4.1 Introduction

Text provided by Professional Surveyors Canada Professional Liability Insurance Committee

The Professional Surveyors Canada Professional Liability Program includes individual surveyors and survey firms from eight provinces across Canada as well as throughout the territories. It includes sole practitioners and large firms involved in all aspects of the surveying profession. The policy covers all areas of practice that are the normal purview of a surveyor in a given jurisdiction.

Although program statistics are confidential to a large extent, the Committee has developed a solid relationship of trust with the program's insurance managers and the broker and are privy to detailed program statistics on a regular basis. A variety of program statistics are collected and analyzed to provide a very good overall picture of the number, types and sizes of claims in which Canadian surveyors have been involved over an extended number of years.

One of the keys to practice exposure analysis is the accurate coding of claims according to the type of project or survey, the type of client, the allegations made and the resulting damage or loss. When a claim report is submitted the surveyor is asked to circle the appropriate codes for the claim. The Committee, working with the Insurer and the Broker, use this information to identify patterns within areas of a surveyor's practice that repeatedly result in claims or which result in particularly large claims.

4.1.1 New and Emerging Patterns

From time to time new patterns emerge with changing sectoral economies and the changing methodologies, technologies and areas of expertise of the surveying profession across the country. A boom in oil and gas exploration caused by international politics, radial data gathering methods replacing more traditional offset traverses, the new waste management system work undertaken by Nova Scotia Land Surveyors, the recent requirement for Canada Lands Surveyors to provide proof of insurance to receive or maintain their license; are all examples of events seemingly unrelated to insurance that directly affect the program and its insureds.

4.1.2 Old Culprits

That said, the age-old problems associated with improper checking procedures, insufficient research, inadequate communication, result in a large majority of claims against surveyors and other professionals. Simple transposition of numbers, not caught by closing to an second benchmark or closing a traverse are disturbingly frequent examples. This is especially evident when times are good, when there is plenty of work and everyone is busy and may not spend the extra time needed to follow established procedures despite knowing the potential consequences. It can be a challenge to repeatedly inform our insureds of the basics of good practice management and basic measurement science without sounding condescending or patronizing.

One common myth that the Committee has found to be inaccurate is that it is the younger, newly licensed and less experienced surveyors that are most

frequently involved in professional liability claims. It should be recognized that the state of complacency that can result from years of practice can prove to be equally, or even more, problematic.

4.1.3 Balancing Risk and Remuneration

It has also been noted that some areas of practice, the most recently notable being well site surveys, may involve relatively small fees for the surveyor yet result in disproportionately large claims due to potential damages. The costs associated with drilling for any length of time based on incorrect location of well site, either vertically or horizontally, far outweighs the return afforded the surveyor in providing the required positional information. Experiences such as this seed the discussion of basing certain professional fees based at least in part on how the information is to be used and the risk involved should an error occur. **Structuring fees based on exposure to liability is not a common practice amongst surveyors but is one that, in this environment of increasing litigation, and continuing problems with appropriate fees for our professional services, bears careful consideration.**

4.1.4 The Measured Response

As a team, the Committee, the Insurer and the Broker respond to the challenges of identified practice exposures in four basic ways.

1. Information is regularly provided to insureds about which areas of practice traditionally cause problems and which emerging areas of practice may prove to do likewise, including statistics of claims frequency and size. This information enables the insured to make prudent business decisions regarding appropriate coverage amounts and deductibles including addition project insurance, and in assessing the balance of risk versus earnings potential of specific types of projects.

2. Continuing education is provided to our insureds through loss prevention initiatives such as bulletins, seminars and articles in this guide. Information about how to identify and minimize the exposure when practicing in particular areas allows the surveyor to participate in these areas without inviting undue risk.

3. Premiums within the program are structured in part to create an equitable system whereby those participating to a significant extent in areas of practice that are known to have more frequent or particularly large claims pay appropriate premiums.

As noted elsewhere in this guide, the importance of a loss prevention program, supported by all those involved in the Professional Surveyors Canada program, and backed by statistical information provided by the insurers, is the key to individual surveyors enjoying infrequent claims and low premiums for their professional liability insurance. All members of the program are encourage to actively take advantage of the information regarding practice exposure presented by loss prevention resources such as this guide. Please be sure that you and the other surveyors and staff members within your firm recognize where their particular liability exposure lies and how to minimize its consequences.

4.2 Claim Coding Chart

The following chart of claims codes are currently used in the Professional Surveyors Canada supported insurance program. The claim codes are used to track the type project and type of problem which lead to the claim. Statistics are maintained by the insurance managers and the Professional liability Insurance Committee so that specific problem areas can be addressed within the program through loss prevention products or risk related calculations in order to maintain a balanced program of professional liability insurance. The coding chart is updated periodically as new practices within surveying develop.

Claim Coding Chart Professional Surveyors Canada Professional Liability Insurance Program

Discipline Codes

	Type of Survey/Project		Client/Claimant
01	Seismic	01	Municipality
02	Geodetic/Control	02	Government (Provincial/Federal)
03	Mapping/Topography	03	Commercial/Developer
04	Marine/Hydrographic	04	Resource
05	Engineering Survey	05	Private/Individual
06	Construction Layout	06	Agricultural
07	Oil/Mining	07	Lawyer
08	Mortgage Certificate/Building Certificate	08	Engineer
09	Legal Survey/Quieting of Title Survey	09	Industrial
10	Other – Please list:_____	10	Other – Please list:_____
	_____		_____

Cause Codes

	Alleged Error/Allegation		Resulting Problem/Loss
01	Transposition of number	18	Elevation incorrect
02	Technical computation error	19	Horizontal location incorrect
03	Horizontal measurement	20	Encroachment problem
04	Vertical measurement	21	Property boundary located incorrectly
05	Lack of information/incorrect information provided	22	Property damage
		23	Bodily injury
06	Incorrect survey monument used	24	Area calculation error
07	Improper or insufficient check of documentation	25	Delay
		26	Other – Please specify:_____
08	Drafting error		_____
09	Communication problem between Surveyor and Client		_____
10	Other – Please specify:_____		
	_____		
	_____		

4.3 Addressing Specific Areas of Exposure

The PLIC has a number of sources of information that they use to determine what areas of professional surveying lead to potential claims. These include claims statistics from the insurer, experience in dealing with specific claims, feedback from insureds, issues brought forward by the associations, and the personal experience of the practicing surveyors on the Committee. This information is passed on to Canadian surveyors through this Guide, Loss Control bulletins published by ENCON (see section 7), presentations to Association annual meetings, loss control seminars, and articles addressing specific issues. The following sections contain articles prepared by the PLIC and others for this purpose.

4.3.1 Measurement Practices in Construction Layout

The Professional Liability Insurance Committee (the "PLIC") on behalf of the Professional Surveyors Canada has recently been involved in renewal negotiations with our insurer. The Committee feels their negotiations were successful in providing fair value premium increases to program participants, however in our discussions it was pointed out to us by our insurer that we have several "frequent flyers" insured under the Professional Surveyors Canada Program. ***"Frequent Flyers" are insureds with multiple claims.*** The majority of these claims involve construction layout problems. When reviewing the circumstances the PLIC became concerned that most of these claims are the direct result of poor or improper layout and the lack of checking procedures.

Professional Surveyors Canada and the Encon Group Inc. have previously targeted loss control bulletins at these problems. Bulletins 3, 4 and 9 all address layout matters. It appears the message of these bulletins has not yet reached its target audience.

Construction layout accounts for more than 60% of our claims. It is obvious that a lack of proper procedures is the root cause of these claims.

If you do construction layouts, we wish to reiterate again the message of the above noted bulletins and the information in the "Loss Prevention and Practice Management Guide" which can be found on the Professional Surveyors Canada website at www.psc-gpc.ca/

The following statement is in the Guide, and was highlighted in Bulletin No. 9, but is certainly worth repeating -

"... the age old problems associated with improper checking procedures, insufficient research, inadequate communication, result in a large majority of claims against surveyors and other professionals. Simple transposition of numbers, not caught by closing to a second benchmark or closing a traverse are disturbingly frequent examples. This is especially evident when times are good, when there is plenty of work, and everyone is busy and may not spend the extra time needed to follow established procedures despite knowing the potential consequences. It

can be a challenge to repeatedly inform our insureds of the basics of good practice management and basic measurement science without sounding condescending or patronizing."

Bulletin No. 3 was titled ***"Measure Twice, Cut Once".*** This statement was recently made to me by a carpenter doing some renovation work in our office. This simple carpenter's motto is applicable to surveyors as well. How much trouble is it to measure twice and then do a completely independent check on your placement and measurements? Several recent claims have resulted from foundations not meeting sideyard or setback requirements. Could these errors have been prevented by measuring the distance twice or better yet confirming the location by checking a tie to a different property boundary or grid line?

Bulletin No. 9 offered several procedures that could assist in prevention of most construction layout errors, and other humbling mistakes. We feel it is an important enough issue to again highlight, and expand on, these solutions.

1. Implement proper (and clearly understood) independent field check procedures.
2. Do not be overly influenced by unreasonable client demands.
3. Do not be overly reliant on the technology you elect to use.
4. Check the source data thoroughly, whether it is paper or electronic.
5. Have an experienced staff member look at the data from a logic and possibility aspect; that is, ***get a second opinion on the data integrity.***

Effective verbal and written communication does not come naturally for most people. Some who are adept at the spoken word may have trouble writing a clear concise letter. There are others who can write effectively and clearly but find it difficult to communicate the same ideas in a speech. To further complicate matters, when people feel that they understand one another perfectly, they may think they have reached a common understanding when in reality they have not. The way in which individuals interpret certain words and phases depends greatly on their backgrounds.

Communication failures are often at the centre of disputes and ultimately claims. For this reason it is important that ***any verbal communication regarding a project should be reduced to writing and confirmed by all parties in a simple letter of confirmation.*** The letter should be endorsed by all parties involved in the verbal communication. Several of the program claims have resulted from misunderstandings of verbal instructions. Written confirmation of these discussions, in many cases, would have enhanced our insured's position. Verbal agreements are very difficult to prove at a later date.

Before field crews are dispatched for fieldwork, are surveyors reviewing with staff exactly what has to be done and why it has to be done? Are there clear procedures in place so that the time in the field can be spent completing the survey to the necessary standard of care?

No measurement either horizontal or vertical, and no calculation, no matter

how simple, should be regarded as correct until it is verified. No monument should be considered to be in its correct location until its position has been confirmed by verifying its location relative to other found monuments. ***As far as practical, a method of verification should be independent from the original method of measurement and calculation.*** It is a fact of life that persons and procedures are liable to mistakes. However, on any 'survey' project, by implementing proper checking and control procedures, mistakes will be reduced and errors virtually eliminated.

One useful tool to assist in minimizing mistakes is to develop a checklist - a list of items that should be completed for each particular type of project. This checklist should include the necessary independent checks and redundancies. The proper use of a checklist makes it unlikely that someone would unconsciously omit any required provision. Once a checklist is developed it must be used properly. A checklist is only useful if it is completely filled out and reviewed, by project supervisors.

A mistake can still happen in our business, but it is the repeated frequency of the same mistakes that is of concern to the PLIC and our insurers. The fact that a few of our insureds have more than one claim, caused by similar errors, is a major concern to the PLIC. ***Let us not jeopardize the Professional Surveyors Canada Professional Liability Insurance Programme by losing sight of long established survey principles and standards of care.*** Modern technology does not replace the need for independent verification and common sense.

4.3.2 The Three C's of Construction Layout: Not Just Check, Check, Check

Reprinted, with permission, from "The Ontario Land Surveyor" magazine, Volume 48, No. 1 – Winter 2005.

By: Paul J. Gregoire, OLS, CLS, Chair of the Association of Ontario Land Surveyors, (AOLS) Insurance Advisory Committee

One of the functions of the AOLS members who serve on the [AOLS] Insurance Advisory Committee is to assist the insurance adjuster in survey matters relating to an insurance claim or a potential claim made by a policyholder. [Editor's Note: The members of the Professional Surveyors Canada Professional Liability Insurance Committee (PLIC) serve the same function for the Professional Surveyors Canada insurance program.] On most occasions the events or survey activity giving rise to the claim are fairly straightforward, on other occasions a more detailed review of the project activity is required.

A review of a number of the claims made over the past few years would reveal that there are numerous ways (some would say an endless number) in which the surveyor finds him or herself party to a claim. Some claims do not result in damages and are reported due to an over abundance of caution, other claims can be resolved by mutual agreement between all of the parties involved, and still others lead to litigation and result in payment of damages.

The following article attempts to outline some of the survey practices, which if followed, may help reduce the surveyor's exposure to risk and potential liability claims. A majority of these best practices are most relevant to our field staff, who are the eyes and ears of the surveyor on each project. Some of the practices are relevant to the computations staff or the project manager and/or the project surveyor.

The survey practices are grouped into one of three categories; Communication issues, Contractual issues, and Computations issues. A detailed look at each of these categories will help the surveyor identify the scope of work that is to be contracted. It will help to identify potential risks and will assist in preparing a successful plan to complete the work in an efficient and cost effective manner.

Communication Issues

- What are the client's requirements and specifications/tolerances, i.e. building corners, gridlines, offsets, temporary benchmark locations?
- What are the client's critical timelines for project start-up?
- What are the existing site conditions, i.e. can a crew work safely on site or is there construction activity ongoing, such as earthworks or the installation of services that will affect your work? Familiarity with the site prior to providing a written quotation is essential - don't take the word of someone who may not have personally been on the site or who provides general information, which you rely on to make assumptions. Go visit the site prior to preparing a fee estimate.
- Determine what the future work schedule is going to be – can a crew lay out all key points in one or two days or do they need to return to the site twice a week for the next month as excavation progresses, i.e. caisson layout. (This has a big impact on pricing the work).
- Has the client provided a set of drawings that are stamped "Issued for Construction" and has the client provided you with a clear understanding of his expectations on which you are to base the fee estimate.
- Ensure that you understand the work schedule so that you have enough time to prepare for upcoming project requirements and are not rushed into providing layout before all the initial prep work has been completed.
- When issuing survey returns to the client (or third parties), which include data derived from other sources, be sure to include a disclaimer note on the plan indicating the source of the data and that you provide no assurances as to it's correctness and accept no responsibility for it's use. Provide a similar disclaimer for topographic surveys conducted during winter conditions.

Contractual Issues

- Provide a written estimate or quote so that you can obtain proper work authorization for the survey layout work to be undertaken. This can be in the form of a sign back, a purchase order, etc. Include a defined scope of work, an identified work schedule and an agreed upon compensation (lump sum or hourly

rates) prior to commencing work. It's a good idea to specify that you require advanced notice prior to sending a crew to the site, you may not always be able to prevent rush requests for urgent layout but it gives you an out if you need some lead time prior to attending on site.

- Obtain written authorization for additional survey work, i.e. a sign back letter of authorization or client purchase order. Ensure that the party chief does not undertake work that was not scheduled or approved for layout that day, i.e. don't let the site super redirect the crew's activity to do extras that were not planned nor approved.
- Identify who is responsible for work that has to be redone due to design changes or construction activity. This can be minimized by ensuring that you only work from drawings that have been "issued for construction."
- Document each survey milestone as well as each change order including telephone/fax/Email correspondence with the client, the site superintendent and each of the other consultants from whom you have received data or who have issued instructions to you.

Computations Issues

- Review the approved site drawing to ensure that building and site dimensions work, i.e. that the building closes and the site dimensions agree with the boundary survey.
- Pre-compute site boundary geometry and position the building to ensure setbacks comply with minimum requirements and the approved site plan.
- Compute grid line positions relative to the building face and position caisson locations relative to grid intersections.
- Establish horizontal and vertical control stations on site and reference these points for future re-establishment. Level loops are to be closed, reduced and double-checked at the time of field observation.
- Integrate cadastral fabric to horizontal control if applicable.
- Compute layout data for the field crew by preparing a coordinate list and/or polar layout for all points from each control station.
- Upon completion of layout, the field crew must provide confirmation of what was laid out by preparing a sketch for the site supervisor. The sketch must clearly indicate offsets used and illustrate the location of the site's temporary benchmark(s).
- Complete an office review of all layout performed by the field crew after each field trip. Check the notes to ensure that redundant measurements have been taken and that closures have been calculated and checked by the crew while on site (i.e. level loops).

General Do's & Don'ts

- Do not accept a digital file from the client or his/her consultant for layout purposes without getting the hardcopy version of the site plan marked "Issued for Construction."

- Do not accept a site benchmark from another source without first verifying the elevation by levelling to an independent municipal benchmark.
- Do not accept the contractor's layout points for layout without proper verification.
- Do not accept revised site drawings for layout purposes without first verifying in the office that all new values work.
- Do not work from a set of drawings that are only available in the site trailer.
- Do not issue or provide benchmark information to a third party in the field.
- Use published dimensions only – do not scale drawings or interrogate digital files for dimensions without proper checks.
- Issue a sketch illustrating the building, gridlines, property boundaries, etc. with final computed dimensions to the architect to get confirmation that the siting is correct prior to field layout.
- Ensure all points that are laid out have redundant ties or check measurements to eliminate blunders.
- Elevations for temporary benchmarks must be derived from at least two municipal benchmarks.
- Confirm the source of the vertical datum of the drawings and establish a minimum of two temporary benchmarks (TBM) in close proximity to the site.
- Run a level loop through the site control (turning on each control point) and close on to a second municipal benchmark (ensures an independent, redundant check).
- Do not establish temporary benchmarks on objects that can move (including survey monuments, fire hydrants, utility pads, posts and poles) but instead use things that are stable, i.e. the finished floor slab of an adjoining building, a spike in a tree that is outside the construction area.
- Finally, review all of the layout prior to allowing the contractor to use it – it's your last chance to check, check, check.

The points raised in this article will hopefully serve as a reminder to all survey staff about the importance of proper planning and field procedures as well as the need to institute proper quality control and quality assurance in our daily survey practices. By following these good practice guidelines, our clients will be well served and the chances of being involved in an insurance claim will be minimized.

Paul Gregoire, OLS, CLS, is an Associate Partner at Marshall Macklin Monaghan Limited. He can be reached by email at gregoirp@mmm.ca.

4.3.3 Towards Achieving Measurement Redundancy

Reprinted with permission from "ALS News" September 2006 VOL. 35-3.

By: Fred Cheng, ALS.

Background

In the past eight months, I have observed a serious lack of measurement redundancy during my review of land surveying practices. Measurement redundancy is a requirement of our Manual of Standard Practice (MSP).

Often, I am provided pages of printed co-ordinates and then expected to accept them as field notes of the survey. It appears that these co-ordinates were generated from either data collectors, or Global Positioning System (GPS) observations. At times, I receive the explanation that Real Time Kinematic (RTK) redundancy was achieved by gaining lock and logging followed immediately by losing lock, relocking and relogging.

I have often asked practitioners to provide their detailed in-house policy to demonstrate how the practitioner achieves measurement redundancy.

Once a statutory iron post is placed in the ground and the plan is registered at the Land Titles Office, the iron post governs the property corner wherever it is placed in accordance with the Surveys Act. As such, it is extremely important that the iron post is in the correct position. Alberta Land Surveyors should make every effort towards placing survey monuments with care and due diligence, by introducing stringent redundant measurements during the course of their surveys.

In my opinion, co-ordinate printouts are not field notes simply because a printout of a set of numbers could mean a lot of things, we do not know if they are raw data, adjusted data, co-ordinates generated from computation, and/or they could be altered. If the information is derived from conventional surveys using a theodolite and data collector, we require the practitioner to submit a copy of the raw data file of his field measurements.

As for GPS RTK redundancy, recording and losing lock, and immediately regaining lock is hardly considered redundant observations; even if done with an intervening time span. Re-measurement from the same base station set-up on the same day it was performed can only be considered a blunder check, and should not be considered to have eliminated any systematic errors or random errors. An independent set-up, preferably on a different day, is recommended. Also, proper written field notes are essential for keeping track of different field conditions for GPS observations at different epochs.

Some practitioners are hung up on technology and readily accepting "black box" solutions that come out of a GPS receiver. Without proper methods, sufficient checks and balances to ensure random, multipath, systematic and other errors are eliminated, the survey is not reliable.

One practitioner suggests that, in RTK surveys potentially multipath, systematic, human, random, and other

sources of error may be reduced by the following redundancy measures:

- performing the surveys again on a different day;
- using different receivers for the base and rover (i.e. switch receivers);
- re-observing under different ionospheric conditions;
- re-observing using different HI's (height of antenna in this instance);
- careful selection of a different base station location preferably with reduced multipath and improved field condition;
- be aware of other surveyors working in the vicinity, their same frequency signals might interfere with yours; and
- using different procedures for blunder checks often during the surveys (i.e. using time change and/or dropping the integers to ensure multipath and poor PDOP conditions are remedied).

If one suspects the observations are not reliable one should try some or a combination of the above suggested procedures and see if the results would improve. After all, it is your name that stays on the plan and resides on public record for a long time.

Current Standards on Redundancy

Currently, Part C, Section 1.4 of our MSP calls for practitioners to provide redundant checks on their work as stated below:

All surveys conducted under the Surveys Act must be verified by one or more of the following:

- *closure on prior or current work;*
- *closure on existing Alberta Survey Control;*
- *check-measuring all observations; or*
- *other appropriate means.*

Sufficient field measurements shall be made to ensure there are no errors of layout or measurement.

Also, as for measurements and accuracy for GPS surveys, MSP Part C, Section 2.4 states:

The position of every monument included in a GPS survey either found or placed shall be verified with sufficient redundant observations. This applies to both static and kinematic surveys.

Redundancy in Conventional Survey Measurements

With permission, I have reprinted a practitioner's field instructions and procedures for attaining redundancy in his field surveys.

As with a conventional survey, your work must be checked. All important points must be checked, including all found evidence, any ASCM tied-in for horizontal control, all planted posts on an R/W survey and well centre on a wellsite survey...Your check shot should be no more than 2.0 cm from your original.

An alternative technique is to tie it in conventionally. If you have to get your instrument out for a side shot anyway, this may be the most practical method.

When tying-in to Fd Is, you can check them to (against) plan. If they fit plan to 1:5000, they won't need any other work. However, if you are at a hard to get at location, do not have the other point tied-in yet, and you do not want to risk having to come back to it, consider double shooting it anyway.

We are still having problems with insufficient check measurements with the field works.

I want to go through what evidence has to be checked, what is a suitable check and what is not.

The following evidence must always be checked:

- *all found posts;*

- *all planted posts;*
- *any tied-in in ASCM's;*
- *well centre (both horizontally and vertically);*
- *any found spikes or I. bars if used for control.*

The following are suitable checks:

- *checking found evidence to plan distance (if it fits 1:5000 for better);*
- *directly including in a loop that closes;*
- *using other plans (1:5000 or better);*
- *using your own work or GPS to (1:7500 or better);*
- *double shooting with GPS (this GPS observation procedure is administered to support previous conventional measurements and simply used as a check);*
- *tie in with both GPS and conventional (use caution not to over control it);*
- *an angle and distance from different set-up;*
- *an angle from different back sight and check chaining;*
- *if placed on line, shooting the long distance and both short distances;*
- *for elevation (if trig, vertical distance should be booked in both phases).*

The followings are not suitable checks:

- *a doubled angle is required to reduce horizontal collimation error and to avoid booking errors. It is not an independent check measurement;*
- *shooting the same distance multiple times, booking either metres/feet or horizontal distance/slope distance/vertical angle are required but only to check booking error. These are not to be used as independent check measurements;*
- *coming off or tying-off to evidence that has not been check measured itself is not a sufficient check.*

In short, it is not checked until you have proven that it is where your field notes say it is. All these techniques have been discussed in detail. We appreciate your cooperation in ensuring the overall quality of our work.

The above is one of many good examples that we have observed. We anticipate that each and every practitioner observes similar examples and develops redundancy measurement procedures of their own which best cater to their resources.

Redundancy in GPS Survey Measurements

I have received several in-house GPS policies from different practitioners. They are professionally developed and can be used as yardsticks for other surveyor's practices.

It is interesting to note that the state government of Victoria, Australia has developed a set of formal guidelines towards GPS observations in legal surveying applications. The following are selected highlights from their GPS philosophy in legal surveying [Eddie Cichocki, Office of Surveyor-General, State Government of Victoria, Australia, 2006]:

- "Legal Traceability" is the term used to describe the traceability of physical measurements back to a recognized-value standard.
- The National Measurement Act 1960 (of Australia) requires measurements made for legal purposes to be in terms of the Australian legal unit derived. from reference to an appropriate standard of measurement.
- Measurements made for legal purposes are substantiated at law through a continuous chain of verifications from the recognized-value standard to a working standard being the device used to take the measurements.

- For GPS, an associated recognized-value standard is the Australian Fiducial Network (AFN). It was gazetted as a standard on April 22, 1998.
- There is currently no formally accepted process to provide legal traceability of GPS measurements. Despite this, GPS can, and is, being used for legal measurement on cadastral surveys.
- GPS should not be used as the sole method of determining length in cadastral surveys.
- A quality-assurance approach based on best practice guidelines for the use of GPS for surveying applications is recommended.
- General and specific requirements (for utilizing GPS in cadastral surveys):
    - The guidelines generally refer only to relative GPS positioning, which requires two or more GPS receivers.
    - Users should familiarize themselves with the procedures contained in the GPS equipment and software manuals.
    - Redundant observations should be built-in to detect errors.
    - Conventional observations of an appropriate accuracy to be included.
    - Connection, where possible, to at least two know Third Order or better markers in the Survey Control Network.
    - All ancillary equipment must be in good adjustment and repair.
    - Generally, GDOP no greater than 8 & elevation mask not less than 15 degree.
    - Occupation times should be increased where multipath is likely.
    - Rapid static
      - attention to be paid to multipath errors.
    - Post Processed Kinematics Baselines
      - each point should be reoccupied in a different session with different satellite geometry.
    - Real Time Kinematics
      - base stations should be located in a low multipath environment.
      - re-occupations of points should be made.
      - new base stations on very large projects should be established using static or fast/rapid static GPS techniques.
    - Analysis of Results
      - least squares network adjustments for classic static and rapid static techniques.
      - misclosure comparisons for techniques where there are no direct measurements between stations (i.e. RTK or rapid static).
    - Digital Data Storage
      - raw observational data, results from baseline processing and final adjustments, should be archived (RTK or rapid static).
    - GPS measurements are being supported/validated by comparison with ‘known’ ground markers, multiple occupancy of stations and comparison with conventional measurements.
    - Abstract of field records (proposed) needs to clearly show or state:
      - the method used to perform the survey;
      - the base stations and coordinates of the origin of the GPS datum control (if appropriate);

  - the measurements that have been derived from GPS observations.
- Survey report (proposed) to include:
  - details of the equipment used;
  - the process used to validate the equipment;
  - an indication of the integrity of the measurements;
  - details of the base stations used and their coordinates (if appropriate);
  - the observation technique employed;
  - the method of reduction and software used;
  - a statement of the precision obtained.

The above excerpts are highlighted from the guidelines to be utilized in Victoria, Australia and are contained in their GPS Best Practice Guidelines that were produced by ICSM (Intergovernmental Committee on Surveying and Mapping). Further details regarding the Victoria government recommended procedures for the use of GPS in legal surveys are now included in their publications entitled, *Standards and Practices for Control Surveys (publication SP1), and Survey Practice Handbook.* They can be found in the following web sites respectively: www.icsm.gov.au/icsm/publications and www.land.vic.gov.au/surveying.

Similar guidelines regarding GPS in cadastral surveying can be found in the New South Wales government document entitled, *Surveyor General's Directions (Document no.9) GPS Surveys*. Within which, it refers to another ICSM document entitled, *Best Practice Guidelines - Use of the Global Positioning System For Surveying Applications,* and it can be found in the following web link: www.icsm.gov.au/icsm/publications/sp1/sp1.htm.

A Private Practitioner's Opinion on GPS Redundancy

I had lengthy discussions with one of our members, whom has been practicing extensively with GPS since its introduction to land surveying in Alberta. This private practice member is of the opinion the method of initialization – loss of lock – re-initialization or time interval methods do produce redundant observations if performed under the right conditions. "Under the right conditions," is difficult to quantify and, as a result, less experienced individuals may find they are not achieving accurate positions when they have mistakenly accepted confirmation of position using this technique.

The above initialization – loss of lock – re-initialization method is perceived to almost always produce a precise confirmation measurement (i.e. two coordinated observations that are within 0.02m of each other); while the (initialization – loss of lock – time interval method) might appear to provide a less precise confirmation measurement, it in fact provides a lot more confidence in the position.

This same individual is of the opinion that, as a profession we should be placing less emphasis on precision and more on reliability (i.e. accuracy, and detection of blunders) in our work.

His rankings from best to worst redundancy technique to confirm a GPS position is tabulated as follows:

1. GPS position confirmed by conventional or other completely independent positioning technique;
2. Position confirmed by being part of a closed GPS network, consisting of static observations, wherein the position is occupied at least a second time on a different day;
3. Multibase observations (i.e. not two bases with one-point observation but two separate occupations of the monument);
4. Time separation with new GPS satellite constellation;
5. Time separation (30 minutes or less); and
6. Observation – loss of lock – reinitialization.

The second procedure puts the most emphasis on GPS accuracy, and blunder detection. For additional reference, please consult the "Guardpost" article on RTK and Measurement Closures published in the December 2005 issue of *ALS News*.

All of the above discussions assume that the GPS personnel has undergone rigorous trainings and that GPS system, procedures, and techniques have been verified through calibration/validation on the Alberta Government's GPS Three Dimensional Positioning Basenet [*ALS News* Winter Issue 1990 Vol. XIX-1]. As section 11(2)(b) of the Surveys Act stipulates that electronic linear measuring equipment used by land surveyors be calibrated against this standard of measure periodically.

Conclusion

The above excerpts and discussions for achieving redundant measurements in GPS (and conventional) surveys are, in my opinion, good references. It should be noted though they are not considered to be Practice Review Board or Systematic Practice Review directives.

As I understand, the current MSP standard for achieving redundancy measurement is under review by the Standards Committee. In the meantime, I urge every practitioner to develop their own policy to achieve reliable survey results based on their resources such that redundancy can be achieved in a consistent fashion within their own practice.

Please note that redundancy is not just confined to field practices and procedures. If proper checks and balances are in place in both the field and office, getting it done right the first time is achievable. For example, in some instances, field errors can be identified during a stringent plan examination process. In addition, good records and note keeping is key to achieving communication between field and office staff to further detect and resolve potential errors.