge of the target, where

$$E^o = \tan^{-1} \frac{\sqrt{2}f}{F} \quad \text{and}$$

f is focal length of air survey camera to be used
F is format width of air photograph.

4.5 Fencing

In areas running cattle it usually will be necessary to enclose the target with a temporary fence to ensure its preservation until after air photography is complete. Where possible use should be made of existing fences to minimise the length of temporary fencing needed. Two strands of barb wire on steel fence posts should prove satisfactory. In sheep country wire-netting laid directly over the target material will provide sufficient protection.

5. STATION MARKING

5.1 Photogrammetric Cadastral Stations may be established as either:

- (a) On Site Station where the Permanent Survey Mark can be placed and targetted exactly on the agreed property corner which is to be co-ordinated, constituting the terminal of the boundary of the subdivision to be defined, or
- (b) Offset Station where the Permanent Survey Mark cannot be placed and targetted exactly on the agreed property corner because of some obstruction (i.e. fence strainer post in the case of a subdivision 'as occupied') or for some other reason, and therefore must be placed at a suitable position offset from the corner point.

5.2 Permanent Survey Mark (PSM)

The PSM should comprise a star sectioned picket not less than 800mm in length driven either to refusal or to a point such that the top protrudes 10mm above the level of a concrete collar. such collar

to be 200mm in depth and 200mm in diameter, protruding 20mm above natural ground level. The concrete collar is to have three brass insets on which are stamped:

- (a) The Photogrammetric Cadastral Station number;
- (b) PSM number;
- (c) Any portion number.

5.3 Reference Marks

Reference Marks should comprise at least 2 nearby trees horseshoe blazed with the point of reference marked by a galvanised iron roofing nail or a chisel cut, and connected to the PSM by compass and chain. Where suitable reference trees are not available, a Witness Post of painted galvanized iron pipe 1.5m in length fitted with a cap and set 0.5m in the ground adjacent to the PSM may be used. Where the Witness Post could constitute a danger to either land users or stock it should be sited in a safe position away from the PSM and connected thereto by compass and chain. Witness Posts substantially add to overall marking costs and should be used only where absolutely necessary.

5.4 Recovery Marks

Where the PSM is placed on the property corner at least one recovery mark should be placed, comprising an iron pin 300mm in length driven at least 50mm below ground level, approximately 2m from the PSM on line to one reference tree. In the case of an offset station the pin is to be placed on line approximately one metre from the property corner.

5.5 Property Corner

5.5.1 In the case of an 'as occupied' subdivision where the property corner is marked by an existing fence strainer post, a galvanized nail in the strainer post is to define the corner and is to be connected to the PSM.

5.5.2 Where the adopted and agreed boundary is not fenced and there is no obstruction on the property corner, but where it is deemed desirable to offset mark the station, a

standard wooden peg is to be placed on the property corner and connected to the PSM.

5.6 Auxiliary Survey Marks (ASM)

5.6.1 Permanent Auxiliary Survey Marks (PASM)

Where an Auxiliary Survey Mark with aerial target is placed in order to establish a photogrammetric azimuth line (see para. 6.1.3) the Auxiliary Survey Mark is to comprise the same marking as the PSM referenced to at least two blazed trees with one iron pin approximately 2 metres from the Auxiliary Survey Mark on line to a blazed tree. The Permanent Auxiliary Survey Mark should be connected to the PSM by compass bearing and paced or measured distance for records purposes only.

5.6.2 Temporary Auxiliary Survey Marks (TASM)

The Temporary Auxiliary Survey Mark is a rectangular sectioned wooden peg. Its use is described in para. 6.1.4.

6. CONNECTION TO PROPERTY CORNER

6.1 In the case where the aerial targetted PSM is offset from the corner point, the photogrammetric adjustment through the process of aerotriangulation will provide co-ordinate values of the PSM, from which must be calculated the co-ordinate values of the corner point. A connection must therefore be made between the PSM and the corner point by the most economical means within the permissible accuracy tolerance of the photogrammetric survey. The following techniques are suggested for use:

6.1.1 On Line Connection

Where the proposed boundary is already fenced or intervisibility exists to the opposite terminal of the proposed boundary line, the PSM is placed either on the prolongation of, or set back along the proposed boundary line and a measured distance connection made from the PSM to the corner point.

6.1.2 Compass and Chain Connection

Where the Offset PSM is sited within 10 metres of the corner point, a compass and chain connection may be made. Where compass bearings are used for this purpose or for connection to a reference or recovery mark, a compass check bearing must be taken along the

line of the boundary or between adjoining intervisible PSMs to allow a direct comparison to be made between magnetic meridian and the meridian adopted for the photogrammetric adjustment.

6.1.3 Azimuth Line Connection

Where it is necessary due to excessive clearing or some other reason to offset the PSM a considerable distance from the corner point, an Auxiliary Survey Mark must be placed at a sufficient distance from the PSM to allow a reliable orientation azimuth to be established. The distance to the Auxiliary Survey Mark from the PSM should not be less than the distance from the PSM to the corner point. The azimuth along the Azimuth Line may be determined by a meridian observation or by co-ordinate differences read in the photogrammetric adjustment. The angle from the Azimuth Line to the corner point is read by theodolite to a comparable accuracy.

6.1.4 Photogrammetric Connection

Where the distance from the corner point to the PSM is in excess of 10 metres the placement of a Temporary Auxiliary Survey Mark (TASM) to form an equilateral triangle with the PSM and the property corner will allow co-ordinate values of the corner point to be calculated from the photogrammetric co-ordinates of the PSM and the TASM. Both the PSM and the TASM must be targetted. Measurements need not be taken in the field other than for records or checking purposes. The PSM and the TASM should be sufficiently spaced to avoid interlocking and confusion of their respective targets.

6.2 All radiations should be measured by a self checking method.

7. AERIAL TARGETS

7.1 Aerial Targets should be placed in position as close as practicable in time to the flying of photography. Close liaison between the project manager and the pilot is desirable to allow for last minute checks of targetting before the photographic mission is attempted.

7.2 Target Material

7.2.1 Material selected for Aerial Targets should have the following qualities:

- (a) Provide good contrast with natural ground surface. This usually implies the use of a light coloured diffusive material. Experience has shown that white, orange ("day glow") or yellow plastic sheeting is satisfactory in most conditions. Cotton or calico may also be used. Plywood or masonite panels painted flat white are especially good where accurate target layout is critical.
- (b) Be of sufficient strength to allow fastening to the ground without tearing, especially in windy conditions and to withstand interference by animals. Fibre reinforced plastic or polythene material (e.g. 'Fortecon') is very suitable. In areas of high wind in open conditions it may be necessary to overlay the target material with wire netting.
- (c) Be relatively inexpensive. In some situations recovery of targets may be uneconomical.

7.2.2 Black polythene does not produce a suitable photographic image against a light background due to its reflectivity (see also para. 7.3.3.)

7.2.3 Fastening

In rocky ground it may be necessary to place rocks on the target to securely hold it to the ground. On flat firm ground, 10cm nails driven through 5cm squares of thin fibre board and the target material into the ground have proved satisfactory. Eight such pins are required to secure a single target panel. More substantial fasteners may be required to secure the target in softer soil conditions. Where rocks or other heavy objects are placed to secure the target care must be taken to ensure that not more than 10% of the target surface is covered.

7.3 Target Siting

7.3.1 The essential purpose of the target is to obtain a positively identified photographic image on the air photograph of the ground control point or point to be co-ordinated. Unless the target can be positively identified on the air photograph, the effort of establishing the station on the ground is totally wasted. If the point concerned is a control station then the absolute accuracy of the resulting photogrammetric adjustment may be affected adversely, so compromising the value of every aerotriangulated station read out from the adjustment. The target is identifiable within the photographic imagery because of:

- (a) its distinctive shape; and
- (b) its contrast with the natural ground surface in the immediate vicinity of the target.

7.3.2 While it is important that the target material adopted has the overall property of offering good contrast with the natural surface in general, it is equally essential that the target be located on an area of natural surface which sustains good contrast with the target material. The following factors bear on site selection in relation to maintaining good contrast:

- (a) Avoid areas of high surface reflectivity such as clay pans, white (beach) sand, and areas denuded of grass and trampled by cattle. Such areas show white on panchromatic film and flair with the target material, so obliterating the target pattern in the photographic imagery.
- (b) Avoid unnecessary disturbance of the natural surface adjacent to the target site. Grass which has been trampled and flattened has increased reflectivity.
- (c) Take all possible actions to improve or sustain contrast.

7.3.3 If it is not possible to avoid siting the target on a reflective surface then possible solutions are:

- (a) To outline the target with a porous non-reflective material such as cut brush or bark between the arms of the target and extending to an area surrounding the target for a width at least equal to a target panel length.
- (b) To form the target shape by pouring a substantial quantity of sump oil directly onto the ground or alternatively using cut brush to form the target. In this latter instance the dimensions of the target need to be at least double or three times the size of the standard target. This 'negative' target is particularly effective in light sand areas.

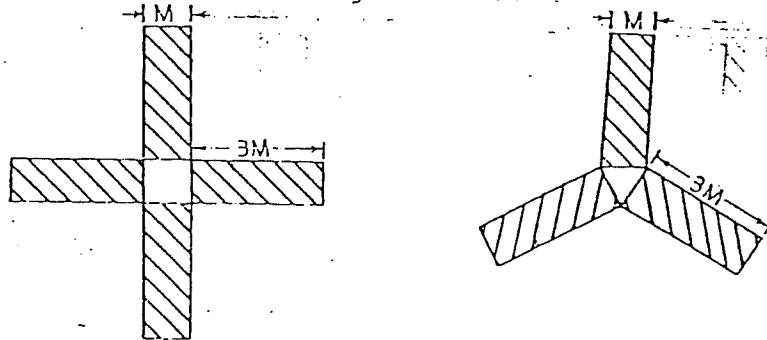
7.3.4 The shadows of trees or man-made structures falling across the target cause the distinctive shape of the target to be interrupted and its photographic imagery therefore difficult to identify. Shadows also cause loss of contrast between target material and ground surface. Therefore sufficient clearing must be carried out to ensure that shadows will not fall across the target during normal hours of air photography, taking into account the position of the sun and the time of year. The clearing requirements specified in para. 4.4 will normally meet this requirement.

4 Target Design and Layout

- 7.4.1 The aerial target must be laid out accurately and symmetrically about the PSM. The ability to place the photogrammetric reference mark (floating dot) exactly on the PSM control station or cadastral station to be co-ordinated is dependent on the symmetry and accuracy of the target with respect to the PSM.
- 7.4.2 A simple target design is preferable to more complicated designs. Experience has shown that the simple 'cross' or 'Y' configuration is distinctive, identifiable, economic and easy to lay out on the ground. The 'cross' has the advantage over the 'Y' that should one leg be disturbed or lost the remaining three legs provide a useful if impaired target. Other configurations may be used, e.g. 'hollow square' or 'T' which may better suit some terrain characteristics or be better suited to low altitude large scale photography.

7.4.3 Size

The dimensions of the target are determined by its acceptable image size at photo scale. Experience has shown that the area of exposed ground between the inner ends of each leg or panel forming the cross or Y should measure 0.06mm x 0.06mm at photo scale. Thus on photography at scale 1:20 000 this inner area becomes 1.2 metres x 1.2 metres. Each panel should have the same dimension in width and a length not less than three times the width. The diagram below illustrates the 'cross' and 'Y' configurations:



8. PHOTGRAMMETRIC CONSIDERATIONS

8.1 In designing a control configuration expert photogrammetric advice should be sought at an early stage. The density and dispersion of horizontal and vertical control points will be determined by the positional accuracy requirements of the cadastral stations to be co-ordinated in the photogrammetric adjustment related to the flying height of the photography and the type of photogrammetric adjustment planned for the block. It is thus necessary to determine for the desired accuracy pertaining to each cadastral station, the following:

- (a) The optimum photo scale, flying height and camera focal length to give the most economic solution;
- (b) The position of the control stations needed to control the network;
- (c) The required accuracy of horizontal and vertical control, in the form of both existing cadastral or other points and additional points which may need to be established;
- (d) The need for some redundancy in the control network for the purpose of final accuracy assessments, especially where network control is based predominantly on existing cadastral surveys.

8.2 In all cases the most economic solution must be achieved.