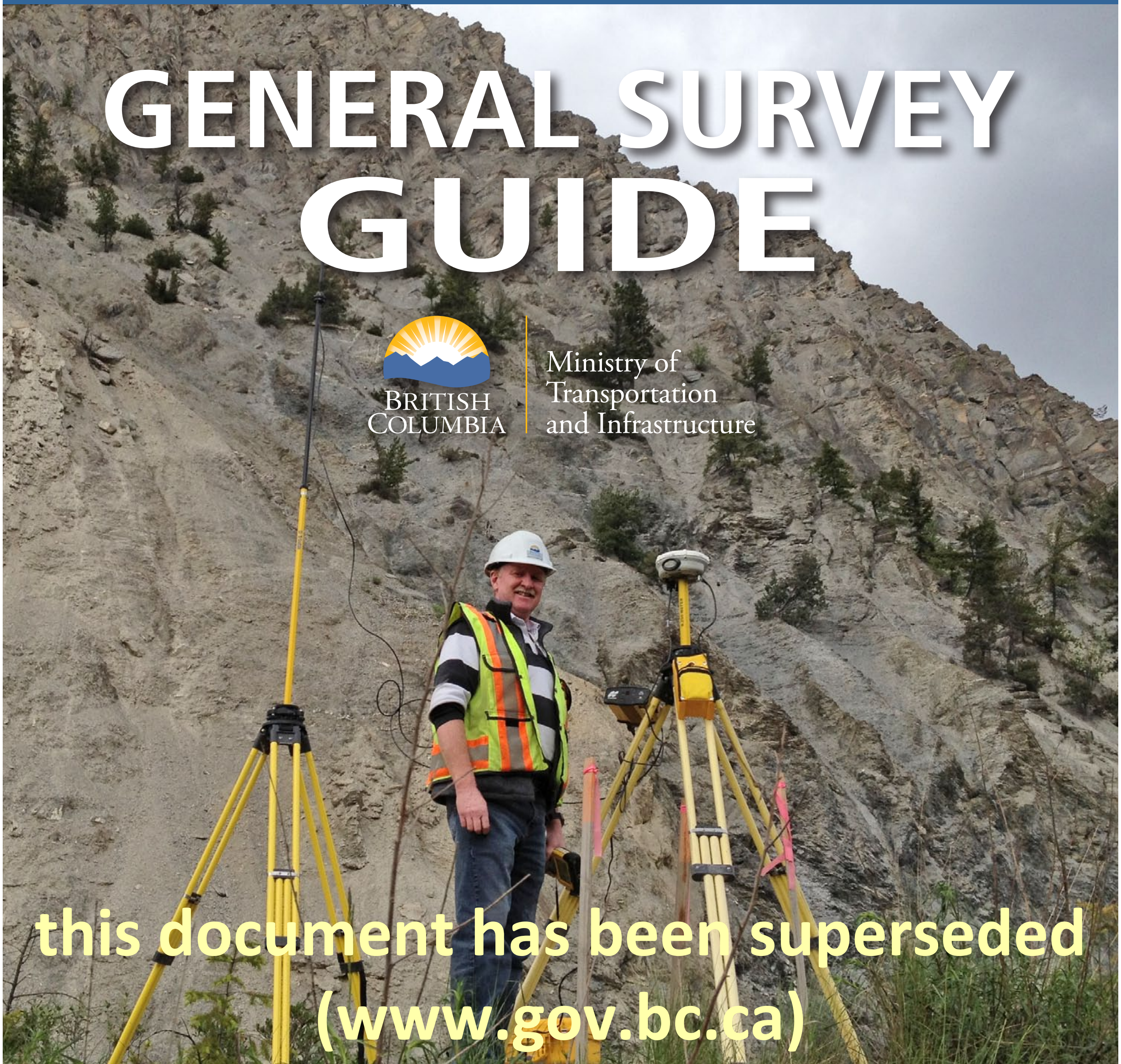
ENGINEERING BRANCH

Traffic, Electrical, Highway Safety & Geometric Standards Section

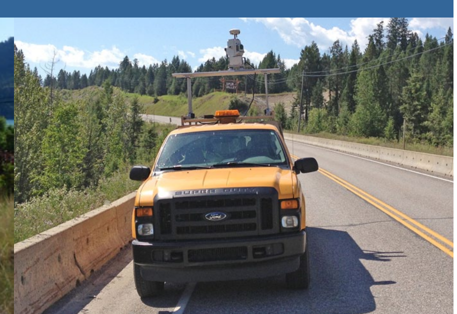
GENERAL SURVEY GUIDE

BRITISH COLUMBIA | Ministry of Transportation and Infrastructure



this document has been superseded (www.gov.bc.ca)

OCTOBER 2013



PREFACE

This is the October 2013 edition of the General Survey Guide for the BC Ministry of Transportation and Infrastructure (BC MoT). This guide replaces the previous version dated January 2005.

This edition of the General Survey Guide has been updated to reflect current standard procedures and required deliverables. Hyperlinks to reference information have been updated as well.

The contents of this guide are relevant to both Ministry staff and consultants. The guide is designed to be used as a contract, a reference guide, and a terms of reference guide.

The content of this guide shall be considered as the minimum requirement for all surveys.

When survey services are required, the contract Terms of Reference will include a reference to this guide, or sections as applicable, as per the following example:

This survey shall provide deliverables as defined in the BC Ministry of Transportation and Infrastructure General Survey Guide, and as applicable.

The General Survey Guide has been developed by the Ministry Field Survey Emerging Technologies Committee and its members:

Jim Turner	Sr. Geomatics Resource Technician, Engineering Branch, Victoria
Bob Gourley	Project Supervisor Ground Modelling, Field Services, Kamloops
Ernie Gross	Regional Survey Project Supervisor, South Coast Region
Dave Peet	Consultant Services Survey Manager, North Region
Sabrina Larsen	Sr. Geomatics Survey Technician, North Region
Trevor Key	Geomatics Survey Project Supervisor, North Region
Mike Skands	Consultant Services Survey Manager, South Interior Region
Rod Ralston	Geomatics Survey Project Supervisor, South Interior Region
Luke Dickieson	Sr. Geomatics Survey Technician, South Interior Region
Ian Busby	Sr. Business Analyst, Information Management Branch, Victoria
Greg Toews	Project Analyst, Information Management Branch, Victoria
Ken Blood	Geomatics Technologist, Focus Corporation

Technical Advice

Questions on interpretation and application of standards and guidelines should be directed to:

Sr. Geomatics Resource Technician, Engineering Branch
Traffic, Electrical, Highway Safety and Geometric Standards Section
BC Ministry of Transportation and Infrastructure

Email: moti.geomatics@gov.bc.ca

General Survey Guide

Table of Contents

100 Introduction, Project Initiation, Research

100.01 Introduction

The surveyor is expected to use proven industry methods to safely, correctly and efficiently achieve the desired objective and required deliverables. The Ministry encourages innovative and viable alternative solutions that will satisfy project deliverables.

The Ministry requires the following:

1. Professional and qualified surveyors
2. Well maintained and properly calibrated equipment
3. A complete and clear understanding of project assignments
4. The ability to perform survey requirements in adverse weather conditions
5. Documentation to substantiate quality management procedures

100.02 Project Terms of Reference, Scope, Schedule and Budget

All survey projects are governed by a **Terms of Reference** that includes the following:

1. Methodology to be employed
2. Specific work orders and schedules for assignments
3. Ministry standards to be followed
4. The cost for the provided services

100.03 RISP (Contracts, Consultant Procurement and Selection)

Contracts for Engineering and Technical Services valued at less than $1,000,000 must be awarded through the RISP (Registration, Identification, Selection and Performance Evaluation) system.

Reference for additional information on the selection process:
Ministry eRISP Website
http://www.th.gov.bc.ca/erisp/home.htm

100.04 Policies

All Ministry and WorkSafeBC safety policies will apply to all surveys. This includes policies regarding safety equipment, signs, traffic control and procedures.

Reference:
WorkSafeBC Resources Website
http://www.worksafebc.com

Reference:
Ministry Traffic Control Manual
https://www.gov.bc.ca/gov/content?id=10C12D22228C46BD9825E2EEF80156A9

Private property owners must be contacted prior to property entry. The Ministry Representative or Project Manager will initiate notification and coordinate contact with the property owner on behalf of project and consultant surveyors. The notice will state the intent to enter the property and request permission as per Ministry policies and procedures.

Reference for information and guidelines for entry onto private land:
Ministry Form H0224
See Section 200.05 of this guide

Reference for information:
BC OnLine Resources Website
https://www.bconline.gov.bc.ca

Survey staff must follow all Ministry policies and procedures for entry onto private land, railway and utility right-of-ways and any areas deemed not generally accessible to the public.

Advise the Ministry Representative in the event that entry is denied where entry is required in order to properly complete the survey assignment.

100.05 Research

Proper research ensures correct information representation in the base survey. This reduces problematic process errors in the Design and Construction phases. Research information includes, but is not limited to, survey control, property ownership, cadastral information and municipal utilities.

100.06 Correspondence

Retain all records of correspondence that form part of the deliverable. This will include records of telephone calls, emails, property owner notification letters and any other project related enquiries and/or details.

200 General Survey Requirements

200.01 Technical Research

A project scope may require information such as orthophotos, air photos, topographic maps, LiDAR data, composite plans, as constructed plans and ALR (Agricultural Land Reserve) plans.

Relevant material related to Properties, Crown Lands, Aboriginal Lands, Gazette Notices and Municipal Utilities may be obtained through the following links:

Gazette Searches - *request searches on gazette notices and road surveys*
HighwaysInformation.RecordsServices@gov.bc.ca

Geo BC Geospatial Reference Systems - *survey monuments*
http://a100.gov.bc.ca/pub/mascotw

BC One Call - *must be contacted prior to survey to supplement utility information*
http://www.bconecall.bc.ca

Local Municipal Websites - *municipal utilities and related information*
http://www.civicinfo.bc.ca/11.asp

Cadastral Search Tools - LTSA Online Cadastre - ICIS
http://webmaps.gov.bc.ca/imf5/imf.jsp?site=olc
http://www.icisociety.ca

Property Information, Cadastral Plans - *plan retrieval (PDF) - plan number or PID required*
https://www.bconline.gov.bc.ca

Mapping - *aboriginal lands, national parks, municipal boundaries, parcels, surveys*
http://clss.nrcan.gc.ca/map-carte/mapbrowser-navigateurcartographique-eng.php

BC Land Title and Survey (LTSA) - *survey general notes, r/w plans, gazette notices, etc.*
http://www.ltsa.ca

During archaeological and environmental surveys for planning and engineering studies, survey staff is required to work closely with the appropriate specialists and the Ministry Representative, to correctly identify archaeological and environmentally sensitive areas for survey.

200.02 Terrestrial 3D Laser Scanning

Deliverables

- Bare Earth XYZ file and/or LAS files
- Default XYZ files and/or LAS files
- MTS files
- ECW and TIFF files
- Planimetric files
- Quality control files
- LiDAR survey report

200.03 Aerial LiDAR & Orthophotography

Aerial LiDAR and Orthophotography have been accepted as a viable, cost effective and productive means to <u>supplement</u> transportation corridor surveys.

Aerial LiDAR is not intended and will not be used as a standalone representation of the corridor infrastructure and digital elevation model.

Aerial LiDAR deliverables must pass QA testing to ensure horizontal and vertical compliance with Ministry specifications.

No attempt will be made to disguise Aerial LiDAR as ground survey. Boundaries encapsulating each data source are required. All data within those boundaries is to be homogenous.

200.04 Merging Data from Different Sources and Accuracy Specifications

When digital mapping and ground survey are merged into a single digital elevation model, ensure that there are distinct transitions and evidence as to the origins of the data.

200.05 Entry onto Private Properties

Images of Ministry form H0224 are shown on the following pages. Note that this is for reference only, the Ministry Representative or Project Manager will initiate notification and coordinate contact with the property owner on behalf of project and consultant surveyors.

BRITISH COLUMBIA | Ministry of Transportation and Infrastructure

NOTICE OF SURVEY, ENVIRONMENTAL OR GEOTECHNICAL INVESTIGATION

[name of recipient] [date]
[address of recipient]

Dear Sir or Madam:

Re: Project/Product Description

This letter is to advise you that the Ministry of Transportation and Infrastructure is conducting a study for a transportation project or improvements in your area. This study is being undertaken on behalf of Ministry design, environmental or geotechnical representatives who are responsible for survey or sub-surface investigations for new or remedial transportation construction purposes.

During this study, crews employed by the Ministry and on behalf of the Ministry will be conducting survey or sub-surface investigations and it may be necessary to enter your property. Some clearing of vegetation or other activity on your land may be necessary. Ministry representatives have been instructed to contact all residents prior to entry and, if you wish, a supervisor will discuss plans with you or your representative on site. Extreme care will be used to minimize disturbance and the site will be restored as closely as possible to its original condition, but where restoration is not practical, compensation will be paid.

Therefore, we are advising you of our intent to enter upon the lands described below:

Parcel Identifier(s): [PID#(s)]
[Legal Description(s)]

Should there be any questions, please contact:
[Contact Name]
[Contact Title]
[Contact phone number(s)]

Sincerely,

[Name of sender]
[Title of sender]

[Enclosure/attachment if applicable]

H0224 February 10, 2009

This section to be filled out after work authorized on Page 1 is complete

NOTICE OF COMPLETION OF SURVEY, ENVIRONMENTAL OR GEOTECHNICAL INVESTIGATION

Date [current date]

Further to the letter, on the reverse of this page, dated [date of letter],
I wish to advise you that we have now completed our work and no longer require entry onto the property described in that letter.

Sincerely,

H0224 February 10, 2009

Re: Form H0224 - Notice of Survey, Environmental or Geotechnical Investigation

Form H0224 is to be completed for each task requiring entry onto private property.

Form H0224 should be completed for every different task - i.e. design survey; geotechnical investigation, locational survey; property appraisal, etc. A copy of the completed form is to be placed on file and a copy is to be provided to the property owner.

Upon completion of each task, the back page of Form H0224 is to be completed by the person who has issued the original Form H0224. A copy is to be placed on file and a copy provided to the property owner.

Responsibility for the initiation of Form H0224 rests with Project Managers. Ownership of Form H0224 lies with Properties and Business Management Branch and any concerns about the Form should be directed to Properties and Business Management Branch.

H0224 February 10, 2009

SUBJECT **RIGHT OF ENTRY ONTO PRIVATE LAND**

Approved By:	ADM - Highways Operations
Initiating Director:	Director, Properties
Manager/Supervisor:	Chief Property Agent
Working Contact:	Manager, Property Services

POLICY

Entry

The authority given by the statutes listed below, which provide the right to enter onto private lands for limited purposes, will be exercised with full respect for the rights of the land owner, including:

- Ministry staff, and those acting on behalf of the Ministry, will provide landowners with written notice prior to entry onto their property.
- Written notice will be provided for each task requiring entry (i.e. design survey, geotechnical investigation, property survey),
- Written notice will be provided at the conclusion of each task requiring entry (i.e. design survey, geotechnical investigation, property survey).

Trespass

1. Entry onto private land without the consent of the owner may be granted by the Minister or designate for specific purposes as authorized under the following legislation:
    - Expropriation Act (Section 9 (1))
    - Transportation Act (Section 8)
    - Land Surveyors Act (Section 59.1)
2. Entry onto private property without written authorization from the owner or authorization in accordance with policy statement 1 of this Policy is a trespass and will not be condoned by the Ministry.
3. Ministry personnel, and those acting on behalf of the Ministry, involved in a trespass situation will:
    - terminate the trespass immediately upon becoming aware of it and
    - advise their Property Services Manager and Project Manager at the earliest opportunity.
4. Consequences - Ministry personnel and those acting on behalf of the Ministry involved in a trespass situation will be held responsible for their actions with respect to trespass.

H0224 February 10, 2009

PURPOSE

1. To prohibit unauthorized entry upon private property by Ministry personnel and those acting on behalf of the Ministry.

2. To clearly state the prohibition against entry upon private property without written authorization and the liability for consequences of the offender.

It is incumbent on all Ministry personnel, and those acting on behalf of the Ministry, to treat owners of property who may be affected by any Ministry project in a fair, equitable and competent manner.

SCOPE

This policy applies to all Ministry activities in which trespass upon private property could occur.

REFERENCES

Legislation:

Expropriation Act

- Section 9 (1)

Transportation Act

- Section 8

Land Surveyors Act

- Section 59.1

Ministry Form:

H0224 – Notice of Survey, Environmental or Geotechnical Investigation and Notice of Completion of Survey, Environmental or Geotechnical Investigation

Manual:

Properties Branch Standards and Procedures Manual

- Chapter 5.6

H0224 February 10, 2009

200.06 Points and Chains Coding

All collected data must be identified with alphanumeric feature codes that conform to the BC MoT Feature Table. See Section 1000.02 - CAiCE Feature Table.

All survey data must be compatible with the current version of **Autodesk CAiCE Visual Transportation** in use by the Ministry.

Reference:
Ministry Website for CAiCE Support
https://www2.gov.bc.ca/gov/content?id=CF7969D9BDB04E31B7EF662E6509558E

Point Survey

Survey data points are used to define specific feature codes and provide DTM resolution in areas that lack defined features and breaks.

Chain Survey

Chains are used to ensure correct DTM formation by defining **linear features**, transitions in terrain and ground material.

Linear features must be surveyed using the chain survey method. Point density along chains should maintain a maximum 20m spacing average, adjusted where applicable at the direction of the Ministry Representative.

200.07 Topographic Survey Requirements

All collected chains must have the following **minimum attributes**:

- Unique Chain Identifier (containing the feature code of chain)
- Feature Code (refer to Section 1000.02 - CAiCE Feature Table)

All collected points must have the following **minimum attributes**:

- Unique Point Identifier
- Northing
- Easting
- Elevation
- Feature Code (refer to Section 1000.02 - CAiCE Feature Table)

Collected points may include the following attributes:

- Point Description (specific information such as culvert size, type of pipe, type of headwall, manhole type, utility type, etc.)

Survey Point Accuracy

The horizontal and vertical accuracy specifications for detail pickup are as follows:

Point Location	Required Accuracy
Curb & Gutter	2cm
Pavement Overlay	2cm
Pavement	3cm
Urban Detail	3cm
Gravel Road Prism	5cm
Open Terrain	15cm
Heavy Ground cover	15cm
Undulating Terrain	15cm
Steep Terrain	30cm
Inaccessible Terrain	50cm

Survey Point Density

The horizontal and vertical nature of the terrain dictates most of the point spacing and chain requirements required to produce an accurate ground model.

Point density may be established by the Ministry Representative or within the project Terms of Reference to sufficiently represent the topography and features. As a rule, spacing of points in all directions should maintain a **maximum 20m average spacing**.

There will be circumstances where higher point densities will be required to ensure drainage issues, plan representations, and quantity concerns are satisfied.

Surveyor shot location selection is critical when surveying along a road template where adjacent and parallel chains are involved. For example, gutter and top of curb shots must be side by side. In these situations, triangle (TIN) model formation should be considered when selecting point locations.

Point spacing will accurately depict the horizontal and vertical geometry of the mapped feature. Point spacing examples are shown in Section 800 - Missing or Problem Project Data Archive Content, particularly note the examples for incorrect and correct point density.

Location	Suggested Point Spacing
Intersections	1 to 5m
Curb Returns	1 to 5m
Traffic Islands	1 to 5m
Ditches and Watercourses	1 to 5m
Curb & Gutter	5 to 10m
Rock Areas	5 to 10m
Small Radius Curvature	5 to 10m
Ditches	5 to 10m
Watercourses	5 to 10m
Wider Open Ditch	10 to 20m
Parking Areas	10 to 20m

Survey Limits

Gaining an understanding of the survey objective is critical to the proper determination of the required topographic and planimetric extents. Consultation with the Ministry Representative is required in this regard.

As an example, special consideration shall be given to intersecting driveways and roads, changing terrain, and any other features that may impact or affect the anticipated design requirements. These situations can significantly extend the intended corridor limits. Survey limits may be adjusted by the Ministry Representative as needed.

200.08 Standard Corridor Topographical and Planimetric Features

See Section 1000 - CAiCE Feature Table for the feature coding table. The listing below shows some examples of particular interest.

- Landslides and rock slides
- Debris torrents
- Avalanche chutes and identification
- Tree lines and cover (with type and size)
- Cultivated fields and land improvements
- Solid rock outcroppings and talus slopes
- Swamps
- Mine shafts
- Gravel pits and stockpiles
- Log jams and beaver dams
- Geotechnical test holes and pits (with elevations)
- Monitoring wells (with instrumentation)
- Wells, dugouts and reservoirs (with water elevations)
- Irrigation and drainage ditches (with direction of flow)
- Log jams and beaver dams
- Bicycle and hiking trails
- Decorative shrubs, trees and gardens
- Culverts and drainage features (with type and size)
- Lakes and water courses (with names and direction of flow)
- Present and high-water elevations (with recording date)
- Bridges and retaining walls, piers and abutments (with type and structure details)
- Crown of road
- Pavement and shoulder edges
- Existing laning, markings and traffic islands
- Gravel or dirt roads, driveways (with function/purpose of road or driveway)
- Road and highway names and numbers
- Roadside median barrier and drainage curbing
- Sidewalks and drop curbs
- Contours and spot elevations as required
- Commercial road and traffic signs (with type and commercial business name)
- Fences (with description and type)
- Buildings (with street address)
- Commercial buildings (with business name)

- Underground, surface and overhead utilities: telephone, electrical, cablevision, gas, water, septic tanks and fields, storm and sanitary sewers (with numbers of wires/cables, pipe size and type and wire elevations at road crossings)
- Water valves, fire hydrants, gas valves and markers, manholes, catch basins and culverts (with ground and invert elevations)
- Railway tracks (with top of rail elevations for 100 metres either side of highway centreline at 20 metre intervals)
- Any unusual items that may impact the design: e.g. graves, archaeological sites, etc.
- All curbs, sidewalks and paved surfaces shall show the surface type: e.g. concrete, asphalt, paving blocks, brick

200.09 Horizontal Alignment Layout

When locating a proposed centerline, alignments must be staked at an interval suitable to the objective. For example, the intent may be visualization in the field or station/offset referencing.

When staking proposed alignments, the stakes are identified by alignment and stationing.

At the Ministry Representative's request, when traverse lines are used to establish offsets to proposed alignments, stations must be identified in the field by an offset stake. Offset stakes must be identified by alignment, station and offset distance left or right.

A point report may be required by the Ministry Representative. The point report shall show the control points used to establish proposed alignments and used to identify closure details.

200.10 Cadastral

The location, dimensions and orientations of all individual Land Title Plans and Crown Land information shall be represented. Sufficient legal monuments, iron pins, and other property markers shall be tied to the project grid for this purpose.

Legal Property boundaries on Ministry drawings must be sufficiently accurate to ensure right of way, utility offsets, land areas, encroachments, etc. can be calculated and/or displayed to the required precision.

GIS or other electronic cadastral composite overlays may only be used with approval from the Ministry Representative. Usage must be stated clearly on all drawings.

Indicate all closures, and any methods of averaging or pro-rating, in the project binder or the quality management report. The obtained accuracy must be conveyed in the quality management report.

Notes, sketches, and digital photos should be obtained for the markings and numbers on the brass caps of tied monuments.

An explanation must accompany tied and drawn property markers that have no boundary line through them, or are shown on a boundary line for no apparent reason. For example, an explanation is required for a point not at a property line intersection, corner, curve, or witness point.

200.11 Underground Utilities

Provide as much information as possible related to underground utilities. Note that this information is usually obtained without digging. Include the utility type, location, depth, pipe type, pipe size, invert elevations, etc.

The extent of research to be done will be discussed and detailed during the project initialization meeting. Sources of information and methods of compiling this information will be conveyed in the surveyor's quality management documentation.

Refer to Section 600 - Quality Management Methods, Records, Results and Reporting.

An example process:

1. Contact BC One Call (http://www.bconecall.ca)
2. Contact utility owners
3. Survey ties to existing valves, pipe inverts, etc.
4. Mapping out of utilities using survey and corresponding plans
5. Ground penetrating radar or other methods of pipe location if required for design

Ground penetrating radar, as an option, should accomplish most of the requirements for underground utilities.

Involve the owner of the utility for enquiries defining the services and distribution or location/size of the required utilities.

200.12 Planimetric Detail and Ties

All planimetric detail surveyed for the Ministry, shall use the standard BC MoT feature table identified in Section 1000 - CAiCE Feature Table.

The type of planimetric detail identified in Section 200.08 and Section 1000.02 must be supplemented with descriptive information (**attributes**) that apply to each feature, including, but not limited to, the examples shown here:

- Culverts:
  - type and size
  - condition
  - invert elevation, inlet and outlet
- Building types, business names and address
- Commercial and road sign detail:
  - name
  - type
  - road and street names
  - electrified sign
  - sign base material (e.g. concrete)
  - overhead directional signs
  - signal lights
  - speed signs
  - Ministry sign number
- Lamp standards (whether privately owned or Ministry owned)
- Underground utilities types:
  - sanitary sewer, storm,
  - telephone, electric,
  - water, gas
  - show manhole type and size
- Trees:
  - species
  - tree height
  - diameter
- Roadside barrier:
  - type and dimensions
- Overhead utilities
- Poles:
  - number
  - direction
  - type of cables between poles
  - elevation of the lowest point of sag for cable/wire
    (Where it crosses proposed alignments and existing roadways)
  - other required attributes
  - show pilasters, transformers, pole numbers and other required information
- Fencing:
  - Condition and type (barbed wire, page wire, chain link, timber, etc.)
- Geotechnical exploration detail types:
  - test holes
  - seismic lines
- Retaining walls:
  - base of wall, top of wall
  - type
  - include sufficient break-lines to ensure smooth transition to surrounding surface
- Bridge abutments and wing walls

200.13 Deliverables

Hardcopy Deliverables Required

- All plan drawings

Electronic Data Deliverables

The completed project may be specified to be delivered in one of two electronic formats:

- Section 800 - CAiCE Survey Project Data Format Terms of Reference
- Section 900 - BC MoT Standard Survey File Format (MTS)

Other electronic data delivery options must be preapproved by the Ministry Representative on a per project basis.

Other electronic data deliverable components:

- All plan drawings (must be submitted in the Ministry current AutoCAD DWG format)
- All legal plans
- Surveyor’s quality management documentation
- Control Origin Report (see Section 300.03 - Primary Control Point)
- All project correspondence (see Section 100.06 - Correspondence)
- All project photos
- Geo-tagged photos (submit at the request of the Ministry Representative)

All collected survey data will be made available on request.

300 Control Surveys

300.01 General

Control Surveys are defined as per the following sections.

300.02 Control Point Origins

The Ministry Representative will provide direction on control point origins.

300.03 Primary Control Point

A Primary Control Point is a point established by surveying directly for highway purposes or a point taken from the Geodetic Control Monument Database.

These points are used as a basis to integrate mapping resources, adjacent project extension/revision, topographic survey, construction survey, and future control extension. Primary control will encompass project limits and ensure no extrapolation or compounding errors will be encountered.

All Primary Control Points are set permanently and clearly marked with stakes, offset/station stakes, pickets, flagging and/or paint. Control Points are typically #10 rebar, 300mm or longer, and set approximately 100mm below ground level to reduce the chance of being disturbed.

The location requires an unobstructed view of the sky, and is to be clear of obstacles (trees, signs, buildings, etc.) to facilitate GNSS RTK base constellation. Control points should be set in locations where there is negligible opportunity for disturbance and located to facilitate future GPS occupation and to address safety issues.

Primary Control Points are established using rectangular coordinates based on NAD-83 UTM with elevation based Canadian Geodetic Vertical Datum (CGVD). The project will be scaled to ground; the Ministry Representative will supply definition and parameters.

Unless otherwise instructed by the Ministry Representative, in rural areas, such as bush or open fields, flagged tripods must be constructed and placed over the point. This will protect the point and increase visibility for future use.

A minimum of three (3) Primary Control Points per project must be established in stable locations. The maximum distance between these points is 5km. The Ministry Representative may establish an adjusted maximum distance as needed.

Primary Control Network Reporting

Prepare a **Control Origin Report**, including the following:

- Relative accuracies
- Date of survey
- Notes, diagrams, digital pictures
- Combined scale factor
- Local coordinates
- UTM coordinates
- Geographic coordinate
- Orthometric height
- Ellipsoid height
- Quality control documentation showing closures

Supply raw data files as requested by the Ministry Representative.

See Section 800.04 - Project Folders and Organization for an example **Control Origin** table and a link to sample **Control Origin Report** files.

Secondary Control Point

Secondary Control Points originate from the primary control network.

Control points established via traverse with a total station or by GPS/RTK methods are classified as secondary control points.

Points are located at approximately 300m intervals, where required along the survey corridor, or as directed by the Ministry Representative.

Secondary control points are to be supplied at the Ministry Representative's request.

300.04 Primary Control Point Names

Primary Control Points will use unique identifiers, i.e. project name/point number.

Primary Control Point names will be used on all documentation, drawings, control point labelling in the field and in the CAiCE survey database.

400 Site Plans

400.01 General

All applicable site plan features as outlined below shall be in addition to Section 200 - General Survey Requirements and Section 1100 - Drawing Standards and Content.

Base Site Plans shall be prepared for all river and major creek crossings, highway and road crossings where structures will be required, railway crossings, bridge alterations or relocations, and major intersections.

The survey contract Terms of Reference or the Ministry Representative may define specific project limits for site plan creation.

Photographs should be taken and catalogued for ongoing reference.

400.02 Bridge and Culvert Site Plans

Reference:
BC MoT Supplement to TAC Geometric Design Guide
Section 1000 Hydraulics Chapter
http://www.th.gov.bc.ca/publications/eng_publications/geomet/TAC/TAC.htm#chapters

Reference:
Example Bridge Site Plan AutoCAD Project
Bridge Site Plan Example (AutoCAD ZIP - 8.45 MB)

Site plans contain special requirements to satisfy environmental and hydrology concerns, as well as roadway and structural design objectives. It is common practice for environmental and hydrology specialists to be involved during the early stages of the design process. These specialists may flag out areas of interest, or suggest survey limits which would benefit their tasks. These requests will be confirmed by the Ministry Representative.

The site plan shall be prepared using geodetic datum and shall contain the following information:

High Water Mark

Identifying the High Water Mark, some indicators are as described here:

- Top of bank, or wetted perimeter defined as: a change in vegetation (> 2yrs old) from bare ground, with no trees, to vegetated ground etc.
- A topographic break from vertical to flat floodplain, in cases where the floodplain is beyond the vertical break position
- A topographic break from steep bank to a more gentle slope
- The highest elevation from which no fine woody debris (needles, leaves, cones or seeds) occurs
- A change in texture of deposited sediment (e.g. from clay to sand, or sand to pebbles, or boulders to pebbles)

Active Flood Plain

The method(s) of determining the active flood plain must be conveyed and retained on the drawings.

An active floodplain is any level area with alluvial soils, adjacent to streams, which is flooded by stream water on a periodic basis and is at the same elevation as areas showing evidence of the following:

> *While these items are not necessarily unique to floodplains, they will provide consultants with a basis of investigation and reporting for an active floodplain.*
>
> *The Ministry Representative and/or specific contract terms of reference may add additional items as required.*

- Flood channels free of terrestrial vegetation
- Rafted debris or fluvial sediments newly deposited on the surface of the forest floor or suspended on trees or vegetation
- Recent scarring of trees by material moved by flood waters.
- A river/creek alignment and profile along the centre of the river/creek will be shown on the site plan with stationing commencing from the downstream side for a distance of 150 metres downstream and 150 metres upstream of the crossing. The surveyor should be cognizant of any issues that may impact stream flow and current i.e. beaver dams, sharp horizontal/vertical changes in topography etc. beyond the 150m requirement, and extend accordingly. **The Ministry Representative may require extension beyond the 150 metre requirement as part of the contract.**
- Using the above alignment, cross sections will be extracted from the DTM model at 10 metre intervals, extending laterally a considerable distance beyond the top of bank to adequately capture the river/creek channel and neighbouring area.
- A profile at existing centerline showing the ground line and the existing grade of any structures.
- Establish an elevation benchmark integrated from primary control points at the site.
- Indicate the nature of terrain (i.e., swamp, solid rock limits, and boulders). A brief description and geotagged pictures are suitable. Orthophotography may be required at the Ministry Representatives request.
- Provide a description of all vegetation (e.g. heights and diameter)
- Existing rip rap, extent and size
- All underground and aerial utilities plus line locations and elevation of lowest wire at proposed centerline crossings.
- Location and general description of existing structures including all available foundation data within site area plus vertical clearances
- Profile of water course bed to the limits of survey
- Description of water course bed (i.e., gravel, rock, silt etc.)
- Extreme high water mark and date.
- Present water level (indicate the date of survey)
- Description of driftwood, logs, debris, or log jams and provide digital pictures
- Description of scouring and silting and provide digital pictures
- Description of any shifts in channels and provide digital pictures
- Direction of stream flow.
- UTM coordinate at proposed intersection point of the structure and highway centreline.

400.03 Railroad Underpass/Overpass Site Plans

Survey within Railroad R/W corridors requires contact and permissions from the appropriate Railroad company. Permission must be obtained prior to entering Railroad property for any reason. Due Diligence is required to contact local Track Officials to obtain a permit. Permits granted must have the appropriate railway contact information and emergency protocols.

Reference:
BC MoT Supplement to TAC Geometric Design Guide
Section 1110 Railway Crossings & Utility Chapter
http://www.th.gov.bc.ca/publications/eng_publications/geomet/TAC/TAC.htm#chapters

Reference page 8 of the following PDF document:
CN-Industrial Track Specifications Document
CN Industrial Track Specification (PDF 2.3MB)

The **base site plan survey DTM limits** shall cover a minimum area of 50m each side of the structure and 50m either side of the proposed centerline

All railway infrastructure details including utilities, switches, frogs, lights, etc. within the right of way and DTM coverage within ditch limits shall be picked up for an additional 150 metres in each direction beyond the base site plan DTM limits indicated above.

All road infrastructure details including utilities, lights, etc. within the right of way and DTM coverage within ditch limits shall be picked up for an additional 150 metres in each direction beyond the base site plan DTM limits indicated above.

The site plan will include a profile of the top of each rail:

- Feature shots are to be taken on the top of each rail, at 10m intervals on curves and at 20m intervals on tangents
- Shots taken on the top of each rail require a vertical accuracy of 2cm
- Shots taken to define ballast as per TAC specifications are to be taken to 200 metres minimum left and right of the proposed highway centerline.

Show all aerial and underground utilities, plus line locations, and the elevation of the lowest wire at the proposed centreline crossing.

Show extraordinary features that may impact proposed highway sight distances; hedges, trees etc.

Ties to railway mileage posts are required.

500 Other Surveys

500.01 Monitoring (Slope Stability / Settlement / Structures)

Long term monitoring surveys require a sensible approach to collecting the information required to derive the differences between one set of monitoring data and the next. A thorough understanding of survey methodology is required to ensure reliable results. Consultants will be required to provide documentation outlining methodology, schedule and procedures to complete the survey deliverable.

500.02 Gravel Pits/Piles and Miscellaneous (Slide Material) Volume Calculation Requirements

Gravel Pit Control:

A minimum of three control points are required, located outside of the working area. One control point is required to be a primary control point as per Section 300.03 - Primary Control Point.

Gravel Pit Survey Requirements:

- Survey detail as defined in Section 200 - General Survey Requirements
- Sufficient detail to define the gravel pit for volume analysis and pit development

Gravel Pit Survey Processing/Deliverables:

- Logical interpolation of the pit floor when inaccessible due to a pile placement
- CAiCE project
- AutoCAD drawings (for plans production, drawings will include contours and volumes)
- Calculated volume reports

Gravel Pile Survey Requirements:

- Survey of pit base prior to crushing and placing of gravel piles if possible
- Sufficient detail of gravel pit to ensure that piles will not fall outside the pit perimeter
- Closed base of pile survey chain, and closed offset base of pile survey chain *survey information is required beyond the base of pile*
- Classify Aggregate type/size (25mm, 75mm, SGSB etc.)
- Sufficient detail to define pile, and base of pile
- Logical interpolation of the base of pile when inaccessible due to pile placement

Slide Materials Volume Calculations:

- CAiCE project
- Calculated volume reports

500.03 Hydrographic (Rivers and Lakes)

Acquisition of data requires a knowledgeable approach for data acquisition. Consultants will be required to submit a proposal outlining methodologies and procedures to complete the deliverable. In most scenarios, consultants are required to employ automated data collection methods. Methodologies will be reviewed and approved by the Ministry Representative.

Safety is always a prime concern, particularly near high velocity, fast moving active watercourses.

Survey datum shall be CGVD-Canadian Geodetic Vertical Datum

Methods used and calibration details must be documented for quality control purposes.

Reference:
BC MoT Supplement to TAC Geometric Design Guide
Section 1000 Hydraulics Chapter
http://www.th.gov.bc.ca/publications/eng_publications/geomet/TAC/TAC.htm#chapters

600 Quality Management Methods

600.01 Requests for Quality Records

Requests may be made for Quality Records to ensure the project meets the specifications of this guide and the objectives outlined in the terms of reference.

600.02 Project Overview

Proponents provide a brief summary of the task, location, and purpose of the work completed. The office and contact persons who did the work and names of any significant resources from the company's other offices and sub consultants who contributed.

600.03 Methodology Employed

The following is a brief summary of how each component of the job is to be completed. The samples shown are examples only and do not dictate formatting to be used.

a. Project Survey Control
b. GNSS Survey
c. Total Station Survey
d. Underground Utility Information
e. Cadastral
f. Aerial and Ground Based LiDAR
g. Aerial Mapping
h. CAiCE Project
i. AutoCAD Drawing Creation
j. Miscellaneous Components

a. Project Survey Control

- As per Section 300 - Control Surveys

b. GNSS/GPS/RTK Survey

- Periodic checks or ties to known points must be done. Data files must be supplied to the Ministry Representative on request.

c. Total Station Survey

- Describe which total station instruments were used. Provide explanations as to how each segment of work was verified. Each setup must be verified with ties to known points.
- Data and Raw Data files will be supplied to the Ministry Representative on request.

d. Underground Utility Information

- Summarize the sources of information and overall confidence level. For example, describe areas and utilities where field locations were performed, mention areas where utility location is in doubt.
- Identify sources of information
  - BC One Call communication http://www.bconecall.bc.ca
  - Identify all contacts

e. Cadastral

- Summarize LTO plans used and property markers found. Confirm overall confidence level of cadastral representation. Describe areas where the confidence level may be questionable and could potentially become an issue during design and right of way acquisition.

f. Aerial and Ground Based LiDAR

- Document how LiDAR data was integrated into the project deliverables. Describe quality control measures taken to ensure compatibility with ground survey data.

g. Aerial Mapping

- Provide an explanation of the source, date, and scale of photos used. Include the scale of mapping compilation and provide assurance that ground checking was completed and that the results were within specification. Ground check records may be requested by the Ministry Representative.

h. CAiCE Project

- Provide an explanation of quality management procedures
- Refer to Section 800 - CAiCE Survey Project Data Format Terms of Reference

i. AutoCAD Drawing Creation

- Provide an explanation of quality management procedures

j. Miscellaneous Components

- Other components that may be included would be a list of equipment used, records of soundings, monitoring records, etc. Also, a description of any application of atypical methods and the equipment used.
- Provide records proving that equipment has been maintained and calibrated for the task.

700 Emerging Technology

700.01 Alternate Data Acquisition and Delivery Methods

The Ministry acknowledges there are alternate technologies that may supply survey data deliverables that meet current Ministry standards for specifications and accuracies.

The Ministry Representative may consider alternate delivery methods when surveyor safety and/or cost benefits can be obtained.

The Ministry Representative will have sole discretion in decisions allowing new technology data acquisition methods. These decisions will be reviewed on a project by project basis where an alternate technology is proposed.

Deliverables

Deliverables must meet the specifications outlined in this guide and be compatible with Ministry engineering systems. This is a critical component for consideration of alternate data collection technologies.

800 CAiCE Survey Project Data Format Terms of Reference

800.01 General

The Ministry policy that all Survey Contracts are to be completed using the **CAiCE Survey Project Data Format** was officially applied January 2005. All survey contracts reference this section of the General Survey Guide.

Reference:
CAiCE Sample Project
Williams Lake - 4 Laning Project (ZIP 42.0 MB)

Reference:
AutoCAD Sample Project
Williams Lake - 4 Laning Project (ZIP 29.2 MB)

The Ministry implemented the CAiCE Survey Project Data Format Policy for the following reasons:

1. The policy provides the Ministry with a standard format for all survey data, regardless of whether Ministry staff or consultants complete the work.

2. The policy provides the opportunity for the Ministry to maintain a repository of survey data that can be easily utilized in the future.

3. The common format improves the flow of survey data to design offices and ensures that surveys are completed in an acceptable consistent format for design purposes.

The Proponent, after completing a project, must submit a CAiCE Project Archive, namely the survey archive file, as detailed in Section 800.08 - Survey Project Data Archive Preparation.

The **Survey Archive** containing either the completed **Location Survey** or **As Constructed Survey** is specifically required for the following reasons:

- Provides a detailed record of the completed location survey
- Provides the necessary information for design offices to utilize the completed survey
- Provides a detailed record of the completed construction project

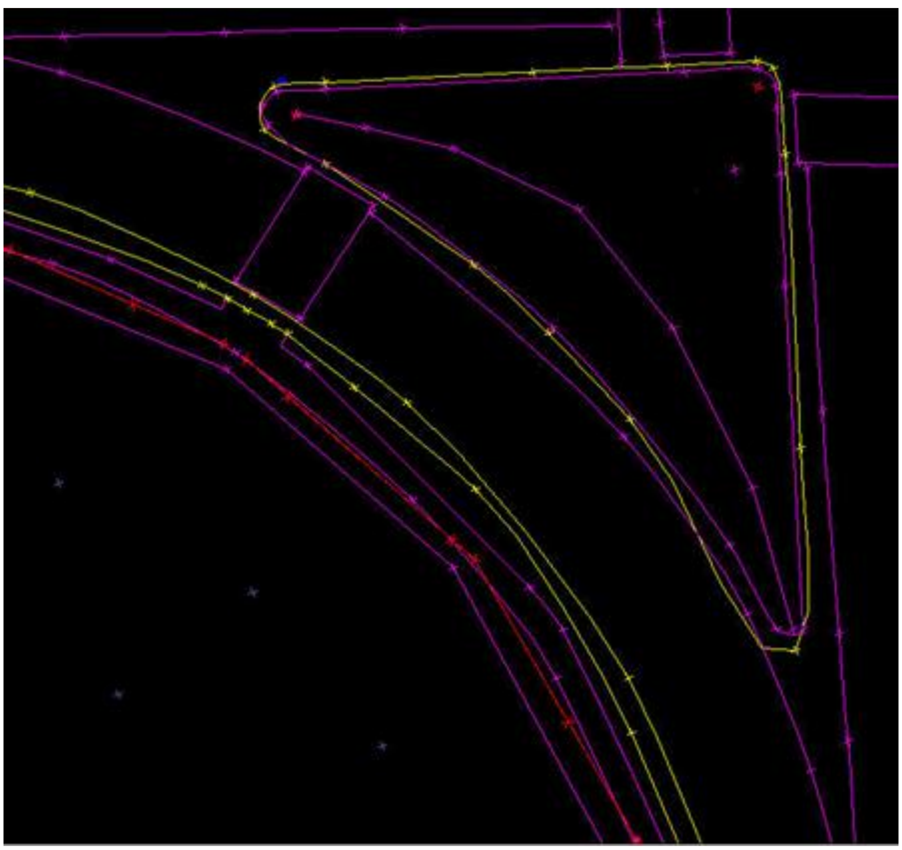
800.02 Missing or Problem Project Data Archive Content

The CAiCE Survey Project Data Archive File must contain the information specified in this section of the General Survey Guide as referenced by the Contract Terms of Reference for each **Location Survey** or **As Constructed Survey**.

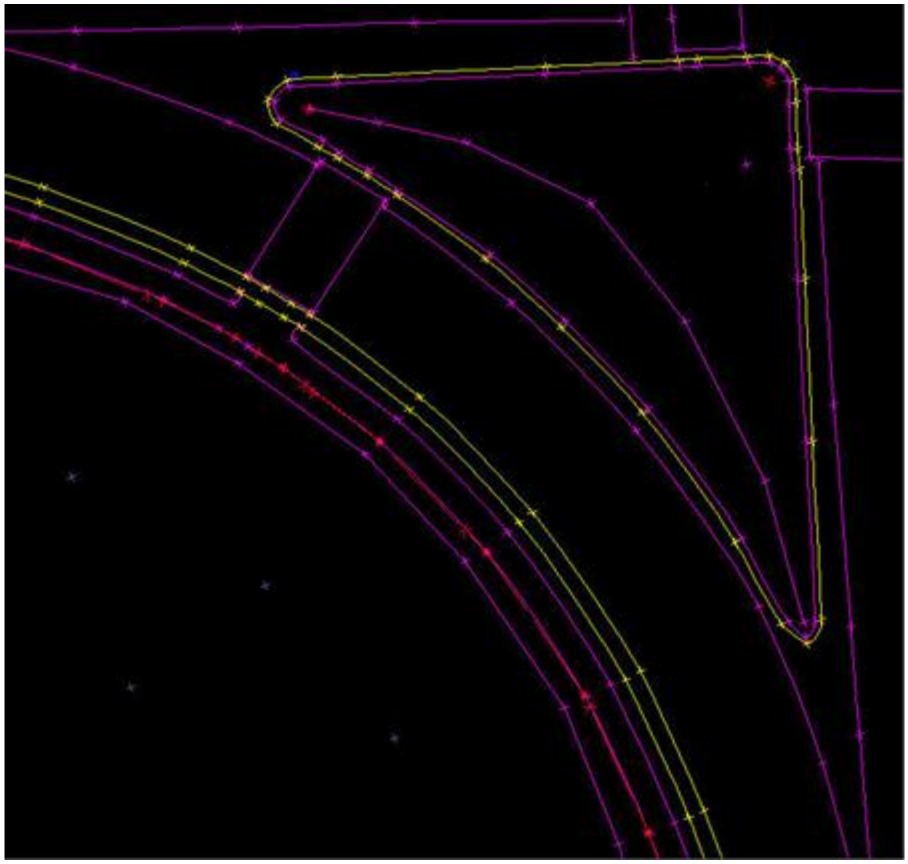
While performing survey processing in CAiCE, careful attention should be paid to dealing properly with common errors such as those shown in the examples below:

- Improper feature coding
- Crossing chains
- Unintended point and chain duplication
- Improper chain direction for drainage flow representation
- Missing point comments and/or descriptions
- Not defining changes in surface material
- Surveyed points, not chained together, that are obvious breaklines
- Spikes and dips in elevation not indicative of the terrain
- Improper designation of feature and ground points
- Irrelevant survey data not clipped
- Incorrect or inconsistent point density

Example: Incorrect Point Density

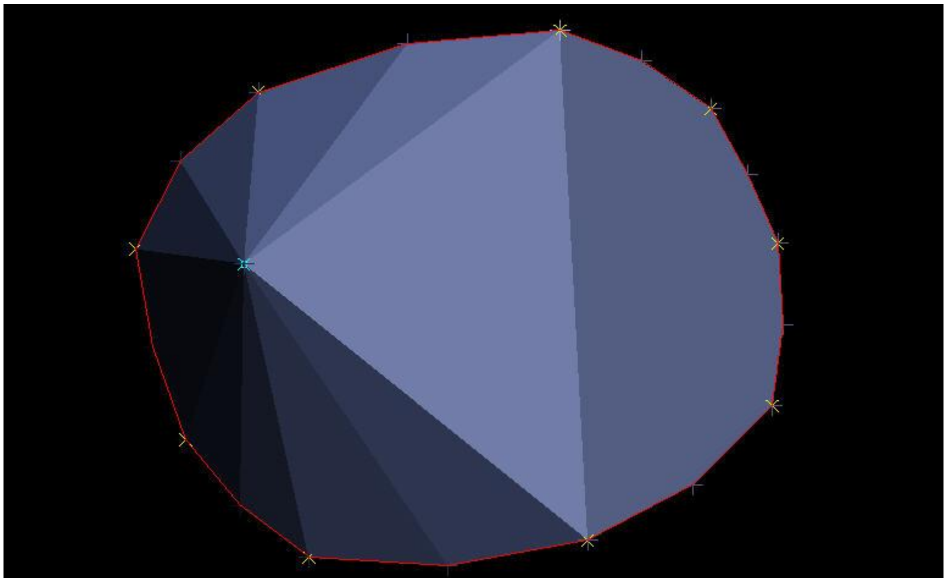


Example: Correct Point Density

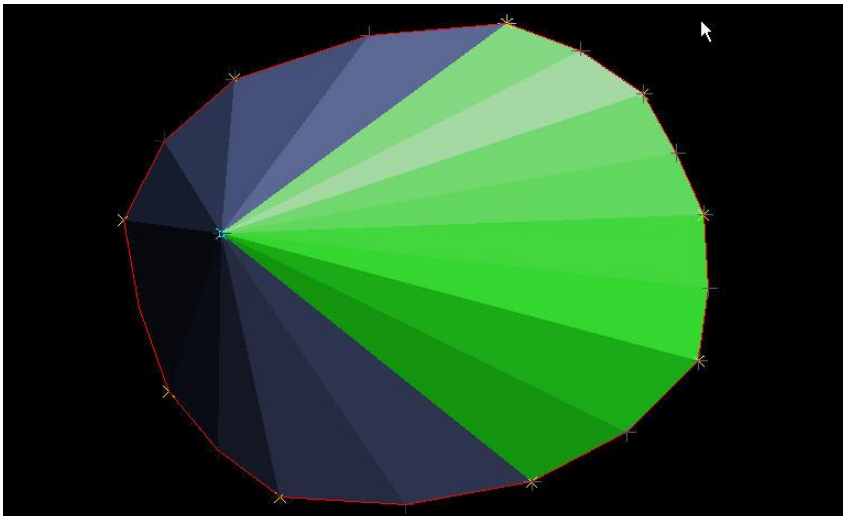


- Missing survey or geometry chain boundaries
- Missing **Survey Chain Check for DTM Compliance Report**
- Feature points mistakenly used in DTM formation
- DTM triangle sides joining to non-adjacent chain points (DTM refinement needed)

Example: Incorrect DTM Formation (No DTM Refinement)

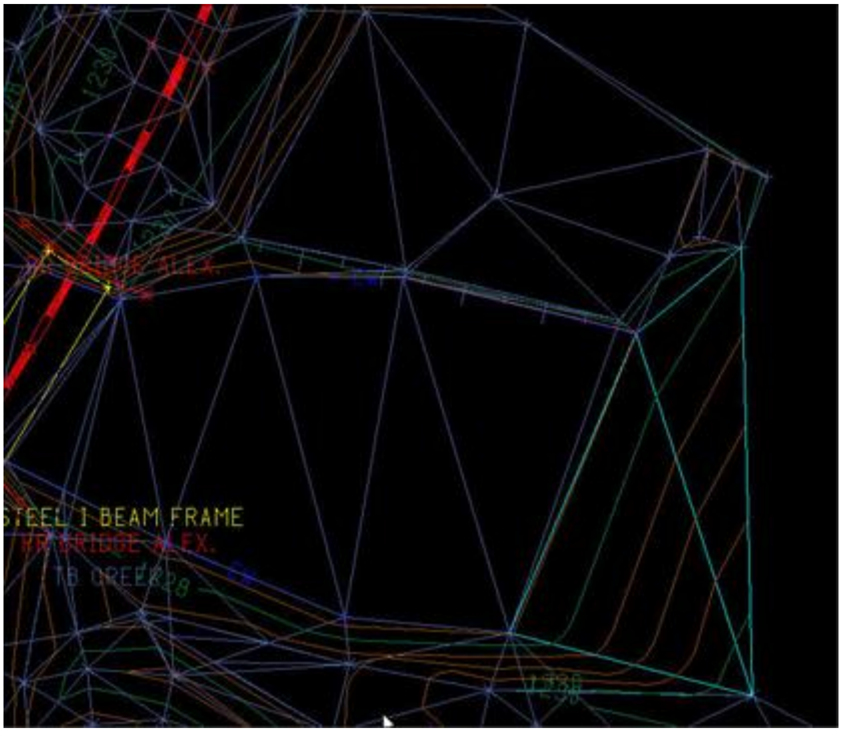


Example: Correct DTM Formation (Subsequent to DTM Refinement)

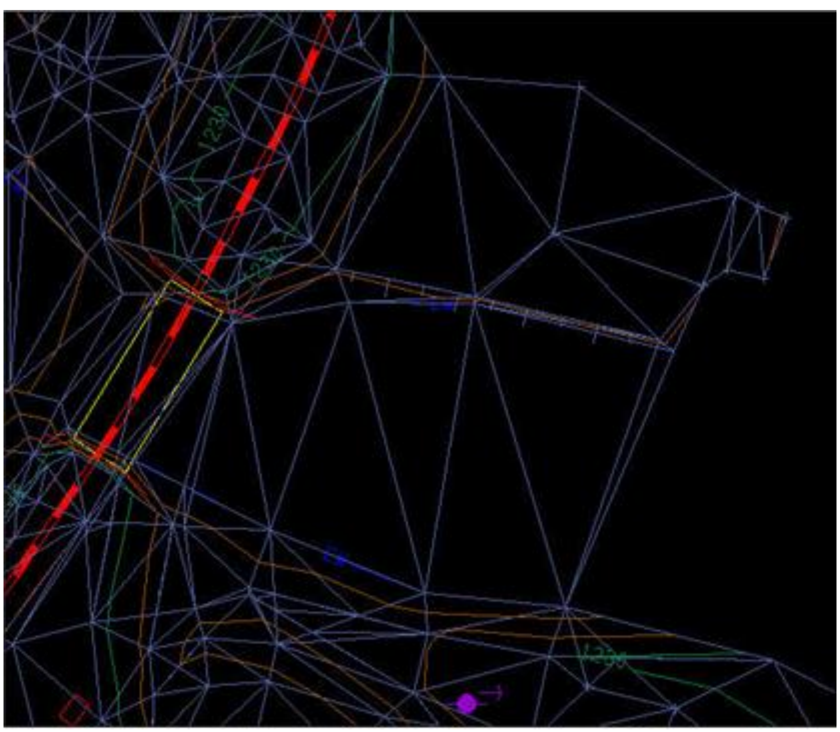


- Irrelevant DTM Triangles not obscured

Example: Incorrect - Triangles Not Obscured



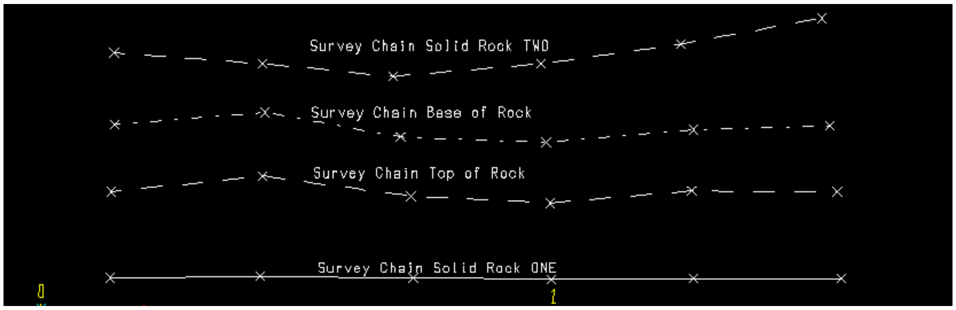
Example: Correct - Triangles Obscured

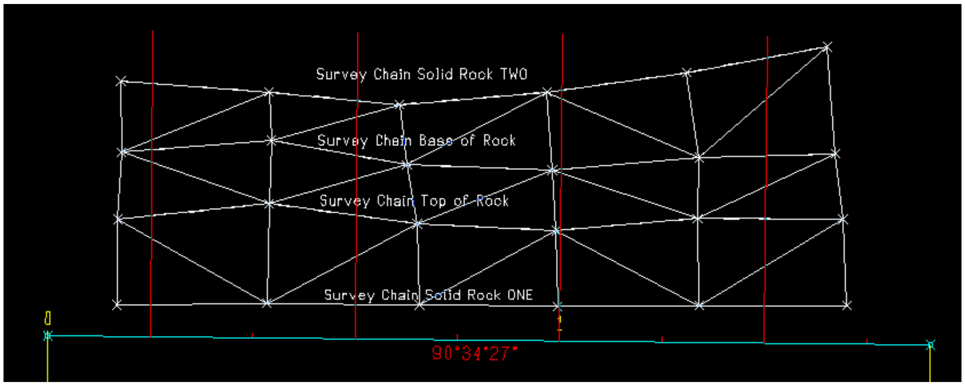


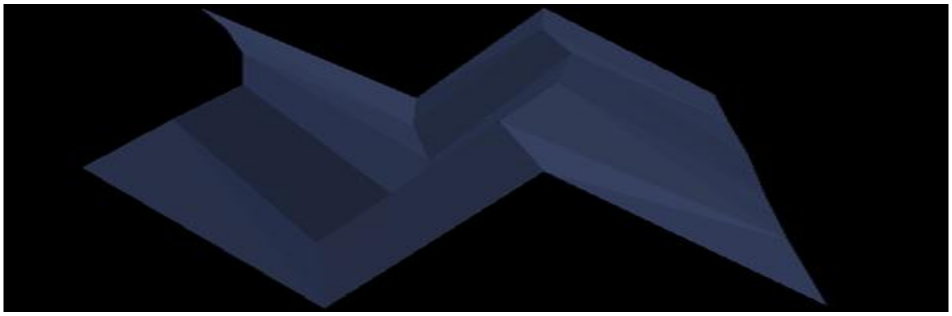
- Incorrect seams where data sources and/or DTM surfaces join
- Improper survey of overhang area and creation of resultant DTMs

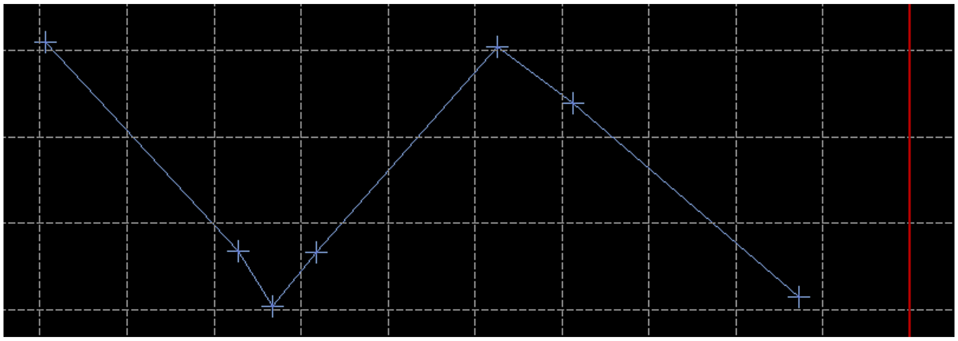
Example: Missing Overhang Area DTMs

The image below shows four survey chains defining an overhang area. If these survey chains are used to form a single DTM, an incorrect model of the overhang area is produced as can be seen in the subsequent three images.





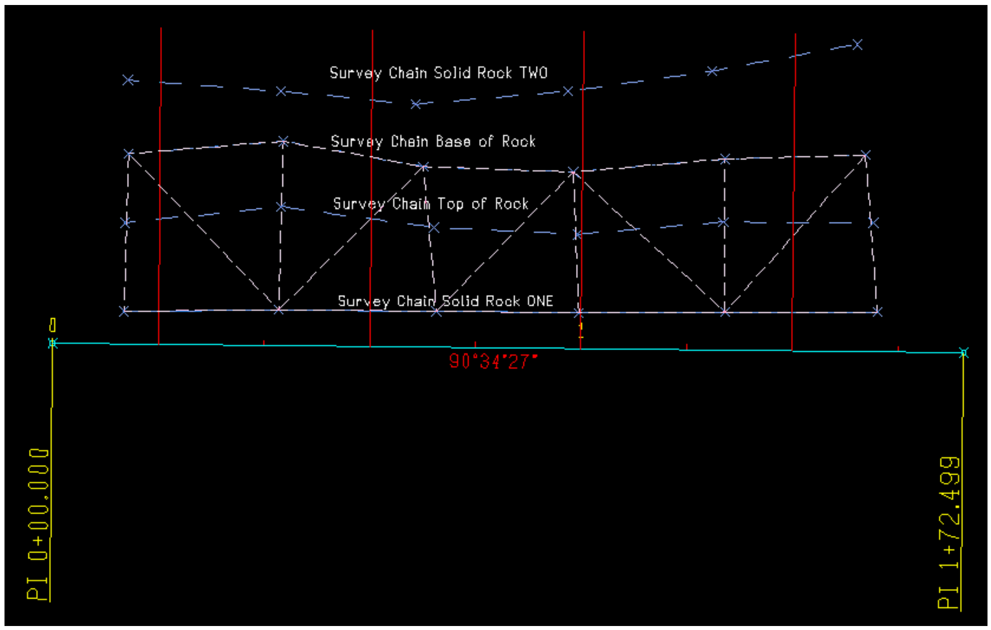




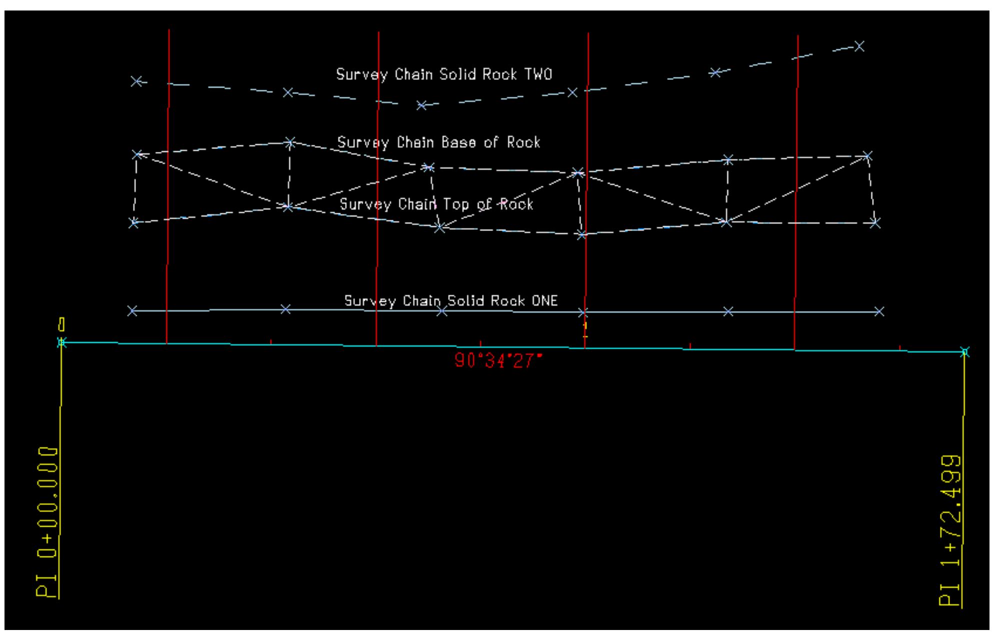
Example: Correct Model of the Overhang Area

The correct method for modeling this overhang area is to form three separate DTMs. Multiple DTMs may be simultaneously activated for design base cross section extraction.

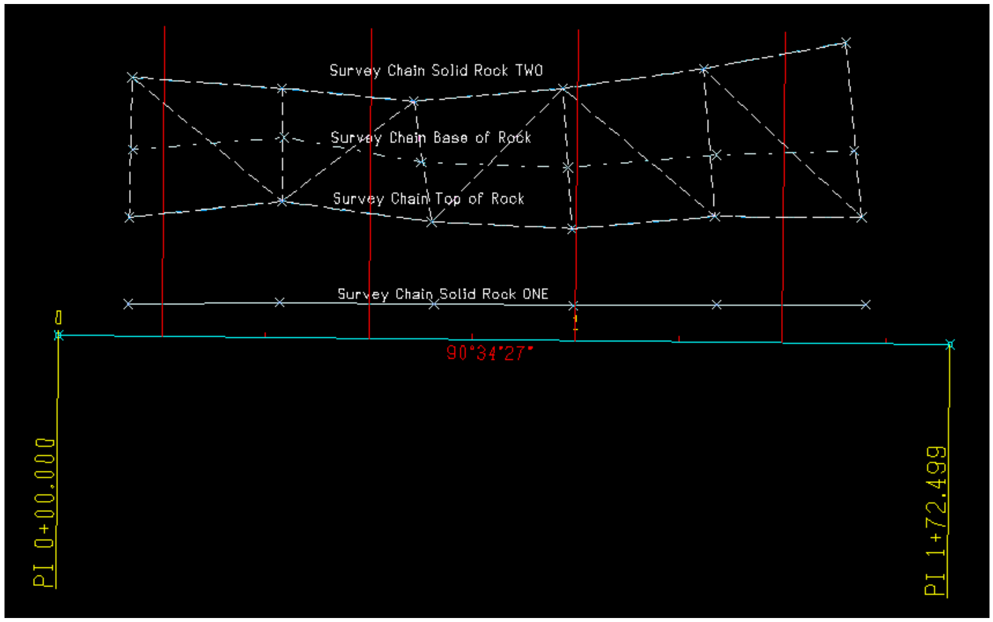
The following images show the correct overhang modeling method. The first DTM is the bottom of the overhang area as shown below.

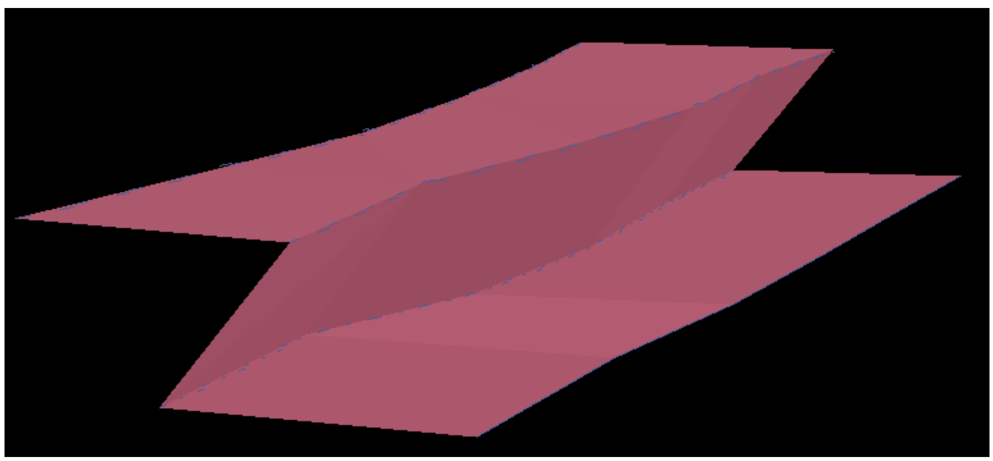


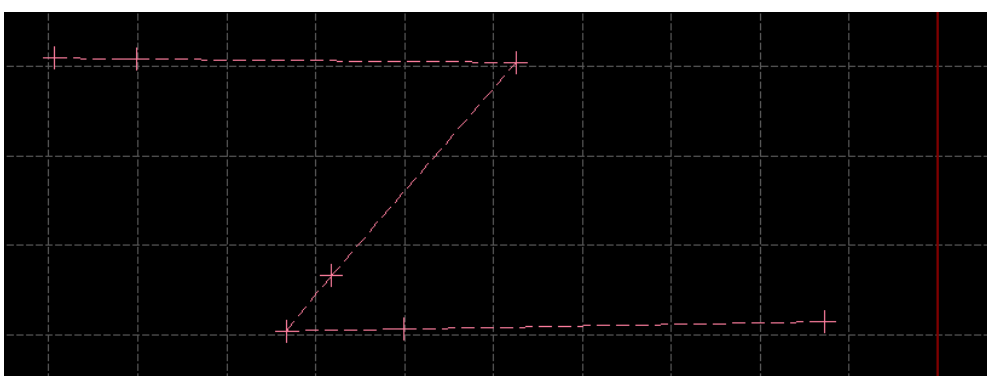
The second DTM is the underside of the overhang area as shown below.



The third DTM is the top of the overhang area as shown below.







800.03 Ministry Standard Libraries, Tables, Macros

To assist consultants with the completion of surveys to Ministry standards, a complete set of standard CAiCE libraries, tables and macros is provided.

Reference:
BC MOT CAiCE Web Page
http://www.th.gov.bc.ca/publications/eng_publications/geomet/CAiCE/CAiCE.htm

This web page is updated regularly and the downloaded files include an automatic update utility.

In addition, consultants may register with the Ministry CAD Standards email list service. This service is used to distribute notifications related to AutoCAD and CAiCE CAD standards.

Reference:
BC MoT CAD Standards List Service
http://lists.gov.bc.ca/mailman/listinfo/l_tran_cad_standards

Technical Support for Ministry standard CAiCE libraries, tables and macros is available via email as needed.

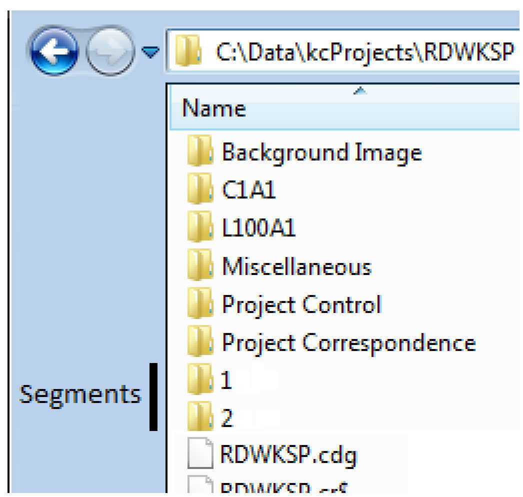
Contact information for technical support:
Greg Toews
Project Analyst - Information Management Branch
Ministry of Transportation and Infrastructure
Greg.Toews@gov.bc.ca

Any other CAiCE technical support should be directed to the Autodesk Reseller or Autodesk as per the consultant's software maintenance agreement.

800.04 Project Folders and Organization

Project Folder

A CAiCE Project Folder can become very difficult to work with as a project grows and the number of project files increase. To improve the general organization of a CAiCE Project for Design use, surveyors are now required to implement the following **Folder Structure**:



Project Folder (e.g. RDWKSP)

→ Background Image
→ ***<Alignment Folders>***
→ Miscellaneous
→ Project Control
→ Project Correspondence
→ ***<Segment Folders>***

↓
All other project files are under the main project folder

Background Image Folder

The **Background Image** folder will contain only the AutoCAD DWG and MicroStation DGN (Trim Mapping) background image files that are created for use by the surveyor and designer.

Alignment Folders

Individual alignment folders are to contain files that directly relate to the named alignment. The folder name should match the alignment name without the use of special characters. Separate folders must be created for the mainline, minor and sideline alignments. Files that should be typically placed in these folders are as follows:

CDG	CAiCE Drawing Graphics Files
CLP	DTM Clip Polygon Files
DOC	Word Documents
EAR	Base Cross Section and Design Cross Section Files
INI	Alignment Specific Parameter Files
LIS	List Files
LOG	Log Files
PF$	Terrain Profiles
RPT	Report Files
RTF	Rich Text Format Documents
TPR	Report Files
TXT	Text Files
XLS	Excel Spreadsheet Files

Miscellaneous Folder

A **Miscellaneous** folder will contain surveyor created files that do not specifically relate to a single horizontal alignment. Files that could be typically placed in this folder are shown below. Files of the types listed above, common to multiple alignments, are also placed in this folder.

CCL	Standard or Project Specific Cell File
CDG	CAiCE Drawing Graphics Files
DOC	Word Documents
INI	Parameter Files
FTB	Standard or Project Specific Feature Table (paired with FTM file of same name)
FTM	Geometry Chain Display Settings (paired with FTB file of same name)
LOG	Log Files
RPT	Report Files
TPR	Report Files
TXT	Text Files
XLS	Excel Spreadsheet Files

Project Control Folder

A **Project Control** folder must contain a text file and documentation for the location where control points' coordinates are derived from, legal ties, geodetic, level of confidence, etc.

- Text file containing all control points
- Text file containing all legal ties
- Text file that contains a subset of proven control for export to other agencies

Reference:
Sample Control Point Files
Control Point Samples (ZIP 2.0 MB)

Example Control Point Table

<table>
<tr><td>Date:</td><td colspan="3">August 6, 2013</td><td colspan="4">Origin: TER1 (Hold) & 95H1872</td></tr>
<tr><td rowspan="2">Project:</td><td colspan="3" rowspan="2">Frank Street Primary and Secondary Control</td><td colspan="2">Tack PT: COHO13</td><td colspan="2">ACSF: 0.999598</td></tr>
<tr><td colspan="2">North Shift: -6002429.524</td><td colspan="2">East Shift: -210.531</td></tr>
<tr><th>Point ID</th><th>Local Northing</th><th>Local Easting</th><th>Ortho HT</th><th>UTM Northing</th><th>UTM Easting</th><th>Ellipse HT</th><th>Description</th></tr>
<tr><td>COHO13</td><td>41161.521</td><td>523497.415</td><td>61.879</td><td>6041161.521</td><td>523497.415</td><td>53.277</td><td>Brass Cap</td></tr>
<tr><td>G347</td><td>41140.807</td><td>524338.33</td><td>67.094</td><td>6041140.815</td><td>524337.992</td><td>58.475</td><td>Conc. Nail</td></tr>
<tr><td>K3785</td><td>41179.051</td><td>523748.154</td><td>64.765</td><td>6041179.044</td><td>523748.053</td><td>56.158</td><td>Conc. Nail</td></tr>
<tr><td>K3786</td><td>41298.434</td><td>522641.244</td><td>58.668</td><td>6041298.379</td><td>522641.588</td><td>50.091</td><td>Conc. Nail</td></tr>
<tr><td>TER1</td><td>40462.525</td><td>528631.298</td><td>83.776</td><td>6040462.806</td><td>528629.234</td><td>75.109</td><td>Rebar</td></tr>
<tr><td>95H1873</td><td>40713.984</td><td>526134.243</td><td>70.192</td><td>6040714.164</td><td>526133.183</td><td>61.539</td><td>Brass Cap</td></tr>
</table>

Project Correspondence Folder

A **Project Correspondence** folder will contain any project related emails, Word documents, Excel spreadsheets, quality control reports, etc. that will facilitate the project reviewer to understand the scope of the project and issues involved.

Segment Folders

Segment folders are automatically created as topographic survey data is imported into CAiCE using Ministry import macros. They must contain the daily reduced, non-edited, non-combined survey data collection files.

800.05 Survey Archive Project Log File

A **Survey Archive Project Log** file must be created by the surveyor for the Ministry Representative who will receive the archive. The log must provide:

- Directions/instructions to the designers to familiarize them with the project
- Details on any issues that may warrant special attention during the design phase
- Complete contact information for the surveyor who will be contacted regarding any omissions or deficiencies that are found in the completed survey project

The log filename must contain the name of the project and the surveyor’s name as shown:

RDWKSP – SURVEY PROJECT LOG FILE – JOHN SMITH.LOG

The log file must be used as a method of recording details on the completed survey sufficient to allow the designer or anyone else reviewing the project to understand the methods and procedures used to compile the survey. Entries in the log must be as descriptive as possible to limit the amount of correspondence needed between the designer and the surveyor.

The log must be created and maintained in the project **Miscellaneous** folder. A few <u>sample</u> log entries are listed below. If the surveyor is making an addition or revision that directly relates to the use of the completed survey data, this should be documented in the log.

- Note the number of points and chains in the project
- Note the creation of a project specific feature table and cell library (with filenames)
- Note any changes to the feature table and cell library (describe purpose)
- Note the creation of zones (describe usage)
- Note the creation of horizontal alignments (with descriptions)
- Note the creation of alignment profiles (with descriptions)

- Note the creation of all geometry chains (with descriptions)
- Note the creation of all survey EAR and CDG Files (with descriptions)
- Note the creation of all parameter files (with descriptions)
- Note the creation and use of all survey DTMs, their source, such as survey, mapping, 3D laser scanning etc. and any other relevant details
- Note the method of DTM clipping/obscuring irrelevant triangles and particular areas - detail the database elements used in each process
- Note the creation of cross section station text files containing interval and odd stations used for scanline creation and any geometry chains used to limit scanline widths
- Note the relationship between all survey elements and files so that there is a clear understanding of how all survey elements and files link to one another. For example, a specific profile links to a specific horizontal alignment, etc. Note any text file filenames that are created for the completed survey and used for viewing or recalling point, chain or cross section station lists, “@filename”, and relevant details.
- Note where project ground survey has been used and where digital mapping and/or LiDAR airborne 3D laser scanning data has been used
- Other notes regarding additions or revisions

800.06 Project Data Archive Content and Naming Conventions

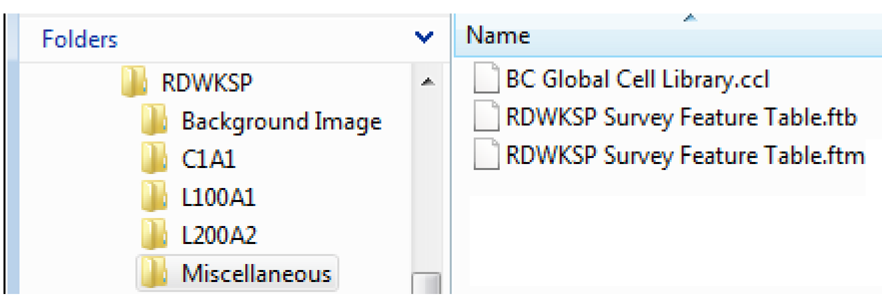
A large number of CAiCE database elements and data files are required to complete a survey project. Requirements for these elements and files are detailed in this section.

The strict naming conventions detailed in this section are critical to enabling subsequent users to work with, review and use the completed project. Surveyors must provide the specified CAiCE archive content and follow the database element and file naming conventions.

Project Specific Feature Table and Cell Library File

The Ministry standard feature table and cell library files must be copied to the project **Miscellaneous** folder.

If the surveyor has the requirement to make modifications, these files must be renamed to reflect the project title. The example below shows a customized/renamed feature table and the standard cell library file (not renamed):



Note the inclusion (and identical names) of both the main feature table FTB file and the associated FTM file. The FTM file stores preferences related to the display of geometry chains and alignments.

Project Cadastral

The surveyor must provide AutoCAD background image files that can be used to display the project cadastral while working within CAiCE. These are to be saved in the project **Background Image** folder.

Survey Segments

Topographic survey data must always be imported into CAiCE utilizing segments. Segment names must always be numeric to avoid potential confusion over the feature code assigned to each point and chain.

Database Element and File Naming Descriptions

Most CAiCE database elements provide an input field for a description. The surveyor should make full use of the description field if additional information is needed to describe an element beyond what is provided or required by the element naming conventions described in this section.

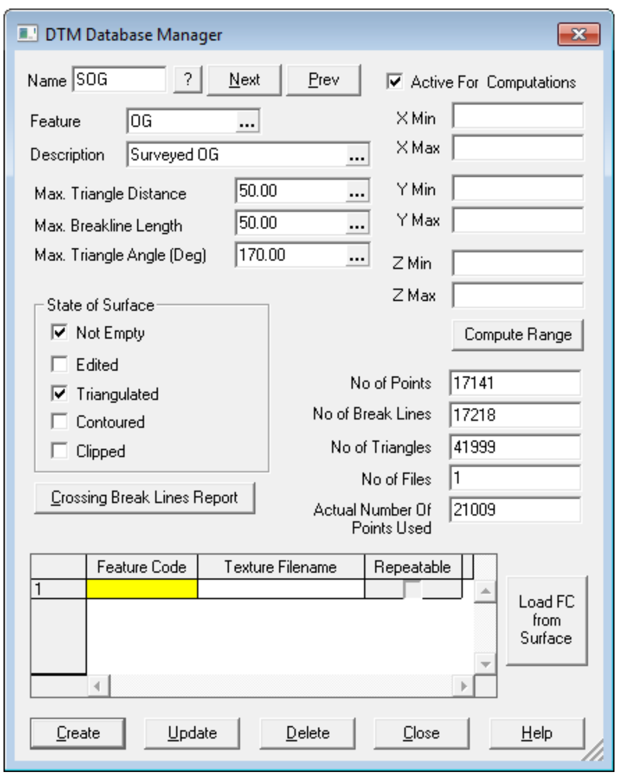
The surveyor should make full use of long file name capabilities when creating files within a CAiCE project. Descriptions and file names can contain such things as alignment references, DTM names, stations, dates, and links to other files, etc.

DTM Naming

All location survey created DTMs must be prefixed with an “S” for survey. The remaining part of the DTM name must be limited to a maximum of 6 characters.

Guidelines for DTM naming and assignment of feature codes are shown in the examples below:

Name	“SOG”	Feature	“OG”	Survey Original Ground
Name	“SMG”	Feature	“MG”	Survey OG - Digital Mapping Surface
Name	“STG”	Feature	“TG”	Survey OG - Terrestrial Scanning Surface
Name	“SKG”	Feature	“KG”	Survey OG - Start of Survey
Name	“SZG”	Feature	“ZG”	Survey OG - Combined Surface
Name	“SFG”	Feature	“FG”	Survey OG - Final Survey Surface



Feature Codes for Survey Points and Chains

The Ministry provides a standard feature table that must be adhered to when creating survey points and chains to be used as a base for design.

A list of feature codes, a sub-set of the BC MoT Feature Table, has been supplied that must be used when completing Ministry Location Survey contracts. Refer to Section 1000.02 - CAiCE Feature Table.

Survey Data Source and Extent Boundary Definition

Data Sources and Extents boundary survey chains must be generated in CAiCE using points from the survey database. Digitized points are not acceptable.

These survey chains will provide the designer with a clear indication of which aspects of the location survey have been collected from each data source (ground surveys, digital mapping, 3D laser scanner, etc.).

Each boundary survey chain name is to be prefixed with the source name (SURVEY, MAPPING, 3DLASER, etc.). A feature of BD must be assigned. The surveyor should make full use of the description field if there is additional information needed to describe the element beyond what is provided or required by the element naming convention.

Survey Points and Chains Data Clipping

Some survey points and chains, or partial chains, may no-longer be required due to duplicate data or more accurate/recent data. These points and chains must be clipped using boundary chains that were created for the data source and extent boundary definition as described above. Points and chains that are clipped should be removed from the project.

Parameter Files

Parameter files are used to save settings for a CAiCE command or BC MoT macro for repetitive use. This is a time saving feature that also promotes consistency in the output. The parameter files are typically text files with designated extensions such as INI, TXT, PXS and PPF.

These files must be saved using a descriptive name that directly relates to the survey function and the data being used. Where a particular folder is not relevant to the parameter file, or the file is common to a number of folders, the file should be stored in the **Miscellaneous** folder.

800.07 Zone Designations

CAiCE zones are a method of segregating data within a survey project. Zones may be used to select information for viewing, editing, reporting, etc.

Zone ranges:

- 1 - 100 used for survey
- 101 - 499 reserved for design
- 500 and above reserved for construction supervision

Surveyors must also make use of zones to segregate individual survey segments. Although this may appear redundant, the usage of zones is necessary as CAiCE automatically removes elements from the original segment when they are edited.

Zone assignments must provide the designer with an easy method for isolating survey data.

Surveyors must detail all zone assignments in the **Survey Archive Project Log** file. Sufficient detail must be provided to the design staff or a survey project reviewer in order that they may understand which zones have been utilized and their contents.

800.08 Survey Project Data Archive Preparation

A CAiCE project archive file (ZIP file created with the CAiCE project archive command) is the standard format used by the Ministry to retain completed projects in a repository of engineering data that can be easily utilized in the future.

The archive is also the format used to transfer completed projects from the surveyor to the designer. This applies whether the survey has been completed by the Ministry or by a consultant.

Upon project completion, the surveyor must include a **CAiCE Survey Archive file** with the submitted project materials.

All data not directly related to the final survey must be deleted from the project database and project folders before archiving. The project archive may only contain the final survey and related work.

Examples of data that should be deleted:

- CAiCE elements: horizontal alignments, geometry chains, cross section scanlines, etc.
- CAiCE project files: terrain profiles, archive files, report files, text files, etc.
- All non-compliant data, files and folders will be deleted
- Other data, files/folders not related to the final survey

The archive file name must be prefixed by the project name, followed by SURVEY and suffixed by the surveyor's name as shown in the following example:

RDWKSP - CAiCE SURVEY Archive - Smith Surveys-JS - dd-mm-yyyy.ZIP

900 BC MoT Standard Survey File Format (MTS)

900.01 General

Under special conditions, a surveyor may be required to supply the completed survey in the **BC MoT Standard Survey File Format (MTS).**

This requirement will depend on the contract terms of reference and the specific data format specified in the contract.

900.02 Survey File Format Details

The MTS file (MTS file extension) is a comma delimited format with line records containing up to 15 fields for topographic survey records and 7 fields for x-section survey records. A file may contain either topographical records or x-section records or both. Topographical records will be imported directly to the CAiCE database and x-section records will be imported directly to a CAiCE X-Section EAR file associated with a specific horizontal alignment.

Topographical Survey Record

This format has been updated to support 15 fields from the original 11.

Field # 1 Record Type

- **T** for topographic survey record

Field # 2 Point Identifier

- Unique numeric point identifier

Field # 3 Feature Code

- Refer to Section 1000.02 - CAiCE Feature Table

Field # 4-6 Point Northing, Easting, Elevation

- Numeric values

Field # 7 DTM Attribute

- **Feature** for points not in the DTM or **Ground** for points in the DTM

Field # 8 Point Description

- Specific point attribute information such as culvert size, type of headwall, etc.
- Optional depending on feature surveyed

Field # 9 Point Comment

- Surveyor on-site specific point comment
- Comment assigned to first point of chain may represent a comment assigned to a chain
- Optional depending on feature surveyed (describes specifics of the point or situation)

Field # 10 Chain Identifier

- Unique identifier containing the feature code of the chain. Blank for surveyed points representing items such as signs or manholes that are not assigned to a chain.

Field # 11 Point Connectivity

- **Straight** for a point on a tangent or **Curve** for a point on a curve. CAiCE requires a minimum 3 curve points in a row to generate a curve. 3 points will generate a fixed radius curve, 4 or more curve points will generate a spline fit curve.
- Blank for a non-chain point record such as a sign or a manhole. These points will default to **Straight** when imported into the CAiCE database.

Field # 12 Point Zone

- Contains the zone of the point if the MTS file is exported from CAiCE, blank otherwise

Field # 13 Chain Description

- Contains the chain description, this field is only present for the first point of the chain. This field is typically only present if the MTS file is exported from CAiCE.

Field # 14 Chain Comment

- Contains the chain comment, this field is only present for the first point of the chain. This field is typically only present if the MTS file is exported from CAiCE.

Field # 15 Chain Starting Station

- Contains the starting station of the chain in decimal format, this field is only present for the first point on the chain (010+230.23 would be entered as 10230.23) . This field is typically only present if the MTS file is exported from CAiCE.

Miscellaneous Format Rules

- General comment lines may be added to a file if prefixed with the number sign #. Such lines will be ignored when the file is imported into CAiCE.

- Topographic records may have up to **15** fields. Each field, except for the last, will have a trailing comma. Two commas in a row indicate a blank/unused field. Field #8 and above are optional and may be completely left out with no trailing comma if subsequent fields are also left out with no trailing comma. If a subsequent field is not left out or has a trailing comma, then all preceding fields must at least include the trailing comma.

- A single chain may contain both ground and feature points (DTM Attribute). Such a chain will be stored in the CAiCE database as a feature chain. This reduces the chance of the chain being used in a DTM database (breakline). Break such a chain into multiple chains if parts of the chain are required for breaklines.

- Chain points must be in ascending order

- Chains may be continued in different parts of the file as long as the points on the chain are in ascending order.

- A single point may be repeated multiple times in the file if it is common to multiple chains or used as both the start and end of a boundary chain. In this case the point identifier (field #2) will not be unique. This typically only occurs after survey editing is performed inside CAiCE and the survey data is exported in MTS format.

  During import, only the first occurrence of a duplicate point will create a new survey point, subsequent occurrences would cause the point to be added to the indicated chain and any differences in fields #3 to #15 would be ignored, unless the point represents a first point on a chain, in which case fields #8 to #15 may be applied to the chain.

Survey File MTS Format Example

```
#General File Comment
T,102,EP,1234567.124,1234567.123,1234.1234,Ground,Desc,Comment,EP101,Curve,,Cmt,Desc,0.0
T,103,EP,1234567.124,1234567.123,1234.1234,Ground,,Surveyors Comment,EP101,Curve
T,103,EP,1234567.124,1234567.123,1234.1234,Ground,,Surveyors Comment,EP101,Curve
T,105,EP,1234567.124,1234567.123,1234.1234,Ground,,,EP101,Curve
T,106,EP,1234567.124,1234567.123,1234.1234,Ground,,,EP101,Straight
T,107,EP,1234567.124,1234567.123,1234.1234,Ground,,,EP101,Straight
T,202,SI,1234567.124,1234567.123,1234.1234,Feature,Sizes and Types,Surveyors Comment,,
T,204,MH,1234567.124,1234567.123,1234.1234,Ground,Sizes and Types,Surveyors Comment,,
T,205,FE,1234567.124,1234567.123,1234.1234,Feature,Sizes and Types,,FE24,Straight
T,206,FE,1234567.124,1234567.123,1234.1234,Feature,,,FE24,Straight
T,207,FE,1234567.124,1234567.123,1234.1234,Feature,,Surveyors Comment,FE24,Straight
T,208,FE,1234567.124,1234567.123,1234.1234,Ground,,Surveyors Comment,FE24,Straight
T,209,FE,1234567.124,1234567.123,1234.1234,Ground,,Surveyors Comment,FE24,Straight
T,300,EP,1234567.124,1234567.123,1234.1234,Ground,,,EP101,Straight
T,301,CL,1234567.124,1234567.123,1234.1234,Ground,,,CL235,Straight
T,302,EP,1234567.124,1234567.123,1234.1234,Ground,,Surveyors Comment,EP102,Straight
X,303,SH,OG,10120.000,-12.234,1234.1234
X,304,EP,OG,10120.000,-10.234,1234.1234
X,305,CL,OG,10120.000,-5.234,1234.1234
X,306,EP,OG,10120.000,-1.455,1234.1234
X,307,SH,OG,10120.000,1.556,1234.1234
X,308,BS,OG,10120.000,6.378,1234.1234
X,309,BS,OG,10120.000,11.567,1234.1234
X,310,TS,OG,10120.000,12.456,1234.1234
```

1000 CAiCE Feature Table

1000.01 General

To assist Consultants with the completion of a survey to Ministry standards, the Ministry provides all consultants with a complete set of standard Libraries, Tables and Macros.

1000.02 CAiCE Feature Table

BC MoT Global Feature Table.ftb

The Ministry CAiCE feature table is to be attached when CAiCE is used by consultants completing Ministry survey, design and construction supervision projects.

BC MoT Global Feature Table.xls

The Ministry CAiCE feature table formatted into an Excel spreadsheet for easy reference purposes.

The feature codes listed below are a sub-set of those in the BC MoT feature table. These codes are to be used when completing Ministry survey contracts. This table undergoes periodic review and will be updated accordingly.

Description	Code	Description	Code
Abutment	BU	Bush Line	BH
Abutment - Concrete	CA	Catch Basin - Existing	CB
Abutment - Wooden	AW	Catch Basin / Manhole	CM
Active Flood Plain	AF	Cattle Guard	CG
Aluminum Post	AP	Centerline - Existing	CL
Anchor	AN	Centerline - L-Line	C
Area of Exclusion	AE	Clearing and Grubbing	GC
Asphalt Curb	AC	Commercial Sign	CSN
Asphalt Spillway	AS	Concrete	CC
Benchmark	BM	Concrete Median Barrier - 2.5m	MBR
Berm in Cut or Fill	BE	Concrete Pad	CE
Bottom of Curb	CF	Concrete Pillar	CN
Boulder	BO	Concrete Roadside Barrier - 2.5m	RB
Boundary Line	BD	Control Monument - Geodetic	LM
Break in Ground-Line	B	Crosswalk	CW
Brick	BK	Crown of Road	CR
Bridge	BB	Culvert	CUL
Building	BG	Culvert Inlet	CI
Culvert Kink	KK	Gate Post	GA

Description	Code	Description	Code
Culvert Outlet	CO	Gazette Boundary	GB
Curb - Concrete	CU	Gravel	GL
Curb - Top	TU	Gravel - Edge of Gravel	EG
Deadman	DM	Gravel - Gravel Driveway	GD
Deceleration Lane	DECL	Gravel - Gravel Road	GR
Decorative Boulder	DB	Ground - Original Material	OM
Decorative Tree	DT	Ground Crack	GK
Delineator Post	DO	Guard Rail with Posts	GS
Direction Arrow	DA	Gutter	GU
Dominion Iron Post	DIP	Guy Pole - Power	GE
Drain - Storm / Sewer	DS	Guy Pole - Power / Telephone	GY
Drainage Grate	DG	Guy Pole - Telephone	GT
Driveway - Concrete	CD	Guy Wire	GW
Easement	EA	Hedge Line	HG
Edge of Travelled Road	ET	High Tension Pole	HV
Electrical Outlet	EO	High Tension Tower	HT
Existing Manhole	MH	Hog Fuel	HF
Ex. Manhole - Power	MHP	House	H
Ex. Manhole - Sanitary Sewer	MHS	Hub - Detail / Traverse Hub	DH
Ex. Manhole - Storm Sewer	MHM	Ice	IC
Ex. Manhole - Telephone	MHT	Indefinite Elev - Mapping Requirement	IE
Ex. Manhole - Unknown	MHU	International Boundary	IB
Ex. Manhole - Vault	MHV	Iron Pin - Standard	IP
Ex. Manhole - Water	MHW	Iron Post - Angle Iron	AI
Ex. Manhole/Catch Basin - Drywell	DRY	Irrigation - Junction Box	IRJ
Fence	FE	Irrigation - Pipeline	IRP
Filler Cap	FC	Irrigation - Sprinkler Head	IRS
Fire Hydrant	FH	Island	I
Flag Pole	PF	Junction Box	JB
Flagging	F	Lagoon	LG
Flower Box	FB	Lamp Standard	LA
Flume	FL	Lawn	L
Foundation	FN	Lead Plug	LP
Fuel / Gas Pump	FU	Log Jam	LJ
Fuel Tank	FT	Mailbox	MB
Garage	G	Marsh / Swamp	MS
Garden	GN	Meter - Service Meter	SV
Gas Main	GM	Meter - Water Meter	WM
Gas Valve	GV	Miscellaneous	ZZ
Monument - Concrete Post	MN	Road	RD

Description	Code	Description	Code
Non-Standard Round Iron Post	RIP	Road - Dirt Road	DR
Non-Standard Square Iron Post	SIP	Rock - Base of Rock	BR
Oil Line	OL	Rock - Broken Rock	BN
Original Ground	OG	Rock - Loose Rock	LR
OG - Combined Surface	ZG	Rock - Solid Rock	SR
OG - Digital Mapping Surface	MG	Rock - Top of Rock	TR
OG - Terrestrial Scanning Surface	TG	Rock Post Monument	RPM
Overbreak	OB	Sand	SA
Overhang	OV	Sanitary Sewer Line	SU
Parcel Boundary - Old Road R/W	PLB	Section Line / District Lot Boundary	SL
Patio	PA	Septic Tank	ST
Pavement	P	Shoulder - Existing (Left)	LS
Pavement Crack	PK	Shoulder - Existing (Right)	RS
Pavement Edge - Finished	EP	Shoulder - Finished Gravel Shoulder	SH
Pavement Left - Existing	PL	Sidewalk / Walkway	SW
Pavement Right - Existing	PR	Sign - Road Sign - One Post	SI
Pedestal - Utility	PD	Signal - Traffic Signal	SN
Pier	PE	Slide, Sluff (Scarp) Line	SF
Piling	PG	Slope - Base of Slope	BS
Pipeline	PN	Slope - Top of Slope (Embankment)	TB
Pipeline - Cast Iron	CT	Sound Barrier / Wall	SB
Pipeline - Corrugated Steel	CS	Spot Elevation	SE
Pipeline - Plastic	PC	Sta. on Offset Line	OS
Pool - Swimming Pool	MP	Staircase / Steps	SZ
Post - Guard Post	PO	Standard Brass Cap Monument	BCM
Post - Witness Post	WP	Standpipe - Water Blowoff	SDP
Post - Wooden Post	WN	Stop Bar Line	STP
Power / Telephone Pole	PT	Stripping	S
Power / Tel Pole with Transformer	PH	Talus	T
Power Pole	PP	Telephone Booth	PB
Power Pole with Transformer	PS	Telephone Pole	TP
Pump House	PU	Toe	TO
Quarter Section Line	QS	Toe - Left Toe - Existing	LT
Railway	RR	Toe - Right Toe - Existing	RT
Railway Ballast	BA	Traffic Counter	TA
Reference Point	RP	Traffic Signal Control Box	TX
Rest Area	RA	Trail - Mapping Requirement	TI
Right of Way	RW	Traverse PI	PI
Riprap	RI	Tree	TE
Tree Line	TL	Wall - Base of Wall	BW

Description	Code	Description	Code
Type A Horizon	A	Wall - Bin Wall	BI
Type B Horizon	ZB	Wall - Head Wall	HD
Type C Horizon	ZC	Wall - Retaining Wall	RE
Type D Horizon	D	Wall - Top of Wall	TW
Underground Electrical Power	UE	Wall - Wing Wall	WW
Underground Electrical Transformer	UXF	Waste	WE
Underground Gas Service Line	US	Water - Stream Center - Narrow Waters	CK
Underground Marker	UM	Water - Ditch Center	DC
Underground Miscellaneous	UG	Water - Ditch Edge	DE
Underground Telephone	UT	Water - Edge of Water - Wider Waters	EW
Unmarked Measured Point	PM	Water - Extreme High Water Mark	EH
Urban Paintline	UPL	Water - High Water Mark	HW
Utility Kiosk	K	Water - Reservoir Tank	WT
Utility Pole	UP	Water - Seepage	SG
Valve	V	Water - Stream	SM
Valve - Air Release Valve	AR	Water - Water Main	WR
Valve - Water Valve	WV	Weighscale	WS
Vegetation	VN	Well	W
Vegetation - Orchard	O	White Line	WL
Vent Pipe - Breather / Vent Pipe	VP	White Line - Broken White Line	BL
		Wire Height	WH
		Yellow Line	YL
		Yellow Line - Double Yellow Line	DL

1100 Drawing Standards and Content

1100.01 General

All plans and profile drawings must be submitted in AutoCAD DWG format to the standards as outlined in the TAC Supplement.

Reference:
BC MoT Supplement to TAC Geometric Design Guide
Section 1200 Contracts and Drawings Chapter
http://www.th.gov.bc.ca/publications/eng_publications/geomet/TAC/TAC.htm#chapters

Reference:
CAiCE Sample Project
Williams Lake - 4 Laning Project (ZIP 42.0 MB)

Reference:
AutoCAD Sample Project
Williams Lake - 4 Laning Project (ZIP 29.2 MB)

1100.02 Key Plans

Include the key plan items documented in the TAC Supplement.

Reference:
BC MoT Supplement to TAC Geometric Design Guide
Section 1200 Contracts and Drawings Chapter
http://www.th.gov.bc.ca/publications/eng_publications/geomet/TAC/TAC.htm#chapters

1100.03 Alignments

A horizontal alignment may be requested by the Ministry Representative. The alignment may be generated from a number of sources, as approved by the Ministry Representative.

Reference:
BC MoT Supplement to TAC Geometric Design Guide
Section 300 Alignments Chapter
http://www.th.gov.bc.ca/publications/eng_publications/geomet/TAC/TAC.htm#chapters

1100.04 Profiles

A profile may be requested by the Ministry Representative. The profile should include items as documented in the TAC Supplement.

Reference:
BC MoT Supplement to TAC Geometric Design Guide
Section 1200 Contracts and Drawings Chapter
http://www.th.gov.bc.ca/publications/eng_publications/geomet/TAC/TAC.htm#chapters

In addition, and as applicable, the profile will show the following:

- Existing ground line with road edges and road name for all road crossings
- Pavement edges
- Lake/water course edges with current and high water elevations (with date recorded) (include the time of day if the water level is affected by tide action)
- Swamps
- Railway track elevations
- Transmission line wire elevations
- Stationing at intersecting alignment crossing
- Benchmark and/or primary control points (vertical control point) (with descriptions and elevations)
- Culverts (with sizes, types and invert elevations)

Note: A profile must be supplied with a corresponding horizontal alignment.

1100.05 Plans

Plans shall include items as documented in the TAC Supplement.

Reference:
BC MoT Supplement to TAC Geometric Design Guide
Section 1200 Contracts and Drawings Chapter
http://www.th.gov.bc.ca/publications/eng_publications/geomet/TAC/TAC.htm#chapters

In addition, and as applicable, the plans will show the following:

Drawing Scales

Drawing scales will be determined by the amount of drawing detail, size of project area, spacing and density of individual survey shots and/or purpose of the drawing. Multiple standard drawing scales may be required. PDF plots (drawn to scale) are required.

Title Block

- Surveyed by
- Survey date
- Office processing by
- Subsequent updates by
- Subsequent updates date

Grid markings

- Full grid required
- 200 metre interval for 1:1000
- 100 metre interval for 1:500
- Scale plans with sufficient annotation on the grid crosses

Control Points

- Primary
- Secondary if requested by the Ministry Representative

Cadastral

- Tied property markers
- Property lines will show the proper legal description for all lots and easements (i.e., lot number, block, etc.)
- District lot and section lines, township lines, etc.
- Subdivision, lot number., etc.
- Mineral claims and numbers
- First Nations Reserve boundaries including internal subdivisions
- City, regional, provincial boundaries
- R/W boundaries for gas, hydro, highway, railroads, etc.
- Easements
- All legal plan numbers
- Agricultural Land Reserve

1200 Glossary of GPS/GNSS Terminology

This glossary contains the definitions of many, but not all GNSS RTK and Survey related terms. As a greater number of Design Survey data acquisition include primarily GNSS-RTK methods, this glossary is available in the General Survey Guide as a terms of reference only, with the recognition that other descriptions may exist for the terms and acronyms listed below.

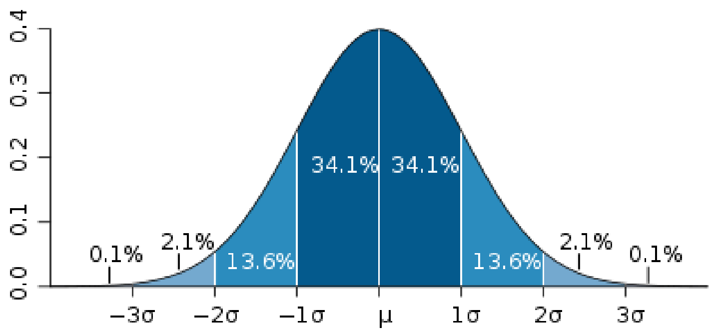
References

National Geodetic Survey User Guidelines for Single Base Real Time GNSS Positioning Version 1.0, January 2010

Texas Survey Manual, Texas Department of Transportation (TxDOT) Revised June 2010

1200.01 1

1-Sigma – one standard deviation (error) from the mean. Represents 68.27% of data that is closest to the mean (plus and minus).



1-Sigma accounts for 68.27 percent of the data; while 2-Sigmas account for 95.45 percent; 3-Sigmas account for 99.73 percent; and 4-Sigmas account for 99.994 percent.

1200.02 A

AASHTO – American Association of State Highway and Transportation Officials

Accidental Error – an error for which it is equally probable that the sign of the error is a plus or minus value; an error for which there is no proportional change or relationship between measurements, conditions and the sign or magnitude of the error; an error, evident in a series of measurements, which is compensated in total effect.

Accuracy – how close measurements are to the accepted value of truth. In classical RT or RTK this is the defined by the horizontal and/or vertical positional error ellipse (or covariance matrix) at 95 percent (2σ) confidence level directly related to the base station as the representative of the datum. The base accuracy should always be known relative to the project datum.

Accuracy of the Bearing (or Course) – in relation to source, accuracy of the bearing (or course) is the relationship of each bearing as expressed on a map, plat and/or in a description of the new survey shall not exceed the angular relationship of the stated source by more than the following tolerance:

- Sin angle = (approximately) and rounded to nearest 5 seconds
- Where angle = + bearing accuracy in seconds (rounded)
- p = the denominator of the allowable error of closure (precision) for the particular Condition (i.e. 5,000; 7,500; 10,000 or 15,000)

Acquisition – the process of locking onto a satellite's available C/A and P code. A receiver acquires all available satellites when it is first powered up, then acquires additional satellites as they become available and continues tracking them until they become unavailable.

Adjusted Values – Adjusted values are the values derived from observed data (measurement) by applying a process of eliminating errors in that data in a network adjustment.

Adjustment – the process of determining and applying corrections to observations for the purpose of reducing errors in a network adjustment.

Adjustment Convergence – occurs when the network adjustment has met the defined residual tolerance or last ditch residual tolerance within a defined number of iterations.

Algebraic Sign – a sign (+ or -) associated with a value which designates it as a positive or negative number.

Algorithm – a set of rules for solving a problem in a finite number of steps.

Almanac – data transmitted by a GNSS satellite which includes orbit information on all the satellites, clock corrections, and the atmospheric delay parameters. This data is used to facilitate rapid SV acquisition within GNSS receivers.

Ambiguity – the unknown integer number of cycles of the reconstructed carrier phase contained in an unbroken set of measurements. The receiver counts the radio waves (from the satellite as they pass the antenna) to a high degree of accuracy. However, it has no information on the number of waves to the satellite at the time it started counting. This unknown number of wavelengths between the satellite and the antenna is the ambiguity. Ambiguity is also known as integer ambiguity or integer bias.

Angular Closure – angular closure for each condition is expressed as the number of seconds allowable for any angle multiplied by the square root of the number of angles in the traverse. This value should not be exceeded in any loop closure. The basis for this angular value is well documented in standard textbooks on surveying practice and procedures.

Antenna Height – is the height of a GNSS antenna phase center above the point being observed. The uncorrected antenna height is measured from the observed point to a designated point on the antenna, and then corrected to the true vertical manually or automatically in the software.

Antenna Phase Center – is the electronic center of the antenna. It often does not correspond to the physical center of the antenna. The radio signal is measured at the Antenna Phase Center.

Antenna Phase Correction – is the antenna phase correction is the phase center for a GNSS antenna is neither a physical nor a stable point. The phase center for a GNSS antenna changes with respect to the changing direction of the signal from a satellite. Most of the phase center variation depends on satellite elevation. Modeling this variation in antenna phase center location allows a variety of antenna types to be used in a single survey. Antenna phase, center corrections are not as critical when two of the same antennas are used since common errors cancel out.

Anti-Spoofing (AS) – is a feature that allows the U.S. Department of Defence to transmit an encrypted Y-code in place of P-code. Y-code is intended to be useful only to authorized (primarily military) users. AS is used with selective availability to deny the full precision of GPS to civilian users. AS applies to GPS constellation only.

Autonomous Positioning – is a mode of operation in which a GNSS receiver computes position fixes in real time from satellite data alone, without reference to data supplied by a base station. Autonomous positioning is the least precise positioning procedure a GNSS receiver can perform, yielding position fixes that are precise to ±100 meters horizontal RMS when selective availability is in effect, and to ±10-20 meters when it is not. This is also known as absolute positioning and point positioning.

Azimuth – is a surveying observation used to measure the angle formed by a horizontal baseline and geodetic north. The number of degrees from north that a line runs measured clockwise. When applied to GNSS observations, it refers to a normal section azimuth.

1200.03 B

Base Station – is an antenna and receiver set up on a known location. It is used for real-time kinematic (RTK) or differential surveys. Data can be recorded at the base station for later post processing. In GNSS surveying practice, the user may observe and compute baselines (that is, the position of one receiver relative to another). The base station acts as the position from which all other unknown positions are derived.

Baseline – is the position of a point relative to another point. In GNSS surveying, this is the position of one receiver relative to another. When the data from these two receivers is combined, the result is a baseline comprising a three-dimensional vector between the two stations. A Baseline is a computed 3-D vector for a pair of stations for which simultaneous GPS data have been collected. It is mathematically expressed as a vector of Cartesian Earth Centered Earth Fixed (ECEF) X, Y, Z coordinate differences between the base or reference station and the rover or unknown station.

Bench Mark – is a relatively permanent object, natural or man-made, bearing a marked point, whose elevation above or below an adopted datum is known. Usually designated as "**BM**," such a mark is sometimes further qualified as a PBM (permanent bench mark) or as a **TBM** (temporary bench mark).

Bias – all GNSS signals are affected by biases and errors. Biases are systematic errors that cause the observed measurements to be different from truth by a predictable or systematic amount, such as the lengthening of the signal path due to tropospheric refraction. Biases must somehow be accounted for in the data processing if high accuracy is sought. In classical RT positioning, many of the biases are treated as the same at the base station and the rover. Unmodeled biases such as multipath are outliers in the observables contributing to the position solution. One nanosecond of time delay is equivalent to 30 cm in range error.

Blunder – a gross error that prevents the desired position accuracy from being achieved. As opposed to *systematic errors*, such as a mal-adjusted circular vial level at the base station, or *random errors* that are typically mitigated through least squares techniques, blunders might be using the wrong antenna height, or recording a float solution before the solution becomes initialized.

1200.04 C

C/A (Coarse/Acquisition) Code – a code embedded in the signal unique to each satellite allowing the GPS receiver to recognize data from multiple satellites operating on the same frequency – C/A code is also known as the civilian code while P code (military use) provides higher accuracy. The GPS receiver must know the codes for the satellites it is tracking.

(CAF) Combined Adjustment Factor – is the product of the scale factor and the elevation factor. The CAF times the surface distance yields the corresponding distance on the state plane grid.

Calibration – in a horizontal coordinate sense, it is the transformation of the projected GNSS ECEF WGS 84 coordinates realized by the satellites to project specific planar grid coordinates. Typically, the project area is calibrated by occupying several monuments outside of the project's perimeter to record GNSS positions. The local planar grid coordinates for these monuments are imported or entered into the database. Data collector firmware/software then can perform a four parameter rotation, translation and scale to enable an unweighted least squares adjusted solution. This best fit solution can be viewed and the residuals at each calibration point reviewed. In addition, the scale of the horizontal calibration and the slope of the (multi-point) vertical calibration should be checked to ensure they are realistic and reasonable. A vertical calibration is performed similarly, and can be used to convert WGS 84 ellipsoid heights to "elevations", either with or without a geoid model. The vertical calibration may be a simple vertical shift to match a single elevation, or can be a best-fit planar correction surface computed using least-squares. The user then must decide which, if any, monuments to reject in horizontal and/or vertical components. Once readjustments or additional occupations are completed and the calibration is accepted, the project work is then done henceforth using the calibration. Care must be exercised to prevent different calibrations from being used on the same project, as the calibration can also be done in the office software and uploaded to the field data collector. Calibrations, when used, should be done carefully by a qualified professional to correctly assess local control and eliminate outliers.

Carrier Frequency – the primary frequency of the transmission signal, if the data is frequency modulated, the variation in frequency about the carrier frequency is the data.

Carrier Phase Measurements – by using the wave lengths of the two GNSS frequencies, ≈19 cm for L1 and ≈ 24 cm for L2, precise positioning can be accomplished. By tagging the partial wave length at the time of lock on the satellites, it is theoretically possible to resolve a position to a few millimetres if the whole number of wave lengths from each satellite on each frequency is known to translate the total into a distance. By using frequency combinations and *Differencing* techniques, iterative least squares adjustments can produce a best set of integer numbers and centimetre level positioning can commence. This is known as a *fixed solution*. Once the receiver is tracking the satellites with a fixed solution, the continuous count of the integer number of cycles correctly shows the change in range seen by the receiver. If the receiver loses lock on the satellites the count is lost and the solution will be seen to jump an arbitrary number of cycles, known as a *cycle slip*. This can be determined by the triple difference solution.

Carrier Phase Ambiguity – the unknown number of integer carrier phase cycles (or wave lengths) between the user and the satellite at the start of tracking.

Channel – a GNSS receiver locks into a specific frequency (or channel)

Clock Bias – is the difference between the clocks' indicated time and true universal time.

Clock Offset – is the constant difference in the time reading between two clocks. In GNSS usually refers to offset between SV clocks and the clock in the user's receiver.

Closure – is a mathematical application whereby a determination is made as to the exactness that a geometrical form is generated or attained within its confined elements of connecting lines and points. It is a computation method used by a surveyor to test the quality of field survey measurements and to apply corrections in balancing or adjusting the survey to meet precision specifications.

Collection Rate – the rate at which a receiver collects SV data.

Constellation – refers to either the specific set of satellites used in calculating a position, or all the satellites visible to a GNSS receiver at one time.

Control Point – a monumented point to which coordinates have been assigned by the use of terrestrial or satellite surveying techniques. The coordinates may be expressed in terms of a satellite reference coordinate system (such as WGS 84) or a local geodetic datum.

Constant Systematic Error – an error that does not change during a series of measurements.

Constellation – a specific set of satellites used in calculating positions: three satellites for 2-D fixes, four or more satellites for 3D fixes. It is all of the satellites visible to a GNSS receiver at one time. The optimum constellation is the constellation with the lowest PDOP.

Constrained – a way to hold (fix) a quantity (observation and coordinate) as true in a network adjustment.

Constraint – external limitations imposed upon the adjustable quantities (observations and coordinates) in a network adjustment.

Contour Interval – a predetermined difference in elevation (vertical distance) at which contour lines are drawn. The contour interval is usually the same for maps of the same scale.

Contour Line – an imaginary line on the ground, all points on which are at a specific elevation.

Contour Map – a map that portrays relief by means of contour lines.

Control – a system of points whose relative positions have been determined from survey data.

Control monument – a monumented land corner to which a land survey is referenced.

Control Point – a point that has a very accurate coordinate. Also called a control station or geodetic control station. A monumented point to which coordinates have been assigned by the use of terrestrial or satellite surveying techniques. The coordinates may be expressed in terms of a satellite reference coordinate system (such as WGS 84), or a local geodetic datum.

Control Survey – a survey that provides positions (horizontal and vertical) of points to which supplementary surveys are adjusted.

Conventional Survey or Survey Observation – an observation in the field obtained using an optical instrument such as a Total Station, Robotic Total Station or Theodolite.

Component – one of the three surveying observations used to define a three-dimensional baseline between two control points. The same baseline can be defined by azimuth, delta height, and distance (in ellipsoid coordinates); by delta X, delta Y, and delta Z in (Earth Centered Cartesian coordinates); and by delta north, delta east, and delta up (in local plane coordinates).

Coordinates – linear or angular quantities, or both, which designate the position on a point in relation to a given reference frame.

Correlated – when observations are correlated, there are two or more observations (or derived quantities), which have at least one common source of error

Covariance – a measure of the correlation of errors between two observations or derived quantities. Covariance also refers to an off-diagonal term (that is, not a variance) in a variance-covariance matrix.

Covariance Matrix – a matrix that defines the variance and covariance of an observation. The elements of the diagonal are the variance and all elements on either side of the diagonal are the covariance.

Covariant Values – the publication of the propagated (computed) a posteriori errors in azimuth, distance, and height between pairs of control points resulting from a network adjustment. The term covariant indicates that this computation involves the use of covariant terms in the variance-covariance matrix of adjusted control points.

Cycle Slips – a discontinuity in the measured carrier beat phase resulting from a temporary loss of lock in the carrier loop of a GNSS receiver.

1200.05 D

Data Collector – a ruggedized handheld electronic hardware data entry computer, with operational Survey software. It connects to a conventional total station, robotic total station, electronic level, or GNSS receiver to receive, process, and temporarily store survey data. Most data collectors have coordinate geometry capability, as well as calibration functionality for GNSS datum, as well as mapping screen graphics displays. Many have touch screen command functionality and are Wi-Fi and internet capable.

Data Logging – the process of recording satellite data in a file stored in the receiver, or a survey data collector.

Data Message – a message included in the GNSS signal which reports the satellite's location, clock corrections, and health.

Datum – a mathematical model of the earth designed to fit part or all of the geoid. It is defined by the relationship between an ellipsoid and a point on the topographic surface established as the origin of the datum. It is usually referred to as a geodetic datum. The size and shape of an ellipsoid, and the location of the center of the ellipsoid with respect to the center of the earth, usually define world geodetic datum.

Datum Grid/Multiple Regression – are datum transformations, usually convert data collected, in the WGS-84 datum (by GNSS methods) onto datum's used for surveying and mapping purposes in individual regions and countries.

Datum Transformation – defines the transformation that is used to transform the coordinates of a point defined in one datum to coordinates in a different datum. There are a number of different datum transformation methods including seven-parameter and three-parameter (or Molodensky).

De-correlate – to remove the covariance between observations. This may be done through elaborate orthogonal transformations, or by computing separate horizontal and vertical adjustments.

Deflection of the Vertical – the angular difference between the upward direction of the plumb vertical line (vertical) and the perpendicular (normal) to the ellipsoid.

Degrees of Freedom – a measure of the redundancy in a network.

Delta Elevation – the difference in elevation between two points.

Delta N, Delta E – coordinate differences, expressed in a local geodetic horizon delta U coordinate system.

Delta X, Delta Y, Delta Z – coordinate differences, expressed in a Cartesian coordinate system.

Differential Positioning – Precise measurement of the relative positions of two receivers tracking the same GNSS signals.

Discrepancy – The difference between two measurements of the same quantity.

(DOP) Dilution of Precision – a measure of the accuracy of a GNSS position based on the relative positions of the satellites. DOP is an indicator of the quality of a GNSS position. It takes account of each satellite's location relative to the other satellites in the constellation and to the GNSS receiver. A low DOP value indicates a greater probability of higher accuracy.
Standard **DOPs for GNSS** applications are:
PDOP- Position (three coordinates, and most common value assessed during RT or RTK survey. Small values, associated with widely separated satellites, represent greater accuracies)
HDOP- Horizontal (two horizontal coordinates)
VDOP- Vertical (height only)
TDOP -Time (clock offset only)

Doppler Shift – the apparent change in frequency of a signal caused by the relative motion of satellites and the receiver.

Double Differencing – an arithmetic method of differencing carrier phases simultaneously measured by two receivers tracking the same satellites. This method removes the satellite and receiver clock errors.

(DTM) Digital Terrain Model – a representation, in graphic form, on a computer, of the terrain through the area being surveyed.

Dual Frequency – a type of receiver that uses both L1 and L2 signals from GNSS satellites. A dual-frequency receiver can compute more precise position fixes over longer distances and under more adverse conditions because it compensates for ionospheric delays.

1200.06 E

Earth-Centered-Earth-Fixed (ECEF) Coordinates – a Cartesian coordinate system used by the WGS-84 reference frame.

Easting – an eastward reading of grid values. Easting is read left to right on a grid (x-axis).

Elevation – is the vertical distance of a point above or below a datum plane.

Elevation Mask – the angle above the horizon, below which satellite signals are not used. Typically, angles are set between 10-15 degrees for RT or RTK surveying.

Ellipsoid – the approximated shape of the Earth which is neither perfectly smooth nor round. Geodesists have mathematically smoothed the surface of the Earth by averaging the highs and lows. This calculation is called an ellipsoid. GNSS uses WGS 84 as its ellipsoid base. The ellipsoid is a mathematical model of the earth formed by rotating an ellipse around its minor axis. For ellipsoids that model the earth, the minor axis is the polar axis, and the major axis is the equatorial axis. An ellipsoid is defined by specifying the lengths of both axes, or by specifying the length of the major axis and the flattening.

Ellipsoid Distance – the length of the normal section between two points. Ellipsoid distance is not the same as the geodesic distance.

Ellipsoid Height – the distance, measured along the normal, from the surface of the ellipsoid to a point.

Ephemeris – a set of data that describes the position of a celestial object as a function of time. Each GPS satellite periodically transmits an ephemeris describing its predicted positions through the near future, uploaded by the control segment. Post processing programs can also use an ultra-rapid, rapid or precise ephemeris, which describes the exact positions of a satellite in the past. Broadcast Ephemeris data is sufficient for short baseline RTK work, i.e. for baselines under 30km.

Epoch – the time interval when the receiver logs data to its memory, the measurement interval of a GNSS receiver. The epoch varies according to the survey type. RT or RTK GPS carrier phase measurements are made at a given interval (e.g. every 1 second) or epoch rate.

Epoch Date – the date, usually expressed in decimal years for which published coordinates and data are valid.

Error – the difference between the measured value of a quantity and its true value. Surveying errors are generally divided into three categories: blunders, systematic errors, and random errors. Least squares analysis is used to detect and eliminate blunders and systematic errors, and least squares adjustment is used to measure and properly distribute random error.

Error Ellipse – a coordinate error ellipse and is a graphical representation of the magnitude and direction of the error of network adjusted points.

Error of Closure – reflects the precision of the survey and is the result of mathematically determining the latitude and departures and subsequently the misclosure of the traverse. Once this value has been determined and found to be of no lesser quality than required, any suitable adjustment may be made.

Events – represented as a record of an occurrence, such as the closing of a photogrammetric camera’s shutter. A GNSS receiver can log an event mark which contains the time of the event and an alphanumeric description entered through the keypad. An event can be triggered through the keypad or by an electrical signal input on one of the receivers’ ports.

1200.07 F

Fast Ambiguity Resolution – rapid static or fast static GNSS surveying techniques, utilizing multiple observables (dual-frequency carrier phase, C/A and P codes) to resolve integer ambiguities, with shortened observation periods. The method may also be used for observations with the receiver in motion known as on-the-fly ambiguity resolution.

Fast Static – a method of GNSS surveying using occupations of up to 20 minutes to collect GNSS raw data, and then post processing to achieve sub-centimetre precisions. Typically the occupation times vary based on the number of satellites (SVs) in view. **Fast Static** is also referred to as **Rapid Static**.

Feature Codes – abbreviations used to define an object collected during a radial survey.

Fixed (ECEF) – Earth-centered-earth fixed (ECEF) is a Cartesian coordinate system used by the WGS-84 reference frame. In this coordinate system, “fixed” refers to the center of the system that is at the earth’s center of mass. The z-axis is coincident with the mean rotational axis of the earth and the x-axis passes through 0×N and 0× E. The y-axis is perpendicular to the plane of the x and z-axes.

Fixed Coordinates – coordinates that do not move when performing a network adjustment.

Fixed Elevation – an elevation obtained, either as a result of tide observations or previous adjustment of levelling, which is held at its accepted value in any subsequent adjustment.

Fixed Position – an adjusted value of the position of a point on the earth. The positions obtained by the adjustment are called adjusted positions, and when used as control for other survey work they are called fixed positions.

Fixed Solution – a solution obtained when the baseline processor is able to resolve the integer ambiguity search with enough confidence to select one set of integers over another. It is called a fixed solution because the ambiguities are all fixed from their estimated float values to their proper integer values

Flattening (f) – a mathematical expression of the relative lengths of the major and minor axes of an ellipsoid.

Flattening Inverse (1/f) – an expression of the flattening that is easier to read and edit.

Float Solution – a solution obtained when the baseline processor is unable to resolve the integer ambiguity search with enough confidence to select one set of integers over another. It is called a float solution because the ambiguity includes a fractional part and is non-integer.

Free Adjustment – a network adjustment in which no point (coordinate) is constrained, the network adjustment uses inner constraints.

Frequency – how often an event occurs within a period of time.

Frequency Modulation (FM) – a method of encoding information in a carrier signal by altering the frequency while amplitude remains constant. The GPS carrier frequencies are modulated by the C/A code, P code and Navigation message.

Fully Constrained – a network adjustment in which all points in the network that are part of a larger control network are held fixed to their published coordinate values. Fully constrained is used to merge smaller control networks with larger and older networks to newer.

1200.08 G

(GDOP) Geometric Dilution of Precision – the relationship between errors in user position and time and errors in satellite range. See also DOP.

Geodetic Azimuth – the angle between the geodetic meridian and the tangent to the geodesic line of the observer, measured in the plane perpendicular to the ellipsoid normal of the observer; clockwise from north.

Geodetic Datum – a mathematical model designed to fit part or all of the geoid. It is defined by the relationship between an ellipsoid and a point on the topographic surface established as the origin of a datum.

The size and shape of an ellipsoid and the location of the center of the ellipsoid with respect to the center of the earth define world geodetic datums; various datums have been established to suit particular regions.

For example, European maps are often based on the European datum of 1950 (ED-50). Maps of the United States and Canada are often based on the North American Datum of 1927 or 1983 (NAD-27, NAD-83).

All GNSS coordinates are based on the WGS-84 datum surface.

Geodetic Survey – surveys for the establishment of control networks (comprised of active or passive Reference or Control Points), which are the basis for accurate positioning and navigation under, on, or over the surface of the earth. May be carried out using either terrestrial or satellite positioning (e.g. GPS) techniques. "Geodetic" surveys imply that refraction, curvature of the earth, atmospheric conditions and gravity are taken into account in the measurements rather than "plane" surveys in which these factors are generally ignored. The outcome is a network of stations which are a physical realization of the Geodetic Datum or Reference System.

Geographic (Geodetic) Coordinates – latitude, longitude, and ellipsoid height.

Geoid – an Earth model that takes into account the Earth's gravity field. Geodesists have recalculated the Earth's surface so that an object does weigh the same no matter where it is placed. A geoid is the surface of gravitational equipotential that closely approximates mean sea level. It is not a uniform mathematical shape, but is an irregular figure.

Generally, the elevations of points are measured with reference to the geoid. However, points fixed by GNSS methods have heights established in the WGS84 datum (a mathematical figure).
The relationship between the WGS-84 datum and the geoid must be determined by observation, as there is no single mathematical definition that can describe the relationship. The user must utilize conventional survey methods to observe the elevation above the geoid, and then compare the results with the height above the WGS84 ellipsoid at the same point.
By gathering a large number of observations of the separation between the geoid and the WGS84 datum (geoidal separation), grid files of the separation values can be established.
This allows the interpolation of the geoidal separation at intermediate positions. Files containing these grids of geoidal separations are referred to as geoid models. Given a WGS84 position that falls within the extents of a geoid model, the model can return the interpolated geoidal separation at this position.

Geoid Model – a mathematical representation of the geoid for a specific area, or for the whole earth. The software uses the geoid model to generate geoid separations for the user's points in the network.

Geoid Separation – is the distance between the ellipsoid and geoid at a given point.

Geomatics – the design, collection, storage, analysis, display, and retrieval of spatial information. The collection of spatial information can be from a variety of sources, including GNSS and terrestrial methods. Geomatics integrates traditional surveying with new technology-driven approaches, making geomatics useful for a vast number of applications.

(GIS) Geographic Information System – a computer-based system that is capable of collecting, managing and analyzing geospatial data. It includes the networking systems, personnel, and software, hardware and communication media to integrate the data. Generally speaking, it is a tabular database hot-linked to a graphical display of points, lines and polygons. Layers of data types of much different accuracy are represented separately or together. It has the ability to provide answers to data queries and can perform spatial analysis topologies from graphical and tabular data. RT techniques are frequently used with many facets of GIS, such as populating a utility infrastructure or locating photo points for photogrammetric applications.

GLONASS – Globalnaya Navigatsionnaya Sputnikovaya Sistema / **GL**obal **O**rbiting **Na**vigation **S**atellite **S**ystem; This is the Russian Federation counterpart to GPS. It is designed to consist of a constellation of 24 satellites (though the number is presently less due to difficulties in funding for the system) transmitting on a variety of frequencies in the ranges from 1597-1617 MHz and 1240-1260 MHz (each satellite transmits on different L1 and L2 frequencies). **GLONASS** provides worldwide coverage; however its accuracy performance is optimized for northern latitudes, where it is better than GPS's SPS. **GLONASS** positions are referred to a different datum than **GPS**, i.e. PZ90 rather than WGS84. Most survey firmware/software converts from the PZ90 datum to WGS84 for processing.

(GNSS) Global Navigation Satellite System – an umbrella term used to describe the generic satellite-based navigation/positioning system(s). It was coined by international agencies such as the International Civil Aviation Organization (ICAO) to refer to GPS and GLONASS, as well as any augmentations to these systems, and to any future civilian developed satellite system. For example, the Europeans refer to GNSS-1 as being the combination of GPS and GLONASS, but GNSS-2 is the blueprint for an entirely new system. Future constellations may include China's Compass/Beidou, Europe's Galileo, Japan's QZSS, etc.

GPS – a system for providing precise location which is based on data transmitted from a constellation of 30+ satellites. It comprises three segments: (a) the Control Segment, (b) the Space Segment, and (c) the User Segment. The GPS constellation is a realization of the WGS 84 datum and is maintained by the U.S. Department of Defence. Users access the satellite specific codes and the L-band carrier signals to obtain positions.

GPS Baseline – a three-dimensional measurement between a pair of stations for which simultaneous GPS data has been collected and processed with differencing techniques. This baseline is represented as delta X, delta Y, and delta Z; or azimuth, distance, and delta height.

GPS Observation – an uninterrupted collection of GPS data at a particular point in the field. A number of observations are done simultaneously in a session to create baselines by processing the data.

GPS Raw Data – the data collected by a GPS receiver or Survey Data Collector for the purpose of processing at a later time.

GPS Time – a measure of time used by the NAVSTAR GPS system. GPS time is based on Universal Time Coordinated (UTC) but does not add periodic leap seconds to correct for changes in the earth's period of rotation.

Grid – a two-dimensional horizontal rectangular coordinate system, such as a map projection.

Grid Azimuth – distance measured from grid north.

Grid Conversion – the conversion between geographic and map projection coordinates.

Grid Coordinates – the numbers of a coordinate system that designates a point on a grid.

Grid Declination – the angular difference between grid north and true north at a location.

Grid Position – Grid position are the grid coordinates of a point.

Grid Distance – the distance between two points expressed in mapping projection coordinates.

Grid North - the direction northwards along the grid lines of a map projection.

Ground Distance – the horizontal distance (with curvature applied) between two ground points.

Ground Plane – a large flat metal surface, or electrically charged field, surrounding a GNSS antenna used to deflect errant signals reflected from the ground and other near-by objects.

1200.09 H

Height (Ellipsoid) – height above or below a mathematically defined ellipsoid (e.g., WGS 84) that approximates the surface of the Earth at the geoid. The height coordinate determined from GNSS observations is related to the surface of the WGS 84 reference ellipsoid. The WGS 84 ellipsoid height is natively displayed in RT GNSS positioning in a transformation from the original computed ECEF X, Y, and Z coordinates to Latitude, Longitude and *ellipsoid height*. However, data collection firmware/software can transform this into an orthometric height by use of a geoid model or by localization to several known vertical bench marks.

Height (Orthometric) – the height of a point, usually on the on the earth's surface, measured as a distance along the curved local plumb line and normal to gravity from the reference surface to that station.

Hertz – a unit used to measure a wave's frequency (cycles per second). The three GPS frequencies are L1=1575.42 MHz (million hertz), L2=1227.60 MHz and L5=1176.45 MHz (future). GLONASS uses unique frequencies in the L band for each satellite.

(H.I.) Height of Instrument – is a measurement from point on the ground to the antenna of either the base or rover receiver.

Horizontal Datum – a set of precisely surveyed points on the ground that has been referenced to a given ellipsoid.

Hub – a wooden stake set in the ground with a tack or other marker to indicate the exact position. A guard stake protects and identifies the hub.

1200.10 I

Integer Ambiguity – the distance between the satellite and receiver that must be determined in order to obtain centimetre level accuracy. This distance is measured in the number of wavelengths of the carrier frequency (the L1=1575.42 MHz wavelength is 19.05cm). The correct integer would be the distance divided by 19.05cm removing the fractional part of the result.

Integer Search – the process of resolving the Integer Ambiguity. The search involves trying various combinations of integer values and selecting the best result.

(Iono Free) Ionospheric Free Solution – a solution that uses a combination of GNSS measurements to model and remove the effects of the ionosphere on the GNSS signals. Often used for high-order control surveying, particularly when observing long baselines.

Ionosphere – The band of charged particles 50 to 1000 km above the Earth's surface.

Ionospheric Delay – a signal delay or acceleration as a wave propagates through the ionosphere. Phase delay depends upon the electron content and affects the carrier signal. Group delay depends upon the dispersion as well, and affects the code signal.

Ionospheric Modeling – the time delay caused by the ionosphere, varies with respect to the frequency of the GNSS signals and affects both the L1 and L2 signals differently. When dual frequency receivers are used, the carrier phase observations for both frequencies can be used to model and eliminate most of the ionospheric effects. When dual frequency measurements are not available, an ionospheric model broadcast by the GNSS satellites can be used to reduce ionospheric affects with less precision.

Iteration – a complete set of adjustment computations includes formation of the observation equations, normal equations, coordinate adjustments, and computation of residuals.

1200.11 K

Kinematic Surveying – a method of GNSS surveying using short Stop and Go occupations, while maintaining lock on at least 4-5 satellites. Done in real-time or post processed to centimetre precisions.

Known Point Initialization – is used in conjunction with kinematic initialization. If two known points are available, the baseline processor can calculate an inverse between the two points and derive an initialization vector. This initialization vector, with known baseline components, is used to help solve for the integer ambiguity. If the processor is able to successfully resolve this ambiguity a fixed integer solution is possible, yielding the best solutions for kinematic surveys.

1200.12 L

L1 Frequency – The 1575.42 MHz GPS carrier frequency which contains the C/A code, the P code (encrypted by the Y code) and the Navigation Message. Commercial GPS navigation receivers can track only the L1 carrier to make pseudo-range (and sometime carrier phase and Doppler frequency) measurements.

L2 Frequency – The 1227.60 MHz GPS carrier frequency contains only the encrypted P code and the Navigation Message. Military receivers can, in addition to making L1 measurements, make pseudo-range measurements on the L2 carrier. The combination of the two measurements (on L1 and L2) permits the Ionospheric Delay to be corrected for.

Dual frequency GNSS receivers intended for surveying applications can make L2 measurements, without decoding, using proprietary signal processing techniques to yield accurate positional differences. This technique requires multiple location measurement comparisons and is therefore not applicable to general GPS navigation which must be instantaneous by nature.

L-Band – the group of radio frequencies extending from 390MHz to 1550MHz. The GPS carrier frequencies L1 and L2 are in the L-Band.

Latency – the age or time lapse in corrections used in RTK-GNSS. The longer the time lapse between the corrections, the less accurate they become at the rover.

Least Squares – a mathematical method for the adjustment of observations, based on the theory of probability. In this adjustment method, the sum of the squares of all the weighted residuals is minimized.

Level of Confidence – a measure of the confidence in the results, expressed as a percentage or sigma.

Level Datum – a level surface to which elevations are referred. The generally adopted level datum for levelling is the mean sea level. For local surveys, an arbitrary level datum is often adopted and defined in terms of an assumed elevation for some physical mark (bench mark).

Levelling – directly or indirectly measuring vertical distances to determine elevations.

Loop Closure – provides an indication as to the amount of error in a set of observations within a network. A loop closure is calculated by selecting a point from which one or more observations were taken, adding one of those observations to the point's coordinates, and calculating coordinates of the second point based on that observation. This process is repeated one or more times around a loop, finally ending at the original starting point. If there were no errors in the observations, the final calculated coordinate would be exactly the same as the original starting coordinate. By subtracting the calculated coordinate from the original coordinate a misclosure is determined. Dividing by the length of the line allows the error to be expressed in parts per million. This technique can also be used between two different points when both points are known with a high degree of accuracy. This is also known as a traverse closure.

1200.13 M

Mapping Angle – the angle between grid north on a mapping projection and the meridian of longitude at a given point, also known as convergence.

Map Projections – representations of the Earth's features that are transferred to a flat two-dimensional plane, such as, paper maps and computer generated maps.

Mapping Projection – a rigorous mathematical expression of the curved surface of the ellipsoid on a rectangular coordinate grid.

Mean Sea Level – the mean height of the surface of the ocean for all stages of the tide. Used as a reference for elevations.

Meridian – a north-south line from which longitudes (or departures) and azimuths are reckoned.

Minimally Constrained – a network adjustment in which only enough constraints to define the coordinate system are employed. It is used to measure internal consistency in observations.

Mistake or Blunder – an unintentional fault of conduct arising from poor judgment or from confusion in the mind of the observer.

Modeling – the expressing of an observation and its related errors mathematically and geometrically on some defined coordinate system, such as an ellipsoid.

Multipath – an interference (similar to ghosts on a television screen) that occurs when GNSS signals arrive at an antenna after traveling different paths. The signal traveling the longer path yields a larger pseudo-range estimate and increases the error. Multiple paths may arise from reflections from structures near the antenna.

Multipath Errors – errors caused by the interference of a signal that has reached the receiver antenna by two or more different paths. This occurs when the antenna is placed too close to a large object, such as water towers, overhead storage tanks, buildings etc.

Multi-Channelled Receiver – a receiver that can simultaneously track more than one satellite.

1200.14 N

NAD83 – North American Datum of 1983 referenced to the GRS80 ellipsoid.

Narrow-Lane – A narrow-lane is a linear combination of L1 and L2 carrier phase observations (L1+ L2) that is useful for cancelling out ionospheric effects in collected baseline data. The effective wavelength of the narrow-lane is 10.7 centimetre. The narrow-lane observable can help resolve carrier-phase ambiguities.

NAVDATA – NAVDATA is the 1500-bit navigation message broadcast by each satellite. This message contains system time, clock correction parameters, ionospheric delay model parameters, and details of the satellite's ephemeris and health. The information is used to process GPS signals to obtain user position and velocity.

NAVSTAR – The GPS satellite system of the US Department of Defense. NAVSTAR is an acronym for **NAV**igation **S**atellite **T**iming and **R**anging.

Negligent Error – the difference between the measurement and the true value

(NMEA) National Marine Electronics Association – a U.S. standards body that defines message structure, content and protocols to allow electronic equipment installed within ships and boats to communicate with each other. GPS receivers can be configured to output various types of messages in the "NMEA format". The NMEA GSV message type should contain signal to noise ratio information and the GGA message contains the raw position.

Network – a set of baselines.

Network Adjustment – a solution of simultaneous equations designed to achieve closure in a survey network by minimizing the sum of the weighted squares of the residuals of the observations.

Network Status – an indication that a particular observation will be included in the adjustment. 'Network' means that it is included in the adjustment and 'non-network' means that it is excluded from the adjustment.

NGS – National Geodetic Survey (U.S.)

Noise – an interfering signal that tends to mask the desired signal at the receiver output and which can be caused by space and atmospheric phenomena, can be human made, or can be caused by receiver circuitry.

NSRS – National Spatial Reference System. (U.S.)

Normal – in geodesy, the straight line perpendicular to the surface of the ellipsoid.

Northing – a northward reading of a grid value.

1200.15 O

Observation – an uninterrupted collection of GNSS data at a particular point in the field. A number of observations are done simultaneously in a session to create baselines by processing the data.

Observation Residual – correction to the observation as determined by the adjustment.

Occupation Time – the amount of time required on a station, or point, to achieve successful processing of a GNSS baseline. The amount of time will vary depending on the surveying technique, the type of GNSS receiver used, and the precision required for the final results. Occupation times can vary from a couple of seconds (kinematic surveys) to several hours (control or deformation surveys that require the highest levels of precision and repeatability).

Offset Line – a supplementary line close to, and usually parallel to, a main survey line to which it is referenced by measured offsets. When the line for which data is desired is in such position that it is difficult to retrieve measurements, the required data is obtained by running an offset line in a convenient location and measuring offsets to salient points on the original line.

Order of Accuracy – a mathematical ratio defining the general accuracy of the measurements made in a survey. The orders of accuracy for surveys are divided into four classes named: first-order, second-order, third-order, and fourth-order.

Origin – the intersection of axes in a coordinate system. It is the point of beginning.

Orthometric Height – the distance between a point and the surface of the geoid. It is usually called the elevation.

(OTF) On-the-fly – GNSS baseline processing, whether real-time or post processed, requires fixed integer solutions (Integer Ambiguity) for the best possible results. Historically, this search was done using measurements collected while two or more receivers were stationary. Modern receivers and software can use the measurements collected while the rover is moving. Because the receiver is moving, the data can be described as collected OTF.

Outlier – an observation which is identified by statistical analysis as having a residual too large for its estimated error. Relates to the graphical position of an observation in a histogram.

1200.16 P

Parallax – a change in positions of the image of an object with respect to the telescope cross hairs when the observer's eye is moved using optical equipment. This can be practically eliminated by careful focusing.

Parameter – A parameter is an independent variable in terms of which the coordinates of points on a line or surface are given.

Parity – a form of error checking used in binary digital data storage and transfer. Options for parity checking include even, odd, or none.

P Code – the Precise or Protected code. A very long sequence of pseudo-random binary bi-phase modulations on the GPS carrier at a chip of 10.23 MHz which repeats about every 267 days. Each segment of the code is unique to one GPS satellite and is reset each week.

(PDOP) Position Dilution of Precision – an indication of the current satellite geometry. A PDOP is a unitless figure of merit expressing the relationship between the error in user position, and the error in satellite position. It is the result of a calculation, which takes into account each satellite's location relative to the other satellites in the constellation. A **low PDOP** indicates a higher probability of accuracy. Usually a PDOP of 6 or below gives excellent positions. Geometrically, PDOP is proportional to 1 divided by the volume of the pyramid formed by lines running from the receiver to four satellites that are observed. Values considered "good" for positioning are small, for example 3. Values greater than 7 are considered poor. Thus, small PDOP is associated with widely separated satellites.

PDOP is related to horizontal and vertical DOP by: PDOP2 = HDOP2 + VDOP2

Phase Difference Processing (relative positioning) – phase difference processing is a computation of the relative difference in position between two points by the process of differencing simultaneous reconstructed carrier phase measurements at both sites. The technique allows cancellation of all errors which are common to both observers, such as clock errors, orbit errors, and propagation delays. This cancellation effect provides for determination of the relative position with much greater precision than that to which a single position (pseudo-range solution) can be determined.

PI – the Point of Intersection of back tangent and forward tangent.

Plane survey – A plane survey is a survey in which the effect of the curvature of the earth is almost entirely neglected, and computations of the relative positions of the stations are made using the principles of plane geometry and plane trigonometry.

Positions – the place occupied by a point on the surface of the earth. Positions are data that defines the location of a point with respect to a reference system.

Positional Tolerance – a measure of the accuracy of the position of a monumented boundary corner with respect to its described location without error.

Post Processing – a procedure used to obtain accurate coordinates by correcting errors in the rover receiver data. This is accomplished by processing the rover receiver data with the base receiver data. The rover receiver and the base receiver must run concurrently and include the same satellites.

(PPM) Parts Per Million – PPM are a standardized representation of a scale error in distance measurements. A 1 PPM error would result in 1 millimetre of measurement error for every 1000 meters of distance traveled.

Precision – the degree of repeatability that measurements of the same quantity display, and are therefore a means of describing the quality of the data with respect to random errors. Precision is traditionally measured using the standard deviation and therefore is shown in the RMS error on the data collector screen. It can be thought of as the spread of the positional error.

Prime Meridian – a prime meridian is the initial or zero median from which longitudes are reckoned. At an international conference in 1884, the Greenwich Meridian was adopted by most countries as the prime meridian for the earth.

(PRN) Pseudo Random Number – Each satellite is assigned a PRN number/code to uniquely identify it. The codes must be suitable for auto/cross correlation so a random selection from all possible 2^{1023} codes is not possible and there are in fact only 37 codes that are used. Because there are only a few possibilities, the codes are pseudo random and not actually random.

Probability – a statistical percentage expressing what portion of a hypothetical number of observations will fall within the defined limits. It is sometimes called level of significance.

Probable Value – the adjusted value for observations and other quantities, assuming that the adjustment has been done correctly. It is the closest possible approximation to the true value.

Projection – used to create flat maps that represent the all or parts of the Earth’s surface.

Pseudo-Range – a measure of the apparent propagation time from the satellite to the receiver antenna, expressed as a distance. The apparent propagation time is determined from the time shift required to align a replica of the GPS code generated in the receiver with the received code. The time shift is the difference between the time of signal reception (measured in the receiver time frame) and the time of emission (measured in the satellite time frame). Pseudo-range is obtained by multiplying the apparent signal-propagation time by the speed of light. Pseudo-range differs from the actual range by the amount that the satellite and receiver clocks are offset, by propagation delays, and other errors including those introduced by selective availability.

1200.17 Q

Quality Acceptance Test – one or more software evaluation tests, performed on raw GNSS data, to determine if the data passes or fails a set of tolerance values that the user defines. Removes data from further processing or marks data requiring quality improvement.

Quality Control (QC) Records – these records are used with precise positioning applications.

1200.18 R

Ratio Test – used during initialization. The receiver determines the integer number of wavelengths to each satellite. For a particular set of integers, it works out the probability that the set is correct. The ratio of the probability of correctness of the current best set of integers to the next-best set determines the confidence of the result. The ratio must be above 5 for new point and OTF initializations.

Real-Time Corrections – real-time DGPS uses a data link (beacon or commercial) to transmit correctional data from the reference to the rover receiver. These corrections are used by the rover receiver to correct its errors as the satellite signal is received.

Real-Time Kinematic (RTK) – a method of GNSS surveying in real-time using short (stop and go) occupation, while maintaining lock on at least 4-5 satellites. Real-Time Kinematic method requires a wireless data link between the base and rover receivers.

Rectangular – coordinates in any system in which the axes of reference intersect coordinates at right angles.

Redundancy – the amount by which a control network is over-determined, or has more observations than are needed to strictly compute its parts.

Redundant Baselines – a baseline observed to a point that has already been connected to the network by other observations. A redundant baseline can be either an independent re-observation of a previous measurement, or an observation to a point from another base. It is redundant because it provides more information than is necessary to uniquely determine a point. Redundant observations are very useful. They provide a check on the quality of previous measurements.

Reference Frame – the coordinate system of a datum.

Reference Station (Base Station) – a ground station at a known location used to derive differential corrections. The reference station receiver tracks all satellites in view, corrects pseudo-range errors, and transmits corrections with the carrier phase observables to the rover.

Reference Variance – the square of the reference factor.

Relative Positioning – the determination of relative positions between two or more receivers which are simultaneously tracking the same GNSS signals. One receiver is generally referred to as the reference or base station, whose coordinates are usually known in the project datum. The second receiver (rover) moves to various points to be recovered or located. Its coordinates are determined relative to the base station. In carrier phase based positioning this results from the determination of the delta X,Y,Z coordinates applied as a baseline vector, which is added to the base station’s coordinates to generate the rover's coordinates.

Relative Precision – a measure of the tendency of a set of numbers to cluster about a number determined by the set (e.g. the mean). The usual measure is the standard deviation with respect to the mean. Relative precision denotes the tendency for the various components (X, Y, Z) between one station and other stations in the network to be clustered about the adjusted values. Current custom is to express relative precision at the two-standard deviation (95% confidence) level. This may be stated in terms of a relative error ellipse or as a proportion of the separation distance (e.g. 10 ppm or 1:100,000).

Residual – the correction or adjustment of an observation to achieve overall closure in a control network. It is also the difference between an observed quantity and a computed value.

RINEX – **R**eceiver **IN**dependent **EX**change format – a RINEX is a standard GPS raw data file format used to exchange files from multiple receiver manufacturers. An interchange format that permits data collected by one specific receiver to be read by another vendor's receiver.

(RMS) Root Mean Square – expresses the accuracy of point measurement. It is the radius of the error circle within which approximately 68% of position fixes are found. It can be expressed in distance units or in wavelength cycles.

Rotated Meridian – a zone constant for the oblique Mercator mapping projection.

Rotation – in transformations, a rotation is an angle through which a coordinate axis is moved around the coordinate system origin.

Rover – a mobile GNSS receiver that when used in conjunction with a stationery receiver can obtain differentially corrected ground coordinates. Any receiver used in a dynamic mode is called a rover.

ROW or R/W – right of way, legally granted access to a specified land area.

1200.19 S

Satellite Constellation – the orbiting satellites and their broadcast signals. The GNSS refers to the entire array of available satellites. GPS, GLONASS, Galileo and Compass are some individual constellations that can be used for positioning, navigation and timing either collectively as they become available or individually.

Satellite Geometry – position and movement of GNSS satellites during a GNSS survey.

Satellite Vehicle (SV) – a U.S. Department of Defence satellite.

Scalar – in least squares, a scalar is a value applied to the variances (errors) based on the required level of confidence.

Scale – a multiplier used on coordinate and other linear variables, such as for map projections and transformations.

(SDMS) Survey Data Management System – a standardized detailed data structure which has been defined by AASHTO for recording field survey information.

SDMS Collector – a survey data collection software system that can be used for common surveying tasks, and which complies with the AASHTO SDMS standard data structure.

Selective Availability (S/A) – an artificial degradation of the GPS satellite signal by the U.S. Department of Defence. The error in position caused by S/A can be up to 100 meters.

Semi Major Axis – one-half of the major axis.

Semi Minor Axis – one-half of the minor axis.

Session – a period during which a number of GNSS receivers log satellite data simultaneously for the purpose of creating baselines.

Setup Error – errors in tripod (tribach) centering or height of instrument at a control point
.

Side Shot – an observed baseline with no redundancy

Sigma – a mathematical symbol or term for standard error (see 1-Sigma).

Signal to Noise Ratio (SNR) – an indicator of the strength of a satellite signal compared with ambient radio frequency (RF) noise. SNR ranges from 0 (no signal) to around 35.

Single Frequency – is a type of receiver that only uses the L1 GPS signal. There is no compensation for ionospheric effects.

Site Calibration – a process of computing parameters which establish the relationship between WGS-84 positions (latitude, longitude and ellipsoid height) determined by GNSS observations and local known coordinates defined by a map projection and elevations above mean sea level. The parameters are used to generate local grid coordinates from WGS-84 (and vice versa) real-time in the field when using RTK surveying methods (see Calibration).

Sky Plot – a polar plot graph showing the paths of visible satellites for a specified time interval. The elevation of the satellite is represented in the radial dimension and the azimuth is shown in the angular dimension. The result depicts the paths as they would appear to an observer looking down from directly above the survey point.

Slope Distance – the distance in the plane parallel to the slope between the points.

Solution Types – a description of both the data and techniques used to obtain baseline solutions from GNSS measurements. Typical solution types include descriptions such as code, float, and fixed. These describe techniques used by the baseline processor to obtain a baseline solution. Solution types also may include descriptions such as L1, L2, wide-lane, narrow-lane, or ionospheric free. These describe the way the GNSS measurements are combined to achieve particular results.

Standard Deviation – describes how much variation exists from the average (mean or expected value). A large standard deviation indicates inaccurate data. Surveying applications use the conventional formula for standard deviation (see Sigma, 1-Sigma).

Standard Error – a statistical estimate of error for the sample data. The particular sample may not be representative; more data points would yield a more accurate estimate.

Static Surveying – is a method of GNSS surveying using long occupations (hours in some cases) to collect GNSS raw data, and then post processing the data to achieve sub-centimetre precisions.

Static Network – a network that describes the geometry and order in which GNSS baselines collected using static and fast static techniques are organized and processed. The baseline processor first examines the project for points with the highest quality coordinates, and then builds the processing network from those points. The result is a set of static baselines that are derived using accurate initial coordinates.

Survey Observation – the measurements made at or between control points using surveying equipment (conventional or GNSS).

Systematic Error – an error which, for known changes in measurement conditions, results in proportional changes of values which remain unchanged, both in magnitude and sign. This error, evident in a series of measurements, may be instrumental, personal, or natural and always follows some definite mathematical or physical law and is cumulative in total effect.

1200.20 T

Target – any object to which the instrument is pointed. A target may be a plumb bob or cord, a nail in the top of a stake, a taping arrow, a range pole, or any other object that will provide a sharply defined stationary point or line.

Tau Value – computed from an internal frequency distribution based upon the number of observations, degrees of freedom, and a given probability percentage (95%). This value is used to determine if an observation is not fitting with the others in the adjustment. If an observation's residual exceeds the tau, it is flagged as an outlier. Tau values are known as tau lines in the histogram of standardized residuals; vertical lines left and right of the center vertical line.

Tau Criterion – Allen Pope's statistical technique for detecting observation outliers.

TDOP – Time Dilution of Precision.

Terrestrial Observation – an observation in the field using a laser rangefinder or conventional instrument.

Tie – a survey connection from a point of known position to a point whose position is desired.

Total Station – an electronic Theodolite that provides both angle and distance measurements and displays them automatically.

Total Systematic Error – in any given number of measurements, is the algebraic sum of the individual errors of the individual measurements.

Tracking – the process of receiving and recognizing signals from a satellite.

Transformation – the rotation, shift, and scaling of a network to move it from one coordinate system to another.

Transformation Group – a selected group of observations used to compute transformation parameters unique to that group of observations. Typically, the observations within the group are the same type with similar errors and measured using a common method.

Transformation Parameters – a set of parameters derived for a network adjustment or user-parameters defined, that transform one datum to another. Typically, with GNSS the parameters are generated to transform WGS-84 to the local datum.

Tribrach – a centering device used for mounting GNSS antennas and other survey instruments on survey tripods.

Tropo (Tropospheric) Model – GNSS signals are delayed by the troposphere. The amount of the delay will vary with the temperature, humidity, pressure, height of the station above sea level, and the elevation of the GNSS satellites above the horizon. Corrections to the code and phase measurements can be made using a Tropo Model to account for these delays.

Turning Points – temporary points of known elevation.

1200.21 U

Universal Time – universal time is local solar mean time at Greenwich, UK. UT0 - Universal Time as deduced directly from observations of stars and the fixed numerical relationship between Universal and Sidereal Time; 3 minutes 56.555 seconds. UT1 - UT0 corrected for polar motion. UT2 - UT1 corrected for seasonal variation in the earth's rotation rate. UTC - Universal Time Coordinated; uniform atomic time system kept very closely to UT2 by offsets. Maintained by the U.S. Naval Observatory. GNSS time is directly relatable to UTC. UTC - GPS = 9 seconds (in 1994).

Universal Transverse Mercator (UTM) – a projection created by the U.S. Army to obtain a series of maps that would encircle the Earth. BC is predominantly in UTM Zones 8-11.

Unknowns – the computed adjustments to coordinates and transformation parameters; also used to compute observation residuals.

(UTC) Universal Time Coordinated – a time standard based on local solar mean time at the Greenwich meridian.

1200.22 V

Variance – the square of the standard deviation.

Variance Factor – a statistical measure of how close the observation residuals match the predicted errors. If the errors in a network have been weighted correctly, the variance factor will approach 1.0.

Variance Component – a least-squares technique for estimating the relative error estimation of different portions of a network.

Variance Group – one of the groups of observations for which variance component estimation is being used in a network adjustment.

Variance-Covariance – the set of numbers expressing the variances and covariances matrix in a group of observations.

Variable Systematic Error – changing conditions resulting in corresponding changes in the magnitude of the error.

VDOP – Vertical Dilution of Precision.

Vector – a three-dimensional line from one point to another point.

Vertical – similar to the normal, except that it is computed from the tangent plane to the geoid instead of the ellipsoid.

Vertical Adjustment – a network adjustment of vertical observations and coordinates only.

Vertical Control – an established benchmark.

Vertical Control Point – a point with vertical coordinate accuracy only. The horizontal position is of a lower order of accuracy or is unknown.

Vertical Control Survey – is performed in order to accurately determine the orthometric height (elevation) of permanent monuments to be used as bench marks for lower quality levelling. Spirit levelling is the usual method of carrying elevations across the country from “sea level” tidal gauges. However, GNSS can be used indirectly but with less accuracy. Eight measurements from the ellipsoid (as opposed to the “sea level” geoid) can be determined very accurately with GNSS and only with GNSS.

Vertical Datum – a set of precise levels that have been referenced to a geoid to establish mean sea level.

Vertical Datum Plane – is the level surface to which elevations are referred.

1200.23 W

(WAAS) Wide Area Augmentation System – a satellite-based system that broadcasts GPS correction information. WAAS capable GPS receivers can track WAAS satellites. WAAS is synonymous with the European Geostationary Navigation Overlay (EGNOS) and Japan’s Multifunctional Transport Satellite Space-based Augmentation System (MSAS).

Water Course – a stream of water such as a river, brook, creek, bayou, etc. A water course is a visible channel for water such as a ditch, channel, or streambed.

Weight – the inverse of the variance of an observation.

Weights – the set of weights or the inverse of the variance-covariance matrix of correlated observations.

WGS84 – World Geodetic System. Datum referenced to the WGS 1984 ellipsoid. WGS is the mathematical ellipsoid used by GPS since January 1987. WGS84 is used to identify both a datum and an ellipsoid.

Wide-Lane – a linear combination of L1 and L2 carrier phase observations (L1 - L2). This is useful for its low effective wavelength (86.2 cm) and for finding integer ambiguities on long baselines.

1200.24 X

X, Y and Z – In the ECE system, X refers to the direction of the coordinate axis running from the system origin to the Greenwich Meridian; Y to the axis running from the origin through the 90° east longitude meridian, and Z to the polar ice cap. In rectangular coordinate systems, X refers to the east-west axis, Y to the north-south axis, and Z to the height axis.

1200.25 Y

Y Code – is the encrypted form of the P code, received by military authorized hardware.

1200.26 Z

Zenith – the point at which a line opposite in direction from that of the plumb line (at a given point on the Earth’s surface), meets the celestial sphere.

Zenith Angle – angle measured positively from the observer’s zenith to the object observed.

Zenith Delay – the delay, caused by the troposphere, of a GNSS signal observed from a satellite directly overhead. As a satellite approaches the horizon, the signal path through the troposphere becomes longer and the delay increases.